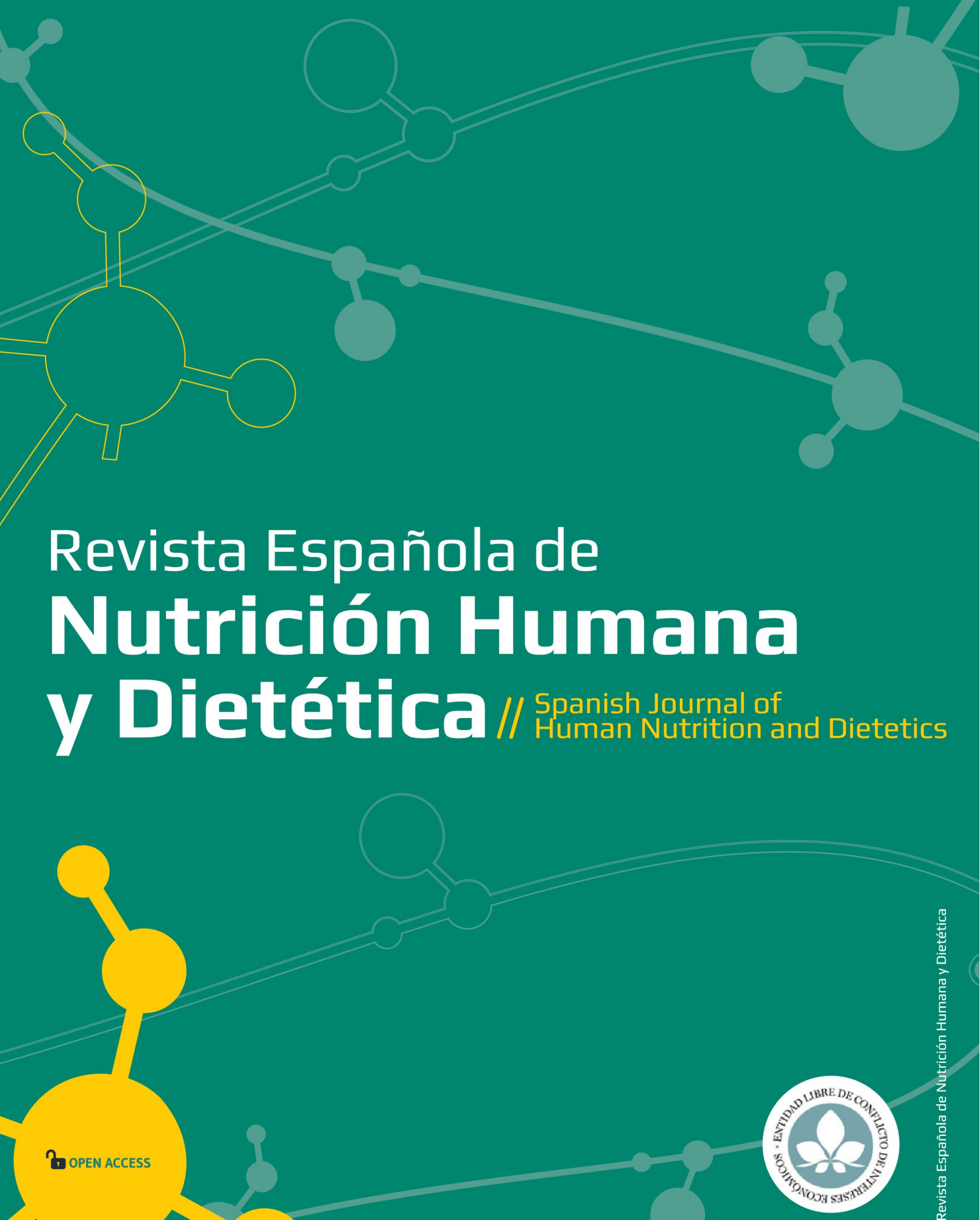




Revista Española de **Nutrición Humana y Dietética** // Spanish Journal of Human Nutrition and Dietetics

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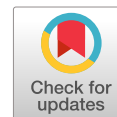
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EDITORIAL

Etiquetado frontal de alimentos: de la evidencia científica a la implementación de políticas públicas

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El etiquetado frontal de alimentos (FOPL, por sus siglas en inglés) es una de las principales herramientas para promover elecciones alimentarias más saludables a partir de una mejora en la comprensión de la calidad nutricional de los alimentos que favorezcan compras más saludables y mejorar los entornos alimentarios¹⁻³. Frente a la complejidad del etiquetado nutricional tradicional, el FOPL sintetiza la información nutricional y facilita su interpretación en el momento de la compra, convirtiéndose en una intervención regulatoria clave para prevenir las enfermedades no transmisibles relacionadas con la alimentación^{1,2}. Sin embargo, en Europa, el debate científico se ha centrado en identificar el modelo FOPL más adecuado, sin dar paso a su implementación en la política pública.

Actualmente existen diversos sistemas de FOPL que difieren en la información que proporcionan y en su objetivo. Pueden clasificarse en sistemas específicos para nutrientes y sistemas de resumen, que sintetizan la calidad nutricional global del alimento^{1,2} (Figura 1). Entre ellos, los Sellos de Advertencia (SdA) identifican alimentos con un contenido elevado de nutrientes críticos, mientras que Nutri-Score (NS) resume la calidad nutricional mediante cinco categorías codificadas por colores, calculadas a partir de un algoritmo^{1,2}. Ambos modelos han concentrado el mayor interés científico y político durante la última década y centran la discusión de esta editorial.

Investigaciones sobre los SdA han demostrado ser uno de los FOPL obligatorios con mayor comprensión objetiva por diversos grupos poblacionales, además de facilitar la identificación de productos de baja calidad nutricional y reducir la compra y/o selección de alimentos altos en azúcar, sodio o grasas saturadas⁴. Además, un estudio reciente en población española con y sin enfermedades crónicas observó que los sellos de advertencia reducían con mayor eficacia que NS el efecto halo saludable en productos como el yogur griego, el yogur de frutas y el pan integral⁵.

Por otro lado, se ha documentado que NS mejora la comprensión de la calidad nutricional de los alimentos, facilita la comparación entre productos y favorece elecciones alimentarias más saludables frente a productos sin FOPL o a otros sistemas, como NutriInform Battery o los de tipo semáforo^{3,6,7}. Sin embargo, los distintos sistemas de FOPL pueden mostrar rendimientos diferentes según el resultado evaluado. A pesar del creciente volumen de publicaciones, persiste una limitada evidencia sobre su impacto en condiciones reales y en poblaciones vulnerables⁷. Además, en el caso de NS, se ha señalado la necesidad de fortalecer la investigación independiente, ya que una proporción relevante de los estudios publicados procede de grupos vinculados a su desarrollo y presenta resultados mayoritariamente favorables al sistema⁸.

De la evidencia a la implementación de políticas públicas

El reto actual de la investigación sobre los FOPL no es solo determinar cuál es el más adecuado, sino generar evidencia suficiente para diseñar, implementar y evaluar políticas públicas

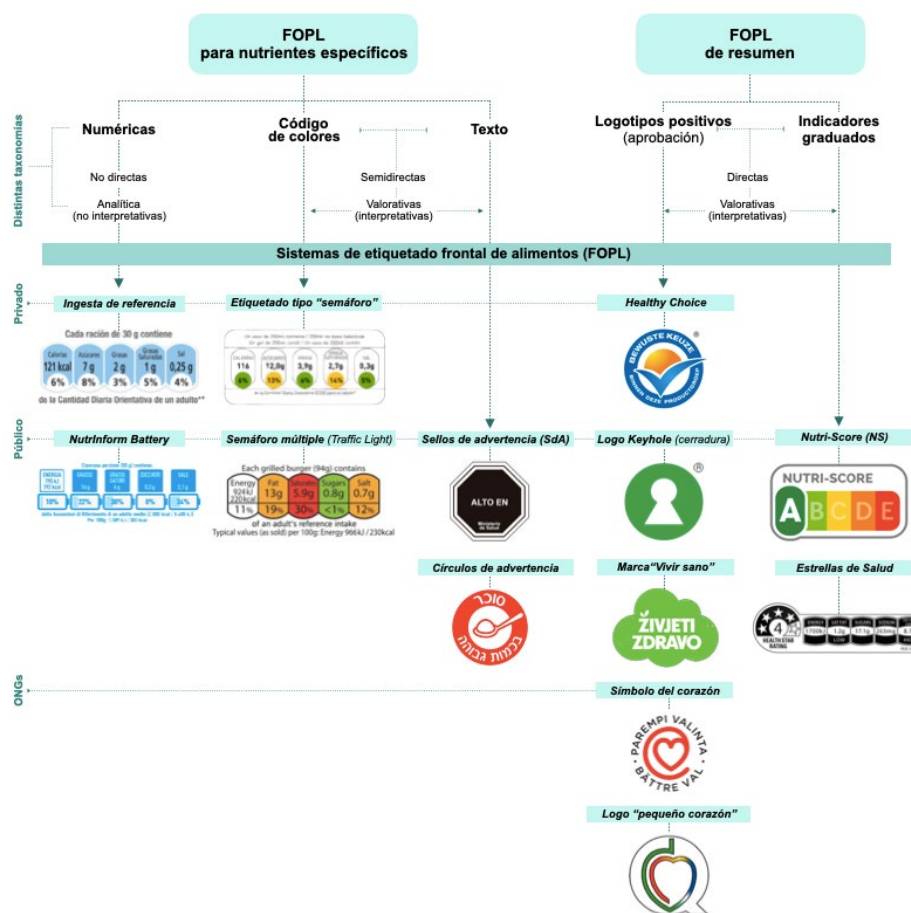
capaces de transformar los entornos alimentarios y mejorar la salud de la población. Para ello, es necesario considerar la respuesta de la industria y los sistemas alimentarios, así como las implicaciones económicas y regulatorias de su implementación^{2,9}. Los SdA han sido implementados por diversos países latinoamericanos, entre los que se encuentran Chile, Perú, México, Uruguay, Argentina y Colombia, con diferencias en su grado de implementación y en su integración con otras medidas regulatorias, como las restricciones a la publicidad dirigida a menores, las medidas aplicadas en el entorno escolar, las leyendas precautorias sobre edulcorantes o cafeína, las políticas fiscales o la regulación de las declaraciones saludables⁴. La experiencia de Chile, país pionero en la implementación de los SdA, muestra que su aplicación, integrada con otras medidas regulatorias, se ha asociado con la reformulación de productos y cambios favorables en los patrones de compra^{3,10} e, incluso, con una reducción del exceso de peso infantil¹¹, reforzando el potencial de las políticas integrales que combinan el FOPL con otras intervenciones.

Por su parte, NS no es de aplicación obligatoria en la Unión Europea (UE). Aunque en 2020 la Comisión Europea anunció, en el marco de la Estrategia “De la Granja a la Mesa”, el desarrollo de un sistema armonizado de FOPL y de perfiles nutricionales para toda la UE¹², ambas iniciativas siguen pendientes y persisten diferencias entre los Estados miembros. Hasta ahora, es la propia industria alimentaria la que, de forma voluntaria, ha implementado NS en sus productos. La evidencia en condiciones de compra indica que este FOPL puede favorecer la selección de alimentos de las categorías más favorables, como A y B, sin afectar a aquellos ubicados en categorías intermedias¹³. Además, puede facilitar la reformulación de productos², aunque persisten interrogantes sobre la naturaleza de estas reformulaciones y las estrategias adoptadas por la industria.

No obstante, los efectos observados en condiciones reales tienden a ser menores que en los estudios de simulación y presentan limitaciones importantes, como la reducida presencia de NS en los envases, su coexistencia con productos sin FOPL y su carácter voluntario¹³. Este último permite que las empresas prescindan del logotipo ante clasificaciones menos favorables, como ocurrió tras la actualización del algoritmo de 2022-2023, cuando algunas empresas que inicialmente apoyaban el sistema dejaron de mostrarlo en determinados productos, como los lácteos azucarados¹⁴.

Por último, la implementación de políticas públicas de salud requiere también de voluntad y consenso político. En España, el debate sobre la implantación de NS evidenció que la elección de un sistema de etiquetado trasciende la evidencia científica y está condicionada también por factores económicos, productivos y políticos. Las discrepancias entre el Ministerio de Consumo y el Ministerio de Agricultura, Pesca y Alimentación, así como la posterior Proposición de Ley basada en los SdA —finalmente rechazada por el Congreso de los Diputados en abril de 2026—, ilustran la complejidad regulatoria y política de la implementación de un FOPL^{15,16}.

Figura 1. Principales tipologías de los sistemas de etiquetado frontal de alimentos (FOPL) implementados, propuestos o anunciados en diferentes países. Elaboración propia.



Por lo anterior, la Revista Española de Nutrición Humana y Dietética (RENHyD) busca contribuir a la difusión de investigaciones sobre la implementación y evaluación de políticas públicas de alimentación y nutrición, como los FOPL, promoviendo estudios independientes en condiciones reales, que consideren su integración con otras medidas regulatorias y su impacto en poblaciones vulnerables. Esta evidencia resulta necesaria para fundamentar políticas orientadas a mejorar la salud de la población.

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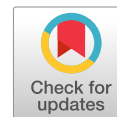
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RESEARCH ARTICLE

Effects of a Nutrition Education Program on Mediterranean Diet Adherence in School-Age Boys Playing Amateur Soccer: A Pilot Pre-Post Study

➤ Efectos de un programa de educación nutricional sobre la adherencia a la dieta mediterránea en niños en edad escolar que practican fútbol amateur: estudio piloto pre-post

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KEYWORDS

Mediterranean Diet
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➤ ABSTRACT

Introduction: Evidence on nutrition education in amateur youth soccer is limited. This study evaluated the effects of a structured nutrition education program on Mediterranean diet quality, dietary intake patterns (food-group consumption frequency), anthropometrics, and healthy eating self-efficacy in school-age boys playing amateur soccer.

Methods: A single-group pilot pre-post study was conducted in a sports club, including 60 boys aged 8–10 years (9.10 ± 0.80). The intervention comprised four weekly sessions based on the Turkish Dietary Guidelines (TÜBER), delivered in four groups (~15 children/group), each lasting 20–30 minutes, with take-home leaflets for parents. Outcomes included height, body mass and BMI (WHO AnthroPlus Z-scores), the Children's Healthy Eating Self-Efficacy Scale (CHSE-ES), the Mediterranean Diet Quality Index for Children and Adolescents (KIDMED), and food consumption frequency, and 3-day dietary records.

Results: KIDMED scores increased after the program ($p < 0.001$), with fewer children classified as low adherence and more as high adherence. Overall, reported consumption shifted toward more nutrient-dense choices and less energy-dense snack foods (all $p < 0.05$). Healthy eating self-efficacy did not change significantly ($p > 0.05$). Height and body mass increased significantly, and height-for-age classification shifted; BMI and the other anthropometric classifications remained unchanged.

Conclusions: A brief nutrition education program delivered in a sports club setting was associated with improved Mediterranean diet quality and favorable changes in reported dietary patterns, while self-efficacy and BMI remained unchanged; the modest anthropometric changes may reflect normal growth. Controlled studies with larger samples and longer follow-up are warranted.

Funding: No funding was received to conduct this study.

RESUMEN

PALABRAS CLAVE

Dieta mediterránea

Educación
nutricional

Estudio piloto

Antropometría

Fútbol juvenil

Introducción: La evidencia sobre la educación nutricional en el fútbol juvenil amateur es limitada. Este estudio evaluó los efectos de un programa estructurado de educación nutricional sobre la calidad de la dieta mediterránea, los patrones de ingesta dietética (frecuencia de consumo por grupos de alimentos), los indicadores antropométricos y la autoeficacia para una alimentación saludable en niños en edad escolar que practican fútbol amateur.

Metodología: Se realizó un estudio piloto pre-post de un solo grupo en un club deportivo, en el que participaron 60 niños de entre 8 y 10 años ($9,10 \pm 0,80$ años). La intervención consistió en cuatro sesiones semanales basadas en las Guías Alimentarias para Turquía (TÜBER), impartidas en cuatro grupos de aproximadamente 15 niños. Cada sesión tuvo una duración de 20–30 minutos y se proporcionaron folletos para llevar a casa dirigidos a los padres. Las variables evaluadas incluyeron la talla, el peso corporal y el índice de masa corporal —expresados como puntuaciones Z mediante WHO AnthroPlus—, la Escala de Autoeficacia para una Alimentación Saludable en Niños (CHSE-ES), el Índice de Calidad de la Dieta Mediterránea para Niños y Adolescentes (KIDMED), la frecuencia de consumo de alimentos y registros dietéticos de tres días.

Resultados: Las puntuaciones del KIDMED aumentaron tras el programa ($p < 0,001$), con menos niños clasificados con baja adherencia y más con alta adherencia. En general, el consumo informado se desplazó hacia opciones más densas en nutrientes y una menor ingesta de alimentos tipo snack de alta densidad energética (todos $p < 0,05$). La autoeficacia para una alimentación saludable no cambió de forma significativa ($p > 0,05$). La talla y la masa corporal aumentaron significativamente, mientras que el IMC permaneció sin cambios; entre las clasificaciones antropométricas, solo cambió la talla para la edad.

Conclusiones: Un breve programa de educación nutricional aplicado en un club deportivo se asoció con una mejora de la calidad de la dieta mediterránea y cambios favorables en los patrones dietéticos informados, mientras que la autoeficacia y el IMC permanecieron sin cambios; las variaciones antropométricas observadas pueden reflejar el crecimiento normal.

Financiación: No se recibió financiación para llevar a cabo este estudio.

KEY MESSAGES

1. In this pilot, short follow-up study, a brief club-based nutrition education program was associated with improved diet quality in youth soccer players.
2. Mediterranean diet adherence (KIDMED score) increased significantly after the education program.
3. Reported dietary patterns shifted toward more nutrient-dense foods and less energy-dense, nutrient-poor snacks, while BMI and healthy eating self-efficacy remained unchanged; other anthropometric changes may reflect normal growth.

CITATION

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INTRODUCTION

Nutrition is a key determinant of health, growth, and development in childhood. In school-age children, adequate and balanced dietary intake supports optimal growth, immune function, and cognitive outcomes, and this period is critical for establishing dietary habits that may persist into adulthood^{1,2}.

For children who participate regularly in organized sports, nutrition is also central to performance and overall health. Adequate energy and nutrient intake supports training adaptation, competition performance, and recovery in young athletes undergoing growth and maturation³⁻⁵. Appropriate nutrition practices have been associated with better performance-related outcomes, whereas insufficient or unbalanced intake may contribute to early fatigue, increased injury risk, and impaired growth⁶. Healthy dietary behaviors in this group have also been linked to stronger immune resilience, fewer illness and injury episodes, and more favorable body composition⁴.

Nutrition education may represent a practical and scalable intervention during this developmental stage. Evidence indicates that nutrition education in childhood can improve nutrition-related knowledge, attitudes, and behaviors⁷. This is especially relevant for young athletes, who often have limited nutrition knowledge and rely on informal sources such as family, coaches, or popular media, which may contribute to non-evidence-based practices. Developmentally appropriate, evidence-based education may therefore help children adopt dietary habits that support both performance and long-term health⁸.

However, evidence remains limited regarding the combined effects of nutrition education on self-efficacy, diet quality, eating behaviors, and objectively recorded dietary intake, particularly among amateur youth athletes. In Türkiye, comprehensive intervention studies evaluating nutrition-related self-efficacy, diet quality, eating behaviors, dietary records, and anthropometric measures in school-age amateur football players are scarce. Therefore, as a pilot pre-post study, the present research aimed to explore the preliminary effects and practical feasibility of a structured nutrition education program delivered to school-age boys playing amateur football on nutrition-related self-efficacy, diet quality, eating behaviors, and dietary habits.

We hypothesized that the nutrition education program would be associated with improvements in nutrition-related self-efficacy, Mediterranean diet adherence/diet quality, and selected eating behaviors and dietary intake indicators after the intervention period.

METHODS

Study Design and Participants

This single-group pre-post study included boys aged 8–10 years playing amateur soccer at a sports club in Istanbul, Türkiye. Of

66 eligible children registered at the club, 60 participated with parental informed consent; children with chronic disease, missing consent, or who declined participation were excluded. As this was a pilot study, the sample size was based on feasibility (the number of eligible children available at the club during the study period and logistical capacity to deliver the sessions), rather than on an *a priori* power calculation.

Ethical Approval

Ethical approval was obtained from the Non-Interventional Scientific Research Ethics Committee of Istanbul Atlas University (15/06/2022; No: E-22686390-050.99-24224), and written permission was granted by the sports club.

Registration

This pilot pre-post study was not prospectively registered in a public trial registry due to its exploratory, feasibility-focused nature. Future confirmatory trials will be prospectively registered.

Nutrition Education Program and Procedure

The study comprised baseline assessment, a 4-week education phase, and post-intervention assessment. At baseline, participant characteristics and physical activity were recorded, anthropometric measurements were obtained, and the Children's Healthy Eating Self-Efficacy Scale (CHSE-ES), Mediterranean Diet Quality Index (KIDMED), a food frequency questionnaire (FFQ), and a 3-day dietary record were administered. A food frequency questionnaire (FFQ) tailored to Turkish dietary patterns was used to assess usual consumption frequency over the previous month, structured by food-group categories and ordered frequency response options (e.g., every day, 5–6 times/week, 3–4 times/week, 1–2 times/week, never).

The education program was based on the Turkish Dietary Guidelines (TÜBER) program was developed based on the main themes of the TÜBER⁹ and informed by Özcan et al.¹⁰ Four sessions were delivered once weekly; each lasted 20–30 minutes (total ~90 minutes). Children were divided into four groups (~15/group). Sessions were supported with presentations and brochures, and summary leaflets were provided for parents. After a 21-day consolidation period¹¹⁻¹³, post-intervention assessments were repeated using the same procedures.

Measures

Sociodemographic and health information were collected using an 11-item researcher-developed form. Healthy eating self-efficacy was assessed using the CHSE-ES^{14,15}, a 9-item, 3-point Likert scale (0–2; total 0–18; higher scores indicate greater self-efficacy). Diet quality was evaluated with KIDMED^{16,17}; a 16-item index scored from 0 to 12 (≥8 optimal, 4–7 needs improvement, ≤3 very low).

Body mass (0.1 kg precision; Tanita) and height were measured by the same trained researcher under standard conditions, BMI was calculated (kg/m^2), and BMI-for-age Z-scores and percentiles were evaluated using World Health Organization (WHO) AnthroPlus. Dietary intake was assessed using 3-day dietary records analyzed using the BeBiS nutrition information system (BeBiS 7.0; Ebispro for Windows, Stuttgart, Germany; Turkish version) to estimate total energy and nutrient intakes, including macronutrients as well as calcium and vitamin D (Table 5). Usual monthly food-group consumption was assessed via a food frequency questionnaire (FFQ) (Table 4).

Statistical Analysis

Data were analyzed in SPSS v21.0. Normality was assessed using the Kolmogorov–Smirnov test and graphical methods. Continuous variables were summarized as mean $\pm$ SD or median (min–max), and categorical variables as n (%). Pre–post comparisons of continuous variables used paired-samples t-tests or Wilcoxon signed-rank tests as appropriate. Pre–post comparisons of paired categorical variables were performed using the marginal homogeneity test. A p value < 0.05 was considered statistically significant. Given the pilot pre–post design and multiple outcomes assessed, analyses were considered exploratory and hypothesis-generating.

RESULTS

Sixty boys aged 8–10 years participated, with most clustered in the 9–10 age range (See Table 1). The highest proportion of children were in the 4th grade (35.0%). The mean number of siblings was 1.9 ± 0.7 , with two siblings being the most common category (58.3%). As seen in Table 2, height and body mass increased significantly ($p = 0.001$ and $p = 0.006$, respectively), whereas BMI remained unchanged ($p = 0.116$); weight-for-age and BMI-for-age distributions also remained unchanged ($p = 0.705$ and $p = 0.763$, respectively), while height-for-age categories showed a significant shift ($p = 0.046$). As shown in Table 3, healthy eating self-efficacy did not change significantly ($p = 0.072$). In contrast, Mediterranean diet adherence improved markedly, with higher diet quality scores ($p < 0.001$) and a favorable shift from low toward high adherence categories ($p = 0.008$). Table 4 shows changes in food consumption frequencies before and after the intervention. Post-intervention, consumption frequency increased for several nutrient-dense items (notably vegetables and fish) and decreased for several energy-dense snack items (including ice cream, biscuits/cookies, chips, and sugary products), with statistically significant changes observed across these items (all $p < 0.05$). As seen in Table 5, overall, no significant pre–post differences were observed in total energy or most macro-nutrients between baseline and post-intervention (all $p > 0.05$). However,

Table 1. Demographic characteristics of participating children

	n (%)	Mean(SD)	Median [min-max]
Age (years)		9.10(0.80)	9 [8-10]
8	15 (25.00)		
9	22 (36.70)		
10	23 (38.30)		
Grade		4.10(1)	4 [2-6]
2.	5 (8.30)		
3.	11 (18.30)		
4.	21 (35.00)		
5.	20 (33.30)		
6.	3 (5.00)		
Number of Siblings		1.90(0.70)	2 [1-4]
1	14 (23.30)		
2	35 (58.30)		
3	9 (15.00)		
4	2 (3.30)		

the percentage of energy from protein increased ($p = 0.021$) and calcium intake increased ($p = 0.044$), whereas vitamin D intake decreased ($p = 0.032$). When interpreted against TÜBER recommendations using mean-based adequacy, CHO% and protein% remained adequate both pre-and post-intervention, whereas fat% persisted above the recommended upper range.

Paired-samples t-test or Wilcoxon signed-rank test. $p < 0.05$ statistically significant

The adequacy classification reported in this table is mean-based (based on the group mean relative to the TÜBER recommendation). For single-value recommendations, adequacy ratio (%) = (mean intake / reference value) $\times$ 100; values may exceed 100%. For range recommendations (e.g., CHO%, protein%, fat%), adequacy ratios were not calculated (shown as “—”); categories were assigned as below/within/above the recommended range. Supplementary Table S1 provides the full three-category display and 95% confidence intervals for adequacy ratios (single-value recommendations). †Energy: NA because inputs required to compute EER were unavailable. ‡Protein (g/day): adequacy ratio computed using the upper bound of the reference range (28 g/day) as the denominator. §Fat (g/day): NA because no single gram-based target value was provided; fat adequacy was evaluated using fat (%). Abbreviations: CHO, carbohydrate; EER, estimated energy requirement; CI, confidence interval; SD, standard deviation; kcal, kilocalorie; g, gram; mg, milligram; μg , microgram; NA, not assessable; TÜBER, Turkey Dietary Guidelines (Türkiye Beslenme Rehberi).

Table 2. Comparison of children's anthropometric Z-score classifications and anthropometric measurements before and after the intervention

Z-score classification	Pre-intervention n (%)	Post-intervention n (%)	p
Weight -for- age			
Underweight (≥- 2SD- <- 1SD)	3 (5.00)	3 (5.00)	0.705 ^a
Normal (≥- 1 SD- <+ 1SD)	42 (70.00)	41 (68.30)	
Overweight (≥ + 1SD- <+ 2SD)	13 (21.70)	14 (23.30)	
Obese (≥ + 2SD)	2 (3.30)	2 (3.30)	
Height -for-age			
Very Short (<- 2SD)	1 (1.70)	0 (0)	0.046 ^a
Short (≥- 2SD- <- 1SD)	7 (11.70)	5 (8.30)	
Normal (≥- 1 SD- <+ 1SD)	42 (70.00)	45 (75.00)	
Tall (≥ + 1SD- <+ 2SD)	9 (15.00)	9 (15.00)	
Very Tall (≥ + 2SD)	1 (1.70)	1 (1.70)	
BMI- for -age			
Extremely Underweight (<- 2SD)	3 (5.00)	0 (0)	0.763 ^a
Underweight (≥- 2SD- <- 1SD)	4 (6.70)	5 (8.30)	
Normal (≥- 1 SD- <+ 1SD)	36 (60.00)	40 (66.70)	
Overweight (≥ + 1SD- <+ 2SD)	14 (23.30)	12 (20.00)	
Obese (≥ + 2SD)	3 (5.00)	3 (5.00)	
Anthropometric measurements			
	Mean(SD)	Mean(SD)	
Height (cm)	136.0 (7.4)	136.4 (7.1)	0.001 ^b
Body Mass (kg)	32.5 (6.4)	32.9 (5.9)	0.006 ^b
BMI (kg/m²)	17.6 (2.7)	17.7 (2.5)	0.116 ^b

^aMarginal homogeneity test; ^bPaired t-test. p< 0.05.

BMI: Body Mass Index, cm:centimetrer; kg:kilogram

Table 3. Comparison of children's scale scores before and after the intervention

Scales		Pre-intervention	Post-intervention	p
Children's Healthy Eating Self-Efficacy Scale (CHSE-ES)	Median [min-max]	3 [0-14]	3 [0-12]	0.072 ^a
Mediterranean Diet Quality Index (KIDMED)	Median [min-max]	5 [0-11]	7 [3-11]	<0.001 ^a
	Low (≤ 3), n (%)	12 (20)	4 (6.70)	0.008 ^b
	Moderate (4-7), n (%)	34 (56.70)	34 (56.70)	
	High (≥ 8), n (%)	14 (23.30)	22 (36.70)	

^a Wilcoxon signed-rank test (pre-post scale scores). ^b Marginal homogeneity test (pre-post KIDMED categories). KIDMED, Mediterranean Diet Quality Index; CHSE-ES, Children's Healthy Eating Self-Efficacy. Scale. p< 0.05 statistically significant.

Table 4. Changes in food consumption frequencies before and after the intervention

Foods n (%)	Every day	5–6 times/week	3-4 times/week	1-2 times/week	Never	p
Ice cream						
Pre-intervention	10 (16.7)	9 (15)	15 (25)	20 (33.3)	6 (10)	0.001
Post-intervention	5 (8.3)	8 (13.3)	12 (20)	25 (41.7)	10 (16.7)	
Cheese and cheese products						
Pre-intervention	18 (30)	7 (11.7)	10 (16.7)	17 (28.3)	8 (13.3)	0.014
Post-intervention	23 (38.4)	13 (21.7)	7 (11.7)	11 (18.3)	6 (10)	
Meat and Meat Products						
Pre-intervention	6 (10)	11 (18.3)	14 (23.3)	28 (46.7)	1 (1.7)	0.029
Post-intervention	3 (5)	21 (35)	19 (31.7)	17 (28.3)	0 (0)	
Fish						
Pre-intervention	2 (3.3)	1 (1.7)	4 (6.7)	37 (61.7)	16 (26.7)	0.044
Post-intervention	2 (3.3)	2 (3.3)	7 (11.7)	42 (70)	7 (11.7)	
Green leafy vegetables						
Pre-intervention	2 (3.3)	8 (13.3)	15 (25)	30 (50)	5 (8.3)	0.008
Post-intervention	3 (5)	14 (23.3)	21 (35)	19 (31.7)	3 (5)	
Other vegetables						
Pre-intervention	3 (5)	8 (13.3)	19 (31.7)	26 (43.3)	4 (6.7)	0.033
Post-intervention	3 (5)	16 (26.7)	20 (33.3)	18 (30)	3 (5)	
Fresh fruit juice						
Pre-intervention	4 (6.7)	5 (8.3)	13 (21.7)	25 (41.7)	13 (21.7)	0.019
Post-intervention	6 (10)	12 (20)	11 (18.3)	24 (40)	7 (11.7)	
Vegetable Oils						
Pre-intervention	24 (40)	7 (11.7)	13 (21.7)	8 (13.3)	8 (13.3)	0.035
Post-intervention	15 (25)	11 (18.3)	10 (16.7)	10 (16.7)	14 (23.3)	
Sugar						
Pre-intervention	15 (25)	5 (8.3)	15 (25)	11 (18.3)	14 (23.3)	0.026
Post-intervention	2 (3.3)	8 (13.3)	15 (25)	26 (43.3)	9 (15)	
Chocolate, etc.						
Pre-intervention	15 (25)	10 (16.7)	16 (26.7)	15 (25)	4 (6.7)	0.011
Post-intervention	9 (15)	11 (18.3)	12 (20)	24 (60)	4 (6.7)	
Biscuits/Cookies						
Pre-intervention	8 (13.3)	9 (15)	11 (18.3)	22 (36.7)	10 (16.7)	0.029
Post-intervention	3 (5)	6 (10)	17 (28.3)	16 (26.7)	18 (30)	
Chips						
Pre-intervention	5 (8.3)	4 (6.7)	10 (16.7)	28 (46.7)	13 (21.7)	0.045
Post-intervention	2 (3.3)	3 (5)	8 (13.3)	28 (46.7)	19 (31.7)	

Marginal homogeneity test, $p < 0.05$ statistically significant

Table 5. Changes in energy and nutrient intakes before and after the intervention and adequacy relative to TÜBER recommendations

Nutrient	TÜBER recommendation	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	p	Pre adequacy ratio (%)	Pre category	Post adequacy ratio (%)	Post category
Energy (kcal)	Age-/sex-specific EER	1186.8 (378.1)	1097.3 (291.3)	0.183	NA†	NA	NA†	NA
CHO (%)	45–60%	45.9 (7.2)	45.1 (7.9)	0.554	—	Adequate	—	Adequate
CHO (g/day)	130 g/day	131.8 (54.7)	122.3 (32.5)	0.275	101.4	Adequate	94.1	Adequate
Protein (%)	5–20%	16.9 (4.4)	18.6 (4.1)	0.021	—	Adequate	—	Adequate
Protein (g/day)	23–28 g/day	48.78 (16.6)	51.6 (15.6)	0.316	173.9‡	Excessive	184.3‡	Excessive
Fat (g/day)	No single reference value	49.8 (17.9)	44.9 (14.8)	0.108	NA§	NA	NA§	NA
Fat (%)	20–35%	36.8 (5.6)	36.4 (10.0)	0.379	—	Excessive	—	Excessive
Vitamin D (µg/day)	15/day	2.91 (4.24)	2.05 (1.85)	0.032	19.4	Inadequate	13.7	Inadequate
Calcium (mg/day)	800 mg/day	489.9 (251.2)	533.3 (183.1)	0.044	61.2	Inadequate	66.7	Inadequate

DISCUSSION

This study examined the effects of a structured nutrition education program delivered to school-age boys playing amateur soccer on anthropometric indicators, Mediterranean diet adherence, and healthy eating self-efficacy. Overall, the findings indicate that the intervention was associated with improvements in dietary quality and selected eating behaviors. This is particularly relevant for sports requiring regular training, such as soccer, where adequate nutrition supports healthy growth, training adaptation, recovery, and injury risk management¹⁸. However, given the single-group pre–post design, the findings should be interpreted as exploratory and do not allow causal attribution.

The significant post-intervention increase in KIDMED scores suggests an overall improvement in Mediterranean diet adherence. Following the education program, the proportion of children with low adherence decreased, while the proportion with high adherence increased. Increases in vegetable and fish consumption likely contributed to this improvement. Given the widespread use of the KIDMED index in children and adolescent populations, including youth soccer players, these findings support the role of education-based approaches in improving diet quality among young athletes^{19,20}. Nutrition education was also associated with

favorable changes in food consumption patterns, with a shift toward more nutrient-dense foods and reduced intake of energy-dense, nutrient-poor snacks. Together, these findings indicate a shift toward healthier food choices following the intervention.

From a growth and sports performance perspective, increased intake of protein- and calcium-rich foods is particularly important, as these nutrients support muscle repair, bone health, and overall growth in young athletes²¹. In the present pilot study, the observed increases in calcium intake and in the percentage of energy derived from protein should be viewed as hypothesis-generating, particularly because dietary data were self-reported and no objective biomarkers or performance outcomes were assessed. These findings align with previous school-based nutrition education studies demonstrating improvements in children’s dietary patterns, particularly increased fruit and vegetable intake²². Height and body mass increased significantly, whereas BMI remained unchanged. Weight-for-age and BMI-for-age Z-score distributions remained similar before and after the education program, suggesting that short-term nutrition education did not translate into measurable changes in body mass status. In growing children, relative body mass stability over short periods may reflect appropriate energy balance, and the absence of marked anthropometric change is therefore not unexpected²³.

Although no change in body mass status was detected, a modest

improvement was observed in height-for-age Z-score distribution, with an increase in the proportion of children classified as having normal height. This finding should be interpreted with particular caution, as it may reflect normal growth and maturation over time. Given the short follow-up period and the absence of a control group, it is not possible to attribute this modest shift to the intervention. Accordingly, any linkage between improved diet quality and height-related outcomes should be considered exploratory rather than confirmatory. With respect to psychosocial outcomes, no significant change was found in healthy eating self-efficacy scores. Although a slight decline was observed, this was not statistically significant, suggesting that short-term education alone may be insufficient to strengthen children's confidence in applying healthy eating behaviors. Previous studies have similarly reported low levels of healthy eating self-efficacy among school-age children²⁴. According to Bandura's social cognitive framework, self-efficacy requires not only knowledge acquisition but also confidence in one's ability to implement that knowledge. Thus, while diet quality indicators improved, children's perceived ability to independently sustain healthy eating behaviors may not change over a short intervention window without additional behavioral practice and reinforcement. Environmental and contextual factors may further influence self-efficacy among young athletes, including food availability, meal planning around training and competition, and guidance from family members and coaches. In line with this, Kasımoğlu and Gürarslan Baş reported an inverse relationship between healthy eating self-efficacy and family support, suggesting that excessive caregiver control over dietary choices may limit opportunities for autonomy and self-efficacy development²⁴. Accordingly, future interventions that actively involve families coaches, and incorporate behavior change techniques (e.g., goal setting, self-monitoring, and guided practice) may better support children in applying learned behaviors in both home and sports settings. When energy and nutrient intakes were compared before and after the intervention, no significant differences were observed in total energy intake or in carbohydrate, protein (g), and fat (g and % of energy) intakes. This indicates that changes primarily reflected food quality rather than quantity. Children reduced consumption of packaged snacks and sugary foods while shifting toward more nutrient-dense options, without increasing total caloric intake. According to TÜBER, mean carbohydrate and protein energy shares were within the recommended ranges at both time points, whereas mean fat energy share was above the upper limit. Importantly, the proportion of energy derived from protein increased significantly, alongside a significant increase in calcium intake. These changes are particularly relevant for bone health and tissue repair in physically active children and may contribute to reduced long-term injury risk^{21, 23}.

Overall, the nutrition education program was associated with positive changes in dietary quality and eating behaviors among school-age children playing amateur soccer. Improvements in Mediterranean diet adherence and nutrient intake profiles suggest that meaningful dietary changes may be achieved even over relatively short periods when education is appropriately structured. To enhance long-term impact, such programs should be sustained and reinforced through coordinated efforts involving schools, families, and sports clubs. Future studies incorporating control groups, larger samples, and longer follow-up periods are needed to more robustly evaluate effects on growth-related and psychosocial outcomes.

Several limitations should be acknowledged. The single-group pre-test/post-test design limits causal inference, dietary assessments relied on self-report and may be subject to recall bias, and the short duration of follow-up, along with unmeasured sport-specific factors, may have constrained interpretation of anthropometric and self-efficacy findings.

Another limitation is that parents were not actively involved beyond take-home leaflets; future interventions should incorporate parent-focused components to better support dietary changes at home.

CONCLUSIONS

In this pilot pre–post study, a brief nutrition education program delivered in a sports club setting was associated with improved Mediterranean diet quality (higher KIDMED scores) and favorable changes in reported dietary patterns. BMI and healthy eating self-efficacy remained unchanged, while the modest changes in height and body mass may reflect normal growth. Given the exploratory pilot design, reliance on self-reported dietary data, and absence of a control group, the findings should be considered hypothesis-generating. Controlled studies with longer follow-up are needed to assess sustained effects.

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AUTHORS' CONTRIBUTIONS

Conceptualization: Ö.U., H.Y-Ö; methodology: Ö.U., H.Y-Ö; formal analysis: E.B., C.A.; investigation: Ö.U.; writing-original draft: Ö.U.; supervision: H.Y-Ö.

FUNDING

The authors declare that there has been no funding to carry out this study.

CONFLICTS OF INTEREST

The authors state that there are no conflicts of interest when writing the manuscript."

DATA AVAILABILITY

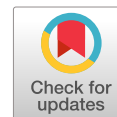
Data available on request to the author of the correspondence.

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ARTÍCULO DE INVESTIGACIÓN

Addiction-Like Eating Behaviour Scale-Mx: Adaptación y Validación para la Población Mexicana

➤ Addiction-Like Eating Behaviour Scale-Mx: Adaptation and Validation for the Mexican Population

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PALABRAS CLAVE

Conducta Alimentaria
Adicción a la Comida
Psicometría
México

RESUMEN

Introducción: La conducta alimentaria de tipo adictivo (CADTA) se caracteriza por impulso apetitivo incrementado y bajo control dietético, factores relacionados con obesidad y trastornos alimentarios. En México hasta la fecha no existe una herramienta validada para evaluar este aspecto.

Metodología: Estudio instrumental con diseño no experimental longitudinal. La validez de contenido se evaluó mediante razón de validez de contenido (RVC) con profesionales de la salud, y la validez aparente se determinó mediante prueba piloto. Para la validez de constructo, los participantes se asignaron aleatoriamente a un análisis factorial exploratorio o confirmatorio (AFE-AFC). La validez convergente se evaluó con la Escala de Atracción Alimentario, y la validez discriminante con la herramienta ORTO-14-MX mediante correlaciones de Spearman. La consistencia interna se determinó con alfa de Cronbach (AC), y la reproducibilidad mediante el coeficiente de correlación intraclase (CCI). Los análisis estadísticos se realizaron usando JASP, estableciendo la significancia en $p < 0,05$.

Resultados: En la validez de contenido ($n = 3$), todos los ítems obtuvieron $RVC = 1$, y 7 ítems fueron modificados en su redacción para mejorar claridad. La validez aparente ($n = 37$) confirmó claridad y pertinencia de los ítems. En la validez de constructo ($n = 516$), el AFE y AFC confirmaron estructura bifactorial ("Impulso apetitivo"-8 ítems y "Bajo control dietético"-5 ítems) tras eliminar dos reactivos con cargas factoriales inadecuadas ($< 0,40$), obteniendo una herramienta de 13 ítems. La AEBS-Mx mostró fuerte validez convergente con BES ($r = 0,702$, $p < 0,001$) y validez discriminante adecuada con ORTO-14-MX ($r = -0,247$, $p < 0,001$), AC excelente (0,89) y CCI satisfactorio (0,81).

Conclusiones: La AEBS-Mx de 13 ítems mantuvo la estructura bifactorial original y presentó propiedades psicométricas adecuadas en población mexicana. Su validación proporciona una herramienta para el tamizaje clínico y para la investigación sobre CADTA en México.

Financiación: No existió financiación para realizar este estudio.



KEYWORDS

Feeding Behavior
Food Addiction
Psychometrics
Mexico

ABSTRACT

Introduction: Addiction-like eating behavior (AEB) is characterized by increased appetite and poor dietary control, factors related to obesity and eating disorders. To date, there is no validated tool in Mexico for assessing this aspect.

Methods: Instrumental study with longitudinal non-experimental design. Content validity was assessed using content validity ratio (CVR) with health professionals, and face validity was determined through a pilot test. For construct validity, participants were randomly assigned to exploratory factor analysis or confirmatory factor analysis (EFA-CFA). Convergent validity was assessed using the Binge Eating Scale (BES) and discriminant validity using the ORTO-14-MX tool through Spearman correlations. Internal consistency was determined using Cronbach's alpha (CA) and reproducibility by means of the intraclass correlation coefficient (ICC). Statistical analyses were performed using JASP, setting significance at $p < 0,05$.

Results: In content validity ($n = 3$), all items obtained CVR = 1, while 7 items were modified in their wording to improve clarity. Face validity ($n = 37$) confirmed clarity and relevance of the items. For construct validity ($n = 516$), EFA and CFA confirmed the two-factor structure ("Appetitive drive"-8 items and "Low dietary control"-5 items) after removing two items with inadequate factor loadings ($< 0,40$), resulting in 13 items. The AEBS-Mx showed strong convergent validity with BES ($r = 0,702$, $p < 0,001$), adequate discriminant validity with ORTO-14-MX ($r = -0,247$, $p < 0,001$), excellent CA (0,89) and satisfactory ICC (0,81).

Conclusions: The 13-item AEBS-Mx maintained its original two-factor structure and exhibited adequate psychometric properties in the Mexican population. Its validation provides a tool for clinical screening and for research on AEB in Mexico.

Funding: No funding was received to conduct this study.

MENSAJES
CLAVE

1. La AEBS-Mx es el primer instrumento validado en población mexicana para evaluar conducta alimentaria de tipo adictivo, demostrando excelente consistencia interna, fuerte validez convergente con trastorno por atracón y reproducibilidad satisfactoria.
2. La validación de contenido con expertos alcanzó consenso total en todos los ítems. La validación aparente mediante prueba piloto confirmó la claridad, pertinencia cultural y la comprensibilidad de los reactivos para la población objetivo.
3. El análisis factorial confirmó la estructura bifactorial del instrumento original ("Impulso apetitivo" y "Bajo control dietético") tras eliminar dos ítems con cargas factoriales inadecuadas.
4. Este instrumento breve y válido facilita el tamizaje clínico de conducta alimentaria de tipo adictivo en consulta nutricional y psicológica, estudios epidemiológicos sobre su prevalencia en México, y diseño de intervenciones personalizadas dirigidas a mecanismos específicos de desregulación alimentaria.

CITA

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INTRODUCCIÓN

El 16% de adultos a nivel mundial presentan obesidad, siendo el principal factor de riesgo para el desarrollo de enfermedades crónicas no transmisibles¹. Aunque tradicionalmente atribuida a un desequilibrio energético positivo, la obesidad es un fenómeno multifactorial donde convergen determinantes conductuales, sociales, biológicos, económicos e institucionales².

Pese a que la obesidad es prevenible y tratable, las intervenciones convencionales centradas en la restricción calórica y el aumento de gasto energético muestran éxito limitado a largo plazo y altas tasas de recaída, sugiriendo que los modelos tradicionales no abordan los mecanismos psicopatológicos que impulsan el sobreconsumo alimentario^{3,4}. En ese sentido, la “conducta alimentaria de tipo adictivo” (CADTA) (del inglés, *addiction-like eating behaviour*), emerge como un enfoque prometedor para explicar la poca adherencia al tratamiento desde una perspectiva conductual.

Existen dos enfoques principales para explicar la CADTA. El primero se centra en la composición de los alimentos, especialmente los hiperpalatables, y su capacidad para activar los sistemas de recompensa cerebrales (“adicción a la comida”)⁵. El segundo enfatiza patrones de conducta alimentaria problemáticos independientemente del tipo de alimento consumido (“adicción a comer”)⁵.

Ruddock y colaboradores argumentan que la analogía de la “adicción a la comida” como una adicción a sustancias presenta limitaciones biológicas y clínicas⁶, dado que la alimentación es una función vital y sus rutas neurobiológicas difieren en potencia de las drogas psicoactivas⁶⁻⁸. Así, la CADTA no refleja dependencia a un nutriente específico sino una desregulación en el comportamiento de ingesta⁷. Por ello, los criterios clásicos de dependencia de sustancias no captan plenamente la adicción a comer⁹, que se manifiesta como una pérdida de control persistente ante la comida, independientemente de su composición química⁶.

Actualmente, la CADTA no constituye un diagnóstico del Manual Diagnóstico y Estadístico de los Trastornos Mentales (DSM)¹⁰. Existen herramientas psicométricas fundamentadas en los criterios para el diagnóstico de trastornos por consumo de sustancias como la *Yale Food Addiction Scale* (YFAS)^{10,11}.

En contraste, la *Addiction-Like Eating Behaviour Scale* (AEBS) evalúa la “adicción a comer” desde un enfoque conductual⁶. Esta se fundamenta en la teoría del procesamiento dual, que postula que la alimentación desregulada resulta del desequilibrio entre un sistema apetitivo hiperactivo (generador de impulsos) y uno ejecutivo regulador deficiente (incapaz de inhibirlos), promoviendo el desarrollo de obesidad¹³. Esta dinámica justifica la estructura de la escala, cuyos 15 ítems repartidos en dos factores evalúan ambos mecanismos: “Impulso apetitivo” (mayor sensibilidad a señales de recompensa) y “Bajo control dietético” (disminución del control inhibitorio)^{6,12}.

Desarrollada en Reino Unido⁶, la AEBS ha sido validada en Canadá^{7,8}, Italia³, China¹², Brasil¹⁴, Turquía¹⁵ y Perú¹⁶, pero no en México.

Considerando que México presenta una de las prevalencias de obesidad más altas del mundo, resulta imperativo contar con este instrumento validado. Por lo tanto, el objetivo del presente estudio fue adaptar y validar la AEBS en población mexicana adulta.

METODOLOGÍA

Diseño del estudio

Estudio instrumental con diseño no experimental longitudinal^{17,18}.

Participantes

Para la fase de validez de contenido, los criterios de inclusión fueron: licenciatura en psicología, nutrición o medicina, contar con posgrado, y experiencia en validación de herramientas. Se reclutó a los expertos vía correo electrónico.

Para alcanzar el tamaño muestral requerido, los participantes para las fases de validez aparente y de constructo fueron reclutados mediante muestreo no probabilístico por conveniencia. La difusión se realizó a través de un póster digital difundido en redes sociales durante el periodo de agosto a noviembre de 2025. El póster incluía un código QR y un hipervínculo que redirigía a los interesados a un formulario de Google.

Al acceder al enlace, la primera sección presentaba el consentimiento informado; solo tras su aceptación el sistema permitía avanzar a los cuestionarios. El formulario fue autoaplicado de manera electrónica. Para la resolución de dudas se proporcionó el correo electrónico del investigador principal. El procedimiento fue el mismo para la prueba piloto.

Los criterios de inclusión para las fases de validez aparente y de constructo fueron: edad ≥ 18 años, hispanohablante nativo, saber leer/escribir, acceso a un dispositivo electrónico y otorgar consentimiento informado. Se excluyó a quienes no firmaron el consentimiento o no completaron los cuestionarios.

El tamaño muestral se determinó empleando una relación participante-reactivo de 10:1¹⁹, resultando en un mínimo de 150 participantes.

El estudio se realizó conforme a la Declaración de Helsinki y a la Ley General en Materia de Investigación para la Salud de México²⁰.

Instrumentos

Addiction-like Eating Behaviour Scale (AEBS)

Cuestionario de 15 ítems repartidos en dos factores: “Impulso apetitivo” (9 ítems) y “Bajo control dietético” (6 ítems)⁶. Los participantes responden mediante escala Likert de 5 puntos. Al calcular las puntuaciones, deben invertirse los ítems 11 a 14. La puntuación total oscila entre 15 y 75. Mayores puntuaciones indican mayor presencia de CADTA⁷.

Escala de Atracón Alimentario (BES)

Escala validada de autorreporte que evalúa conductas de atracón (consumo de cantidades inusualmente grandes de comida en un periodo corto, acompañado de una sensación de pérdida de control)²¹. Consta de 16 ítems con escala Likert de 4 puntos²¹. Los puntos de corte son: ≤17 (ausencia o pocos atracones); 18-26 (gravedad o frecuencia moderada de atracones); y ≥ 27 (atracones graves o alta frecuencia). En el presente estudio, el alfa de Cronbach fue de 0,92.

Escala ORTO-14-MX

Escala validada de autorreporte de 14 ítems con escala Likert de 4 puntos²². Mide la presencia de conductas y cogniciones asociadas a la ortorexia nerviosa (preocupación excesiva y control rígido sobre la selección de alimentos)²². Puntuaciones ≤40 indican la presencia de ortorexia. En el presente estudio, el alfa de Cronbach fue de 0,75.

Procedimiento

Fase de traducción y validación de contenido

La versión original de la AEBS se tradujo mediante el método de traducción-retrotraducción²³. Dos investigadores (psicólogo y nutrióloga) tradujeron independientemente el instrumento del inglés al español de México; tras consensuar los reactivos, otros dos profesionales (médico y nutrióloga) realizaron la retrotraducción al inglés para verificar la conservación del significado original. La versión traducida (AEBS-Mx) fue enviada a 3 profesionales de la salud para evaluar su contenido. Tras otorgar consentimiento informado, recibieron un enlace al cuestionario diseñado para evaluar la claridad, relevancia, representatividad y especificidad de cada ítem²⁴. Posteriormente, se calculó la razón de validez de contenido (RVC) según los criterios de Lawshe²⁵ y las sugerencias recibidas fueron analizadas cualitativamente. La RVC se calculó con la fórmula $RVC = [ne - (N/2)] / (N/2)$, donde “N” corresponde al total de

expertos que evaluaron el ítem, mientras que “ne” es el número de expertos en acuerdo con dicho ítem²⁵. El valor de RVC oscila entre 0 y 1, donde 1 representa máximo acuerdo. Con base en el número de evaluadores, el RVC mínimo necesario para mantener los ítems en la herramienta fue de 0,99²⁵.

Tres profesionales de la salud evaluaron el instrumento. Todos los ítems obtuvieron un RVC= 1. El análisis cualitativo de los comentarios condujo a la modificación de 7 ítems para incrementar su claridad (ver [Tabla 1](#)). Las sugerencias realizadas por los evaluadores pueden verse en el [material suplementario 1](#).

Fase de validación aparente

Tras la validez de contenido, se realizó una prueba piloto. De cada ítem, los participantes evaluaron la claridad (si el lenguaje era comprensible) y la relevancia (si se relacionaba con la conducta de comer). Se empleó un formato dicotómico (claro/no claro) y una sección de comentarios donde los participantes podían expresar recomendaciones o dificultades experimentadas. Se incluyó a 37 participantes con una mediana de edad de 31 años (Q1=28 - Q3=38), un peso de 75 kg (Q1=61 - Q3=86), una talla de 1,69 metros (Q1=1,63 - Q3=1,76) y un IMC de 25,96 (Q1=24,13 - Q3=28,79). El 59,50% eran mujeres; 48,60% eran solteros, 32,40% eran casados y 18,90% vivían en unión libre; 21,60% tenía un nivel de estudios básico y 78,40% superior; 16,20% reportaron tener una enfermedad crónica y 37,80% un trastorno mental. Tras la evaluación, no se detectó la necesidad de modificar ningún ítem.

Fase de validación de constructo

Mediante un formulario digital autoadministrado se recolectaron datos sociodemográficos (sexo, estado civil y nivel de estudios). Se preguntó también por su formación profesional, solicitando especificar si eran estudiantes o profesionales de alguna ciencia de la salud; así como por la presencia de enfermedades crónicas (¿Tienes alguna enfermedad crónica diagnosticada?) o trastornos men-

Tabla 1. Ítems modificados posteriores a la validez de contenido

Ítem	Versión original ^a	Versión modificada
2	Me sirvo porciones demasiado grandes.	Considero que las porciones que me sirvo son demasiado grandes.
3	Me resulta difícil limitar qué o cuánto como.	Me resulta difícil limitar qué/cuánto como.
5	Cuando se trata de comida, tiendo a exagerar.	Cuando se trata de comida, suelo excederme.
6	Puedo tomar decisiones alimentarias saludables fácilmente.	Me resulta fácil tomar decisiones alimentarias saludables.
9	Como hasta sentirme mal.	Como hasta sentirme mal física (p. ej. con náuseas o dolor de estómago) y/o emocionalmente (p. ej. culpable o avergonzado).
11	Tiendo a no comprar alimentos procesados con alto contenido de grasas, sal y azúcar.	Evito comprar alimentos procesados con alto contenido de grasas, sal y azúcar.
13	Creo que llevo una dieta saludable.	Creo que mi alimentación es saludable.

Comparación entre la versión original de los ítems y su versión modificada tras la validación de contenido.

^aVersión original de los ítems traducidos al español de México por los autores.

^bLos ítems no incluidos en la tabla no sufrieron modificaciones.

^cLa distribución final de los ítems en sus respectivos factores tras la validación de constructo se detalla en la [Tabla 4](#).

tales diagnosticados (¿Te han diagnosticado con algún trastorno mental?), y el peso y talla autorreportados. El formulario incluyó también la AEBS⁶, la BES²¹, y la ORTO-14-MX²².

Análisis estadístico

Se analizó la distribución de los datos mediante la prueba de Shapiro-Wilk. Debido a que los datos no mostraron distribución normal, las variables cuantitativas se presentan como mediana (Q1 - Q3) y las cualitativas como frecuencia (porcentaje). Así mismo, la comparación entre grupos para las variables cuantitativas y ordinales se realizó mediante la prueba U de Mann-Whitney y para las nominales se usó la prueba chi-cuadrado.

Para la validez de constructo, se realizó un análisis factorial exploratorio (AFE) con rotación oblicua promax y un método de factorización de máxima verosimilitud. A priori, se aplicaron la prueba Kaiser-Meyer-Olkin (KMO) para evaluar la idoneidad del modelo (valor aceptable $\geq 0,70$) y la prueba de esfericidad de Bartlett para determinar la suficiencia de correlaciones entre variables (valor significativo $p < 0,05$). Se consideraron aceptables cargas factoriales $\geq 0,40$.

La estructura resultante se evaluó a través de un análisis factorial confirmatorio (AFC). Para evaluar el ajuste del modelo se utilizaron las siguientes pruebas: error cuadrático medio de aproximación (RMSEA) (valor aceptable $< 0,05$), índice de bondad de ajuste (GFI) (valor aceptable $> 0,90$), índice de ajuste comparativo (CFI) (valor aceptable $> 0,90$), índice Tucker-Lewis (TLI) (valor aceptable $> 0,90$), raíz del error cuadrado medio estandarizado (SRMR) (valor aceptable $< 0,08$), e índice de ajuste incremental de Bollen (IFI) (valor aceptable $> 0,90$)²⁶.

La consistencia interna se evaluó mediante alfa de Cronbach (valor aceptable $\geq 0,70$)²⁶. La reproducibilidad se determinó con el coeficiente de correlación intraclass (CCI) entre el test-retest, considerando aceptables valores $\geq 0,50$ ²⁷.

La validez convergente y discriminante se evaluó mediante correlaciones de Spearman entre las puntuaciones del AEBS y sus dimensiones con las de BES²¹ y ORTO-14-MX²².

Los análisis estadísticos se realizaron en el software JASP v.0.95.4, estableciendo la significancia en $p < 0,05$.

RESULTADOS

Descripción de la muestra

Se incluyeron 516 participantes quienes, para evaluar la validez de constructo mediante validación cruzada y evitar el sobreajuste del modelo, fueron asignados aleatoriamente empleando Excel al grupo de AFE (grupo 1, $n = 258$) o al de AFC (grupo 2, $n = 258$). No se observaron diferencias significativas entre grupos, confirmando su equivalencia. La [tabla 2](#) muestra sus características.

Análisis factorial exploratorio

Se obtuvo un valor X^2/df de 2,93, un valor en la prueba de esfericidad de Bartlett $< 0,001$, y un valor en la prueba KMO de 0,88. Se mantuvo la estructura bifactorial de la versión original; sin embargo, los ítems 6 y 15 presentaron cargas factoriales $< 0,40$ por lo que se excluyeron del AFC (ver [Tabla 3](#)).

Análisis factorial confirmatorio

El instrumento obtuvo un CFI de 0,91, TLI de 0,89, IFI de 0,91, RMSEA de 0,09, SRMR de 0,07, y GFI de 0,88. Las cargas factoriales fluctuaron de 0,50 a 0,84 (ver [Tabla 4](#)).

La covarianza entre factores fue significativa (estimado = 0,242, $DE = 0,042$, $p < 0,001$). El factor "Impulso apetitivo" explicó 49,21% de la varianza y el factor "Bajo control dietético" 44,56%.

Validez convergente y discriminante

La puntuación total de la AEBS-Mx mostró correlación positiva fuerte con BES²¹ ($r = 0,702$, $p < 0,001$) y negativa débil con ORTO-14-MX²² ($r = -0,247$, $p < 0,001$). El factor "Impulso apetitivo" mostró correlación positiva fuerte con BES²¹ ($r = 0,688$, $p < 0,001$) y negativa moderada con ORTO-14-MX²² ($r = -0,344$, $p < 0,001$). El factor "Bajo control dietético" mostró correlación positiva moderada con BES²¹ ($r = 0,448$, $p < 0,001$) y no significativa con ORTO-14-MX²² ($r = -0,018$, $p = 0,684$).

Confiabilidad

La escala AEBS-Mx total mostró un alfa de Cronbach de 0,886 (IC 95% = 0,868–0,904). Los factores "Impulso apetitivo" y "Bajo control dietético" obtuvieron alfas de 0,891 (IC 95% = 0,875–0,90) y 0,819 (IC 95% = 0,790–0,847), respectivamente.

Confiabilidad test-retest

La AEBS-Mx fue contestada por segunda vez por 34 participantes dos meses después de la primera aplicación. La escala total obtuvo un CCI de 0,812 (IC 95% = 0,658–0,901), "Impulso apetitivo" 0,850 (IC 95% = 0,722–0,922) y "Bajo control dietético" 0,553 (IC 95% = 0,272–0,748).

CADTA

La mediana de CADTA fue de 30 (Q1=26 - Q3=37), para "Impulso apetitivo" 17 (Q1=13 - Q3=21) y para "Bajo control dietético" 14 (Q1=11 - Q3=16).

Tabla 2. Características de los participantes (grupos 1 y 2)

Variable ^a	Grupo 1 (n = 258)	Grupo 2 (n = 258)	Valor de p ^b
Edad (años)	23,00 (20 - 29,75)	23,00 (20 - 30,75)	0,529
Peso (kg)	70,00 (61,03 - 82)	68,00 (59 - 83,23)	0,427
Talla (m)	1,67 (1,60 - 1,73)	1,65 (1,60 - 1,74)	0,413
IMC	25,10 (22,50 - 28,80)	25,12 (21,84 - 28,54)	0,745
Sexo			
Mujer	156 (60,50)	168 (65,10)	0,274
Hombre	102 (39,50)	90 (34,90)	
Estado civil			
Soltero(a)	198 (76,70)	187 (72,50)	0,247
Casado(a)	42 (16,30)	50 (19,40)	
En unión libre	18 (7,00)	21 (8,10)	
Nivel de estudios^c			
Básico	90 (34,90)	75 (29,10)	0,157
Superior	168 (65,10)	183 (70,90)	
Estudiante o profesional de ciencias de la salud			
No	117 (45,30)	128 (49,60)	0,332
Sí	141 (54,70)	130 (50,40)	
¿Tiene alguna enfermedad crónica?			
No	246 (95,30)	242 (94,20)	0,553
Sí	12 (4,70)	15 (5,80)	
¿Tiene algún trastorno mental diagnosticado?			
No	201 (77,90)	203 (78,70)	0,831
Sí	57 (22,10)	55 (21,30)	
IMC (categorías)			
Bajo peso	10 (3,90)	7 (2,70)	0,891
Normo peso	114 (44,20)	116 (45,00)	
Sobrepeso	83 (32,20)	85 (32,90)	
Obesidad	51 (19,80)	50 (19,40)	

Variables clínicas y sociodemográficas medidas al inicio del estudio.

^a Todas las variables se presentan como frecuencia (porcentaje), con excepción de la edad, peso, talla e IMC que se presentan como mediana (Q1 - Q3).

^b Todas las comparaciones entre grupos se realizaron usando la prueba de chi-cuadrado, con excepción de la edad, peso, talla, estado civil e IMC (categorías) que se compararon con la prueba U de Mann-Whitney. El valor de p indica la significancia estadística de la diferencia entre grupos.

^c Educación básica: preescolar, primaria, secundaria o preparatoria. Educación superior: licenciatura, maestría, doctorado, especialidad o subespecialidad médica.

Tabla 3. Cargas factoriales de los ítems obtenidas en el análisis factorial exploratorio

Ítem	Factor 1	Factor 2
1. Sigo comiendo aunque ya me sienta lleno(a).	0,711	0,036
2. Considero que las porciones que me sirvo son demasiado grandes.	0,719	-0,106
3. Me resulta difícil limitar qué/cuánto como.	0,808	-0,029
4. Me dan atracones (consumo grandes cantidades de comida en poco tiempo).	0,786	0,010
5. Cuando se trata de comida, suelo excederme.	0,902	-0,054
6. Me resulta fácil tomar decisiones alimentarias saludables.	-0,160	0,203
7. Una vez que empiezo a comer ciertos alimentos, no puedo parar hasta que no queda nada.	0,672	0,081
8. A pesar de intentar comer saludable, termino comiendo alimentos “chatarra”.	0,205	0,582
9. Como hasta sentirme mal física (p. ej. con náuseas o dolor de estómago) y/o emocionalmente (p. ej. culpable o avergonzado).	0,529	0,197
10. Sigo comiendo alimentos poco saludables a pesar de conocer sus efectos sobre mi salud.	0,254	0,559
11. Evito comprar alimentos procesados con alto contenido de grasas, sal y azúcar.	-0,036	0,666
12. No como muchos alimentos altos en grasas y azúcares.	0,124	0,664
13. Creo que mi alimentación es saludable.	-0,014	0,782
14. No suelo comer en exceso.	0,525	0,273
15. Me siento incapaz de controlar mi peso.	0,038	0,361

Los valores representan las cargas factoriales de cada ítem. El AFE se realizó usando una rotación oblicua promax y un método de factorización de máxima verosimilitud.

Tabla 4. Cargas factoriales de los ítems en el análisis factorial confirmatorio

Factor	Ítem	Carga factorial
Impulso apetitivo	1. Sigo comiendo aunque ya me sienta lleno(a).	0,706
	2. Considero que las porciones que me sirvo son demasiado grandes	0,652
	3. Me resulta difícil limitar qué/cuánto como.	0,786
	4. Me dan atracones (consumo grandes cantidades de comida en poco tiempo).	0,734
	5. Cuando se trata de comida, suelo excederme.	0,849
	7. Una vez que empiezo a comer ciertos alimentos, no puedo parar hasta que no queda nada.	0,658
	9. Como hasta sentirme mal física (p. ej. con náuseas o dolor de estómago) y/o emocionalmente (p. ej. culpable o avergonzado).	0,673
Bajo control dietético	14. No suelo comer en exceso.	0,550
	8. A pesar de intentar comer saludable, termino comiendo alimentos “chatarra”.	0,766
	10. Sigo comiendo alimentos poco saludables a pesar de conocer sus efectos sobre mi salud.	0,824
	11. Evito comprar alimentos procesados con alto contenido de grasas, sal y azúcar.	0,509
	12. No como muchos alimentos altos en grasas y azúcares.	0,596
	13. Creo que mi alimentación es saludable.	0,591

Los valores representan las cargas factoriales de cada ítem.

DISCUSIÓN

Este estudio proporciona la primera evidencia de validez y confiabilidad de la AEBS-Mx en población mexicana adulta. Los resultados confirman la estructura bifactorial del instrumento original⁶, con una versión reducida de 13 ítems.

La AEBS-Mx demostró propiedades psicométricas robustas, incluyendo excelente consistencia interna, fuerte validez convergente y reproducibilidad adecuada. Se mantuvo la estructura bifactorial original⁶, indicando que el constructo se mide adecuadamente con los elementos que componen la herramienta. Adicionalmente, los índices de ajuste del modelo bifactorial fueron en su mayoría satisfactorios. El CFI (0,91), IFI (0,91), y SRMR (0,07) cumplieron los criterios establecidos para un buen ajuste del modelo. El TLI (0,89) y GFI (0,88) se ubicaron ligeramente por debajo del punto de corte de 0,90, aunque dentro del rango considerable aceptable para la validación transcultural de instrumentos. Sin embargo, el valor RMSEA (0,09) resultó ser mayor a lo establecido como aceptable ($< 0,05$). Estos últimos valores podrían reflejar la complejidad del constructo CADTA en población mexicana, donde factores culturales en torno a la alimentación pueden introducir variabilidad adicional²⁸.

Los ítems 6 ("Me resulta fácil tomar decisiones alimentarias saludables") y 15 ("Me siento incapaz de controlar mi peso") mostraron cargas factoriales inaceptables y fueron eliminados. Respecto al ítem 15, los resultados concordaron con los de la validación original, donde mostró carga factorial muy baja (0,28)⁶, y con el estudio de Legendre y Bégin⁸, donde obtuvo la carga factorial más baja (0,50). Esto podría deberse a que, como mencionan Legendre y Bégin⁸, es el único ítem del factor "Impulso apetitivo" que no se centra en conductas alimentarias sino en el control del peso, asociándose con muchas otras conductas como el ejercicio y la selección de alimentos²⁹. En el caso del ítem 6, más que a bajo control dietético, este hace referencia a la capacidad de toma decisiones, misma que es influenciada por factores cognitivos, ambientales, sociales, económicos, institucionales y culturales².

El instrumento mostró una buena validez convergente, evidenciada por la correlación positiva entre AEBS-Mx y BES, replicando resultados previos⁶⁻⁸. Lo anterior apoya la conceptualización de la CADTA como fenómeno relacionado pero distinguible del trastorno por atracón, sugiriendo solapamiento en los mecanismos de pérdida de control sobre la ingesta. Por otra parte, resulta notable que el factor "Bajo control dietético" no mostró correlación significativa con ORTO-14-MX, mientras que "Impulso apetitivo" sí presentó correlación negativa moderada. Esto sugiere que un fuerte impulso apetitivo puede coexistir con intentos de restricción alimentaria, fenómeno característico del ciclo restricción-desinhibición descrito en trastornos alimentarios³⁰. Ambos factores mostraron validez convergente satisfactoria con BES, coincidiendo con validaciones previas^{3,7,8}.

La consistencia interna total de la AEBS-Mx fue satisfactoria para la estructura bifactorial, similar a otros estudios^{3,8,14-16}. La

confiabilidad test-retest mostró resultados diferenciados entre los factores de la AEBS-Mx. Mientras que la escala total y el factor "Impulso apetitivo" demostraron excelente reproducibilidad, el factor "Bajo control dietético" presentó reproducibilidad moderada. Esta diferencia podría reflejar los rasgos dependientes del control dietético, que puede variar en función de factores contextuales como el estrés o los eventos sociales.

Este estudio presenta diversas fortalezas metodológicas. En primer lugar, se empleó un proceso riguroso de validación de contenido con profesionales de la salud y validación aparente con población objetivo, asegurando la claridad y pertinencia cultural de los ítems²⁴. En segundo lugar, la muestra ($n= 516$) superó ampliamente los requisitos para análisis factoriales, con división aleatoria apropiada para AFE y AFC. En tercer lugar, se evaluaron múltiples tipos de validez (contenido, aparente, constructo, convergente y discriminante) y confiabilidad (consistencia interna y reproducibilidad). No obstante, esta investigación presenta limitaciones. El tamaño muestral para el CCI fue pequeño ($n= 34$), limitando la precisión de estas estimaciones. Además, la validez convergente y la validez discriminante se realizaron con un único instrumento cada una, restringiendo la posibilidad de triangular hallazgos con múltiples medidas del mismo constructo. Asimismo, aunque el valor de RVC fue 1, este debe interpretarse con precaución debido a la cantidad limitada de evaluadores ($n= 3$). Adicionalmente, la mitad de la muestra estuvo conformada por estudiantes y profesionales de la salud (52,50%), limitando la generalización de resultados a perfiles distintos. Finalmente, la muestra estuvo conformada predominantemente por adultos jóvenes (mediana de edad = 23 años), lo cual podría limitar la generalizabilidad de los hallazgos a otros grupos etarios.

Se sugiere que futuros estudios empleen estrategias para asegurar una muestra más amplia para la evaluación de la reproducibilidad. Adicionalmente, que se empleen más instrumentos para evaluar la validez convergente y discriminante de la AEBS-Mx, así como herramientas para determinar la intensidad de los antojos y la presencia de "picoteo". Nuevas investigaciones podrían aplicar la AEBS-Mx en contextos clínicos para evaluar su validez y confiabilidad en estas poblaciones, así como su sensibilidad al cambio tras el tratamiento.

Las implicaciones prácticas de este estudio son múltiples. Clínicamente, la AEBS-Mx de 13 ítems representa una herramienta breve y válida para el tamizaje de CADTA en consulta nutricional y psicológica. En investigación, el instrumento facilita estudios epidemiológicos sobre prevalencia de CADTA en México y su relación con la dieta y otros desenlaces en salud. Además, la estructura bifactorial permite realizar análisis diferenciados del impulso apetitivo y el control dietético, informando el diseño de intervenciones personalizadas dirigidas a mecanismos específicos de disregulación alimentaria. Futuras investigaciones podrían establecer diseños longitudinales que evalúen la capacidad predictiva de la AEBS-Mx sobre la ganancia de peso y complicaciones metabólicas.

CONCLUSIONES

La disponibilidad de este instrumento en México llena un vacío importante en la literatura, permitiendo transitar de un enfoque centrado en la adicción a sustancias hacia uno centrado en el comportamiento alimentario. Los resultados evidencian que la AEBS-Mx de 13 ítems mantiene la estructura bifactorial original, consolidándose como una herramienta con propiedades psicométricas sólidas para el contexto cultural mexicano.

Su brevedad y precisión la convierten en un recurso valioso tanto para el ámbito clínico como para la investigación científica, donde permitirá profundizar en el estudio de los determinantes de las conductas alimentarias de tipo adictivo en México.

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CONFLICTO DE INTERESES

Los autores expresan que no existen conflictos de interés al redactar el manuscrito.

DISPONIBILIDAD DE DATOS

Los datos que respaldan los hallazgos de este estudio están disponibles a través del autor de correspondencia, previa solicitud razonable.

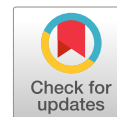
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ARTÍCULO DE INVESTIGACIÓN

Calidad de la dieta y seguridad alimentaria en universitarios de Latinoamérica: estudio multicéntrico

➤ Diet Quality and Food Security in University Students in Latin America: A Multicentric Study

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PALABRAS CLAVE

Inseguridad
alimentaria

Dieta

Estudiantes

Universidades

Determinantes
sociales

➤ RESUMEN

Introducción: El objetivo del presente estudio fue analizar la asociación entre el nivel de seguridad alimentaria (NSA) y la calidad de la dieta (CD) de los estudiantes universitarios latinoamericanos, e identificar aspectos sociodemográficos relacionados con el NSA.

Metodología: Estudio transversal, analítico y multicéntrico. Encuesta a 2572 estudiantes de pregrado de universidades públicas de Colombia, Perú, Brasil y Argentina. Se evaluó el NSA con metodología FIES de FAO, la CD con IASE, y se recolectaron variables sociodemográficas. Se estimaron razones de prevalencia como medida de asociación, a un nivel de significancia de $\alpha = 0.05$.

Resultados: En Brasil, más del 60% de los estudiantes presentó seguridad alimentaria, mientras que en los demás países esta proporción fue inferior al 40%. En todos los países predominó una CD que requiere cambios (78%–94.8%). Una mejor CD se asocia con una mayor prevalencia de seguridad alimentaria ($p < 0.001$). Vivir con la familia se asoció con mayor probabilidad de seguridad alimentaria ($p < 0.001$). Los estudiantes de sexo masculino presentaron menor prevalencia de inseguridad alimentaria moderada y grave ($p < 0.001$).

Conclusiones: La inseguridad alimentaria es alta en los estudiantes universitarios de Latinoamérica y se asocia con la CD. El género masculino y vivir con la familia se asocian con menor prevalencia de inseguridad alimentaria.

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KEYWORDS

Food insecurity
Diet
Students
Universities
Social determinants

ABSTRACT

Introduction: The objective of the present study was to analyze the association between the level of food security (LFS) and diet quality (DQ) among Latin American university students, as well as to identify sociodemographic factors associated with LFS.

Methods: Cross-sectional, analytical and multicenter study. Survey of 2572 undergraduate students from public universities in Colombia, Peru, Brazil and Argentina. Food security was evaluated using the FAO FIES methodology, DQ using IASE, and sociodemographic variables were collected. Prevalence ratios were estimated as a measure of association, at a significance level of $\alpha = 0.05$.

Results: In Brazil, more than 60% of students were food secure, while in the other countries this proportion was less than 40%. In all countries, a DQ that requires changes predominated (78%–94.8%). Food security was positively associated with a healthy diet ($p < 0.001$). Living with family was associated with a higher probability of food security ($p < 0.001$). Male students had a lower prevalence of moderate and severe food insecurity ($p < 0.001$).

Conclusions: Food insecurity is high among Latin American university students and is associated with DQ. Male gender and living with family are associated with a lower prevalence of food insecurity.

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MENSAJES
CLAVE

1. Los estudiantes universitarios latinoamericanos constituyen un grupo vulnerable a la inseguridad alimentaria.
2. La prevalencia de inseguridad alimentaria en estudiantes universitarios latinoamericanos es alta, con variaciones entre países.
3. La calidad de la dieta en estudiantes universitarios latinoamericanos es mayoritariamente deficiente y se relaciona con la seguridad alimentaria.
4. Los estudiantes de género masculino y aquellos que viven con su familia presentan mejores condiciones de seguridad alimentaria.

CITA

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INTRODUCCIÓN

La inseguridad alimentaria constituye una problemática de creciente relevancia en el ámbito de la salud pública, tanto por su alta prevalencia a nivel global como por su particular incidencia en la región de América Latina, que se ha visto agravada por la pandemia del COVID 19¹. Si bien afecta a diversos grupos poblacionales, los estudiantes universitarios presentan características que los pueden predisponer a padecerla.

En este contexto, las políticas de acceso a la enseñanza superior han promovido el ingreso progresivo al sistema universitario de estudiantes de niveles socioeconómicos más desfavorecidos². Sin embargo, si bien el objetivo principal de la educación superior es mejorar las condiciones de vida y empleo de las personas, este efecto no se observa durante la vida universitaria. Por el contrario, se mantienen condiciones de vulnerabilidad, que podrían afectar su rendimiento académico y/o su permanencia en la universidad³. Esta problemática no es exclusiva de países de bajos recursos. Por ejemplo, estudios realizados en universidades de América del Norte revelan que incluso en períodos prepandémicos la inseguridad alimentaria entre estudiantes presentaba una prevalencia de alrededor del 20%⁴. En los últimos cuatro años, estos índices han mostrado un incremento sostenido^{5,6}, alcanzando valores superiores al 44%.

Con relación a América Latina, los estudios realizados sobre esta temática presentan metodologías poco comparables y resultados diversos^{7,8}, con indagaciones sobre aspectos como la ingesta de alimentos, la salud mental, el estado nutricional de los estudiantes, y los efectos de la pandemia sobre los niveles de seguridad alimentaria (NSA). Para contextualizar adecuadamente esta problemática, es necesario considerar el proceso de transición epidemiológica y nutricional que ha tenido lugar de los últimos años en América Latina⁹, donde convergen enfermedades por exceso (como el sobrepeso y la obesidad) y enfermedades por carencia nutricional (como la anemia y otras deficiencias vitamínicas y minerales).

En este contexto, la calidad de la dieta (CD) adquiere relevancia como un concepto integrador que evalúa tanto aspectos cualitativos como cuantitativos de la alimentación; la variedad global de la dieta va más allá del aporte individual de los nutrientes, lo que permite valorar su adecuación nutricional, así como su relación con la salud y el estado nutricional en general¹⁰.

Durante la etapa universitaria, los estudiantes atraviesan un período de transición hacia la autonomía alimentaria y la consolidación de hábitos de vida, por lo que la evaluación de su CD es crucial, pues se ha demostrado que se relaciona ampliamente con el desempeño académico¹¹, con la calidad del sueño¹² y la salud mental¹³. Es probable que muchos estudiantes universitarios no consuman alimentos saludables y mantengan una baja CD por desconocimiento, pero también, porque perciben que los alimentos nutritivos tienen un alto costo¹⁴, lo que limita sus posibilidades de acceso. Este último aspecto es uno de los componentes que sustenta ampliamente la inseguridad alimentaria.

Durante el año 2023 se realizó un estudio multicéntrico en cuatro universidades de América Latina: Universidade Estadual de Ponta Grossa - UEPG (Brasil), Universidad Nacional de Lanús - UNLa (Argentina), Universidad Nacional Mayor de San Marcos - UNMSM (Perú) y Universidad del Valle - UNIVALLE (Colombia). Las cuatro universidades analizadas son de gestión pública, y tienen en común el hecho de atraer estudiantes y ser referentes e influyentes a nivel regional. El objetivo del presente trabajo fue analizar la asociación entre el NSA y la CD de sus estudiantes universitarios e identificar factores sociodemográficos asociados al NSA.

METODOLOGÍA

El estudio utilizó una base de datos de corte transversal proveniente de una muestra representativa de estudiantes regulares de pregrado de las universidades UEPG, UNLa, UNMSM y UNIVALLE. El muestreo fue estratificado por área de conocimiento en cada universidad, con el fin de asegurar la inclusión de los distintos campos de formación. Dentro de cada estrato, la selección de los participantes se realizó por conveniencia. El tamaño de la muestra se definió considerando un nivel de confianza del 95% y un margen de error que osciló entre 3% y 5% según el país.

La encuesta está dividida en tres partes, en la primera se consideraron datos sociodemográficos como edad, género, grupo de convivencia y trabajo.

La segunda parte evaluó la Escala de Inseguridad Alimentaria Basada en la Experiencia (FIES, por sus siglas en inglés) propuesto por la FAO^{15,16}. Esta herramienta permite la medición del NSA por medio de la aplicación de 8 preguntas que indagan subjetivamente el componente de acceso a los alimentos de la seguridad alimentaria. La posibilidad de respuesta a cada pregunta es dicotómica (sí/no), aunque también se consideran las opciones “no sé”, o no responder. En estos dos últimos casos la encuesta se considera inválida para el análisis, debido a que no permite construir la escala.

En la tercera parte, la CD fue medida tomando como base el Índice de Alimentación Saludable (IASÉ)¹⁷, y teniendo en cuenta las recomendaciones de las Guías Alimentarias Basadas en Alimentos de los países latinoamericanos participantes¹⁸. Para ello, previamente se evaluó la ingesta alimentaria mediante la aplicación de un cuestionario de frecuencia de consumo alimentario, elaborado en base a un instrumento validado¹⁹. Se acordaron los grupos de alimentos para que quedaran representadas las particularidades alimentarias de cada uno de los países evaluados. De este modo quedaron constituidos 17 grupos de alimentos, incluidos bebidas (no alcohólicas y alcohólicas) e infusiones. Para cada uno de los grupos de alimentos se ofrecieron 5 opciones de consumo, desde “consumo diario” hasta “nunca”. Posteriormente, para evaluar la CD se tomaron en cuenta los grupos alimentarios propuestos por el IASE, y se calculó la puntuación en base a lo propuesto en el índice¹⁷. El IASE fue categorizado en Saludable, Necesita cambios y Poco saludable, según lo propuesto por Norte

Navarro¹⁷. Se tuvieron en cuenta los puntos de corte establecidos en la bibliografía, a saber: Saludable cuando el estudiante contabilizó más de 80/100 puntos; Necesita cambios cuando obtuvo entre 50 y 80 puntos sobre 100 y Poco saludable si su puntuación fue menor a 50/100.

La depuración de la base de datos en cada país se realizó de forma previa a la estimación del FIES y de IASE. Durante este proceso se identificaron y excluyeron registros con información incompleta o respuestas inválidas.

Para la estimación de los modelos se utilizaron únicamente observaciones completas, es decir, sin datos faltantes en las variables incluidas en el análisis. Dado que la depuración se realizó durante la construcción de la base de datos, no se identificaron pérdidas relevantes que comprometan la consistencia de los resultados.

Los datos se procesaron utilizando el programa estadístico Stata (versión 19). En primer lugar, se obtuvieron estadísticas descriptivas para evaluar las frecuencias absolutas y relativas de las variables de interés.

Posteriormente, se estimaron dos modelos logísticos ordenados, adecuados para variables dependientes categóricas con orden natural. En el primero, se analizó la asociación entre la CD y los NSA. En el segundo, se evaluó la asociación entre los NSA y las variables sociodemográficas.

En ambos modelos se incorporó el país como variable de control mediante la inclusión de variables dummy para cada país, con el fin de capturar posibles diferencias estructurales entre contextos nacionales. Asimismo, en el segundo modelo se incluyeron variables sociodemográficas relevantes (edad, género, grupo de convivencia y situación laboral), seleccionadas con base en evidencia previa que señala su influencia en la seguridad alimentaria en población universitaria²⁰.

Dado el carácter transversal de los datos y su estructura multicéntrica, se consideró la agrupación de los estudiantes por universidad, utilizando errores estándar robustos para corregir posibles problemas de heterocedasticidad.

A partir de los modelos se estimaron probabilidades predichas para cada categoría del desenlace y, con base en ellas, se calcularon razones de prevalencia (RP) como medida de asociación. Para cada variable cualitativa se tomó una categoría de referencia: saludable, femenino, vivir con la familia y no trabajar, para las variables CD, género, grupo de convivencia y trabajo, respectivamente. En el caso de la variable país, se consideró a Brasil como categoría de referencia. Para la variable edad se definieron dos puntos de referencia correspondientes a los deciles 10 y 90 de la distribución, siendo el decil 10 la categoría de referencia. La significancia estadística de los parámetros se evaluó con un nivel del 5%, lo que permitió estimar intervalos de confianza del 95%.

El estudio contó con la aprobación de los respectivos Comités de Ética en Investigación de cada una de las universidades

participantes. Se solicitó la firma del consentimiento informado y se respetaron los principios éticos de la Declaración de Helsinki para las investigaciones en salud con seres humanos.

RESULTADOS

Se encuestaron 2572 estudiantes regulares de pregrado, cuyas edades variaron; los de UNLa tuvieron una media de edad más elevada (34.4 años) y los demás se concentraron en el rango de 21-23 años. Predominó el género femenino, en UNLa y UEPG constituyeron el 86% y 62.7%, mientras que en UNMSM y UNIVALLE fueron el 52.1% y 48.9% de estudiantes. Se identificó la presencia de estudiantes no binarios en UNIVALLE (2%) y UNLa (1%) (Tabla 1). Con excepción de la UEPG, menos del 40% de los estudiantes presentó un nivel adecuado de seguridad alimentaria en cada universidad, lo que evidencia una alta prevalencia de inseguridad alimentaria en sus distintos niveles. La UNMSM (23.2%) y la UNLa (23.0%) registraron las mayores prevalencias de inseguridad alimentaria grave. En UNIVALLE, la inseguridad leve y moderada afecta a más de la mitad de estudiantes (54.7%) (Tabla 1).

Por otro lado, predominó la categoría “necesita cambios” de la CD en las universidades, desde el 94.8% en UNIVALLE a 78% en UNLa; el nivel saludable fue muy bajo, fueron de 9% en UNLa a 1.06% en UNMSM (Tabla 1).

Los resultados del modelo logístico ordenado muestran asociaciones entre la CD y los distintos NSA. En particular, las dietas poco saludables se asocian con una menor prevalencia de seguridad alimentaria y con una mayor prevalencia de inseguridad alimentaria moderada y, especialmente, grave. En el caso de las dietas que requieren cambios, se observa una reducción en la prevalencia de seguridad alimentaria, sin asociaciones estadísticamente significativas en los niveles más severos de inseguridad (Tabla 2).

Las RP muestran diferencias estadísticamente significativas de género entre las categorías de NSA, el género masculino presentó mayor probabilidad de estar en seguridad alimentaria que el género femenino. Tener trabajo se asocia con una menor probabilidad de seguridad alimentaria, lo que podría estar relacionado con condiciones de vulnerabilidad económica entre los estudiantes. Para el grupo de convivencia los resultados evidenciaron gradientes claros: convivir con compañeros, vivir solo o residir en pensión se asocia con menores probabilidades de seguridad alimentaria y mayores probabilidades de inseguridad moderada y grave, en comparación con convivir con la familia. Para la variable edad, se evaluaron probabilidades predichas en valores representativos (18 y 35 años); sin embargo, no se observaron asociaciones estadísticamente significativas entre la edad y los NSA (Tabla 3).

Tabla 1. Características de los estudiantes de grado de las Universidades Estadual de Ponta Grossa (Brasil), Nacional de Lanús (Argentina), del Valle (Colombia) y Mayor de San Marcos (Perú), 2023.

Variables		UEPG (Brasil)	UNLa (Argentina)	UNIVALLE (Colombia)	UNMSM (Perú)
Edad en años (media y desvío estándar)		22.92 (6.2)	34.45 (10.9)	21.30 (4.4)	21.67 (4.3)
Género en frecuencia absoluta (%)	Masculino	524 (37.3%)	53 (13%)	150 (49.2%)	223 (47.9%)
	Femenino	882 (62.7%)	339 (86%)	149 (48.9%)	243 (52.1%)
	No binario	0	3 (1%)	6 (2%)	0
Grupo conviviente	Familia	1030 (73.2%)	315 (80%)	206 (68%)	337 (89%)
	Solo	253 (18%)	61 (15%)	22 (7%)	33 (8.7%)
	Amigos	112 (8%)	17 (4%)	73 (24%)	9 (2.3%)
	Pensión	11 (0.8%)	2 (1%)	4 (1%)	0
Nivel de seguridad alimentaria en frecuencia absoluta (%)	Seguridad alimentaria	903 (64%)	145 (37%)	119 (39%)	130 (34.3%)
	Inseguridad alimentaria leve	168 (12%)	75 (19%)	101 (33.1%)	120 (31.7%)
	Inseguridad alimentaria moderada	143 (10%)	72 (18%)	66 (21.6%)	41 (10.8%)
	Inseguridad alimentaria grave	192 (14%)	103 (23%)	19 (6.2%)	88 (23.2%)
Calidad de la dieta en frecuencia absoluta (%)	Saludable	109 (7.7%)	35 (9%)	7 (2.3%)	4 (1.06%)
	Necesita cambios	1102 (78.4%)	310 (78%)	289 (94.8%)	317 (83.6%)
	Poco saludable	195 (13.8%)	50 (13%)	9 (3%)	58 (15.3%)

UEPG=Universidade Estadual de Ponta Grossa (n=1406), UNLa=Universidad Nacional de Lanús (n=395), UNIVALLE=Universidad del Valle (n=305), UNMSM=Universidad Nacional Mayor de San Marcos (n=466)

Tabla 2. Razones de prevalencia estimadas de los Niveles de Seguridad Alimentaria, y Calidad de la Dieta en estudiantes universitarios de grado de las Universidades Estadual de Ponta Grossa (Brasil), Nacional de Lanús (Argentina), del Valle (Colombia) y Mayor de San Marcos (Perú), 2023.

Nivel de seguridad alimentaria	Necesita cambios (RP)	IC 95%	Poco saludable (RP)	IC 95%
Seguridad alimentaria	0.863***	[0.746; 0.980]	0.495***	[0.401; 0.589]
Inseguridad leve	1.142	[0.960; 1.324]	1.219*	[1.025; 1.414]
Inseguridad moderada	1.270	[0.939; 1.600]	1.891***	[1.396; 2.387]
Inseguridad grave	1.395	[0.915; 1.875]	3.043***	[1.929; 4.158]

Modelo ajustado por país (Brasil como referencia). * p < 0.05; ** p < 0.01; *** p < 0.001; n=2473.

Tabla 3. Razones de prevalencia estimadas de los Niveles de Seguridad Alimentaria, y variables sociodemográficas en estudiantes universitarios de grado de las Universidades Estadual de Ponta Grossa (Brasil), Nacional de Lanús (Argentina), del Valle (Colombia) y Mayor de San Marcos (Perú), 2023.

Variables	Seguridad alimentaria	Inseguridad leve	Inseguridad moderada	Inseguridad grave
Género: Masculino	1.118** [1.039;1.197]	0.944** [0.907;0.981]	0.878** [0.803;0.953]	0.813*** [0.705;0.922]
Género: No binario	1.064 [0.840;1.289]	0.972 [0.865;1.079]	0.934 [0.703;1.165]	0.895 [0.543;1.246]
Trabaja: Sí	0.921* [0.844;0.998]	1.037* [1.001;1.074]	1.094 [0.997;1.191]	1.157 [0.989;1.325]
Grupo: Solo	0.744*** [0.654;0.834]	1.100*** [1.073;1.128]	1.322*** [1.205;1.438]	1.621*** [1.344;1.898]
Grupo: Amigos	0.761*** [0.660;0.863]	1.098*** [1.069;1.128]	1.302*** [1.173;1.430]	1.571*** [1.273;1.869]
Grupo: Pensión	0.387*** [0.147;0.626]	0.937 [0.663;1.210]	1.554*** [1.458;1.650]	3.059** [1.701;4.417]
País: Argentina	0.667*** [0.570;0.764]	1.202*** [1.144;1.261]	1.571*** [1.368;1.774]	2.023*** [1.586;2.459]
País: Perú	0.573*** [0.505;0.641]	1.195*** [1.135;1.255]	1.707*** [1.542;1.873]	2.434*** [2.037;2.831]
País: Colombia	0.764*** [0.690;0.838]	1.177*** [1.115;1.238]	1.412*** [1.253;1.571]	1.665*** [1.384;1.947]
Edad (35 vs 18)	0.937 [0.851;1.023]	1.030 [0.989;1.072]	1.075 [0.968;1.182]	1.124 [0.942;1.306]

Los valores entre corchetes [] corresponden a los intervalos de confianza del 95% (IC95%). p < 0.05; ** p < 0.01; *** p < 0.001. Categorías de referencia: femenino, vivir con la familia, no trabaja y Brasil para la variable país.

DISCUSIÓN

La muestra analizada presenta una prevalencia de inseguridad alimentaria moderada o grave superior a los indicadores reportados para la región por la FAO (28.2%)¹ particularmente en Argentina (41%) y Perú (34%). Sin embargo, estos resultados deben ser interpretados teniendo en cuenta las particularidades de los contextos nacionales. En Argentina, en el período estudiado el país atravesó una fuerte crisis política, social y económica, con variaciones mensuales de inflación superiores al 12%, un alto impacto en el costo de los alimentos²¹. Asimismo, Perú tuvo las cifras más altas de inseguridad alimentaria moderada o grave de la región entre los años 2021-2023 (51.7%)²². Esta problemática podría estar relacionada con las consecuencias de la pandemia del COVID 19, aunada a la crisis política iniciada el 2022, que incrementó la pobreza monetaria²³. En Colombia, a nivel nacional la inseguridad alimentaria moderada o grave afecta al 28.1% de los hogares colombianos en niveles moderado o grave²⁴ y se agravó tras la pandemia por el aumento de la pobreza monetaria, que pasó del 35.7% en 2019 al 39.7% en 2021²⁴. Todas las universidades estudiadas acogen estudiantes de niveles socioeconómicos medios y bajos debido a las políticas implementadas históricamente en los países latinoamericanos, lo que podría explicar los resultados encontrados. Por ejemplo, en Brasil desde los años 2000 el país ha implementado políticas de ampliación de cupos con el objetivo de garantizar el acceso a la educación superior para sectores de la población históricamente marginados, lo que ha contribuido a la construcción de un entorno académico más diverso y representativo de la sociedad brasileña²⁵. Si bien estas políticas han favorecido la democratización del espacio universitario, también exponen el porqué de una mayor vulnerabilidad social y alimentaria entre los estudiantes de la UEPG incluidos en este estudio.

Desde una perspectiva estructural, estos resultados pueden interpretarse como expresión de desigualdades socioeconómicas persistentes en América Latina, que condicionan las condiciones de vida de los estudiantes incluso tras su ingreso a la educación superior. Si bien en las últimas décadas se ha ampliado el acceso universitario en la región, este proceso no ha sido necesariamente acompañado por mejoras equivalentes en las condiciones materiales de los estudiantes, especialmente en lo que respecta al acceso a recursos básicos^{2, 3}. En este sentido, la inseguridad alimentaria puede entenderse como una manifestación concreta de dichas desigualdades estructurales, que limitan tanto el acceso a alimentos como la posibilidad de sostener una dieta de calidad. Más allá de las diferencias observadas en los NSA entre los países, la CD mostró una tendencia común, siendo la categoría “necesita cambios” la más prevalente entre los estudiantes evaluados. Esta observación se alinea con resultados de investigaciones previas que evidencian que la CD en estudiantes universitarios tiende a ser deficiente, independientemente del contexto o país, aunque con variaciones metodológicas entre estudios.

En este sentido, evidencia internacional ha documentado patrones similares. Por ejemplo, en Australia²⁶ se identificó una baja CD tanto en estudiantes nacionales como extranjeros. En China²⁷, estudiantes de medicina presentan bajo consumo de alimentos saludables y alto consumo de azúcares, con diferencias por sexo. En Turquía²⁸, se observó que estudiantes mujeres que realizan actividad física regular presentan mejor calidad dietética. En España²⁹, el 82% de los estudiantes requería cambios en su dieta, asociándose con la calidad del sueño. Asimismo, otro estudio³⁰ evidenció que una peor CD se relaciona con mayor sintomatología psicológica.

En América Latina, estos patrones adquieren características particulares, ya que la CD se encuentra estrechamente vinculada a condiciones de vulnerabilidad social y económica. Estudios en la región evidencian que la inseguridad alimentaria se asocia con cambios en el consumo de alimentos y con el bienestar general de los estudiantes^{8, 7}. En particular, Álvarez Ramírez et al.⁸ muestran que las restricciones económicas influyen en las decisiones alimentarias y en el acceso a alimentos, mientras que Oliveros Mencos et al.⁷ destacan su relación con la salud mental y el rendimiento académico. Estos hallazgos refuerzan la idea de que la población universitaria latinoamericana constituye un grupo especialmente vulnerable, incluso en contextos de expansión del acceso a la educación superior.

Una particularidad de esta investigación es que se vincula la CD con el NSA. Se observa que una peor CD se asocia con mayores NSA. Si bien ha sido poco explorada esta relación, en el estudio realizado en Australia²⁶, citado previamente arroja resultados similares.

Por otro lado, los resultados ajustados muestran que el género y el grupo de convivencia actúan como predictores de los diferentes NSA. Sánchez-Vivero y cols.²⁰, en estudiantes de Nutrición de México encontraron una prevalencia de inseguridad alimentaria del 48%, e identificaron otros aspectos sociodemográficos (seguridad social, nivel socioeconómico, vivienda propia, diversidad de la dieta, entre otros) como predictores de inseguridad alimentaria. Si bien dicho estudio evalúa variables diferentes a las del presente trabajo, se puede observar cómo los estudiantes universitarios se configuran como una población vulnerable a sufrir algún grado de inseguridad alimentaria, y cómo las condiciones contextuales de los mismos pueden predecir dicha situación.

Estos resultados se mantienen incluso tras controlar por el país, lo que sugiere que no se explican únicamente por diferencias estructurales entre contextos nacionales. En este sentido, el presente estudio aporta evidencia multicéntrica comparable en América Latina sobre la relación entre la CD y la seguridad alimentaria en estudiantes universitarios, a partir de una metodología homogénea entre países. A diferencia de estudios previos, que suelen centrarse en contextos nacionales específicos, este enfoque permite identificar patrones comunes y diferencias contextuales, contribuyendo a una mejor comprensión de la problemática en la región.

Las limitaciones del presente estudio deben ser consideradas. En primer lugar, el diseño transversal no permite establecer relaciones causales entre las variables analizadas, por lo que los resultados deben interpretarse en términos de asociación. Asimismo, la información fue obtenida mediante autoinforme, lo que podría implicar sesgos de memoria o de deseabilidad social. En relación con el proceso de muestreo, si bien se utilizó un diseño estratificado por área de conocimiento, la selección de los participantes se realizó por conveniencia dentro de cada estrato, lo que podría introducir sesgo de selección. No obstante, la inclusión de variables de control y del país en los modelos contribuye a mitigar posibles efectos de confusión.

Adicionalmente, la naturaleza multicéntrica del estudio implica heterogeneidad entre los países, incluyendo diferencias en la composición etaria de las muestras, lo que fue considerado en el análisis mediante la inclusión del país como variable de control. Finalmente, se utilizó el IASE considerando las Guías Alimentarias Basadas en Alimentos, ante la ausencia de un instrumento único validado de forma homogénea para todos los países.

CONCLUSIONES

La inseguridad alimentaria es frecuente en estudiantes universitarios de América Latina y muestra variaciones entre países. Asimismo, la CD es en su mayoría subóptima y se asocia con la seguridad alimentaria. Este patrón podría estar relacionado no sólo con limitaciones de acceso, sino también podría sugerir una mayor dependencia de alimentos ultraprocesados. Por otro lado, el género y el grupo de convivencia de los estudiantes se asocian con mejores condiciones de seguridad alimentaria.

Abordar esta problemática requiere políticas integrales que garanticen, además de la disponibilidad de alimentos, la calidad nutricional, implementando estrategias como la educación alimentaria, subsidios a productos saludables y el fortalecimiento de servicios en comedores institucionales, entre otras medidas. Para contribuir con ello, sería pertinente desarrollar estudios que identifiquen las barreras sociales, económicas, culturales y estructurales que enfrentan los estudiantes universitarios de los países aquí analizados para acceder a una alimentación adecuada, posiblemente semejantes a las descritas en una revisión exploratoria reciente.

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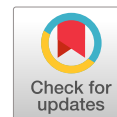
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RESEARCH ARTICLE

Medical Nutrition Therapy with a Plant-Based Diet in Pregnant Women with Chronic Kidney Disease: A Case Series

➤ **Terapia médica y nutrición con una dieta basada en plantas en mujeres embarazadas con Enfermedad Renal**
Crónica: Serie de casos

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KEYWORDS

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Renal insufficiency

Case series

➤ ABSTRACT

Background: Chronic kidney disease (CKD) is a global health problem. Pregnancies in women with CKD face an increased risk of adverse perinatal outcomes. Despite limited data, nutritional care remains a crucial component of multidisciplinary treatment for these women. The aim was to describe clinical and metabolic status and perinatal outcomes in pregnant women with CKD receiving intensive medical and nutritional care, including the recommendation of a plant-based diet (PBD).

Methods: Retrospective analysis of 7 CKD-pregnancies. Participants received care from a perinatal nephrologist, routine obstetric follow-up, and medical nutrition therapy comprising a PBD, micronutrient supplementation, counseling, and education. Renal, nutritional and metabolic status were obtained from institutional records. Perinatal outcomes assessed included preeclampsia, gestational diabetes (GDM), preterm, hospitalization, hemodialysis (HD), intrauterine growth restriction, fetal loss, and neonatal nutritional status.

Results: Six women had stage 4 CKD. Most (n=5) received outpatient care; none required HD. Glomerular filtration rate and proteinuria remained stable in all women. Four women maintained or improved baseline creatinine (peak ≤ 3.0 mg/dL). Third-trimester urea nitrogen was 31.3 ± 11.3 mg/dL, and albumin 2.97 ± 0.09 g/dL. No cases of GDM or fetal loss were observed, and one woman developed preeclampsia. All neonates were born alive. Neonatal outcomes reflected the high-risk nature of CKD pregnancies: three (42%) were preterm and four (57%) presented wasting. Newborn nutritional indices considering length and head circumference were normal.

Conclusion: In this case series of women with CKD receiving intensive medical and nutritional care, complications consistent with CKD pregnancies were observed, although with a low frequency of GDM, preeclampsia, fetal loss, and neonatal stunting. None of the women required initiation of HD, and renal function remained stable.

RESUMEN

PALABRAS CLAVE

Nutrición prenatal
Dieta tradicional
Complicaciones del embarazo
Recién nacido
Insuficiencia renal
Serie de casos

Introducción: La enfermedad renal crónica (ERC) es un problema de salud mundial que puede complicar la gestación. Las mujeres embarazadas con ERC presentan un mayor riesgo de resultados perinatales adversos. Aún con datos limitados, la atención nutricional es un componente crucial del tratamiento multidisciplinario. El objetivo fue describir el estado clínico-metabólico y los resultados perinatales en embarazadas con ERC que recibieron atención médica y nutrición intensiva incluyendo la recomendación de una dieta basada en plantas (DBP).

Métodos: Análisis retrospectivo de 7 embarazos con ERC. Las participantes recibieron atención por un nefrólogo perinatal, seguimiento obstétrico habitual y una terapia médica nutricional (TMN) que incluyó una DBP, suplementación con micronutrientes, consejería y educación. El estado renal, nutricio y metabólico se obtuvo de registros institucionales. Los desenlaces perinatales evaluados incluyeron preeclampsia, diabetes gestacional (DMG), parto pretérmino, hospitalización, hemodiálisis, restricción del crecimiento intrauterino, pérdida fetal y estado nutricio neonatal.

Resultados: Seis mujeres presentaron ERC estadio 4. La mayoría (n=5) recibió manejo ambulatorio; ninguna requirió hemodiálisis. La tasa de filtración glomerular y la proteinuria se mantuvieron estables. Cuatro mujeres mantuvieron o mejoraron su creatinina basal (pico ≤ 3.0 mg/dL). El nitrógeno ureico en el tercer trimestre fue de 31.3 ± 11.3 mg/dL y la albúmina de 2.9 ± 0.09 g/dL. No se observaron casos de DMG ni pérdidas fetales; solo una mujer desarrolló preeclampsia. Todos los recién nacidos nacieron vivos. Los resultados neonatales reflejaron el alto riesgo de los embarazos con ERC: tres (42%) fueron prematuros, y cuatro (57%) presentaron emaciación. Los índices nutricios de longitud y perímetro cefálico fueron adecuados.

Conclusión: En esta serie de casos en mujeres con ERC recibiendo tratamiento intensivo médico y nutricio, se observaron complicaciones consistentes con el embarazo con ERC, pero con baja frecuencia en DMG, preeclampsia, pérdidas fetales y desmedro al nacer. Ninguna mujer requirió iniciar tratamiento con hemodiálisis, manteniendo estable la función renal.

KEY MESSAGES

1. Intensive medical nutrition therapy, including a plant-based diet, in this group of pregnant women with CKD (3-5), was associated with stable renal function and no requirement for dialysis in this case series.
2. Close multidisciplinary care was associated with stable metabolic, electrolyte, and blood pressure control, and no cases of gestational diabetes or fetal loss, and a low frequency of preeclampsia
3. Neonatal outcomes reflected the high-risk nature of CKD pregnancies, with a high frequency of prematurity and wasting, although most newborns had preserved head circumference and length.
4. Culturally adapted plant-based dietary strategies may represent a potentially feasible nutritional approach for high-risk CKD pregnancies, particularly in low-resource or dialysis-limited settings.

CITATION

Perichart-Perera O, Ibarra-González L, Orozco-Guillén A, Hernández-Corona J, Hernández-Hernández L, Flores-reyes M, Rodríguez-Bosch M, Rodríguez-Cano AM. Medical Nutrition Therapy with a Plant-Based Diet in Pregnant Women with Chronic Kidney Disease: A Case Series. Rev Esp Nutr Hum Diet. 2026; 30(3): e2718. doi: <https://doi.org/10.14306/renhyd.30.3.2718>

INTRODUCTION

Chronic kidney disease (CKD) is a significant global health problem affecting around 10% of the population, with higher numbers in low- and middle-income countries (LMIC) and among women¹. The prevalence of CKD in pregnancy has risen to approximately 1-3%². CKD during pregnancy increases the risk of adverse perinatal outcomes, including preeclampsia, preterm birth, intrauterine growth restriction (IUGR), neonatal death, low birthweight, small for gestational age (SGA) newborns, increased neonatal intensive care unit admission and complications associated with prematurity^{3,4}. These risks rise with advancing CKD stage⁴. Despite limited data on nutrition care in these women, it's a crucial component of multidisciplinary treatment⁵. Medical nutrition therapy (MNT) is recommended for adults with CKD (stages 1-5) and should be offered by a clinical nutritionist with close collaboration with a physician⁶. Nutrition therapy is associated with an improvement in nutrition and metabolic status, a reduction in complications, the preservation of residual kidney function, and the promotion of fluid and electrolyte balance, among others^{6,7}. Adequate energy, protein consumption, and optimal micronutrient intake are important nutritional goals in these patients. Protein restriction (0.55-0.60 g/kg/d) in stages 3-5 CKD is advised, associated with reduced disease progression, death prevention, and improved quality of life⁶, however, some controversy exists⁸ about the benefits of low protein diets since these could be the result from a combination of additional strategies, such as the type of protein. KDIGO 2012 guideline states that dietary protein intake <0.8 g/kg/day did not offer any advantage and recommends 0.8 g/kg per day when glomerular filtration rate (GFR) <30 mL/min per 1.73m² in non-diabetic metabolically stable patients with pre-dialysis CKD⁹. This recommendation is considered a safer option to prevent protein-energy malnutrition when alpha-keto analog supplementation is not used. Different dietary interventions have generally been associated with reduced systolic and diastolic blood pressure, and higher GFR and albumin level in CKD patients¹⁰. Plant-based diets (PBD) are nutrient-dense, high-fiber, and lower in protein. Recently, PBD have been recognized as an effective dietary strategy where improvements in nitrogen balance, acid-base metabolism, metabolic control (glucose, lipid profile, insulin resistance), bone mineral metabolism disorders, and proteinuria have been reported^{9,11}.

In a retrospective study, a group of pregnant women who received a PBD as intervention showed a lower risk of preterm birth and SGA newborns¹². In a previous case report, nutrition care with a controlled, unprocessed, healthy diet successfully avoided hemodialysis (HD) in a CKD (stage 5) pregnant woman¹³.

This case series aims to describe clinical and metabolic status, renal function during pregnancy, and the incidence of adverse perinatal outcomes in a group of pregnant women with CKD (stages 3-5) who received intensive medical and nutrition care, including a PBD and individualized micronutrient supplementation. Only single

case studies exist describing outcomes in CKD pregnant women receiving a nutrition intervention.

METHODS

Case series presentation

We performed a retrospective chart review of pregnant women with CKD who received medical and nutrition treatment. This report adheres to the confidentiality guidelines of our institution's Ethics Committee and National regulation on data privacy.

Case identification and eligibility

Cases were identified through institutional medical records of pregnant women attended between August 2019 and November 2021. Eligible cases were defined according to the following criteria: women aged ≥18 years with a confirmed diagnosis of CKD stages 3–5 who had been referred to the Nutrition Coordination for Medical Nutrition Therapy (MNT). From the available records, cases were included if they had completed at least three specialized nutrition visits and had complete perinatal follow-up data. Records with incomplete follow-up or corresponding to patients who initiated dialysis prior to the nutritional intervention were excluded. CKD was defined as an estimated glomerular filtration rate (eGFR) <60mL/min/1.73m² or the presence of markers of kidney damage persisting for >3 months⁹.

Clinical Timeline and Intervention

Medical care was provided by a dedicated obstetric nephrologist, while MNT was administered by a clinical dietitian following a standardized protocol: 1) Initial nephrology and nutrition assessment (baseline) at diagnosis; 2) regular MNT follow-up visits every 2-4 weeks for dietary adjustment and metabolic monitoring; 3) Hospitalization for intensive monitoring in specific cases; 4) Delivery with neonatal anthropometric assessment.

Medical Nutrition Therapy

Medical nutrition therapy consisted of intensive counseling, including dietary recommendations (plant-based diet), micronutrient supplementation, and education delivered through a behavioral approach (goal-setting and problem-solving). Energy and protein requirements were estimated based on pregestational weight, using 25–35 kcal/kg/day and adding the energy cost of pregnancy (+340kcal/d in the second, and +452kcal/d in the third trimester)^{5,6}. Protein intake was estimated at 0.6–0.8 g/kg/day, with additional requirements for pregnancy (+9g/d and +31g/d in the second and third trimesters, respectively)⁵. All patients were supplemented with folic acid, iron, calcium, vitamin D3, and

other nutrients through a multivitamin. Any additional individual micronutrient supplementation was prescribed in consultation with the nephrologist.

An individualized plant-based dietary (PBD) pattern was recommended, defined as a dietary approach emphasizing a high proportion of foods derived from plant sources—such as whole grains, legumes, fruits, vegetables, nuts, seeds, and plant oils—while limiting animal-derived products. Plant-based diets represent a spectrum of dietary patterns (e.g., Mediterranean, DASH), characterized by the predominance of minimally processed plant foods rather than the complete exclusion of animal products^{11,14}. In the context of chronic kidney disease (CKD), this approach was adapted to achieve moderate protein restriction, with a reduced contribution of animal protein and an emphasis on nutrient-dense, fiber-rich foods. This dietary pattern was tailored to a traditional Mexican dietary context, promoting the use of locally available foods and customary dishes (e.g., corn-based products, legumes, fruits, vegetables, seeds, oils, and avocado), in order to enhance cultural acceptability and feasibility.

Individual energy and protein prescriptions were calculated for each patient based on pregestational weight and gestational stage, and portion sizes were accordingly individualized. Animal-derived foods were limited to a maximum of two servings per day of dairy products and/or eggs, while oily fish was recommended up to twice per week as an alternative protein source. Red and processed meats were discouraged. Patients were advised to avoid sugar-sweetened beverages and soft drinks. Added sugars were restricted to <25g/day. The overall dietary approach emphasized whole, minimally processed foods and discouraged ultra-processed products.

This dietary pattern was recommended as part of the intervention; however, actual intake could not be objectively verified. At each visit, usual intake was qualitatively explored, and perceived adherence to recommendations was self-reported on a 0–100% scale. No standardized dietary assessment tools (e.g., 24-hour dietary recalls or food records) were available, precluding objective quantification of dietary intake and adherence. Barriers and facilitators, including socioeconomic and cultural factors, were addressed to tailor recommendations throughout follow-up.

Maternal CKD assessment

Renal function, clinical, nutritional, and metabolic status during pregnancy were obtained from medical records. We present sociodemographic characteristics, clinical data (diagnosis, blood pressure), renal function status (serum creatinine–SCr–, albumin, serum urea nitrogen–SUN, proteinuria), and weight status (pregestational body mass index–pBMI–, gestational weight gain) at baseline and follow-up. The need for HD was registered as a primary outcome.

Perinatal outcomes

Maternal gestational conditions, such as preeclampsia (ACOG criteria¹⁵), gestational diabetes mellitus (GDM) (International criteria¹⁶), preterm birth (deliveries <37 weeks), and hospitalization, were extracted from institutional records. Fetal outcomes documented included IUGR (Fetal weight/gestational age <3 percentile or <10 percentile with placental blood flow alterations¹⁷) and fetal loss. Neonatal outcomes included low birth weight (LBW), small for gestational age (SGA), wasting, stunting, low head circumference for age (HC/A), and NICU admission.

Newborn assessment

Newborn weight, length, and head circumference were measured by attending neonatologists and obtained from institutional records. LBW was defined as birthweight <2500g. Nutrition indices were assessed using World Health Organization (WHO) criteria for term infants and Intergrowth-21st criteria for preterms¹⁸. SGA was classified as a weight for age <-2 z-scores, wasting as weight for length (W/L) <-2 z-scores, stunting as length for age (L/A) <-2 z-scores, and a high risk of neurodevelopment delay as HC/A <-2 z-scores.

Medical Management

An initial exhaustive medical history and physical examination were conducted. Women were inquired about their pregestational SCr or renal function assessment; none knew their previous status. Detailed physical examination and blood pressure (BP) measurements were performed at each visit. Additionally, self-monitoring of BP at home was requested and evaluated at each visit, with a BP goal <140/90 mmHg, ideally <135/85mmHg⁹. Laboratory tests were requested biweekly approximately, including a complete blood count, metabolic and lipid panel, 24-hour proteinuria, and other individualized parameters (e.g., parathyroid hormone, vitamin D). Based on laboratory results, iron deficiency was corrected, with variable doses of erythropoietin initiated to maintain hemoglobin (Hb) levels above 11mg/dL⁹. Individualized iron supplementation doses were prescribed. Acid-base evaluation with CO₂ was monitored every 3–4 weeks to adjust individual oral sodium bicarbonate doses.

During the consultation, edema was clinically evaluated, and a low-dose loop diuretic was started when required, always considering the amniotic fluid index (AFI). In specific cases (cases 1 and 3), cation exchange resins were added to diuretics for potassium management. Our interdisciplinary team closely monitored all patients, maintaining effective communication in case of any change in clinical evolution.

RESULTS

Case series presentation

Overall, three key patterns emerged from the data: (1) maternal renal function remained stable without the need for dialysis, (2) metabolic parameters were generally maintained within target ranges, and (3) neonatal outcomes reflected the high-risk profile of CKD pregnancies, including low birth weight and prematurity, but with all live births and relative preservation of length-for-age and head circumference-for-age in most newborns.

Maternal description

We included 7 women in this analysis. Overall, maternal clinical evolution was characterized by stable renal function and relatively controlled metabolic parameters despite advanced CKD. Table 1 presents sociodemographic data and clinical diagnoses of the studied women. Most women were classified with stage 4-CKD (n=6) and one woman with stage 3-CKD. Mean age was 32.14±4.14 years (range: 28-39 years). Most were housewives (n=6) residing in areas close to Mexico City (Estado de México and Hidalgo) (n=5). Three women completed high school, while the remaining had lower education level. Multiparity was common (n=6). The mean p-BMI was 24.78±3.62kg/m²; with four women classified as normal weight (57.1%), and three as overweight.

Clinical course of pregnant women with CKD

The mean gestational age at the first MNT visit (baseline) was 23.70±5.09weeks (range: 15.4-30.5). MNT visits range from 3 to 7; 85% (n=6) of women assisted to at least four visits. Self-reported adherence to MNT recommendations was 85.7%; based on participants' subjective estimates. The institutional records lacked documentation of dietary recalls, therefore, assessing these women's quantitative/qualitative dietary intake data was not possible. Nutritional management included individualized micronutrient supplementation. Folic acid doses ranged from 400mcg/d to 6mg/d; three women received ≥5mg/d. Four women received 20-60mg/d of iron; one required 300mg of IV iron in the second trimester. The other three women received >100mg/d of supplemental iron. Only two women received <1000mg of calcium supplementation (440-1750mg/d). Three women received ≤400IU/d of vitamin D, most doses ranged from 800-1600IU/d. Omega-3 supplementation was prescribed in four women (300mg/d to 2g/d). Most women received ambulatory treatment. Two women required prolonged hospitalization (65 and 66 days) due to clinical severity and were initially considered candidates for HD. However, HD was not initiated, and both were managed with intensive dietary intervention and close medical monitoring, taking into account clinical judgment as well as contextual factors, including socioeconomic and housing conditions.

Table 1. Clinical and sociodemographic data of included women.

Case No.	Age (years)	Educational Level	Place of Residence	Occupation	Parity	CKD classification (KDIGO)	Etiology	Other comorbidities
1	39	None	Oaxaca	Housewife	Multiparous	4 A3	Unknown	Chronic systemic hypertension, anemia
2	36	Elementary School	Hidalgo	Housewife	Multiparous	4 A3	Advanced global glomerulosclerosis, (kidney biopsy during pregnancy). Unknown	Chronic systemic hypertension, anemia
3	33	Junior High	Oaxaca	Housewife	Multiparous	4 A3	Unknown	Secondary hyperparathyroidism, history of right cephalic vein thrombosis
4	31	High school	Estado de México	Employee	Multiparous	4 A3	Unknown	Chronic systemic hypertension, anemia
5	28	Junior High	Hidalgo	Housewife	Multiparous	4 A3	Unknown	Chronic systemic hypertension
6	28	High school	Hidalgo	Housewife	Multiparous	3 A2	Unknown + Nephrectomy	History of preeclampsia, anemia
7	30	High school	Estado de México	Housewife	Multiparous	4 A3	Unknown	Chronic systemic hypertension

CKD: Chronic kidney disease
KDIGO: Kidney Disease: Improving Global Outcomes

Renal and metabolic parameters remained relatively stable throughout pregnancy. No women required HD treatment. Table 2 shows eGFR values for women at their first and last visits. Five women maintained or decreased bicarbonate doses. BP remained within target range in most women except one with a peak of 145/95mmHg (Table 3). Respecting renal function markers, four women (57%) decreased or maintained baseline SCr, and four (57%) had a peak SCr ≤ 3.0 mg/dL during pregnancy. Mean SUN in the third trimester was 31.30 ± 11.34 mg/dL (19.0 - 52.60 mg/dL); a peak SUN < 35 mg/dL were observed in 4/7 women, while 6/7 had a peak SUN < 50 mg/dL. Highest albumin ranged from 2.9-3.6g/dL; mean serum albumin in the third trimester was 2.97 ± 0.09 g/dL. All women presented proteinuria at the first MNT visit; peak proteinuria during pregnancy ranged from 2168 to 8250mg/24h (Table 4).

Gestational weight gain in the last visit (third trimester) ranged from 2.8kg to 12.9kg (Table 3). Most women (n=5) maintained glucose < 100 mg/dL throughout pregnancy; in the third trimester, one woman had 109 mg/dL, and another had 141mg/dL. Peak triglycerides were 349-627mg/dL in the second or third trimester (Table 3). Peak serum sodium ranged from 133 to 140mEq/L and peak potassium from 4.9 to 5.6mEq/L (Table 4). Four of six women had Hb < 10 mg/dL in the second trimester (one woman without measurement). All women showed an increase in Hb values in the third trimester.

Perinatal outcomes

Perinatal outcomes were characterized by a high frequency of prematurity and wasting at birth consistent with the high-risk profile of CKD pregnancies. One woman developed preeclampsia, and GDM was not present. Gestational age at birth averaged 37.0 ± 1.86 weeks. Three babies (42%) were preterm: 3/7 = 42.9%, including one early preterm (< 34 weeks). IUGR affected three fetuses; no fetal losses occurred. All babies were born alive; with mean birthweight of 2375.42 ± 399.52 g, mean length of 47.57 ± 2.76 cm, and mean HC of 32.71 ± 0.69 cm. Five babies (71%) were classified as LBW, one as SGA, and four were malnourished (wasting). One baby presented stunting and none of them had low HC/A. Two babies required NICU hospitalization.

DISCUSSION

This case series describes stable renal function and perinatal outcomes within the expected spectrum for CKD pregnancies in women receiving intensive multidisciplinary care, which included the recommendation of a plant-based dietary pattern and individualized micronutrient supplementation. Renal function remained stable, with no requirement for hemodialysis, and no cases of gestational diabetes or fetal loss were observed; one woman developed preeclampsia. Neonatal outcomes reflected the high-risk nature of CKD pregnancies, with a high frequency of prematurity, low birth weight and wasting, although length-for-age and head circumference-for-age were preserved in most cases.

These findings should be interpreted in the context of the well-documented increased risk of adverse maternal and neonatal outcomes in CKD pregnancies, particularly in advanced stages. Although available evidence remains limited, previous studies have reported high rates of preeclampsia, preterm birth, and fetal growth restriction in this population^{3,4}. Therefore, the outcomes observed in our series should not be interpreted as optimal, but rather as occurring within the expected clinical spectrum for this high-risk group. CKD during pregnancy, particularly stages 3-5, often leads to renal function decline and increases the risk of multiple adverse maternal, fetal, and neonatal outcomes. Preeclampsia prevalence in these women can exceed 40%, while gestational diabetes mellitus affects approximately 12%¹⁹. Preterm and early preterm birth rates may exceed 30% and reach up to 13%, respectively⁴. Preventing these complications is associated with a better intrauterine environment (better metabolic and hormone status, lower inflammation and oxidative stress, lower infection risk), which promotes optimal fetal growth and mitigates the risk of chronic diseases later in life²⁰.

One of the main objectives in managing CKD is to delay HD and sustain residual renal function by reducing urea generation⁹. HD poses significant health risks for CKD patients, and despite recent protocol improvements in pregnancy, it still carries notable risk (cervical shortening, incompetence, heightened preterm risk, mother-child morbidity)²¹. None of the studied women required HD, and their eGFR remained stable. The treatment target for CKD pregnancies is near-normal SUN levels (< 40 - 42 mg/d)²². Six women in our sample achieved this goal. Four women lowered or maintained their SCr from baseline to the end of pregnancy. Although proteinuria typically increases in pregnant women, especially those already proteinuric²³, it remained relatively stable in our sample. He et. al, identified higher creatinine and proteinuria as significant risk factors for adverse kidney outcomes, including renal failure, even up to 4 years post-pregnancy²⁴. The clinical implications of maintaining stable renal function and avoiding HD in women with advanced CKD are clinically relevant. In our series, renal function remained stable and no patients required dialysis, in the context of close multidisciplinary management that included intensive medical monitoring and a plant-dominant dietary pattern. Although causality cannot be inferred, these findings are consistent with previous reports suggesting that, even in advanced CKD, carefully supervised nutritional interventions may contribute to delaying the initiation of renal replacement therapy. Avoiding dialysis during pregnancy may be clinically relevant, given the potential risks associated with intradialytic hemodynamic instability and electrolyte shifts that could affect fetal perfusion²³. Two women in the study (cases #1 and #3) were hospitalized after being referred from Oaxaca (southeast state in Mexico and one of the most economically marginalized). Despite being candidates for ambulatory HD, their very low socioeconomic and inadequate housing conditions, lead the medical team to opt for conservative management. They continued a PBD with full adherence during

Table 2. Estimated renal disease progression according to serum creatinine values in studied women.

Case No.	SCr (first visit) mg/dL	eGFR (first visit) mL/min/1.73 m ²	SCr (last visit) mg/dL	eGFR (last visit) mL/min/1.73 m ²
1	3.41	17	3.8	15
2	2.2	29	3.06	20
3	2.6	24	2.2	30
4	2.38	27	2.46	26
5	3.25	19	2.63	25
6	2.1	32	1.9	36
7	2.7	24	2.6	25

SCr: serum creatinine; eGFR: estimated glomerular filtration rate

Note: Conversion factors for units: SCr in mg/dL to $\mu\text{mol/L}$, $\times 88.4$ **Table 3.** Weight status, blood pressure and metabolic markers in studied women.

Case No.	Pregestational BMI (Weight status)	Gestational weight gain		Blood pressure		Glucose		Triglycerides	
		2 nd trimester kg	3 rd trimester kg	1st visit mmHg	Peak mmHg	1st visit mg/dL	Peak mg/dL	1st visit mg/dL	Peak mg/dL
1	Normal weight	2	6.4	115/67	118/84	69	141	304	369
2	Normal weight	2.8	5.4	116/77	136/86	68	76	645	627
3	Normal weight	6	7.4	110/70	120/60	86	120	413	387
4	Overweight	3.4	2.8	128/85	-	87	79	402	371
5	Overweight	-	8.8	116/77	145/95	109	95	566	554
6	Normal weight	9.8	12.9	137/80	137/87	72	92	194	349
7	Overweight	5.3	4.7	114/76	129/85	78	85	310	422

BMI: Body mass index

Note: Conversion factors for units: Glucose in mg/dL to mmol/L, $\times 0.05551$; Triglycerides in mg/dL to mmol/L, $\times 0.01129$ **Table 4.** Renal and clinical outcomes of women with chronic kidney disease.

Case No.	SCr		Proteinuria		Serum Urea Nitrogen		Albumin		Potassium		Sodium	
	1st visit mg/dL	Peak mg/dL	1st visit mg/24h	Peak mg/24h	1st visit mg/dL	Peak mg/dL	1st visit g/dL	Peak g/dL	1st visit mEq/L	Peak mEq/L	1st visit mEq/L	Peak mEq/L
1	3.41	4.67	2178	2168	29.9	63.1	2.8	3.6	4.5	5.4	137	138
2	2.2	3.06	4850	5460	31.8	41.1	3.0	2.9	4.7	4.9	137	136
3	2.6	2.6	8688	-	41.1	32.7	3.2	3.0	4.7	5.6	138	138
4	2.38	2.81	8665	8250	29.4	33.2	3.0	3.1	4.9	5.2	134	136
5	3.25	3.16	4680	4653	34.1	36.9	3.1	3.4	4.7	5.0	135	133
6	2.1	2.2	2100	6440	24.3	33.6	3.3	3.5	4.2	5.0	136	140
7	2.7	3.0	635.6	5114	33.6	34.6	3.3	3.2	4.4	5.0	136	139

SCr: serum creatinine

Note: Conversion factors for units: SCr in mg/dL to $\mu\text{mol/L}$, $\times 88.4$; serum urea nitrogen in mg/dL to mmol/L, $\times 0.357$

hospitalization. Both women maintained a reasonably good clinical status and renal function throughout pregnancy. This highlights the potential need for alternative strategies in low and middle-income countries where poverty, food insecurity, and poor housing conditions prevail. Efforts to improve medical intervention are crucial, requiring an interdisciplinary approach involving nephrologists, high-risk obstetricians, nutritionists, and neonatologists, particularly in situations where the body's physiological and compensatory mechanisms allow for avoidance of HD during pregnancy.

Since we delivered a multi-component nutrition and medical treatment, we cannot relate the outcomes to a specific component. Our descriptive design precluded evaluating the isolated effect of the moderate protein-restricted PBD. Nevertheless, previous evidence in CKD pregnancies suggests that moderate protein restriction may have beneficial effects. Low-protein diets have been associated with improved control of hyperfiltration and proteinuria, potentially delaying the need for HD²³. A case reported by Nava et al. showed that a low protein diet supplemented with alpha-keto analogs postponed HD initiation during pregnancy²⁵. Similarly, moderate protein-restricted PBDs have been associated with stable or reduced creatinine levels and lower urea concentrations without apparent detrimental effects on fetal growth²³. A large dietary intervention study in CKD pregnancies receiving moderate protein-restricted PBD reported a lower incidence of preterm and SGA babies compared to controls (combined outcome: 61.54% versus 80.77%; $p=0.03$)¹².

In addition, evidence from non-pregnant CKD populations provides mechanistic plausibility for these findings. Plant-based diets have been associated with reduced generation of uremic toxins, improved acid-base balance, decreased intestinal phosphorus absorption, and potential preservation of glomerular filtration rate through reductions in inflammation, oxidative stress, and proteinuria. The higher fiber content of PBDs may also promote a more favorable gut microbiota profile, contributing to lower production of gut-derived uremic compounds¹¹. However, protein restriction during pregnancy remains a topic of ongoing debate. Concerns persist regarding its potential impact on fetal growth, particularly in the absence of rigorous nutritional monitoring^{26,27}. Therefore, the balance between maternal metabolic control and adequate fetal nutrient supply requires careful, individualized assessment, especially in high-risk populations such as women with advanced CKD.

Neonatal outcomes in this case series reflected the high-risk profile of pregnancies complicated by CKD. A high frequency of low birth weight, prematurity, and wasting was observed, consistent with previous reports in this population^{3,4}, and suggestive of fetal growth restriction, a well-recognized complication in CKD pregnancies. Importantly, all pregnancies resulted in live births, although this finding should be interpreted cautiously given the small sample size and descriptive nature of the study. While birthweight is commonly used to assess neonatal nutritional status, it does not provide

information on body composition or proportional growth. In this context, additional anthropometric indicators such as weight-for-length and length-for-age are important to characterize growth quality, as they reflect different biological responses to suboptimal nutrient supply^{28,29}. In our study, although wasting was frequent, length-for-age and head circumference-for-age were preserved in most newborns, suggesting variability in growth patterns. Head circumference-for-age is a particularly relevant indicator, as it reflects early brain growth and neurodevelopmental potential. Despite the high-risk profile, no cases of low head circumference were observed. In addition, only one newborn presented stunting at birth. Stunting reflects impaired longitudinal growth, and suggests poor maternal nutrition or health throughout a significant portion of pregnancy, which is consistent with the underlying maternal CKD. Stunting is a relevant nutritional status indicator, considering it has been associated with adverse developmental outcomes and increased risk of metabolic dysfunction later in life³⁰. Previous reports have described adequate neonatal anthropometric outcomes in selected cases receiving intensive multidisciplinary care³¹. It should be noted that data on wasting and stunting in CKD pregnancies remain scarce, highlighting the relevance of reporting these indicators beyond birthweight alone.

Data regarding electrolyte status and metabolic parameters (glucose, lipids) in CKD pregnancies are limited³¹. This group showed relatively stable electrolytes, glucose, and triglycerides. All women had adequate control of hyperkalemia. While there's no data on the impact of a PBD on electrolytes during pregnancy, our population exhibited benefits observed in non-pregnant adults with CKD stages 3-5 without dialysis, maintaining stable electrolyte concentrations without dietary potassium or phosphorus restriction³².

Effective dietary interventions require patient commitment for adherence. In these women, self-reported diet adherence was high (85.7%); with most reporting $\geq 90\%$. Following a CKD diet may be challenging; a PBD offers flexibility, enhancing acceptance and commitment. Recommending culturally accepted foods and traditional dishes likely positively influenced adherence due to familiar flavors, easy preparations, and affordability. Our proposed diet emphasizes whole grains, legumes, fruits, vegetables, seeds, oils, and avocado, with some dairy, eggs, and oily fish. Traditional PBD aligns with public health priorities for sustainable, environmentally conscious dietary practices, essential for global food system transformation.

Intensive nutritional counseling and education are essential for promoting dietary adherence as well as supporting and accompanying women through behavioral change. All cases received intensive counseling focusing on addressing individual barriers and developing skills. Common barriers include insufficient nutrition education/guidance, restricted time during medical appointments, concerns about non-compliance, and potential relapse. All medical team members should receive training on CKD-specific dietary challenges, with dietitians ideally integrated into the multidisciplinary team³³. MNT holds a secondary position vs the medical/pharmaceutical treatment. However, given its role

in treating, preventing, or mitigating symptoms, MNT should be a fundamental element in CKD management³⁴.

From a clinical perspective, these findings highlight the potential role of structured, multidisciplinary care in the management of high-risk pregnancies complicated by CKD. Although causality cannot be inferred, the observation of stable renal function without the need for dialysis suggests that, in selected patients, close monitoring combined with individualized nutritional strategies may contribute to maintaining metabolic stability during pregnancy. Importantly, neonatal outcomes in our series—particularly the high prevalence of LBW and prematurity—are consistent with previous reports in CKD pregnancies, reinforcing that fetal growth restriction remains a central clinical challenge in this population. These findings underscore the need for careful fetal surveillance and individualized nutritional and medical management to balance maternal and fetal risks.

This study has several limitations that should be considered when interpreting the findings. First, the small sample size (n=7) limits the generalizability of the results and precludes any statistical inference, restricting the conclusions to descriptive observations within this specific cohort. In addition, most women had stage 4 CKD, which may have influenced the clinical course and the urgency of decisions regarding dialysis initiation. Second, the retrospective design introduces the possibility of information bias and limits the ability to control for potential confounders that may have affected both maternal and neonatal outcomes. A key limitation of this study is the lack of objective dietary assessment. No standardized methods (e.g., 24-hour dietary recalls or food records) were available, which precludes the precise quantification of actual dietary intake, including protein and micronutrient consumption (e.g., potassium, phosphorus). Additionally, adherence was based on self-reported estimates, which is subject to recall bias and social desirability bias. Therefore, the outcomes should be interpreted as results of the recommendation of a plant-based diet within an intensive care model, rather than a strictly measured intake. Finally, economic constraints resulted in incomplete laboratory data in some cases, limiting a more comprehensive metabolic and nutritional evaluation. These limitations underscore the need for prospective studies with larger sample sizes and rigorous dietary assessment to better understand the role of nutritional interventions in CKD pregnancies.

CONCLUSION

In this case series of women with CKD stages 3–4, stable renal function and perinatal outcomes within the expected range for this high-risk population were observed in the context of intensive multidisciplinary care delivered by perinatal nutritionists, nephrologists, and obstetricians. A culturally adapted plant-based dietary pattern with individualized micronutrient supplementation

may represent a feasible nutritional strategy for this high-risk group. More studies are needed to assess this type of intervention in this selected group, reporting clinical, biochemical and relevant newborn nutritional status outcomes.

AUTHORS' CONTRIBUTIONS

O.P-P conceptualized and designed the study, coordinated the project, supervised methodological development, participated in data analysis and interpretation, and led manuscript validation. L.I-G and M.F-R provided nutritional care and supported data collection. A.O-G was responsible for medical care and contributed to manuscript drafting. J.H-C and L.H-H contributed to data curation and analysis, as well as to results visualization. M.R-B provided clinical resources and critically reviewed the manuscript. A.M-R-C participated in data curation and visualization, contributed to manuscript drafting and editing, and supported data interpretation. All authors critically reviewed and approved the final version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest in the preparation of this manuscript.

DATA AVAILABILITY

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

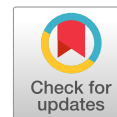
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RESEARCH ARTICLE

A Pilot Randomized Controlled Trial on the Effects of Selenium Supplementation Combined with Exercise on Body Composition and Selenium Bioactivity

➤ Ensayo piloto aleatorizado y controlado sobre los efectos de la suplementación con selenio combinada con ejercicio físico en la composición corporal y la bioactividad del selenio

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Bioactivity
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➤ ABSTRACT

Introduction: Selenium (Se) is a crucial trace element that plays an important role in fat metabolism and muscle building. Selenoproteins, such as glutathione peroxidase (GPx) and selenoprotein P (SEPP), are key examples of Se bioactive proteins that contribute to overall physiological processes. In addition, exercise is well known for its beneficial effects on body composition. However, limited data exist regarding the effectiveness of Se supplementation combined with exercise on changes in body composition and Se bioactivity. This pilot randomized controlled trial aimed to determine the effects of Se supplementation combined with exercise on body composition and Se bioactivity, as indicated by GPx and SEPP levels.

Methods: A total of 40 participants were recruited and allocated into two groups: an intervention group (n = 20) that received 200 µg of Se daily combined with regular exercise for 12 weeks, and a control group (n = 20) that performed regular exercise alone without Se supplementation for 12 weeks. Body composition was assessed using gold-standard and bioelectrical impedance methods, including BOD POD and InBody270. GPx and SEPP concentrations were determined using High-Performance Liquid Chromatography–Inductively Coupled Plasma Mass Spectrometry.

Results: The results showed that at the endpoint, participants in the intervention group had a significantly lower percentage of body fat compared with the control group (p < 0.05). In addition, fat-free mass, GPx activity, and SEPP concentrations in the intervention group were significantly higher than those in the control group (p < 0.05). There were no significant differences in dietary habits between groups, except for Se intake, which was significantly higher in the intervention group at the endpoint (p < 0.05).

Conclusions: Se supplementation combined with exercise was effective in improving body composition by reducing body fat percentage, increasing fat-free mass, and enhancing Se bioactivity compared with exercise alone.

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RESUMEN

PALABRAS CLAVE

Bioactividad
Composición corporal
Ejercicio físico
Selenio
Selenoproteínas

Introducción: El selenio (Se) es un oligoelemento esencial que desempeña un papel importante en el metabolismo de las grasas y en la formación de masa muscular. Las selenoproteínas, como la glutatión peroxidasa (GPx) y la selenoproteína P (SEPP), son ejemplos clave de proteínas bioactivas dependientes del Se que contribuyen a diversos procesos fisiológicos. Además, es bien conocido que el ejercicio físico tiene efectos beneficiosos sobre la composición corporal. Sin embargo, existen datos limitados sobre la eficacia de la suplementación con Se combinada con ejercicio físico en los cambios de la composición corporal y la bioactividad del Se. Este ensayo piloto aleatorizado y controlado tuvo como objetivo determinar los efectos de la suplementación con Se combinada con ejercicio sobre la composición corporal y la bioactividad del Se, evaluada mediante los niveles de GPx y SEPP.

Métodos: Se reclutó un total de 40 participantes, que fueron asignados a dos grupos: un grupo de intervención (n = 20), que recibió 200 µg de Se al día junto con ejercicio físico regular durante 12 semanas, y un grupo control (n = 20), que realizó únicamente ejercicio físico regular durante 12 semanas sin suplementación con Se. La composición corporal se evaluó mediante métodos de referencia y de bioimpedancia eléctrica, incluyendo BOD POD e InBody270. Las concentraciones de GPx y SEPP se determinaron mediante cromatografía líquida de alta resolución acoplada a espectrometría de masas con plasma acoplado inductivamente (HPLC-ICP-MS).

Resultados: Los resultados mostraron que, al final de la intervención, los participantes del grupo de intervención presentaban un porcentaje de grasa corporal significativamente menor en comparación con el grupo control ($p < 0,05$). Además, la masa libre de grasa, la actividad de GPx y las concentraciones de SEPP fueron significativamente mayores en el grupo de intervención que en el grupo control ($p < 0,05$). No se observaron diferencias significativas en los hábitos dietéticos entre los grupos, excepto en la ingesta de Se, que fue significativamente mayor en el grupo de intervención al final del estudio ($p < 0,05$).

Conclusiones: La suplementación con Se combinada con ejercicio físico fue eficaz para mejorar la composición corporal al reducir el porcentaje de grasa corporal, aumentar la masa libre de grasa y potenciar la bioactividad del Se en comparación con la práctica de ejercicio físico sin suplementación.

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KEY MESSAGES

1. Selenium supplementation combined with exercise significantly reduced body fat.
2. Combined intervention significantly increased fat-free mass and improved body composition.
3. Selenium supplementation markedly enhanced GPx and SEPP concentrations, indicating improved selenium bioactivity.
4. Changes in selenium metabolism suggest alterations in selenoprotein synthesis and redox regulation.

CITATION

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INTRODUCTION

Selenium (Se) is a vital trace element that plays an important role in many human physiological functions¹. Se deficiency can lead to complications such as immunological impairment, some types of cancer, hypertension, and other disorders². The recommended Se intake for adults is 55 µg/day, whereas individuals with serum Se concentrations below 40–70 µg/L are considered Se deficient, which is possibly caused by inadequate Se intake³. The major biological activity of Se is its incorporation into several selenoproteins that are essential for supporting normal physiological functions. Glutathione peroxidase (GPx) and selenoprotein P (SEPP) are examples of the main Se-dependent proteins that play vital roles in immune system enhancement, metabolic support, and reduction of oxidative stress⁴. Although Se deficiency is relatively rare, previous studies have shown that Se supplementation to promote Se bioactivity, particularly GPx and SEPP, is necessary to improve health status among certain populations and to prevent serum selenoprotein levels from falling below optimal ranges⁵. Such suboptimal levels may increase the risk of complications, including autoimmune diseases, cancers, heart failure, endothelial dysfunction, and other non-communicable diseases (NCDs)⁶. In addition, Se supplementation may improve body composition by supporting fat metabolism and stimulating lean body mass synthesis⁷, which are key factors in maintaining good health and quality of life throughout the lifespan.

It is well known that regular exercise is strongly recommended for overall health. Efficient circulation, weight control, and enhancement of immune function are examples of the health benefits of exercise⁸. According to current guidelines, 150–300 min of moderate-intensity or 75–150 min of vigorous-intensity physical activity throughout the week, is recommended for generally healthy individuals⁹. In addition to its role in promoting optimal body composition, which is an important factor in maintaining ideal health status, regular exercise has also been reported to enhance immune function by stimulating biomarkers involved in antioxidant defense and Se homeostasis, such as GPx and SEPP¹⁰. However, there are still limited data on the effectiveness of Se supplementation combined with exercise on changes in body composition and selenium bioactivity, primarily due to the need for advanced mass spectrometry and analytical techniques to determine selenoproteins concentration in blood. Therefore, this study aimed to determine the effects of Se supplementation combined with exercise on changes in body composition and Se bioactivity, specifically GPx and SEPP, compared with exercise alone.

METHODS

Ethics

The study protocol was approved by the Institutional Review Board of Human Research Ethics, Burapha University (Approval No. IRB1-101/2568). All participants provided written informed consent prior to participation. The trial was registered at the Thai Clinical Trials Registry (TCTR20250818002).

Design

This study was a 12-week pilot randomized controlled trial designed to evaluate the effects of selenium (Se) supplementation combined with exercise on body composition and Se bioactivity compared with exercise alone.

Sampling

A total of 40 participants were recruited using convenience sampling. Sample size was estimated with consideration of dropout rates. Eligible participants were healthy Thai men and women aged 19–50 years. Inclusion criteria: healthy adults aged 19–50 years, no history of food allergies, and willingness to participate. Exclusion criteria: use of medications or dietary supplements, oral or swallowing impairments, and disabilities or underlying diseases.

Interventions

The participants in the intervention group were asked to follow the protocol: Se supplementation (200 µg/day as selenomethionine; Swanson®, North Dakota, USA). Participants were instructed to take the supplement once daily after a main meal, independent of the timing of exercise sessions, to ensure consistency and minimize gastrointestinal discomfort. Exercise program was assigned. Briefly, participants performed aerobic exercise 3–5 sessions per week (frequency), with each session lasting 30–60 minutes (time), including activities such as brisk walking, jogging, or cycling (type). Exercise intensity was prescribed at 50–85% of maximal heart rate (HR_{max}) and was continuously monitored using a wearable smartwatch (Xiaomi Mi Band 6). Heart rate data were used to ensure participants remained within the target zone, and intensity was adjusted individually as needed throughout the intervention period. Progression was implemented by gradually increasing exercise duration and/or intensity based on participant

tolerance and performance. Participants were initially instructed and periodically supervised by the research team, with ongoing self-monitoring during the 12-week intervention. For control group, they were asked to follow protocol: Exercise only (same protocol) Exercise included aerobic activities (walking, jogging, cycling) at 50–85% HRmax for 12 weeks. Compliance monitored via LINE application and activity logs. The adherence rates of exercise (both 2 groups) and supplement intake (only intervention group) were 70 and 75%, respectively.

Measurements

Body composition were determined using BOD POD (COSMED Inc., Rome, Italy) and InBody270 (InBody Co., Seoul, South Korea). For the BOD POD assessment, participants wore light, tight-fitting clothing and a swim cap, and the device was calibrated before each session according to the manufacturer's instructions. Participants then underwent the measurement in a seated position inside the chamber, and body fat percentage was obtained from the device output. For the InBody270 assessment, participants stood barefoot on the analyzer and held the hand electrodes according to the standard operating procedure after device calibration. Skeletal fat-free mass and related body composition variables were obtained directly from the device output. These procedures have now been described more clearly in the Methods section to improve transparency and reproducibility. In this study, the BOD POD was used as the primary reference method for body composition assessment. The device provided measurements including percentage of body fat, thoracic gas volume, and additional derived parameters such as total body fluid, fat-free mass, basal metabolic rate, and total energy requirement. Among these, body fat percentage was considered the principal outcome derived from the BOD POD. The InBody270 was used to obtain mineral-related body composition data, specifically body weight by mineral content.

Biochemical analyses in blood samples were analyzed using HPLC-ICP-MS (Thailand National Institute of Metrology). The following biomarkers were quantified GPx (U/g) and SEPP (mg/L). All measurement were performed at baseline (week 0) and endpoint (week 12).

Participants were instructed to fast overnight for at least 8 hours prior to all measurements. All assessments were conducted in the morning to minimize diurnal variation. Dietary intake was assessed using a 3-day food record at final week. Nutrient intake was calculated using nutrient analysis software, INMUCAL for Nutrients version 4.0, developed by the Institute of Nutrition, Mahidol University, Thailand.

Randomization

In this study, participants were assigned to either the intervention or control group using a simple random allocation procedure. Specifically, participants were asked to draw a concealed allocation

label (intervention or control) from a container, ensuring that assignment was random at the individual level. To maintain equal group sizes ($n = 20$ per group), a restricted allocation approach was applied such that once one group reached its target sample size, the remaining participants were assigned to the other group. Allocation concealment was maintained by using identical, non-transparent labels placed in a closed container, preventing participants and researchers from predicting group assignment prior to selection.

Standardization

For standardization on dietary habits, participants were instructed to maintain habitual diet throughout study, record 3-day dietary intake during week 11, avoid additional supplements, and fasting blood samples were collected at baseline and week 12.

Order Effects

All measurements were conducted in the same order at baseline and endpoint to minimize procedural variability.

Statistical analyses

Data on sex and education level were presented as percentages. Continuous variables, including body mass index (BMI), body composition parameters, and GPx and SEPP concentrations, were expressed as mean $\pm$ standard deviation (SD). Independent t-tests were used to compare mean differences between the intervention and control groups, while paired t-tests were performed to evaluate within-group changes from baseline to the endpoint. Effect sizes were calculated using Cohen's d . Additionally, estimation statistics were performed using Gardner-Altman plots to visualize mean differences and 95% confidence intervals. All statistical analyses were conducted using Predictive Analytics Software Statistics (SPSS Inc., Chicago, IL, USA), version 25.0. A two-tailed p -value < 0.05 was considered statistically significant.

RESULTS

Regarding the background characteristics of the participants, both groups consisted of females, with no significant difference in mean age. In addition, participants had a normal BMI, and most held a bachelor's degree as their highest level of education. No significant differences in participant characteristics were found between the groups (Table 1).

The effects of Se supplementation combined with exercise, compared with exercise alone, are presented in Table 2. The results revealed that at the endpoint (week 12), participants in the intervention group had a body fat percentage of 20.25%, which was significantly lower than that of the control group (22.15%) ($p < 0.05$). In addition, fat-free mass

Table 1. Background characteristics of the participants

Characteristics	Control group (n=20)	Intervention group (n=20)	p value
Sex			
Male, n (%)	7 (35)	5 (25)	0.73 ^a
Female, n (%)	13 (65)	15 (75)	
Age (year), mean (SD)	24.45 (3.33)	24.70 (3.40)	0.24 ^b
BMI, mean (SD)	22.16 (2.97)	21.27 (2.29)	0.29 ^b
Educational level			
Bachelor's degree, n (%)	16 (80)	12 (60)	0.30 ^a
Graduate's degree, n (%)	4 (20)	8 (40)	

^aFisher's exact test, ^bIndependent t-test**Table 2.** Body compositions and Se bioactivity of the participants

Body composition and Se bioactivity	Baseline		Endpoint		Cohen's d for control	Cohen's d for intervention
	Control	Intervention	Control	Intervention		
Percentage of body fat, mean (SD)	22.98 (2.70)	22.30 (3.29)	22.15 (2.87)	20.25 (2.46)*^	0.29	0.70
Total body fluid (L), mean (SD)	32.93 (3.52)	33.85 (3.33)	32.11 (4.25)	33.42 (2.72)	0.21	0.14
fat-free mass (kg), mean (SD)	19.72 (3.57)	20.19 (2.96)	20.44 (2.82)^	22.18 (2.55)*^	-0.22	-0.72
Mineral weight (kg), mean (SD)	2.59 (0.29)	2.67 (0.36)	2.64 (0.41)	2.84 (0.27)	-0.14	-0.53
Basal metabolic rate (kcal), mean (SD)	1,826.50 (211.50)	1,830.00 (224.79)	1,858.20 (202.42)	1,849.60 (188.03)	-0.15	-0.09
Total energy requirement (kcal), mean (SD)	2,186.90 (358.13)	2,100.80 (268.47)	2,426.60 (285.86)^	2,491.80 (131.01)^	-0.73	-1.85
Thoracic gas volume (L), mean (SD)	3.10 (0.23)	3.18 (0.25)	3.16 (0.25)	3.25 (0.17)	-0.24	-0.32
GPx as Se (U/g), mean (SD)	43.63 (3.38)	42.48 (4.14)	42.84 (2.45)	58.62^ (4.45)	-3.75	-1.87
SEPP as Se (mg/L), mean (SD)	2.96 (0.57)	2.74 (0.41)	2.89 (0.50)	5.88^ (0.98)	-4.18	-2.09

* Significant differences between groups at endpoint were determined using an independent t-test at $p < 0.05$ ^Significant differences within groups compared with baseline were determined using a paired-sample t-test at $p < 0.05$

in the intervention group (22.18 kg) was significantly higher than in the control group (20.44 kg) at the endpoint ($p < 0.05$). Furthermore, GPx and SEPP concentrations in the intervention group at the endpoint were 58.62 U/g and 5.88 mg/L, respectively, which were significantly higher than those in the control group (42.84 U/g and 2.89 mg/L, respectively) ($p < 0.05$). In addition, estimation plots (Figure 1A–D) demonstrated consistent between-group differences at endpoint. The intervention group showed lower body fat percentage and higher fat-free mass, GPx, and SEPP compared with the control group, with confidence intervals not crossing zero, indicating robust effects.

Percentage of body fat was estimated via BOD POD, while fat-free mass was estimated via BIA.

For dietary habits of participants, the results indicated that there were no significant differences between the groups, except for daily Se intake. Participants in the intervention group who received Se supplementation had a significantly higher Se intake than those in the control group ($p < 0.05$) (Table 3).

DISCUSSION

Regular exercise is well acknowledged for supporting various health outcomes. Previous studies have focused on the benefits of exercise in promoting optimal body composition through enhanced body fat metabolism and stimulation of muscle building^{11,12}. In the present study, although participants in the control group who performed exercise alone did not show a reduction in percentage body fat and had lower fat-free mass compared with the intervention group at the endpoint, their fat-free mass was significantly improved compared with baseline. These results support previous findings that exercise can promote lean body mass development in humans^{13,14}. Previous studies have demonstrated that Se plays a crucial role in the human immune system primarily through its incorporation into selenoproteins, such as GPx, thioredoxin reductases (TrxR), and SEPP. These selenoproteins regulate cellular redox balance, thereby protecting immune cells from oxidative

Figure 1. Gardner–Altman estimation plots showing mean differences between intervention and control groups at endpoint. (A) Body fat percentage, (B) fat-free mass, (C) GPx, and (D) SEPP. Points represent mean differences (intervention minus control), and error bars indicate 95% confidence intervals. The horizontal line at zero represents no difference between groups.

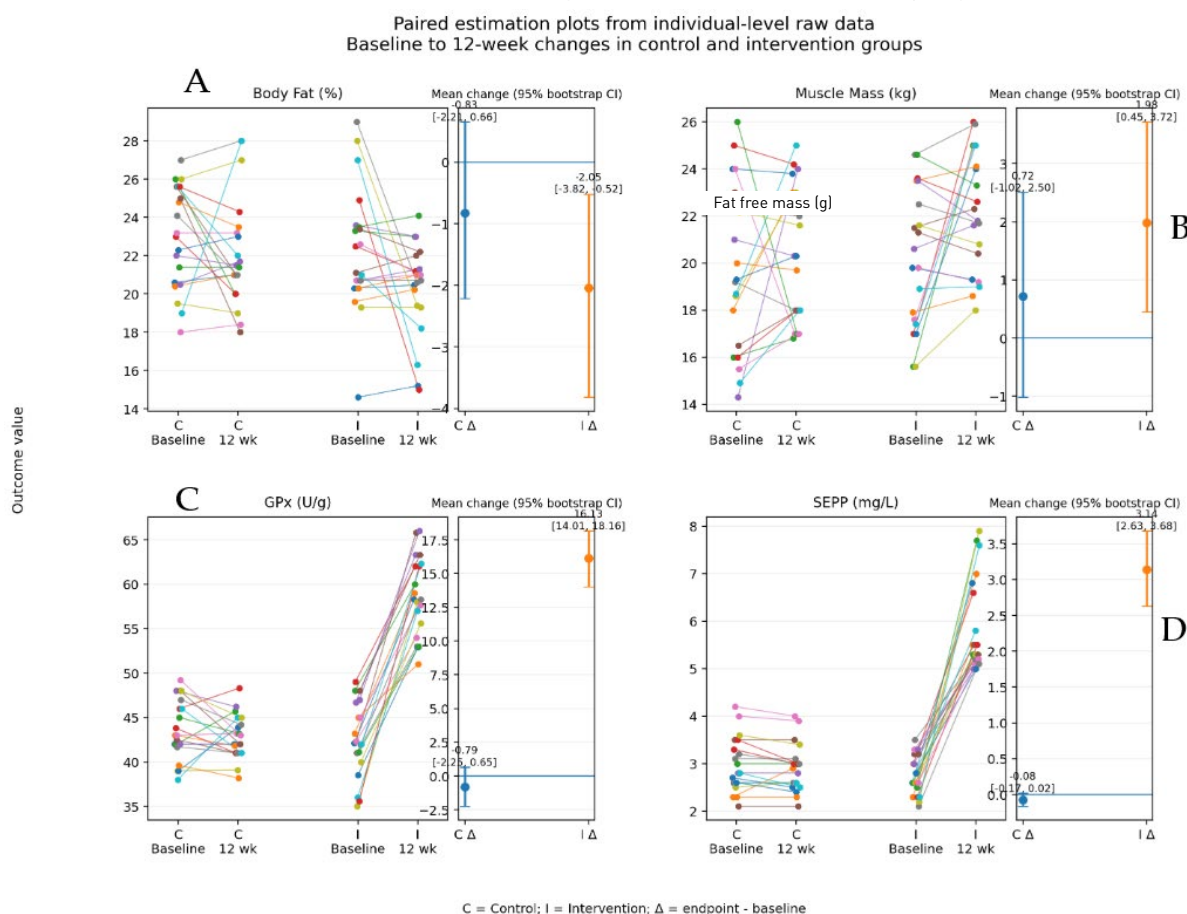


Table 3. Dietary habits of participants.

Nutrients consumed	Control group (n=20)	Intervention group (n=20)	p value
%kcal distributed from carbohydrate, mean (SD)	58.70 (4.30)	56.85 (5.29)	0.27
%kcal distributed from protein, mean (SD)	13.65 (2.43)	14.00 (2.38)	0.59
%kcal distributed from fat, mean (SD)	27.65 (4.80)	29.15 (5.89)	0.42
Amount of estimated daily Se intake, mean (SD)	80.85 (16.65)	281.50 (16.32)	<0.05*

*Significant differences between groups were determined using an independent t-test at $p < 0.05$

damage during activation and proliferation¹⁵. Adequate Se status modulates redox-sensitive signaling pathways, including nuclear factor- κ B (NF- κ B), leading to controlled inflammatory responses and reduced cytokine overproduction. In addition, Se supports both T- and B-cell function, enhances antibody production, and contributes to effective antiviral defense, collectively promoting optimal immune competence¹⁶. Furthermore, Se contributes to body fat metabolism and fat-free mass maintenance mainly through its effects on redox regulation, mitochondrial function, and endocrine signaling¹⁷. As a component of selenoproteins such as GPx, SEPP, and TrxR, Se reduces oxidative stress, improves insulin sensitivity, and enhances lipid metabolism, thereby supporting reduced fat accumulation¹⁸. Se is also involved in thyroid hormone metabolism via iodothyronine deiodinases (DIO), which regulate energy expenditure and basal metabolic rate, influencing both fat oxidation and muscle protein turnover¹⁹. In skeletal muscle, adequate Se status protects myocytes from exercise-induced oxidative damage, supports mitochondrial efficiency, and facilitates muscle recovery and hypertrophy, ultimately contributing to increased fat-free mass and improved body composition^{20,21}. These pathways, when combined with exercise, may explain the findings of this study, in which Se supplementation enhanced the effects of exercise on reducing percentage body fat and supporting fat-free mass in participants. In addition, the results are consistent with previous studies showing that GPx and SEPP levels at baseline were comparable to those reported in earlier investigations of these selenoproteins^{22,23}. Furthermore, supplementation has been shown to increase selenoprotein concentrations, such as GPx and SEPP, thereby enhancing the biological activity of Se in the body²⁴⁻²⁶. These results can be explained by changes in selenocysteine concentrations may indicate alterations in Se utilization for selenoprotein synthesis, which plays a central role in antioxidant defense and redox homeostasis. Moreover, the observed variation in other selenometabolites may reflect adaptive changes in Se metabolic pathways, including Se storage, recycling, and detoxification processes, which together regulate Se availability and biological activity within the cell²⁷. However, this study was used HPLC-ICP-MS to quantify GPx and SEPP as selenium-containing biomarkers, selenium speciation (e.g., selenocysteine and selenomethionine) was not directly measured in

this study. Therefore, interpretations regarding changes in selenium metabolism should be made with caution.

Dietary habits, particularly energy distribution from macronutrients, did not differ between groups. However, participants in the intervention group who received Se supplementation had a significantly higher Se intake. Therefore, these results minimized potential confounding effects from differences in other nutrient intakes and allowed the effects of varying Se intake levels on study outcomes to be more clearly evaluated. Interestingly, although participants in the control group did not receive Se supplementation, their Se intake met the recommended intake of 55 μ g/day²⁸. This finding suggests that participants in this study were not at risk of Se deficiency, likely due to residing in coastal areas with abundant access to marine foods, which are rich sources of Se²⁹⁻³¹. The limitations of this study include selenium speciation (including selenocysteine, selenomethionine, and other selenometabolites) was not quantified in the present analysis and should be investigated in future studies. In addition, the lack of assessment of additional selenoproteins, such as TrxR and DIO, which play important roles in regulating thyroid hormone activation and inactivation and, consequently, energy metabolism, body fat regulation, and muscle protein turnover³². Therefore, future studies are recommended to determine these selenoproteins to further elucidate the effects of Se supplementation combined with exercise. Moreover, studies with larger sample sizes and longer intervention periods are warranted to confirm these findings.

CONCLUSIONS

In conclusion, Se supplementation combined with exercise was effective in improving body composition by reducing body fat and increasing fat-free mass, as well as enhancing GPx and SEPP concentrations, thereby supporting Se bioactivity more effectively than exercise alone.

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AUTHORS' CONTRIBUTIONS

AS designed the study. AS, SK, UB and NR collected the data. AS sought funding. Data analysis and interpretation was performed by SK. AS, UB, and NR reviewed the results. Writing of the original draft was performed by AS and revisions of the manuscript by UB and NR. All authors approved the final version of the manuscript.

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CONFLICTS OF INTEREST

The authors state that there are no conflicts of interest when writing the manuscript.

DATA AVAILABILITY

Provision of data on request to the corresponding author.

PROTOCOL REGISTRATION NUMBER

TCTR20250818002

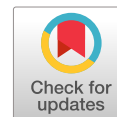
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RESEARCH ARTICLE

Physicochemical and Sensory Characteristics of Sponge Cakes with Addition of Potato and Sweet Potato Peel Flours

➤ Características fisicoquímicas y sensoriales de bizcochos con adición de harinas de cáscara de patata y batata

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➤ ABSTRACT

Introduction: The agro-industrial processing of potatoes and sweet potatoes generates large amounts of peel residues, which are often discarded despite their nutritional value. These by-products represent a potential source of dietary fiber and bioactive compounds, and their valorization aligns with sustainability and circular economy strategies

Methods: Potato peel flour (PPF) and sweet potato peel flour (SPF) were obtained through drying and milling processes. Their physicochemical and functional properties were evaluated, including moisture, water activity, fiber, ash, color, bulk density, water and oil absorption capacities, and total phenolic content (TPC). Subsequently, these flours were incorporated as a 10% replacement for wheat flour in sponge cakes, and the resulting products were assessed for physicochemical and sensory characteristics

Results: Both flours exhibited low moisture (<10%) and water activity (<0.50). SPF showed higher fiber, ash, water absorption capacity, and TPC levels compared to PPF. Incorporation into sponge cakes significantly increased fiber content and firmness without negatively affecting sensory acceptability. The SPF formulation showed the highest phenolic content (21.5 ± 0.80 mg GAE/100 g), while the PPF formulation achieved higher flavor scores. All samples scored above the midpoint on the hedonic scale.

Conclusions: Potato and sweet potato peel flours demonstrate strong potential as functional ingredients in bakery products. Their incorporation improves the nutritional profile of foods while contributing to food waste reduction and the development of more sustainable food systems.

RESUMEN

PALABRAS CLAVE

Harina de cáscara de patata

Cáscara de batata

Bizcocho

Compuestos fenólicos

Valorización de residuos alimentarios

Introducción: El procesamiento agroindustrial de papas y batatas genera grandes cantidades de residuos de cáscara, que a menudo se desechan a pesar de su valor nutricional. Estos subproductos representan una fuente potencial de fibra dietética y compuestos bioactivos, y su valorización se alinea con las estrategias de sostenibilidad y economía circular.

Metodología: Se obtuvieron harina de cáscara de papa (HCP) y harina de cáscara de batata (HCB) mediante procesos de secado y molienda. Se evaluaron sus propiedades fisicoquímicas y funcionales, incluyendo humedad, actividad de agua, fibra, cenizas, color, densidad aparente, capacidad de absorción de agua y aceite, y contenido total de fenoles (CTF). Posteriormente, estas harinas se incorporaron como sustituto del 10% de la harina de trigo en bizcochos, y se evaluaron las características fisicoquímicas y sensoriales de los productos resultantes.

Resultados: Ambas harinas presentaron baja humedad (<10%) y baja actividad de agua (<0,50). La HCB mostró mayores niveles de fibra, cenizas, capacidad de absorción de agua y CTF en comparación con la HCP. Su incorporación a los bizcochos aumentó significativamente el contenido de fibra y la firmeza sin afectar negativamente la aceptabilidad sensorial. La formulación HCB presentó el mayor contenido fenólico ($21,5 \pm 0,80$ mg GAE/100 g), mientras que la formulación HCP obtuvo puntuaciones de sabor más altas. Todas las muestras obtuvieron puntuaciones superiores al punto medio en la escala hedónica.

Conclusiones: Las harinas de cáscara de patata y batata demuestran un gran potencial como ingredientes funcionales en productos de panadería. Su incorporación mejora el perfil nutricional de los alimentos, a la vez que contribuye a la reducción del desperdicio alimentario y al desarrollo de sistemas alimentarios más sostenibles.

KEY MESSAGES

1. Peel flours improved fiber and phenolic content in sponge cakes.
2. Sweet potato peel flour had the highest functional and nutritional value.
3. Peel flours showed low moisture and high-water absorption capacity.
4. All sponge cake samples maintained good sensory acceptability.

CITATION

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INTRODUCCIÓN

Potato (*Solanum tuberosum* L.) is one of the main vegetables consumed worldwide and constitutes an important component of the human diet¹. In Argentina, it is the most widely consumed vegetable, and between 20 % and 30 % of the total production is allocated to industrial processing for the production of frozen pre-fried batons, fried chips, and mashed potatoes². Typically, the starchy portion is utilized, while the peel, depending on the peeling method, accounts for between 15 % and 40 % of the vegetable's weight and is discarded as waste in the processing industry, despite being a source of fiber and phenolic compounds^{1,3}.

Sweet potato (*Ipomoea batatas* L.) is the third most important root crop worldwide, following potato and cassava. In Argentina, although its consumption is lower than that of potatoes, the orange-fleshed Gem variety is valued by consumers for its sweet taste and high yield⁴. This crop plays an important socio-economic role; however, only about 10% of the national production is directed to industrial processing, primarily for the production of traditional sweet potato jelly, as well as frozen pre-fried batons and fried chips. Similar to potatoes, sweet potato peels are commonly discarded during processing, despite being an important source of dietary fiber and bioactive compounds^{5,6}.

Overall, fruit and vegetable residues such as peels, seeds, and pulps are rich in carbohydrates, polysaccharides, proteins, vitamins, minerals, and antioxidants. Although frequently treated as waste, these by-products represent a potential resource for the development of value-added foods⁷. In response to increasing concerns about the environmental impact of food waste coupled with the low dietary fiber intake observed in the Argentine population⁸, the application of drying technologies, such as solar, vacuum, freeze, or microwave drying, has become a viable strategy for producing functional powders that can be incorporated into baked products⁹ not only promotes sustainability but also enhances the nutritional profile of processed foods.

Sponge cakes, baked products with a porous structure and classified as foam-type cakes¹⁰, are among the most widely consumed bakery items globally, appreciated mainly for their ready-to-eat format, availability in various varieties, and affordable price. Their preparation allows the use of composite flours combined with dehydrated vegetable ingredients, presenting a strategy to develop products with high fiber content¹¹. The incorporation of powders derived from fruits, vegetables, or agro-industrial by-products in sponge cake formulations not only improves nutritional value but also affects their physicochemical, sensory, and technological properties. According to Salehi and Aghajanzadeh¹², fiber-rich ingredients have a high-water absorption capacity, increasing the final product's moisture content. However, their addition can decrease cake volume and yield a firmer texture, while contributing to higher levels of polyphenols, and crude fiber.

This study proposes the valorization of potato and sweet potato peels as sources of dietary fiber and bioactive compounds for incorporation into sponge cakes. This approach promotes sustainability by utilizing agro-industrial waste while enhancing the nutritional value of food products. The objectives were to: i) characterize these by-products through physicochemical and functional analyses for flour production; and ii) evaluate the effect of their incorporation on the physicochemical and sensory properties of sponge cakes. It was hypothesized that peel flours would increase fiber and phenolic compound content without negatively affecting sensory acceptance.

METHODS

Preparation of potato and sweet potato peel flours

Potato (*Solanum tuberosum* L., cv. Innovator) and orange-fleshed sweet potato (*Ipomoea batatas* L., cv. Gem) peels were obtained by manual peeling (1.5 mm thickness), washed, soaked in 5% acetic acid for 15 minutes, and dried at 60 °C for 5 hours until constant weight. The dried material was milled (KN 295 Knifetec™, FOSS, Denmark) to approximately 0.2 mm and stored in polypropylene bags.

Moisture, crude fiber, and ash contents were determined according to AOAC methods (2005): oven drying at 105 °C (method 925.09), sequential acid-alkaline digestion (method 962.09), and incineration at 525 °C (method 923.03), respectively. Water activity (Aw) was measured using a LabSwift-aw device (Novasina, Switzerland) after 40–50 minutes of equilibration.

Bulk density was determined following Akter et al.³ with slight modifications, calculated as sample weight divided by its volume in a 100 mL graduated cylinder. Water absorption capacity (WAC) and oil absorption capacity (OAC) were assessed by mixing 1 g of sample with 10 mL of distilled water or sunflower oil, respectively, followed by vortexing, 30-minute standing at 25 °C, and centrifugation at 3000 rpm for 20 minutes (Heal Force®, Neofuge 15R, China). Results were expressed as grams of absorbed water or oil per gram of dry sample, calculated using Equation (1).

$$\text{WAC or OAC} = \frac{(P_2 - P_1)}{P_0} \quad (1)$$

Where P_0 is weight of the dry sample (g), P_1 is weight of the tube plus the dry sample (g) and P_2 is weight of the tube plus the sediment (g).

Color parameters (L^* , a^* , b^*) were measured using a portable colorimeter (Hunter Lab, MiniScan EZ, USA), D65 illumination and a 2° observer. During measurement, the sample was placed in a black box to prevent light interference with the optical beam¹¹. From these values, chroma (C^*) and hue angle ($^\circ\text{hue}$) were calculated using Equations (2) and (3):

$$C^* = \sqrt{a^2 + b^2} \quad (2)$$

$$h^\circ = \arctan\left(\frac{b}{a}\right) \quad (3)$$

Determination of Total Phenolic Compounds

Phenolic extraction was performed following Shepelev et al.¹³ with minor modifications. Ten grams of peel flour were mixed with 100 mL of an ethanol-water solution (4:1, v/v) and subjected to microwave-assisted extraction (Bioeurope, China) at 20% power for 15 minutes. The extract was then centrifuged at 10000 rpm for 15 minutes and filtered. This procedure was repeated three times, and the combined supernatants were collected for subsequent analysis. Total soluble phenolic content was determined according to Singh et al.¹⁴ with slight modifications. 10 µL of extract was combined with 120 µL of distilled water, 100 µL of Folin–Ciocalteu reagent (0.25 N), and 200 µL of 7.5% (w/v) sodium carbonate solution, followed by homogenization with an additional 1,500 µL of distilled water. The mixture was incubated in the dark at 40 °C for 30 minutes, and absorbance was measured at 765 nm using a spectrophotometer (Ultrospec 2100pro, Biochrom Ltd., Cambridge, UK). Results were expressed as milligrams of gallic acid equivalents (GAE) per 100 g dry weight, based on a gallic acid standard calibration curve.

Formulation sponge cakes

Sponge cake formulations (Table 1) were based on a traditional Genoese recipe. Three formulations were prepared: a control (100% wheat flour), SC-PPF (10% substitution with potato peel flour), and SC-SPF (10% substitution with sweet potato peel flour). All ingredients used for sample preparation, including refined type 0000 wheat flour (Ramírez, Molino Harinero de Ramírez S.A., Argentina), sugar (Ledesma, Grupo Ledesma, Argentina), fresh eggs (Clara Huevo, Grupo El Fresno S.R.L., Argentina), and vanilla essence (Alicante, La Virginia S.A., Argentina), were obtained from local retail markets. To prepare the sponge cakes, eggs and sugar were whipped until a stable, aerated mixture formed. Sifted flours were gradually incorporated by folding to preserve aeration. Portions (30 g) were placed in circular molds (8.5 cm in diameter × 4 cm in height) and baked in a convection oven at 170 °C for 10 minutes. After baking, samples were unmolded and cooled at room temperature for 15 minutes before further analysis. The 10% substitution level was selected based on preliminary trials, as higher levels reduced gluten content, negatively affecting cake volume and sponginess. Additionally, increased water retention led to denser batters, while higher concentrations produced stronger residual flavors, compromising the sensory acceptability of the final product.

Table 1. Formulation (%) of sponge cake.

Ingredients	Control	SC-PPF	SC-SPF
Egg	43.25	43.25	43.25
Sugar	26.50	26.50	26.50
Wheat flour	28.00	25.20	25.20
Potato peel flour	0.00	2.80	0.00
Sweet potato peel flour	0.00	0.00	2.80
Vainilla essence	2.25	2.25	2.25

Determination of physicochemical, color, and texture characteristics of sponge cakes

Moisture content (%), crude fiber (%), water activity (Aw), and total phenolic compounds of the sponge cake samples were determined according to the official AOAC methods (AOAC, 2005) previously described. Color measurements of the sponge cake samples (crumb only and including crust) were conducted as described in Section 2. Based on the values obtained for L*, a*, and b* parameters of the sponge cake crust in the CIELAB color space, the browning index (BI), as defined in Eq. (4), is an appropriate indicator for assessing the browning extent in sweet baked products, was calculated using Equation (4):

$$BI = 100 * \left(\frac{0.31 * x}{0.172} \right) \quad (4)$$

$$x = \frac{(a + 1.175L)}{(5.645L + a - 3.012b)}$$

The textural properties were determined using a texture analyzer (Instron 3342™, USA). Cylindrical cake samples (2.5 cm in diameter and 2 cm in height) were cut from the center of each formulation and placed on the equipment platform for analysis. A cylindrical probe with a diameter of 12.5 mm was used to compress the samples to 50% of their original height at a speed of 1 mm/s. The maximum penetration force (Fmax), expressed in Newtons (N), was determined and defined as the resistance of the sample to penetration.

Sensory evaluation of the sponge cakes

Sensory evaluation was conducted with 80 adult panelists (>18 years) at the Faculty of Bromatology, National University of Entre Ríos, following ISO 8589 (2007)¹⁵ standards. Each participant received three sponge cake samples (5 × 5 cm), prepared on the same day, randomly coded and served on white plates. Panelists evaluated color, flavor, taste, texture, and overall acceptability using a nine-point hedonic scale (1 = dislike extremely; 9 = like extremely). Water was provided between samples for palate cleansing. The study was approved by the Institutional Ethics Committee (EXP_FBRO-UER:0000034/2025).

Statistical Analysis

All tests were performed in triplicate, and results are presented as mean $\pm$ standard deviation. Statistical analysis was conducted using the statistical software InfoStat® version 2000 (Universidad de Córdoba, Córdoba, Argentina). Data were analyzed by analysis of variance (ANOVA), and when significant differences were detected, Fisher's Least Significant Difference (LSD) test was applied at a 95% confidence level ($p < 0.05$). Sensory data were analyzed using repeated measures ANOVA followed by Least Significant Difference (LSD) ($p < 0.05$).

RESULTS

Physicochemical characteristics, functional properties and color of the flours

Supplementary Figure S1 presents an image of the sponge cakes obtained in this study. Table 2 summarizes the physicochemical properties of the flours, including moisture, crude fiber, ash content, and water activity (Aw). PPF showed higher moisture content than SPF ($p < 0.05$), although both remained below 10%. SPF exhibited significantly higher fiber and ash contents ($p < 0.05$). Aw values were below 0.50 for both flours. Additionally, bulk density, WAC, and TPC were significantly higher in SPF than in PPF ($p < 0.05$), whereas no significant differences were observed in OAC ($p > 0.05$).

Table 2. Physicochemical characteristics and functional properties of the flours.

Characteristics	PPF	SPF
Moisture (%)	8.23 $\pm$ 0.01 ^b	6.38 $\pm$ 0.11 ^a
Crude fiber (%)	11.9 $\pm$ 0.82 ^a	60.1 $\pm$ 0.12 ^b
Ash (%)	4.20 $\pm$ 0.07 ^a	8.29 $\pm$ 0.03 ^b
Aw	0.35 $\pm$ 0.00 ^a	0.41 $\pm$ 0.01 ^b
Bulk density (g/ml)	0.59 $\pm$ 0.001 ^a	0.70 $\pm$ 0.00 ^b
WAC (g/g)	3.11 $\pm$ 0.06 ^a	3.34 $\pm$ 0.01 ^b
OAC (g/g)	2.09 $\pm$ 0.31 ^a	2.21 $\pm$ 0.13 ^a
Total Phenolic (mg GAE/100 g DW)	17.6 $\pm$ 0.34 ^a	27.7 $\pm$ 1.30 ^b

Values represent the mean $\pm$ standard deviation. Different letters in the columns indicate significant differences according to Fisher's LSD test ($p < 0.05$). DW, dry weight. GAE: gallic acid equivalents

Table 3 summarizes the CIE-Lab color parameters (L^* , a^* , b^*), C^* , and $^\circ$ hue of the flours. PPF showed significantly higher lightness (L^*) than SPF ($p < 0.05$). The a^* value was significantly higher in SPF, whereas the b^* value was higher in PPF ($p < 0.05$). The chroma (C^*) values also differed significantly between samples ($p < 0.05$), with PPF exhibiting higher color saturation. No significant

differences were observed in $^\circ$ hue between the flours ($p > 0.05$).

Table 3. Instrumental color parameters (L^* , a^* , b^*), C^* , and $^\circ$ hue of the flours.

Properties	PPF	SPF
L^*	63.3 $\pm$ 0.00 ^b	45.7 $\pm$ 0.04 ^a
a^*	5.47 $\pm$ 0.02 ^a	6.80 $\pm$ 0.02 ^b
b^*	20.4 $\pm$ 0.05 ^b	19.4 $\pm$ 0.01 ^a
C^*	21.15 $\pm$ 0.05 ^b	20.57 $\pm$ 0.01 ^a
$^\circ$ hue	75.05 $\pm$ 0.04 ^a	75.05 $\pm$ 0.04 ^a

Values represent the mean $\pm$ standard deviation. Different letters in the columns indicate significant differences according to Fisher's LSD test ($p < 0.05$).

Physicochemical characteristics and color and texture of sponge cakes

Table 4 summarizes the physicochemical characteristics of the sponge cakes, including moisture, crude fiber, water activity (Aw), and total phenolic content (TPC). The incorporation of PPF and SPF significantly increased moisture and crude fiber compared to the control ($p < 0.05$). SC-SPF showed higher moisture and fiber contents than SC-PPF ($p < 0.05$). No significant differences in Aw were observed among samples, with values around 0.88. Regarding TPC, the SPF-containing sponge cake exhibited significantly higher values than SC-PPF ($p < 0.05$), indicating a greater contribution of phenolic compounds from sweet potato peel flour.

Table 4 summarizes color parameters (L^* , a^* , b^*), browning index (BI), and firmness of the sponge cakes. The incorporation of PPF and SPF significantly affected both crust and crumb color ($p < 0.05$). Reformulated samples showed lower L^* values, indicating darker products, with SC-SPF exhibiting the darkest crust. The a^* values increased and b^* values decreased compared to the control ($p < 0.05$). For crumb color, control samples had the highest L^* values, while SC-PPF and SC-SPF showed lower values and higher a^* values, particularly in SC-SPF ($p < 0.05$). BI values were higher in reformulated samples ($p < 0.05$), indicating increased browning. Firmness also increased significantly in SC-PPF and SC-SPF, with the highest values observed in SC-SPF.

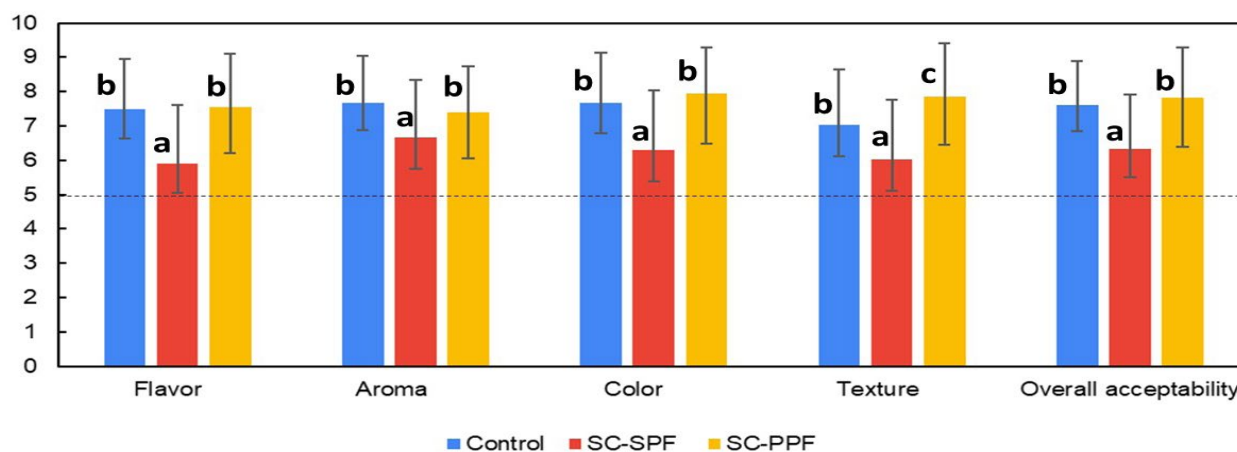
Sensory evaluation of the sponge cakes

Sensory evaluation results (Figure 1) showed that all samples scored above the midpoint (5) for color, aroma, texture, flavor, and overall acceptability. Among the reformulated samples, SC-PPF achieved the highest ratings, particularly for flavor, and showed values comparable to the control in most attributes. In contrast, SC-SPF received the lowest scores across all parameters. Statistical analysis revealed SC-SPF showed significantly lower

Table 4. Physicochemical characteristics and color and texture measurements of sponge cakes

Characteristics	Control	SC-PPF	SC-SPF
Moisture (%)	24.6±0.00 ^a	67.2±0.57 ^b	70.7±0.99 ^c
Crude fiber (%)	0.64±0.01 ^a	6.75±0.85 ^b	15.8±0.96 ^c
Aw	0.88±0.01 ^a	0.87±0.01 ^a	0.88±0.00 ^a
Total Phenolic (mg GAE/ 100 g DW)	ND	14.50±1.25 ^a	21.50±0.80 ^b
L* crust	82.04±0.00 ^c	57.04±1.69 ^b	53.51±1.19 ^a
a* crust	6.57±0.00 ^a	8.28±0.21 ^b	8.08±0.36 ^b
b* crust	41.89±0.00 ^c	36.82±1.02 ^b	33.26±0.59 ^a
L* crumb	92.33±0.41 ^c	69.18±0.99 ^b	59.99±0.39 ^a
a* crumb	-2.49±0.04 ^a	0.38±0.03 ^b	2.92±0.02 ^c
b* crumb	30.77±0.12 ^c	23.96±0.24 ^a	28.11±0.08 ^b
BI	74.75±0.00 ^a	107.52±0.74 ^c	102.71±3.15 ^b
Firmness (N)	0.73±0.06 ^a	1.31±0.08 ^b	2.54±0.2 ^c

Values represent the mean ± standard deviation. Different letters in the columns indicate significant differences according to Fisher's LSD test ($p < 0.05$). DW, dry weight. GAE: gallic acid equivalents.

Figure 1. Sensory attributes of the evaluated sponge cake samples

Different letters within the same sensory attribute indicate significant differences ($p < 0.05$). Values are expressed as mean ± 95% confidence interval.

scores than both the control and SC-PPF samples for flavor, color, texture, and overall acceptability. No significant differences were observed between SC-PPF and the control for flavor, aroma, color, and overall acceptability, while SC-PPF showed significantly higher texture scores than the other formulations ($p < 0.05$). Overall, SC-PPF was the most accepted formulation, followed by the control, while SC-SPF exhibited the lowest overall acceptability.

DISCUSSION

The moisture values obtained in this study were below the recommended 12–15% limit for powdered foods, which is associated with improved stability and shelf life¹⁶. The crude fiber content in PPF was comparable to that reported by Akter et al.³, confirming consistency with previous research, whereas SPF exhibited considerably higher levels than those reported by Admasu et al.¹⁷ for orange-fleshed sweet potato flour. These differences may be attributed to variations in cultivar, agroclimatic conditions, and agricultural practices¹⁸. The low A_w values observed further ensure product stability, as higher values could promote chemical and enzymatic reactions, as well as microbial growth, leading to product deterioration¹⁹. From a sustainability perspective, the utilization of PPF and SPF contributes to reducing agro-food by-product waste²⁰, while their incorporation into widely consumed baked goods may enhance nutritional quality, particularly by increasing fiber content. Since refined wheat flour is typically low in fiber, the use of these flours represents a valuable strategy to improve fiber intake. According to Argentine regulations, foods containing less than 2 g of fiber per 100 g are considered low in fiber²¹, highlighting the functional potential of these ingredients in bakery formulations.

In addition to their compositional attributes, the functional properties of these flours play a key role in their technological applicability. Bulk density, which influences packaging, handling, and transportation, was lower in PPF than in SPF, likely due to differences in fibrous structure and particle arrangement. Variations in initial moisture content may also contribute to these differences³. The results obtained are consistent with those reported by Akter et al.³, although lower than values documented by Jeddou et al.¹¹ and Admasu et al.¹⁷. Water absorption capacity was higher in SPF, which can be explained by its greater fiber content and the abundance of hydroxyl groups that enhance water binding through hydrogen bonding²². This property suggests improved moisture retention in food systems. In contrast, the similar oil absorption capacity observed in both flours indicates comparable performance in terms of flavor retention and texture, which is desirable in bakery products¹⁷. Furthermore, oil retention may contribute to extending product shelf life by reducing moisture migration.

Regarding bioactive compounds, the TPC values confirmed the presence of phenolic compounds in both flours, although at lower levels than those reported in the literature. For potato peel, Hsieh et al.²³ reported a TPC of 86.3 mg/100 g in freeze-dried samples,

while Albishi et al.²⁴ documented concentrations as high as 824 mg/100 g in the Innovator variety. In the case of sweet potato peel, Anastácio and Carvalho²⁵ reported values ranging from 102 to 621 mg GAE/100 g dry weight, and Anastácio et al.²⁶ obtained values up to 1187 ± 0.69 mg GAE/100 g under optimized extraction conditions. These discrepancies may be attributed to differences in botanical origin, postharvest handling, drying conditions, particle size, and extraction efficiency.

Color is also a key quality attribute influencing consumer acceptance. The differences observed in color parameters may affect the visual characteristics of final products, such as sponge cake crumb. The higher redness (a^*) in SPF is likely associated with carotenoid pigments typical of sweet potato varieties, particularly the Gem cultivar. Although differences in chroma indicate variations in color intensity, the absence of differences in hue suggests that both flours share similar chromatic tones within the yellow–green spectrum.

When incorporated into sponge cakes, these flours significantly influenced physicochemical properties. The increase in moisture observed in the reformulated samples, particularly in SC-SPF, can be attributed to the higher water retention capacity of dietary fiber, which reduces moisture loss during baking. The higher crude fiber content in SC-SPF compared to SC-PPF reflects the composition of the corresponding flours, indicating effective transfer of this component to the final product. Although sponge cakes are typically high in sugar and should be consumed in moderation, the incorporation of peel flours significantly enhances their nutritional profile. However, A_w values around 0.88 indicate susceptibility to microbial growth, which may limit product shelf life^{10,19}.

The higher TPC observed in SC-SPF may be attributed to the greater concentration of phenolic compounds in sweet potato peel, suggesting its potential as a functional ingredient to enhance antioxidant properties in bakery products. Nevertheless, both peel flours demonstrated their potential as sources of bioactive compounds, supporting the development of value-added formulations.

The incorporation of peel flours also affected color and texture²⁵. The darker appearance of SC-PPF and SC-SPF may be associated with the intrinsic color of the flours and enhanced browning reactions during baking, consistent with previous reports³. The increase in a^* values and decrease in b^* values indicate a shift toward reddish-brown tones. The higher BI values suggest an intensified browning effect, likely due to both natural pigmentation and enhanced Maillard reactions driven by higher levels of reducing sugars and amino acids²⁸.

Regarding texture, the increased firmness observed in SC-PPF and SC-SPF can be explained by the higher fiber content, which is associated with increased product hardness²⁹. The higher firmness of SC-SPF may be linked to its greater water absorption capacity, resulting in a more compact structure³⁰. The denser crumb structure observed in the reformulated samples may also be due to the interference of dietary fiber with gas retention during baking, limiting expansion, as well as reduced gluten content in the formulations³⁰.

Finally, sensory evaluation indicated that SC-PPF achieved higher acceptance than SC-SPF, suggesting better suitability for product development. The lower scores observed in SC-SPF may be related to its higher fiber content, which can negatively affect texture and flavor perception. These results are consistent with previous findings reported by Akter et al.³. A limitation of the present study lies in the characterization of the sensory panel. Although the use of 80 untrained panelists is appropriate for consumer acceptability studies, it limits the ability to perform fine discrimination among specific sensory attributes and restricts the interpretation of the results to overall consumer perception rather than descriptive sensory analysis. From a formulation perspective, although SPF provides greater nutritional benefits, further optimization, such as adjusting substitution levels, reducing particle size, or applying flavor-masking strategies, may be necessary to improve its sensory appeal.

CONCLUSION

The production of flours from potato and sweet potato peels represents a sustainable approach to valorize agro-industrial by-products and reduce food waste. These flours exhibited low moisture and water activity, contributing to product stability and extended shelf life, along with notable levels of crude fiber and ash, particularly in sweet potato peel flour (SPF). Regarding functional properties, both flours showed suitable bulk density, water absorption capacity (WAC), and oil absorption capacity (OAC), supporting their applicability in bakery systems. Additionally, both flours contained measurable levels of phenolic compounds, highlighting their potential as functional ingredients.

The incorporation of peel flours at a 10% substitution level significantly increased dietary fiber content in sponge cakes, especially in the SPF formulation. Sensory evaluation indicated that all samples were acceptable, with scores above the midpoint of the hedonic scale. SC-PPF showed higher flavor acceptance and overall similarity to the control, while SC-SPF presented lower scores. Furthermore, the addition of peel flours enhanced the total phenolic content of the final products, with SPF contributing the greatest increase.

Overall, these results support the sustainable use of food waste and the development of functional bakery products with potential industrial application.

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AUTHORS' CONTRIBUTIONS

M. A. B.: Formal analysis, Investigation, Methodology, Data curation, Validation, Software, Writing – original draft, Writing – review and editing. M. L.: Formal analysis, Investigation, Methodology, Data curation, Software, Writing – original draft. V. J. L.: Formal analysis, Investigation, Methodology, Funding acquisition, Supervision, Validation, Writing – review and editing. All authors contributed to critical revision of the manuscript.

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CONFLICTS OF INTEREST

The authors state that there are no conflicts of interest when writing the manuscript

DATA AVAILABILITY

Data will be provided upon request to the corresponding author.

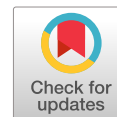
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RESEARCH ARTICLE

Determination of the Glycemic Index in Agave Syrup Obtained by Emerging Technology

➤ Determinación del índice glucémico en jarabe de agave obtenido por tecnología emergente

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KEYWORDS

Ohmic heating

Glycemic response

In vivo

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➤ ABSTRACT

Introduction: Agave syrup is one of the most relevant and increasingly popular byproducts on the market, considered a natural sweetener. Its glycemic index is considered low, but there is some controversy surrounding this. Therefore, the main objective of this research was to evaluate the glycemic index of agave syrup obtained by ohmic heating in apparently healthy volunteers.

Methodology: Agave syrup was obtained by ohmic heating. After recruiting volunteers, those eligible for the study were selected following the official international protocol ISO 26642:2012 and previously established protocols. The area under the response curve of agave syrup against glucose as a standard was evaluated by capillary puncture, with 50 g carbohydrate loads.

Results: Only 15 volunteers were classified as eligible for the study, with an age range of 21-33 years. After performing the corresponding calculations, an *in vivo* glycemic index of 35 was obtained.

Conclusions: Agave syrup obtained by ohmic heating has a slightly higher *in vivo* glycemic index than that widely reported by authors, although it maintains its low classification.

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PALABRAS CLAVE

Calentamiento óhmico

Respuesta glicémica

*In vivo**Agave salmiana*

RESUMEN

Introducción: El jarabe de agave es de los subproductos más relevantes y cada vez más populares en el mercado, considerado como un edulcorante natural. Su índice es considerado bajo, pero existe controversia al respecto, por lo que el objetivo principal de esta investigación fue evaluar el índice glicémico de jarabe de agave obtenido por calentamiento óhmico en voluntarios aparentemente saludables.

Metodología: Se obtuvo jarabe de agave por calentamiento óhmico. Tras reclutar voluntarios, se seleccionaron los aptos para el estudio siguiendo el protocolo oficial internacional ISO 26642:2012 y protocolos anteriormente establecidos. Por punción capilar se evaluó el área bajo la curva de respuesta del jarabe de agave contra glucosa como estándar, con cargas de 50 g de carbohidratos.

Resultados: Únicamente 15 voluntarios fueron clasificados como aptos para el estudio con un rango de edad de 21-33 años. Tras realizar las ecuaciones correspondientes se obtuvo un índice glicémico *In vivo* de 35.

Conclusiones: El Jarabe de agave obtenido por calentamiento óhmico presenta un índice glicémico *In vivo* sutilmente más elevado que lo reportado ampliamente por autores, aunque mantiene la clasificación de bajo.

Financiación: Esta investigación fue financiada como parte del programa de becas de la Secretaría de Ciencia, Humanidades, Tecnología e Innovación (Secihti) en conjunto con la UAdeC, con número de beca 1082548. Así como por el Departamento de Ciencia y Tecnología en Alimentos, UAAAN.

KEY
MESSAGES

1. Agave syrup has been under-studied in *In vivo* analyses.
2. There is controversy surrounding the use of fructose-based sweeteners.
3. The *in vivo* glycemic index of agave syrup obtained by ohmic heating is 35, which is considered low.
4. In an appropriate diet, it can be a natural sweetener with beneficial properties for the consumer.

CITATION

Martínez RM, Cruz M, Martínez-Zavala M, Neira-Vielma AA, Ramírez-Barrón SN, Belmares R. Determination of the glycemic index in agave syrup obtained by emerging technology. Rev Esp Nutr Hum Diet. 2026; 30(3), e2762. doi: <https://doi.org/10.14306/renhyd.30.3.2762>

INTRODUCTION

Plants belonging to the *Agave* genus have been present for millennia. They are important to many regions in the Americas, drought-resistant, and environmentally resilient. Furthermore, their use can be comprehensive, favoring the region's circular economy: from the stalk, core, leaves, flowers, and sap, to the agro-industrial waste left after processing. Agave syrup is one of the most relevant and increasingly popular byproducts on the market, considered a natural sweetener obtained by concentrating the carbohydrates in the sap or nectar of the agave, also called aguamiel^{1,2}.

It has been described as a source of bioactive compounds suitable for everyone, with the thermal process for obtaining this syrup being the traditional and most popular method among producers. However, this process, which usually involves cooking with wood as the main fuel, significantly reduces the bioactive compounds that are beneficial to human health. This provides an opportunity to obtain this syrup without losing properties or characteristics, with ohmic heating being a viable option for preserving these compounds³. Ohmic heating is claimed to be an efficient emerging technology, with lower cost and processing time than its traditional version; as a pretreatment in agave bagasse, it improves the release of bioactive compounds such as phenolic compounds and fiber; likewise, no significant effects on nutritional and functional properties has been reported^{4,5}.

The high fructose content, followed by fructans (agavins), bioactive compounds (saponins, polyphenols and flavonoids) and minerals (iron, calcium, potassium and magnesium) contained in this syrup presents an excellent prebiotic potential and low glycemic index for the prevention, treatment and control of chronic

non-communicable metabolic diseases^{5,6}. The glycemic index is a tool for classifying foods based on the quality and quantity of carbohydrates they contain. Foods high in this index are associated with a higher prevalence of chronic non-communicable metabolic diseases, mainly increasing the risk of mortality from strokes. Therefore, although still controversial, the consumption of products low in this index is widely recommended as part of a healthy lifestyle⁷⁻⁹.

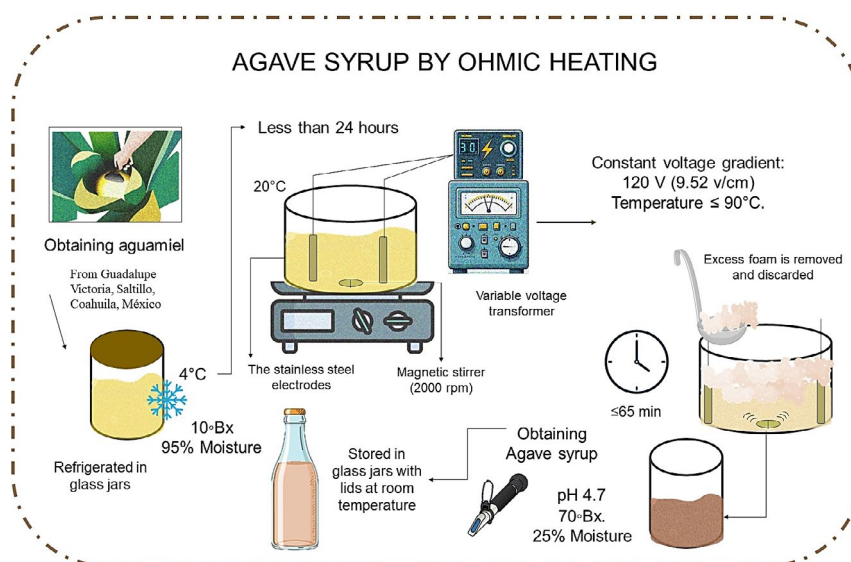
There is literature on the glycemic index in syrups and honeys; however, most of this data is obtained through *In vitro* processes, while *In vivo* studies on agave syrup are scarce and highly variable. Indices ranging from 10 to 36 are normally estimated and reported, but clear and reliable studies are lacking^{10,11}. *In vivo* studies are the gold standard for metabolic responses¹², therefore, the main objective of this research was to evaluate the glycemic index of agave syrup obtained by ohmic heating in apparently healthy volunteers.

METHODOLOGY

Agave syrup

The production of agave syrup by ohmic heating is shown in [Figure 1](#) following the protocol described by Martínez-Zavala (2023)⁵. Agave sap (Aguamiel) from *Agave salmiana* was used, provided by local producers in Guadalupe Victoria, Saltillo, Coahuila, Mexico (24°54'25.25"N 101°06'15.93"W). It was transported and stored at 4°C to prevent fermentation into Pulque, derived from the microorganisms naturally present in the Aguamiel. Initially, the Aguamiel had 89% moisture and a concentration of 10°Bx, measured by the Universal Portable

Figure 1. Agave syrup by ohmic heating



Refractometer (Model: ACT, Brand: JuanJuan, China) at 20°C. Before taking measurements, the refractometer's accuracy was standardized using distilled water at 20°C.

Subsequently, the emerging technology was used: The stainless-steel electrodes were immersed in a flat-bottomed cylindrical glass jar (Diameter: 15.5 cm and Long: 15 cm), with a distance of 12.6 cm between them and connected to a Variable Voltage Transformer (0-300 VAC, 60 Hz, Brand: NAPEE, Model: 2S/10A-140/GVD, Mexico). These cells and devices were designed, manufactured, and/or modified in the Functional Foods and Nutrition Laboratory of the Universidad Autónoma de Coahuila. The process required a constant voltage of 120 V (9.52 V/cm) until the aguamiel reached 70 °Bx, pH 4.7 and 25% moisture. This process takes approximately 65 minutes. The temperature was monitored throughout the process and recorded every 10 minutes with a thermometer (Taylor, SAMA Mercury, Model: 6337M, China); it did not exceed 90°C.

Carbohydrate content

The fructose, sucralose and fructooligosaccharides content in agave syrup were analyzed using an HPLC system (Brand: Jasco, Model: LC4000, USA) with a refractive index detector and an autosampler. The analysis involved a separation process using an ASAHIPAK NH2P-50 4E protective column (Dimension: 4.6 × 250 mm, Particle size 5 µm, Brand: Shodex, Japan) bonded to an ASAHIPAK NH2P-50G 4A protective column (Dimensions: 4.6 × 10 mm, Brand: Shodex, Japan). Sample elution (20 µL) was performed using a mixture of acetonitrile (HPLC grade, Brand: Fisher Chemicals, USA) in Mili-Q water (68:32 v/v) and 0.04% ammonium hydroxide in water (HPLC grade, Brand: Sigma-Aldrich, Germany).

The elution was performed at a flow rate of 1 mL/min with the column temperature maintained at 30 °C. The chromatographic signal was captured and processed using Star Chromatography Workstation Software Version 6.3 (Varian, USA)⁵.

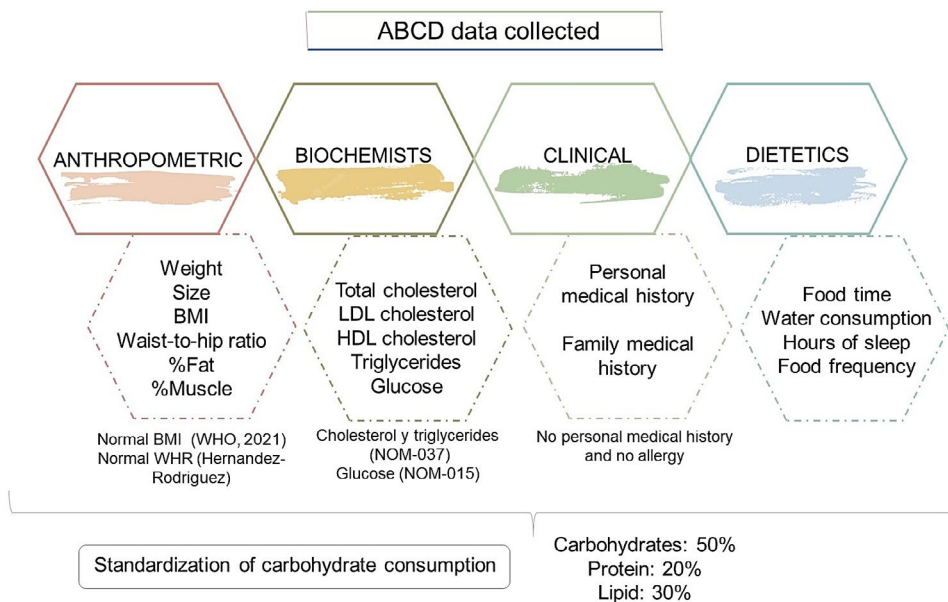
Ethics committee

The project was approved by the scientific ethics committee of the Faculty of Chemical Sciences of the Autonomous University of Coahuila, under the registration TDCYTA-20-10-22-2. All volunteers signed an informed consent form, ensuring their understanding of the study's objectives, risks and benefits, in compliance with ethical regulations of the Sanitary Control Regulations for Products and Services, the Regulations of the General Health Law on Health Research, and the ISO 26642:2012 standard referring to the protocol for the determination of the glycemic index¹³⁻¹⁵.

Volunteers

A call was made to recruit volunteers between the ages of 20 and 40 without food allergies. The protocol described by Martínez et al. (2024)¹⁶ was followed, as shown in Figure 2, for the collection of ABCD data (Anthropometric, Biochemical, Clinical and Dietary) and final selection of those who were healthy according to the Mexican standards. The information was collected through personal and private interviews: A) the same measuring equipment was used for all volunteers to reduce variability; B) an SD Lipid Care® analyzer (brand: SD Biosensor, INC, manufactured by: Kana Undesa SA de CV, Mexico) was used to determine the lipid profile, as well as fasting glucose using capillary blood; C) the absence of any

Figure 2. ABCD data collected for the selection of apparently healthy volunteers. Inspired by Martínez et al. (2024)¹⁶.



pre-existing illnesses or conditions, as well as food allergies, was verified through basic personal medical history; and D) a brief questionnaire on habits, lifestyle, and physical activity was administered. Finally, to standardize carbohydrate consumption prior to the test, volunteers were asked to follow a 2000 kcal meal plan for five days, which was approved and adapted to each volunteer. On three separate occasions, volunteers were asked to fast for 6 to 8 hours before each analysis.

Glycemic index evaluation

Following official international protocols (ISO 26642:2010(E), 2010), glucose tolerance curves were performed using a standardized and stable oral solution (Brand: Glucos, Manufacturer: Materiales y Abastos Especializados SA de CV, Mexico) with a 50 g carbohydrate load. Capillary punctures to measure glucose levels were performed at 0, 15, 30, 45, 60, 90, and 120 minutes after ingestion. If glucose response curves with normal reactions are obtained according to the official Mexican standard¹⁷, the curves for the food under study, agave syrup obtained by ohmic heating, are continued. Using 71.4 ± 0.2 g of syrup (corresponding to 50 g of carbohydrates), the response curves were plotted at the puncture points mentioned above. After obtaining the average Area Under the Curve of both curves, the glycemic index (GI) is calculated using the corresponding equation. [1]:

$$GI\% : \frac{AUC \text{ Agave syrup}}{AUC \text{ glucose}} * 100 \text{ Eq [1]}$$

Statistical analysis

The collected data are presented as mean values with their respective standard deviations (SD). To assess significant differences between the Areas Under the response Curves, a comparison of means was used using Tukey's test ($p < 0.05$). OriginPro 2025-2026 student version (OriginLab Corporation, USA, <https://www.originlab.com/>) and Microsoft 365 Excel® 2022-2025 (Microsoft Windows, USA) were used for data analysis.

RESULTS

Agave syrup obtained by ohmic heating with a final concentration of 70°Brix composed of 45% fructose, 35% sucrose and 19% fructooligosaccharides, presented values that are appropriate under the protocol explained in Martínez-Zavala et al. (2023)⁵. Enough syrup was produced from the same batch of Aguamiel to be used throughout the experiment.

On the other hand, based on the established ABCD data collection standards, only 15 volunteers were classified as healthy, with an

age range of 21–33 years. Table 1 shows the Anthropometrics and Biochemical average data collected from these volunteers. Regarding clinical data: in the personal medical history section, 12 volunteers reported having had COVID-19, and only 2 volunteers reported anxiety disorder. In the family medical history section, volunteers reported having a total of 13 family members with type 2 diabetes mellitus, 12 family members with hypertension, 7 family members who had or currently have cancer, and 4 family members with hypothyroidism. Dietary data revealed an average of 8 hours of sleep for both men and women, with 3 meals a day, and an average consumption of 2 liters of water. Similarly, dietary frequency shows, on average, a high consumption of recommended foods such as leafy green vegetables and fruits, and at the same time, a high consumption of foods not recommended such as baked goods and salty snacks, according to the classification ENSANUT (2022)¹⁸, which denotes this awareness of healthy foods that is matched by the craving for these sweet or salty snacks

Table 1. Anthropometrics and Biochemical data of the selected volunteers

Data	Analysis	Result
Anthropometrics	Weight	64.71 ± 11.3 kg
	BMI	24.08 ± 3.53 kg/m ²
	WHR*	0.85 ± 0.03 M** 0.77 ± 0.05 F***
	%Visceral Fat	4.13 ± 1.46
	%Muscle	37.4 ± 3.39 M 25.92 ± 2.52 F
Biochemistry	Triglycerides	91.93 ± 51.68 mg/dL
	Total cholesterol	150.47 ± 32.63 mg/dL
	LDL cholesterol	90.4 ± 29.45 mg/dL
	HDL cholesterol	41.4 ± 8.63 mg/dL
	Glucose	87.6 ± 5.75 mg/dL

Data are expressed as mean $\pm$ standard deviation; *WHR Waist-to-hip ratio; **M: Male average; *** F: Female average.

Primarily, the results of the *In vivo* clinical trial demonstrated that agave syrup obtained by ohmic heating is a low-glycemic index product. As shown in Figure 3, this is due to the fact that the glucose peaks were significantly lower compared to the control curve. The highest peaks in both the glucose and syrup curves occurred at 30 minutes; however, the glucose peak reached 146.36 mg/dL, while the peak for the ohmic heating agave syrup was 119.64 mg/dL. Subsequently, both curves showed a decrease over time, more pronounced in the syrup than in the glucose. This behavior resulted in an average glycemic index of 35 mg/dL, considered low, as shown in Table 2.

Figure 3. Response curves: Glucose vs Agave syrup

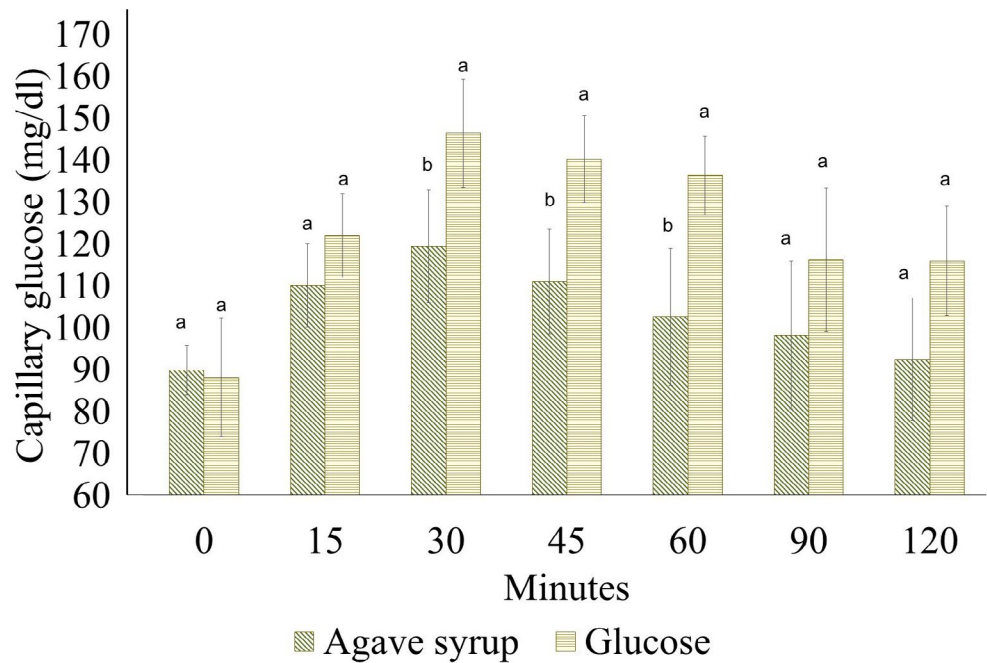


Table 2. Area under the glucose curve and glycemic index

	n	AUC Glucose (mg/dl)	AUC Agave syrup(mg/dl)	GI (mg/dl)
Male	5	5845.5	2078.5	41.6 ± 19.2
Female	10	5342.6	1635.4	30.2 ± 10.7
Total	15	5552.1	1820.0	34.9 ±15.2

DISCUSSION

The average data collected falls within the expected range: a Waist-to-hip ratio indicating low risk, a high prevalence of respiratory diseases in personal history and a high prevalence of chronic non-communicable metabolic diseases among the volunteers’ relatives. The volunteers presented a high prevalence of type 2 diabetes and hypertension in their immediate family history. This seemed to raise awareness among the volunteers about the importance of proper nutrition throughout the different stages of life, as their eating patterns (despite consuming salty and sweet snacks four times a week), show daily consumption of vegetables and almost daily consumption of fruits, legumes, and low-fat cereals. Likewise, the volunteers report doing daily physical activity with a maximum of two rest days per week for general health reasons. It is important to mention that the glycemic index is a controversial tool, as several factors can interfere with this response. These can be dependent factors (age, gender, gut microbiota) or independent

factors (type of food, cooking method) that can introduce bias into the research. In addition, many reported glycemic indexes are obtained through *In vitro* evaluation, which generates reliable results but in “ideal” environments that may differ from the *In vivo* reaction in humans. Despite this, there is clear evidence of the relationship between high glycemic index foods and the prevalence of chronic non-communicable metabolic diseases. Likewise, the relationship has been noted between the composition of nutrients and beneficial bioactive compounds in the food matrix that interfere with glucose absorption or provide sweetness without containing glucose¹⁹.

In this study, agave syrup presented an Index of 35; although in recent reviews indices of 10 to 19 are claimed and even research articles mention an index of 11²⁰. The carbohydrate profile varies from syrup to syrup, generating these variations in the glycemic impact. A clear example is sucrose, which is usually presented at 16-22% in commercial agave syrup, while in this study a higher content (35%) was presented²¹. Although the internationally reported and accepted values are maintained at the Index of 11 with 90% fructose agave syrup²². Most of these studies use commercial syrups, without a carbohydrate profile and do not show a clear methodology, since studies have been found that report index estimates of 36 measuring agave syrup obtained by vacuum rotary evaporation but do not mention the fructose content²³.

Agave syrup typically contains 70 to 90% fructose; this carbohydrate being responsible for its low glycemic impact. The syrup, obtained by ohmic heating, had a 70° Brix with a fructose content of 45%,

notably lower than commercial syrups. Agave syrups from the *A. tequilana* and *A. salmiana* species have been reported with 76° Brix and contain up to 84% fructose²⁴; in contrast, recent studies using *A. salmiana* and *A. atrovirens* species to obtain a syrup with 65° Brix show only 24% fructose²¹. These inconsistencies generate controversy among specialists, although all reported ranges are low, which has favored its commercialization and use as a natural sweetener with functional properties.

The content of compounds and nutrients varies from one species of agave to another, harvest time, growing region, and other factors that will affect the final products and byproducts. Primarily, the considerable fructose content has been linked to an increased prevalence of diseases such as metabolic syndrome, liver disease, and increased blood lipid¹¹. There are even reviews that conclude that there is a direct relationship between excessive fructose consumption and the pathogenesis of ischemia-reperfusion injury, resulting from the accelerated production of reactive oxygen species (highly reactive molecules that generate irreversible chemical changes in macronutrients such as proteins or fats, as well as deep cellular dysfunction and cytotoxicity)²⁵.

Other authors argue that this concern is unrealistic, as these adverse effects occur when fructose is consumed in isolation, in unreasonable quantities and compared to glucose in isolation²⁶. It is worth mentioning that another relevant compound in the syrup, belonging to the prebiotic dietary fiber group is agave inulin. Inulins are a polysaccharide formed by numerous fructose units. Their β configuration makes them resistant to enzymatic hydrolysis in the digestive tract, with partial and variable digestion in the colon, allowing them to be fermented by the gut microbiota. This substrate for probiotic bacteria offers broad health benefits such as reducing blood lipids, modulating appetite, positively influencing the glycemic index and improving the gut microbiota²⁷. Moreover, other fructans and fructooligosaccharides in agave have prebiotic properties, help regulate blood sugar and oxidative stress, provide sweetness and can reduce blood lipid levels²⁸. Mellado-Mojica & López, (2015)²⁹ analyzed the carbohydrate profile of various syrups from different agave species, reporting mainly fructose and fructooligosaccharides in most of the syrups; however, specifically the syrup from *A. salmiana* presented similar proportions of sucrose and fructose with small portions of FOS such as 1-kestose, inulotriose, 6-kestose, and neokestosa, a profile similar to that presented in this research.

Among the most common syrups, we can find that: Corn syrup presents very varied ranges, depending on its production process, however it usually contains glucose or maltooligosaccharides as its main carbohydrate; Honey (with an index of 55) can be widely recommended with adequate consumption, its composition is mostly glucose and fructose: Sugarcane syrup shows a high glucose profile, followed by fructose and sucrose²⁹. These profiles generate a greater glycemic impact, while the profile of agave

syrup containing a wide range of bioactive compounds and micronutrients such as fructans, flavonoids, and tannins that other fructose-based sweeteners do not contain, shows a more varied carbohydrates profile with a lower glycemic impact.

Likewise, as mentioned, the production process is relevant: traditional production involves cooking over an open fire, typically using firewood, where temperatures can exceed 100°C for hours, causing significant changes in its composition, emphasizing the loss of key functional components⁵. Although commercial syrups contain higher amounts of fructose and a lower glycemic index, ohmic heating produces syrups that are also low in this index, in addition to offering both economic and efficiency advantages, as the cost and time invested are lower than their traditional counterparts, with a fructooligosaccharides content higher than the average commercial syrups²⁹.

On the other hand, although the average glycemic index is low (35), significant differences can be observed by gender, with average indices in males and low indices in females. As mentioned, the factors that affect the glycemic index are numerous; however, some gain relevance due to supporting evidence, such as the volunteer's gender: Eldakhakhny et al. (2021)³⁰ concluded that there are undeniable differences between men and women when measuring the glycemic index, even for the same food; this is observed in the area under the glycemic response curves by gender. However, it should be noted that the sample size in this research is limited and asymmetrical, which may cause bias in the interpretation of the results.

CONCLUSION

The glycemic index values reported by other authors are quite low; however, these syrups are primarily commercial, lack clear methodologies, and generally only represent predictions of the index. Agave syrup obtained by ohmic heating has a slightly higher *in vivo* glycemic index than that widely reported by other authors, although it still falls into the low category. In appropriate portions, the numerous nutrients and compounds present in agave syrup make it a viable sweetener option.

LIMITATIONS

This study has a sample of 15 volunteers, without an equal distribution between genders. This could result in low statistical robustness. Furthermore, the suggested serving of agave syrup according to the Mexican System of Equivalent Foods (SMAE) is 12 g, while 71 g was used in this study. Therefore, the prebiotic potential of agave syrup can be evaluated based on the suggested serving in a balanced diet. It is important to note that this *In vivo* study was conducted on apparently healthy young volunteers, so the response may vary depending on the study group.

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AUTHORS' CONTRIBUTIONS

R.MM-H was the main researcher, an important part of sample collection and management of biological waste, interpretation of results and the main writer of this article. RB and MC contributed to the creation and design of the study, supervised compliance with the established protocol and performed data analysis with the work team as well as providing financing from the Universidad Autónoma de Coahuila and Universidad Autónoma Agraria Antonio Narro. MMZ contributed to the collection of data for the approval of the protocol before the ethics committee and performed data analysis with the work team. HAR-L, RMR-J, JCC and AAN-V contributed to the creation of the statistical design and interpretation of results. All authors critically reviewed this and previous versions of the document.

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CONFLICTS OF INTEREST

The authors express that there are no conflicts of interest when writing the manuscript.

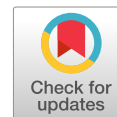
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Entre la restricción y la adaptación: experiencias alimentarias de personas que viven con enfermedad renal crónica

➤ Between Restriction and Adaptation: Dietary Experiences of People Living with Chronic Kidney Disease

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PALABRAS CLAVE

Insuficiencia renal
crónica

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Investigación
cualitativa

Alimentación

➤ RESUMEN

Introducción: La enfermedad renal crónica (ERC) implica transformaciones en la vida cotidiana, donde la alimentación ocupa un lugar central no sólo como parte del tratamiento, sino como práctica social y emocional. Los abordajes biomédicos suelen reducirla a la prescripción dietética y la adherencia, dejando en segundo plano las experiencias asociadas a los cambios alimentarios. El objetivo fue comprender las experiencias alimentarias de personas con ERC y las estrategias que despliegan para afrontar las modificaciones alimentarias derivadas del diagnóstico y el tratamiento.

Metodología: Estudio cualitativo mediante etnografía virtual. La información se recolectó a través de observación participante en dos grupos privados de Facebook dirigidos a personas con ERC y sus familiares (mayo-julio de 2020), así como entrevistas virtuales semiestructuradas entre agosto y noviembre de 2020. Participaron 12 personas adultas con ERC residentes en la Zona Metropolitana de Guadalajara. El análisis se realizó siguiendo la propuesta de teoría fundamentada constructivista.

Resultados: Los hallazgos se organizaron en tres categorías: experiencias en torno a las restricciones alimentarias, estrategias para afrontar los cambios, y la interacción con otros. Las restricciones fueron vividas inicialmente como abruptas y centradas en la prohibición, generando confusión, tristeza y frustración. Con el tiempo, las personas desarrollaron estrategias como el autocontrol, resignificación del placer sensorial, independencia alimentaria y uso de espacios digitales para el intercambio de saberes prácticos. Las interacciones con la familia, amistades, profesionales de la salud y comunidades virtuales influyeron de manera decisiva en la experiencia alimentaria.

Conclusiones: La alimentación en la ERC se configura como un proceso dinámico y relacional que trasciende la prescripción médica. Incorporar las experiencias y estrategias de las personas con ERC puede contribuir a abordajes clínicos más integrales y sensibles a la vida cotidiana.

KEYWORDS

Chronic kidney failure
Nutrition
Experience
Qualitative research
Eating

ABSTRACT

Introduction: Chronic kidney disease (CKD) entails transformations in everyday life, in which food plays a central role not only as part of treatment but also as a social and emotional practice. Biomedical approaches often reduce it to dietary prescription and adherence, overlooking the experiences associated with dietary changes. The aim of this study was to understand the food-related experiences of people with CKD and the strategies they develop to cope with dietary modifications derived from diagnosis and treatment.

Methods: A qualitative study was conducted using virtual ethnography. Data were collected through participant observation in two private Facebook groups for people with CKD and their relatives (May–July 2020), as well as through virtual semi-structured interviews conducted between August and November 2020. Twelve adults with CKD residing in the Guadalajara Metropolitan Area participated. Data analysis followed a constructivist grounded theory approach.

Results: Findings were organized into three categories: experiences related to dietary restrictions, coping strategies, and interactions with others. Dietary restrictions were initially experienced as abrupt and prohibition-centered, generating confusion, sadness, and frustration. Over time, participants developed strategies such as self-control, re-signification of sensory pleasure, food-related autonomy, and the use of digital spaces for exchanging practical knowledge. Interactions with family members, friends, healthcare professionals, and virtual communities played a decisive role in shaping food experiences.

Conclusions: Food in the context of CKD is configured as a dynamic and relational process that goes beyond medical prescription. Incorporating the experiences and strategies of people with CKD may contribute to more comprehensive and context-sensitive clinical approaches.

MENSAJES CLAVE

1. La alimentación en la ERC es una práctica social y emocional que trasciende la prescripción dietética porque reconfigura la vida cotidiana.
2. Las restricciones alimentarias suelen vivirse como abruptas y centradas en la prohibición, generando confusión, tristeza y frustración en las personas con ERC, por esto, los profesionales de la nutrición deben generar intervenciones centradas en los sujetos que viven en condiciones de cronicidad.
3. Las personas desarrollan estrategias activas de adaptación que incluyen autocontrol, resignificación del placer e independencia alimentaria.
4. La experiencia alimentaria está mediada por dinámicas familiares, profesionales y digitales.

CITA

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INTRODUCCIÓN

La enfermedad renal crónica (ERC) es problema de salud pública global por su carácter progresivo, alta carga de morbilidad^{1,2} y complejidad de sus tratamientos³. Vivir con ERC implica no sólo intervenciones médicas continuas, sino cambios profundos en la vida cotidiana⁴, entre los cuales la alimentación ocupa un lugar central al ser parte del tratamiento y una práctica atravesada por dimensiones sociales, culturales y emocionales.

Desde el enfoque biomédico, la alimentación en la ERC se ha concebido, principalmente, como instrumento terapéutico orientado al control clínico, la prevención de complicaciones y la mejora del pronóstico⁵⁻⁸, mediante recomendaciones dietéticas centradas en restricciones y prescripciones⁹. Este enfoque suele relegar la forma en que las personas viven y significan los cambios alimentarios derivados del diagnóstico, así como las tensiones que estos generan en la vida cotidiana y en las relaciones sociales¹⁰.

Estudios cualitativos han mostrado que la experiencia de vivir con una enfermedad crónica se configura a partir de procesos de padecimiento en los que el cuerpo, las emociones y las prácticas cotidianas adquieren nuevos significados^{11,12}. En este marco, la alimentación trasciende la indicación médica y se constituye en una práctica mediante la cual las personas con ERC enfrentan el miedo al deterioro y reconstruyen su identidad^{10,13,14}, convirtiendo el acto de comer, o dejar de comer, en un proceso cargado de sentidos de cuidado, autocontrol, placer, culpa y supervivencia.

Estos factores se configuran en interacción con diversos actores sociales, especialmente la familia, las amistades y los profesionales de la salud^{13,15}, así como en espacios digitales que se han consolidado como escenarios clave para el intercambio de experiencias y la construcción colectiva de saberes prácticos en torno a la alimentación y el padecimiento^{16,17}.

En este contexto, el presente estudio tuvo como objetivo comprender las experiencias que las personas con ERC construyen en torno a su alimentación y las estrategias que despliegan para afrontar las modificaciones alimentarias derivadas del diagnóstico y tratamiento.

METODOLOGÍA

Diseño de estudio

Se realizó un estudio cualitativo con enfoque interpretativo mediante etnografía virtual, que concibe a Internet como espacio social y cultural integrado a la vida cotidiana, donde se construyen comunidades, significados y prácticas¹⁸. Este enfoque respondió a las limitaciones de convivencia derivadas de la pandemia por COVID-19, contexto en que los espacios digitales se consolidaron como escenarios relevantes para la interacción social.

Recolección de datos y participantes: Se realizó observación no participante en grupos privados de Facebook y entrevistas virtuales semiestructuradas (Figura 1). Entre mayo y julio de 2020 se observaron interacciones relacionadas con alimentación y cuidado

en dos grupos dirigidos a personas con ERC y familiares/cuidadores de la Zona Metropolitana de Guadalajara (ZMG). La inclusión de familiares respondió a la relevancia de sus interacciones en torno a dudas alimentarias.

En julio de 2020 se difundió una invitación para entrevistas virtuales semiestructuradas dentro de los grupos de observación. Los criterios de inclusión fueron: ser mayor de 18 años, vivir con ERC en cualquiera de sus etapas y residir en la ZMG.

Entre agosto y noviembre de 2020 se entrevistó a 12 personas, 9 mujeres y 3 hombres (Tabla 1) solo una vez, duración aproximadamente 60 minutos a través de Meet, Zoom o videollamada de WhatsApp, según su disponibilidad. Las entrevistas fueron grabadas, transcritas de forma literal y complementadas con notas de campo y memos analíticos. Se utilizó la saturación teórica¹⁹ para concluir la inclusión de participantes, se consideró alcanzada cuando las entrevistas dejaron de aportar propiedades conceptuales nuevas a las categorías emergentes y los relatos comenzaron a mostrar reiteración temática.

Análisis

Se realizó en ATLAS.ti siguiendo el enfoque de teoría fundamentada constructivista²⁰. Las entrevistas constituyeron la fuente primaria de información y el material recuperado de Facebook fue la fuente secundaria para triangular y corroborar hallazgos (Tabla 2). Ambos materiales se analizaron con codificación línea por línea, identificación de conceptos emergentes, codificación conceptual y axial, e identificación de categorías centrales, apoyado en memos analíticos.

Criterios de rigor metodológico

La calidad del estudio se aseguró mediante criterios de credibilidad, transferibilidad, fiabilidad y confirmabilidad²¹, a través de la triangulación de técnicas, registro sistemático de decisiones analíticas, uso de citas textuales y reflexividad.

Consideraciones éticas

El proyecto fue aprobado por el Comité de la universidad de adscripción de la autora principal (DCSP/317) y se desarrolló conforme a la legislación nacional vigente y a las pautas éticas internacionales para la investigación en seres humanos (CIOMS). Todas las personas participantes otorgaron su consentimiento informado verbal previo a las entrevistas y a las grabaciones.

RESULTADOS

Los resultados se organizaron en tres categorías: experiencias en torno a las restricciones alimentarias, estrategias para afrontar los cambios e interacción con los otros (Tabla 3). Las citas textuales se colocaron en la Tabla 4.

Figura 1. Técnicas de recolección de información empleadas en el estudio

Fuente: Elaboración propia

Tabla 1. Características generales de los participantes

#	Sexo	Edad	Estado civil	Número de hijos	Edad de diagnóstico	Tratamiento
E1	Mujer	27	Soltera	0	24	Prediálisis
E2	Mujer	37	Divorciada	1	9, 35*	Hemodiálisis por rechazo de trasplante
E3	Mujer	35	Casada	1	14, 31*	Diálisis por rechazo de trasplante
E4	Mujer	49	Soltera	2	16	Trasplante
E5	Mujer	31	Casada	0	30	Trasplante
E6	Mujer	37	Casada	2	35	Diálisis
E7	Mujer	55	Casada	3	50	Diálisis
E8	Mujer	28	Casada	1	26	Prediálisis
E9	Mujer	35	Soltera	0	33	Prediálisis
E10	Hombre	31	Soltero	0	28	Prediálisis
E11	Hombre	33	Casado	2	20, 32*	Prediálisis por rechazo de trasplante
E12	Hombre	26	Soltero	0	9	Trasplante

*El primer número corresponde a la edad en que le diagnosticaron ERC por primera vez, el segundo es la edad en que el médico le indica que tiene insuficiencia renal, esto tras haberse realizado un trasplante y haber presentado nuevamente falla renal

Fuente: Elaboración propia

Tabla 2. Origen y función analítica de la información utilizada en los resultados

Fuente de información	Participantes	Tipo de información recuperada	Función en el análisis
Entrevistas virtuales semiestructuradas	12 personas con ERC en cualquiera de sus fases	Experiencias personales, emociones, estrategias de afrontamiento, interacciones sociales y significados atribuidos a la alimentación	Fuente primaria para construcción de categorías analíticas
Observación no participante en grupos privados de Facebook	Personas con ERC y familiares/ cuidadores	Dudas alimentarias, intercambio de recomendaciones, experiencias cotidianas y prácticas de cuidado	Fuente secundaria para triangulación y corroboración de hallazgos

Fuente: Elaboración propia

Tabla 3. Categorías y subcategorías

Categoría	Subcategoría
Restricciones alimentarias	Prohibición, confusión, pérdida
Estrategia de afrontamiento	Autocontrol, resignificación, independencia
Interacción con los otros	Apoyo familiar, exclusión social, comunidades digitales

Fuente: Elaboración propia

Experiencias en torno a las restricciones alimentarias

Los participantes iniciaron narrando el momento del diagnóstico de ERC, precedido por sensaciones físicas que motivaron la búsqueda de atención médica. Los primeros meses posteriores al diagnóstico fueron descritos como un período complejo, marcado por cambios drásticos en la alimentación y por la incorporación de restricciones que, en ocasiones, no estuvieron acompañados de explicaciones claras por parte del personal de salud. En fases más avanzadas de la enfermedad, estas restricciones se sumaron a tratamientos invasivos relacionados con el inicio de terapias sustitutivas de la función renal. Las personas entrevistadas expresaron consternación ante la prohibición de alimentos habituales y señalaron que las recomendaciones dietéticas se enfocaron principalmente en los alimentos restringidos. La entrega de listas de alimentos prohibidos principalmente por médicos, generó frustración al incluir alimentos que disfrutaban, dando lugar a tristeza, frustración y negación. Asimismo, varios participantes describieron una sensación de pérdida de variedad alimentaria y diferenciación respecto a la alimentación del resto de la familia. Hay quien describe este momento como un quiebre en su vida cotidiana (Cita 1, [Tabla 4](#)).

Los relatos reflejaron una percepción de ruptura entre la alimentación previa al diagnóstico y las restricciones posteriores. Aunque existía claridad sobre los alimentos prohibidos, inicialmente se experimentó confusión sobre aquellos que sí podían consumirse, lo que la llevó a buscar asesoría de profesionales de la salud. Esta incertidumbre también se observó en los grupos de Facebook analizados, donde personas con ERC, familiares y cuidadores

recurren a la experiencia de otros para resolver dudas alimentarias. En estos espacios confluyen personas en distintas etapas de la enfermedad que buscan orientación y apoyo. Un ejemplo es el padre de un joven recién trasplantado, quien solicita ayuda en un grupo de Facebook (Cita 2, [Tabla 4](#)). Ante estas publicaciones, otros miembros responden compartiendo recomendaciones basadas en su experiencia (Cita 3, [Tabla 4](#)).

Además de la confusión inicial, las modificaciones alimentarias fueron descritas como constantes y dependientes de los resultados de laboratorio. Entre los discursos de los participantes se narra cómo estos cambios representaron un reto económico (Cita 4, [Tabla 4](#)). Implementar los cambios fue descrito como un proceso con altibajos. Las personas relataron momentos de apego estricto a la dieta y episodios en los que cedieron a los antojos. Estas experiencias solían ir acompañadas de reacciones corporales que reforzaban la idea de evitar determinados alimentos. Una entrevistada relata una de estas experiencias tras consumir pozole durante una reunión familiar y los efectos que observó en su cuerpo (Cita 5, [Tabla 4](#)). En los discursos aparece reiteradamente la idea de que el cuerpo ya no tolera ciertos alimentos, funcionando como un recordatorio de los límites impuestos por la ERC.

Las experiencias variaron según el momento del diagnóstico. Quienes fueron diagnosticados en la infancia o adolescencia señalaron que los cambios pasaron casi desapercibidos, pues su alimentación dependía de sus madres. En contraste, quienes recibieron el diagnóstico en la edad adulta describieron procesos de mayor conciencia y conflicto en torno a las restricciones. En varias de las mujeres entrevistadas emergió la categoría denominada independencia alimentaria, referida a asumir el control directo sobre la selección, preparación y regulación de los alimentos como forma de manejar la ERC. Esta decisión estuvo motivada por experiencias previas en las que la preparación de alimentos por otras personas derivó en reacciones corporales desfavorables, desde mayor retención de líquidos hasta signos de intoxicación.

Los cambios en la alimentación también estuvieron ligados a las transiciones entre etapas de la ERC. El paso de prediálisis a diálisis implicó, para algunos, la reintroducción de alimentos previamente restringidos, lo que requirió una readaptación corporal (Cita 6, [Tabla 4](#)).

Tabla 4. Citas textuales ilustrativas de las categorías de análisis

Sección	#	Cita textual*
Experiencias en torno a las restricciones alimentarias	1	"mi mundo se derrumbó, la comida es lo único que me hace feliz... y ahora me lo quitan"(E1).
	2	"Gracias por aceptarme, acaba de ser trasplantado mi hijo, necesita consejos ¡ayuda!" (Facebook, padre de paciente con ERC).
	3	"Principalmente que siempre tome sus medicamentos, la dieta lo más apegada que se pueda, los primeros meses todo cocido, agua hervida, aunque sea de garrafón, mucha limpieza personal y en general, y siempre una buena actitud" (Facebook, mujer con ERC).
	4	"me decía [la nutrióloga] ahora no vamos a comer arroz, pero vas a comer almendras, ahora no vas a comer plátano, pero si vas a comer otra cosa... cada mes era un batallar... era un gasto bastante fuerte" (E9).
	5	"yo creo que el pozole, aunque lo pedí de pollo, traía puerco porque me llené de ronchitas y no pude dormir y estuve súper mal" (E3).
	6	"cuando entro a hemodiálisis fue otra vez complicado porque me dicen que ahora tengo que comer mucha proteína..." (E11).
Afrontar los cambios	7	"ahorita que lo veo desde otra perspectiva... aceptas y te sometes al régimen y ya" (E12).
	8	"se me va la onda de que tengo el problema... de repente me doy mis pecaditos" (E2).
	9	"yo me alejé de muchas amistades... porque no comprendían que yo ya no podía llevar una vida normal" (E1).
	10	"cuando paso a un lado del menudo se me antoja muchísimo... y me lleno con el puro olor"(E4).
La interacción con los otros	11	"¿Qué sí puedes comer?, ¿qué te preparo?, me dice mi tía"(E10)
	12	"me han dejado de invitar a reuniones familiares por no comer carne"(E9).
	13	"me tocó un nutriólogo la verdad bueno, porque me ayudó a adaptarme muy fácil"(E11).
	14	"todos los doctores me decían, hay dos cosas importantes, tu dieta y que estés feliz"(E3).

*El dato que se encuentra entre paréntesis hace referencia al origen de la cita: de la observación en Facebook o bien de una cita textual de los participantes enlistados en la [tabla 1](#), estos últimos se identifican como E#, en alusión al listado mencionado.

Fuente: Elaboración propia

Afrontar los cambios

Para hacer frente a las modificaciones alimentarias, las personas pusieron en marcha diversas estrategias de afrontamiento. Entre las actitudes descritas destacan la resignación, el optimismo y el uso del humor para sobrellevar la situación. Un entrevistado reflexiona sobre su proceso, señala que al inicio actuó de manera automática, sin cuestionar las indicaciones recibidas (Cita 7, [Tabla 4](#)). Los participantes también describieron mecanismos de defensa como la represión emocional, el aislamiento social y la confrontación. En algunos casos, evitar pensar en la enfermedad llevó a flexibilizar la dieta (Cita 8, [Tabla 4](#)). El aislamiento social apareció como mecanismo de defensa y estrategia de afrontamiento. Una entrevistada explica que decidió alejarse de círculos sociales para evitar presiones relacionadas con la comida (Cita 9, [Tabla 4](#)). Por su parte, el autocontrol, la disciplina y la constancia fueron otras estrategias recurrentes, especialmente en contextos donde abundan alimentos "prohibidos". Una entrevistada relata cómo resignifica el placer a través del sentido del olfato (Cita 10, [Tabla 4](#)). Asimismo, en las entrevistas se describió la independencia

alimentaria, la autoeducación y la modificación de recetas como estrategias relevantes para afrontar las modificaciones alimentarias. Por su parte, en los grupos de Facebook se observaron intercambios frecuentes de estrategias culinarias, sustitutos y recomendaciones para mejorar el sabor de alimentos sin comprometer las restricciones.

La interacción con los otros

Las interacciones sociales desempeñan un papel importante en la experiencia alimentaria de las personas con ERC. La familia aparece como principal actor social, manifestando apoyo mediante empatía y adaptación de la comida (Cita 11, [Tabla 4](#)). Sin embargo, este apoyo no siempre estuvo exento de tensiones. Una entrevistada relata sentirse excluida de reuniones familiares debido a las restricciones de su alimentación (Cita 12, [Tabla 4](#)). Situaciones similares se presentaron con amistades y compañeros de trabajo, donde la diferencia alimentaria se hizo visible y, en algunos casos, generó incomodidad o estigmatización. En cuanto a los profesionales de la salud, los nutriólogos fueron descritos como figuras de acompañamiento que brindan

herramientas prácticas y apoyo emocional, mientras que los médicos aparecieron como referentes centrales en la motivación para seguir la dieta (Cita 13 y 14, [Tabla 4](#)).

En síntesis, los resultados evidencian que los cambios en la alimentación de las personas con ERC se configuran como un proceso complejo, atravesado por experiencias de restricción, estrategias de afrontamiento e interacciones sociales, que influyen en la manera en que las personas ajustan su alimentación según la trayectoria del padecimiento y los contextos relacionales en los que se desenvuelven.

DISCUSIÓN

Los hallazgos muestran que las modificaciones alimentarias asociadas a la ERC trascienden la prescripción médica y se configuran como un proceso complejo, dinámico y situado en la vida cotidiana. En concordancia con la literatura cualitativa, la alimentación emerge como un eje central de la experiencia del padecimiento, donde convergen dimensiones corporales, emocionales y relacionales^{13,22}. Desde una perspectiva más amplia de la cronicidad, estos procesos han sido descritos como parte de una reorganización biográfica y corporal que obliga a reinterpretar prácticas cotidianas e identidad frente al padecimiento^{12,23}.

Las experiencias en torno a las restricciones alimentarias evidencian que el diagnóstico de ERC marca un quiebre en la relación con la comida. Estudios cualitativos han mostrado que las indicaciones dietéticas suelen percibirse como abruptas, centradas en la prohibición y escasamente explicadas, lo que favorece sentimientos de confusión, tristeza y frustración. En este sentido, la dieta es vivida inicialmente como una pérdida —de placer, autonomía y normalidad— más que como una estrategia de cuidado, reforzando la vivencia del diagnóstico como un punto de inflexión en la vida cotidiana^{10,24}.

Asimismo, los resultados muestran que las modificaciones alimentarias no son estáticas ni lineales, sino que se transforman según resultados de laboratorio, transiciones entre etapas y respuestas corporales. Se ha documentado que la incertidumbre característica de la ERC obliga a reorganizar constantemente las prácticas alimentarias mediante procesos de ajuste progresivo y prueba-error²². En este estudio, dicha reorganización se acompaña de un proceso de aprendizaje corporal en el que el propio cuerpo funciona como referente para reafirmar o modificar los límites alimentarios.

En relación con las estrategias de afrontamiento, los hallazgos confirman que las personas con ERC despliegan respuestas más allá del cumplimiento de la dieta. Actitudes como resignación, optimismo y uso del humor, así como mecanismos como aislamiento social o flexibilización ocasional de las restricciones, han sido descritos en estudios cualitativos^{25,26}. Este estudio aporta evidencia sobre cómo estas estrategias se articulan entorno a la alimentación, mediante el autocontrol frente a antojos, resignificación del placer sensorial o evitación de contextos sociales

percibidos como riesgosos, en consonancia con investigaciones centradas en la experiencia dietética en la ERC²².

Un hallazgo relevante fue la importancia que algunas mujeres le atribuyeron a la independencia alimentaria como estrategia de afrontamiento. En contraste con los hombres, quienes enfatizaron principalmente el seguimiento de indicaciones médicas y el apoyo familiar para afrontar las modificaciones alimentarias. Entre las mujeres, asumir la preparación y el control de los alimentos aparece como una forma de recuperar agencia frente a la ERC y reducir la incertidumbre, en consonancia con estudios que muestran cómo el manejo dietético se convierte en un espacio clave de autocontrol y toma de decisiones en la ERC²². Sin embargo, esta independencia también implica una carga adicional al reforzar la responsabilidad individual sobre el control del cuerpo padeciente lo que ha sido descrito en la literatura cualitativa sobre cronicidad como una forma ambivalente de preservación del self^{23,26}. Esta tensión dialoga con investigaciones que han señalado la dimensión de género en las prácticas de cuidado y autocuidado, donde las mujeres tienden a asumir de manera prioritaria y naturalizada las tareas asociadas al control cotidiano de la enfermedad²⁷.

Las interacciones sociales se revelan como un componente clave en la experiencia alimentaria. La familia, amistades y profesionales de la salud influyen en la implementación de las recomendaciones dietéticas, ya sea facilitando la adaptación o generando tensiones, exclusión y percepción de diferencia, como ha sido documentado en estudios cualitativos^{17,22,24}. En este sentido, la alimentación se convierte en un marcador visible del padecimiento, capaz de reconfigurar vínculos sociales y reforzar estrategias como el aislamiento social para proteger el autocuidado, fenómeno ya descrito en investigaciones sobre la experiencia cotidiana de la ERC y sus tratamientos^{10,28}.

En este escenario, los espacios digitales adquieren una relevancia. Los grupos de Facebook analizados funcionan como comunidades de apoyo donde las personas comparten experiencias, intercambian saberes y construyen colectivamente estrategias para afrontar las restricciones alimentarias. Estos hallazgos coinciden con estudios que destacan el papel de los entornos digitales como complementos del cuidado en la ERC, al facilitar acceso a información situada y el reconocimiento entre pares, especialmente en contextos donde el acompañamiento profesional es limitado o discontinuo^{17,29}, lo que refuerza la pertinencia de abordarlas como escenarios relevantes para comprender el padecimiento¹⁸.

En conjunto, los resultados resaltan la necesidad de que los abordajes clínicos de la alimentación en la ERC incorporen una perspectiva más integral que reconozca la alimentación como práctica social, corporal y emocionalmente situada. Considerar las experiencias, estrategias e interacciones puede contribuir al desarrollo de intervenciones más sensibles a la vida cotidiana, favoreciendo procesos de acompañamiento que trasciendan la prescripción y la restricción.

Sobre las limitaciones, los hallazgos no son generalizables y deben interpretarse como una comprensión situada. La recolección

en entornos digitales pudo excluir a personas sin acceso o alfabetización digital. Asimismo, el contexto de la pandemia por COVID-19 y la localización geográfica de la muestra influyen en la interpretación de los resultados.

CONCLUSIONES

Los hallazgos de este estudio destacan la centralidad de la independencia alimentaria y del autocuidado como estrategias de afrontamiento en personas con ERC, particularmente entre mujeres. La preparación y el control de los alimentos emergen no solo como una forma de recuperar agencia frente a la enfermedad, sino también como un espacio cotidiano de toma de decisiones que influye en la percepción de bienestar y en el manejo de la condición. Sin embargo, esta autonomía también implica una carga adicional al reforzar la responsabilidad individual sobre un cuerpo padeciente, lo que puede generar tensiones en la identidad y el sentido de sí mismo.

Asimismo, las prácticas de autocuidado se entrelazan con normas de género, evidenciando cómo las mujeres asumen de manera prioritaria y naturalizada las tareas vinculadas al control cotidiano de la alimentación y del cuidado de la salud. En conjunto, estos hallazgos aportan una comprensión situada de la experiencia alimentaria en la ERC y subrayan la relevancia de integrar las dimensiones psicosociales y de género en el abordaje de la alimentación como parte del cuidado de las personas que viven ERC.

De este modo, las conclusiones responden al objetivo planteado y reafirman la pertinencia de incorporar la perspectiva experiencial puede contribuir al diseño de intervenciones nutricionales más integrales, sensibles a la vida cotidiana y a las realidades sociales de las personas con ERC.

CONTRIBUCIÓN DE AUTORÍA

N.R-C y L.E.H.I. contribuyeron a la creación y diseño del estudio, N.R-C. recolectó la información, la analizó e interpretó, además realizó la búsqueda de literatura, realizó los análisis y escribió el primer borrador con la ayuda de N.G.R.V-S., D.E.D.L.I.G. y E.K.O.L. Todos los autores revisaron críticamente esta y las versiones anteriores del documento.

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CONFLICTO DE INTERESES

Los autores expresan que no existen conflictos de interés al redactar el manuscrito.

DISPONIBILIDAD DE DATOS

Ofrecimiento de datos bajo petición a la autora de correspondencia.

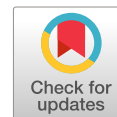
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PROTOCOL

Nutrition Education Protocol in Artistic Roller Skating: A Quasi-Experimental Pre-Post Study Design

➤ Protocolo de educación nutricional en patinaje artístico sobre ruedas: Diseño de estudio cuasiexperimental pre-post

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KEYWORDS

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Anthropometry
Eating disorder risk
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➤ ABSTRACT

Introduction: Artistic roller skating is an aesthetic and weight-sensitive sport in which body composition and appearance may influence performance outcomes. Adolescent athletes in these disciplines may be at increased risk of low energy availability, disordered eating behaviors, and sport-specific weight pressures. However, structured nutritional education programs tailored to this population remain scarce. The objective of this study is to describe and propose a structured Nutritional Education Protocol (NEP) for level 11 artistic roller skaters aged 14 or older, and to outline its planned evaluation using a quasi-experimental pre-post design.

Methods: This 24-month protocol includes three phases: baseline assessment (anthropometric measurements and validated questionnaires: KIDMED, EAT-26, and WPS). The second phase consists of six structured educational sessions based on an active pedagogical approach, followed by post-intervention reassessment. Statistical analyses will compare pre-post changes using paired tests and mixed models.

Results: Primary outcomes: Changes in Mediterranean diet adherence (KIDMED score) and eating disorder risk (EAT-26 score) following the intervention. Secondary outcomes: Changes in sport-specific weight pressure (WPS), selected anthropometric parameters, and adherence to the educational sessions. The implementation of the NEP is expected to provide preliminary evidence regarding the feasibility and potential impact of structured nutrition education in artistic roller skating.

Conclusion: This protocol may contribute to the development of preventive nutritional strategies in aesthetic sports and inform future controlled studies.

RESUMEN

PALABRAS CLAVE

Estado nutricional

Antropometría

Riesgo de trastorno
de la conducta
alimentaria

Adolescente

Introducción: El patinaje artístico sobre ruedas es un deporte estético y sensible al peso corporal, en el que la composición corporal y la apariencia pueden influir en el rendimiento y la puntuación competitiva. Los y las deportistas adolescentes que participan en este tipo de disciplinas pueden presentar mayor riesgo de baja disponibilidad energética, conductas alimentarias de riesgo y presiones específicas relacionadas con el peso corporal. No obstante, existen escasos programas estructurados de educación nutricional dirigidos específicamente a esta población. El objetivo de este estudio es describir y proponer un Protocolo de Educación Nutricional (NEP) dirigido a patinadores/as de nivel 11 de 14 años o más, así como detallar su futura evaluación mediante un diseño cuasiexperimental pre-post.

Metodología: El protocolo, con una duración prevista de 24 meses, consta de tres fases: evaluación basal (mediciones antropométricas y aplicación de cuestionarios validados: KIDMED, EAT-26 y WPS), implementación de seis sesiones educativas basadas en un enfoque pedagógico activo y participativo, y reevaluación posterior a la intervención. El análisis estadístico comparará los cambios pre-post mediante pruebas para muestras relacionadas y modelos de efectos mixtos.

Resultados: Resultados primarios: Cambios en la adherencia a la dieta mediterránea (puntuación KIDMED) y en el riesgo de trastorno de la conducta alimentaria (puntuación EAT-26). Resultados secundarios: Cambios en la presión relacionada con el peso en el contexto deportivo (WPS), en parámetros antropométricos seleccionados y en los indicadores de adherencia a las sesiones educativas. La implementación del NEP permitirá generar evidencia preliminar sobre la viabilidad y el posible impacto de una intervención estructurada de educación nutricional en el patinaje artístico sobre ruedas.

Conclusión: Este protocolo puede contribuir al desarrollo de estrategias preventivas en deportes estéticos y servir de base para futuros estudios controlados que evalúen su efectividad.

KEY MESSAGES

1. Nutritional education is essential for adolescent artistic roller skaters to promote healthy dietary habits and prevent eating disorders, especially in high-performance contexts.
2. A structured intervention protocol (NEP) has been developed and expected for implementation over 24 months, including anthropometric assessments and validated questionnaires (KIDMED, EAT-26, WPS) to evaluate dietary habits and psychological pressures.
3. The intervention includes six educational sessions focused on Mediterranean diet principles, hydration strategies, and practical cooking workshops tailored to athletes' training and competition needs.
4. Findings are expected to suggest a need for ongoing support and adaptation of nutritional programs for younger athletes and those at lower competitive levels, considering the physiological changes during adolescence and the sport's aesthetic demands.

CITATION

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INTRODUCTION

Artistic roller skating, although not currently included in the Olympic Games, is a well-established sport in Spain, with Catalan athletes achieving notable international recognition. The Catalan Skating Federation comprises approximately 25,000 federative licenses across 12 disciplines, of which nearly 50% correspond to artistic roller skating¹.

In 2021, the Federation implemented a new competition system (RollarCat), restructuring athletes into 11 levels according to age and technical proficiency, with level 11 governed by the International Federation World Skate². Despite its relevance and high participation rates, there is a marked scarcity of scientific literature addressing the nutritional requirements, anthropometric characteristics, and health-related risks associated with this discipline.

Artistic roller skating is classified as an aesthetic and weight-sensitive sport, requiring high levels of power, flexibility, coordination, and technical precision. In such disciplines, physical appearance may influence scoring and competitive outcomes, increasing the pressure to maintain a specific body composition. Previous research has demonstrated that athletes in aesthetic sports are at increased eating disorder risk compared to other sport categories^{3,4}. The body ideals commonly promoted in female aesthetic disciplines emphasize leanness with low fat mass, whereas male athletes are often expected to combine muscularity with flexibility. Athletes in these disciplines may therefore experience sport-specific pressures related to weight and appearance⁵.

Although figure skating on ice has been more extensively studied, evidence specific to artistic roller skating remains limited. Vila *et al.* (2013)⁶ analyzed the anthropometric and somatotype characteristics of 29 elite roller skaters to determine whether there were significant differences ($p < 0.05$). The study concluded that male skaters ($n=15$) had an endo-mesomorphic somatotype, while female skaters ($n=14$) were mesomorphic followed by endomorphic, the latter being characteristic of younger skaters (girls and adolescents). In both sexes, normal weight was identified according to the Body Mass Index (BMI). Similarly, Pons *et al.* (2015)⁷ analyzed long-term anthropometric data from athletes registered at the High-Performance Center (CAR) of Sant Cugat over more than 20 years across different disciplines. For artistic skating ($n=28$), the results highlighted a predominance of the mesomorphic somatotype among male skaters ($n=11$), with an average age of 19.7 ± 5.6 years. In contrast, among female skaters ($n=17$), the differences between somatotypes were not significant (average age 16.9 ± 3.6 years); in both sexes, the athletes were within the normal weight range (BMIs of 20.9 ± 3.9 and 20.1 ± 2.2 , respectively). However, neither study explored dietary intake, energy availability, or nutritional risk factors.

Recent evidence indicates that athletes participating in aesthetic and weight-sensitive sports present a higher prevalence of low energy availability (LEA) and eating disorder risk^{3,4,8} compared with athletes from other sport categories. LEA occurs when

energy intake is insufficient to support both exercise expenditure and the physiological functions necessary to maintain optimal health and performance⁸. Prolonged LEA may lead to the development of Relative Energy Deficiency in Sport (RED-S), a multifactorial syndrome affecting metabolic, reproductive, bone, cardiovascular, and psychological health. The International Olympic Committee (IOC) updated its consensus statement on RED-S in 2023, emphasizing the multifactorial health and performance consequences of chronic energy deficiency, as well as the importance of early detection and preventive strategies, particularly in sports where body composition or appearance may influence performance evaluation⁹.

Adolescence represents a critical period characterized by rapid somatic growth, hormonal maturation, bone mass accrual, and psychological development^{10,11}. Inadequate energy intake during this stage may compromise reproductive function, bone health, metabolic regulation, and long-term athletic development^{10,11}. Studies conducted in aesthetic disciplines such as figure skating and gymnastics have documented restrictive eating patterns, inadequate caloric intake, and elevated weight-related pressures, often normalized within the sporting environment^{12,13}. These contextual pressures may increase vulnerability to eating disorders and contribute to the development of RED-S.

From a performance perspective, maintaining an adequate dietary pattern is fundamental for optimizing training adaptations, recovery processes, and competitive outcomes^{14,15}. Evidence-based guidelines emphasize the importance of appropriate macronutrient distribution, nutrient timing (before, during, and after exercise), and individualized hydration strategies to prevent fatigue, injury, and impaired recovery^{14,15}. In adolescent athletes, these nutritional considerations are further compounded by growth-related energy demands¹⁰.

Importantly, systematic reviews have demonstrated that structured, theory-based nutrition education interventions can significantly improve nutrition knowledge, dietary intake, and health-related behaviors in athletic populations¹⁶⁻¹⁸. Nevertheless, few interventions have been specifically designed for aesthetic or weight-sensitive sports, and to our knowledge, no structured nutritional education protocol has been described for artistic roller skating.

Given the combination of aesthetic demands, adolescent vulnerability, and limited sport-specific evidence, the development of a structured Nutritional Education Protocol (NEP) for artistic roller skaters is warranted.

Objectives

The objective of this NEP is threefold: 1) to assess the current dietary habits and anthropometric characteristics of level 11 artistic roller skaters aged 14 years or older; 2) to evaluate their eating disorder risk and sport-specific weight-related pressures; and 3) to implement and subsequently assess the impact of a structured nutritional education intervention aimed at promoting healthy dietary habits and preventing eating disorders.

Hypotheses

Primary Hypothesis

H1: The implementation of the NEP will result in a statistically significant increase in Mediterranean diet adherence (KIDMED score) from baseline to post-intervention.

Secondary Hypotheses

H2: The NEP will result in a statistically significant reduction in eating disorder risk (EAT-26 score) from baseline to post-intervention.

H3: The NEP will lead to a statistically significant reduction in perceived sport-related weight pressure (WPS score).

H4: Anthropometric parameters (e.g., body fat percentage) will remain stable or improve without evidence of increased low energy availability risk.

H5: Improvements in nutrition knowledge and dietary adherence will be greater among female athletes compared to male athletes (exploratory subgroup hypothesis).

METHODS

Design

The evaluation design of the NEP will be quasi-experimental with a pre-post structure, meaning that changes and processes will be observed within the same individuals. In this type of study, there will be no randomization, and therefore, each individual will serve as their own control. The study protocol is preregistered in a publicly accessible registry (Open Science Framework) with identifier <https://osf.io/yjz4u>.

Participants

The estimated sample size is 60 roller figure skaters competing in the individual free modality. The inclusion criteria will be: a) being at least 14 years old during the calendar year in which the NEP is applied, belonging to the cadet, youth, junior, or senior category; b) being federated at level 11 of the Catalan Skating Federation (the highest level in Catalonia, Spain); c) belonging to the artistic discipline and the "individual free" modality. The exclusion criteria for the NEP will be: a) having an injury at the start of the NEP application; b) having a diagnosed eating disorder; c) having a diagnosed psychiatric disorder; d) following a special diet for health reasons.

Sample Size Calculation

The sample size was calculated for the primary outcome, defined as the change in the Mediterranean Diet Quality Index for Children and Adolescents (KIDMED) score, using a paired t-test approach. Assuming a two-sided α level of 0.05 and 80% power, the required sample size was determined according to the expected standardized

effect size (Cohen's d). Using the approximation $n \approx (Z\alpha/2 + Z\beta)^2 / d^2$, with $Z\alpha/2 = 1.96$ and $Z\beta = 0.84$, a total sample of 60 participants would allow detection of a minimum standardized effect size of approximately $d = 0.36$, which can be interpreted as a small-to-moderate effect. To compensate for an expected dropout rate of 15–20%, the target recruitment will be increased to 70–75 athletes.

Recruitment

Participants will be recruited in collaboration with the Catalan Skating Federation and affiliated clubs. Club representatives and coaches will be contacted by email and invited to disseminate information about the study to eligible athletes competing at level 11.

An informational session will be offered to athletes and their families. Written informed consent will be obtained from all participants and, when applicable, from legal guardians for minors. Enrollment will occur consecutively until the target sample size is reached. Reasons for refusal or dropout will be recorded. To enhance retention, reminder communications (email and/or messaging applications) will be sent prior to each session, and flexible scheduling will be offered when feasible. Attendance will be monitored, and participants missing a session will be contacted to facilitate re-engagement. Feedback regarding session satisfaction will be collected to improve adherence and engagement. No financial incentives will be provided; however, participants will receive educational materials and individualized feedback on their assessments.

Study Variables

The primary study variables include changes in Mediterranean diet adherence (total KIDMED score; qualitative, continuous variable, 0–12) and eating disorder risk (EAT-26 score; qualitative, continuous variable, 0–78) from baseline to post-intervention. Secondary variables include changes in perceived weight-related pressure (WPS) (total and subscale scores; qualitative, continuous variable), anthropometric parameters (body mass index, skinfold thickness, muscle mass, estimated body fat percentage, somatotype components; quantitative, continuous variable), and intervention adherence indicators (session attendance, satisfaction survey scores; qualitative). Sex, age, weekly training hours, and years of skating experience will be considered as covariates.

Assessment Instruments

Dietary adherence will be assessed using the Mediterranean Diet Quality Index for Children and Adolescents (KIDMED). Eating disorder risk will be evaluated using the Eating Attitudes Test-26 (EAT-26). Perceived sport-specific weight pressure will be assessed using the WPS scale (WPS-M/WPS-F). Anthropometric measurements will be conducted following International Society for the Advancement of Kinanthropometry (ISAK) standards.

Anthropometric assessment will follow ISAK standards (Level 1 certified evaluator). This includes 21 measurements divided into four different types. Two measurements will be taken for each anthropometric variable, as indicated by the ISAK protocol. If the error percentage exceeds 5% for skinfolds or 2% for other measurements, three measurements will be taken instead of two. As per ISAK guidelines, measurements will be taken on the right side of the body. Only in exceptional cases where this is not possible, the measurement will be taken on the left side and will be duly noted¹⁹. The KIDMED (Altavilla *et al.* 2019) is a 16-question questionnaire (true/false) that assesses adherence to the Mediterranean diet and is intended for individuals between 2 and 24 years old²⁰. Questions with a negative connotation receive a score of -1, while those with a positive aspect receive a score of +1. The total score is classified into three levels: (1) Optimal Mediterranean diet, >8 points; (2) Improvement needed to align intake with Mediterranean patterns, 4–7 points; (3) Very low diet quality, ≤3 points.

The EAT-26 scale (Garner *et al.* 1982) is a 26-question questionnaire with six possible responses and associated scores (never, rarely, sometimes, often, very often, always) used to assess the eating disorder risk²¹. If the total score is equal to or greater than 20, it indicates a risk of developing an eating disorder, requiring further investigation.

Finally, the WPS (Reel *et al.* 2013, Gall *et al.* 2014) is a psychometric test designed to capture the pressure perceived by athletes regarding their body weight, shape, size, and appearance^{5,22}. Both WPS-M and WPS-F consist of 14 and 16 questions respectively, with six possible responses (never, rarely, sometimes, often, very often, always), scored from 1 to 6 in a positive direction (always = 6, never = 1). To obtain the total score, the sum is divided by 14 (WPS-M) or 16 (WPS-F); there are also subscales, such as pressure from the coach and/or teammates (or from the sport itself), and appearance pressure, which are calculated separately based on different items.

Procedure

The total duration of the NEP is estimated at 24 months. The research team members will declare no conflicts of interest. The first two months will be dedicated to preparing the protocol and developing the design; during this time, the topic to be addressed will be defined, and the target group will be selected. Initially, the lead researcher will contact the Catalan Skating Federation to gain a realistic understanding of the relevance of artistic roller skating in Catalonia (Spain), as well as to identify dietary and nutritional needs. Subsequently, the NEP will be evaluated by the Research Ethics Committee of the Universitat Oberta de Catalunya (UOC) to validate its implementation. Hence, all NEP participants will sign an informed consent form after recruitment, as their parents or legal guardians when applicable ([Supplementary Material 1](#)).

The NEP is structured into three phases. The first will be a one-month observational study during which anthropometric data will be collected and three questionnaires will be distributed: KIDMED, EAT-26, and WPS-F or WPS-M. Over the course of one week, a person certified by ISAK Level 1 will conduct the measurements,

while a recorder will document the collected data. Each athlete will be scheduled for a specific day and time, and if the athlete is under-18 years of age, an adult will have to accompany them and be present during the measurements. The certified and properly calibrated equipment used will include: a stadiometer, scale, arm span measurer, skinfold caliper, and small diameter caliper. Cultural beliefs and traditions of each participant will be respected by issuing clothing recommendations to ensure the measurements are taken respectfully, quickly, reliably, and efficiently.

The second phase will be the intervention, which will consist of six nutritional education sessions delivered by a dietitian-nutritionist. These sessions will cover various topics related to nutrition and the practice of artistic roller skating: healthy eating for athletes, adapting the diet to sports practice, nutrition before, during, and after physical activity, the importance of maintaining proper hydration, and strategies for eating away from home, including cooking workshops ([Table 1](#)). This phase will last six months, with one session per month. A one-week dietary record will be requested at the beginning (session 1), in the middle (session 3), and at the end of this phase (session 6).

All sessions are designed to reinforce the role of appropriate nutrition in optimizing training adaptations, competition performance, and long-term athlete health.

Additionally, a satisfaction questionnaire will be distributed after each nutritional education session ([Supplementary Material 2](#)).

The third phase will be the re-evaluation, during which the anthropometric data collection and the same three questionnaires from the first phase will be repeated. The objective of replicating the first phase will be to identify whether any changes have occurred following the intervention, and if so, what those changes are.

Finally, the last three months of the project will be dedicated to the final analysis of all the data collected, the dissemination of results to all those who have participated in the project, and ultimately, the broader dissemination of the findings. Based on the results obtained from the three questionnaires, especially the EAT-26 and WPS, it will be determined whether further investigation is necessary, such as an interview and assessment by a clinician experienced in eating disorders.

Due to the educational nature of the intervention, blinding of participants and educators is not feasible. However, anthropometric assessments will be conducted by an ISAK-certified evaluator who will not be involved in the educational sessions or statistical analysis. When feasible, the evaluator will be blinded to previous measurement results to minimize measurement bias. Although full blinding is challenging in a longitudinal pre-post design involving the same participants, standardized measurement procedures will be strictly followed to reduce potential bias. Personal data will be processed in accordance with Regulation (EU) 2016/679 of the European Parliament and of the Council (General Data Protection Regulation, GDPR) and Organic Law 3/2018 of December 5, on the Protection of Personal Data and Guarantee of Digital Rights.

The study will comply with the principles established in the Convention on Human Rights and Biomedicine (Oviedo

Table 1. Phase 2 – Description of the intervention sessions.

Topic	Description
Sessions	Session 1: How to Maintain a Healthy Diet Session 2: Adapting Your Diet to Sports Practice (Part One) Session 3: Adapting Your Diet to Sports Practice (Part Two) Session 4: My Nutrition on Competition Day Session 5: Hydration for Optimal Sports Performance Session 6: What Should Be in My Lunchbox?
Objectives	Session 1: Improve athletes' knowledge in the field of nutrition to help reduce eating disorder risk. Sessions 2, 3, 4, and 6: Highlight the importance of an optimal healthy diet for athletes, considering their specific needs throughout training and/or competition days. Session 5: Emphasize the importance of proper hydration during both training and competition.
Duration	Sessions 1, 4–6: 2.5 hours each Sessions 2 and 3: 2 hours each All sessions will include a 5-minute break between the lecture and the practical workshop.
Contents Session 1	- Understand what the plate method is, and which foods are typical of the Mediterranean diet. - Analyze myths and beliefs about nutrition and dietary habits. - Learn attractive and diverse ways to cook and eat healthily.
Contents Session 2	- Adapt dietary intake to daily training load and macronutrient needs. - Analyze myths and beliefs about sports nutrition. - How to create a menu tailored to their specific sports practice.
Contents Session 3	- Identify nutritional needs throughout a training day. - Understand how nutritional needs vary depending on the period (before, during, and after training).
Contents Session 4	Plan meal composition for competition days.
Contents Session 5	- Understand the importance of hydration and the side effects of dehydration. - Analyze the challenges of staying hydrated throughout the day. - Maintaining proper hydration has a greater beneficial effect on performance than any other nutritional intervention.
Contents Session 6	- Apply healthy food selection strategies when eating away from home. - Attractive ways to eat using a lunchbox.
Session Dynamics	- Brief introduction of the Nutrition Educator (name, background, etc.) - Presentation of the session objectives - Lecture-style explanation of the content - Group discussion on the content - Break - Cooking workshop - Tasting and discussion of results - Closing - Satisfaction survey to evaluate the Educator and the activity
Session 1 Development	- Explanation of the Mediterranean diet and the foods that comprise it, the plate method, and an overview of different healthy cooking techniques. - An active group discussion will be encouraged around myths and beliefs related to nutrition and dietary habits. - Cooking workshop: Athletes will be divided into four groups, each preparing the same recipe (rice with vegetables and curried chicken) using different cooking techniques (oven, steaming, grilling, and sautéing).
Session 2 Development	- Explanation of how to adapt the diet to sports practice using the Food Pyramid for Swiss Athletes (EPSA), including the role of different macronutrients in the body and the recommended consumption frequency of various food groups. - An active group discussion will be encouraged around myths and beliefs related to sports nutrition. - Cooking workshop: Participants will create a menu based on the weekly frequency of different foods, adapted to their current training routine (using the plate method). - A leaflet with the recommendations explained will be distributed.

Topic	Description
Session 3 Development	- Explanation on how to adapt the diet and what nutrition should look like before, during, and after physical activity. The plate method will also be presented, adjusted according to the athlete's intensity level and training phase. Cooking workshop: Participants will prepare different pre-training snacks, including: - Granola with kefir and red berries - Oatmeal porridge with banana - Carrot sticks with whipped fresh cheese - Toast with avocado and egg
Session 4 Development	- Review of the learnings from previous sessions Cooking workshop: Athletes will be divided into four groups to prepare different healthy dishes for the meal before (2 groups) and after the competition (2 groups). The recipes will include: - Macaroni with vegetables and egg - Quinoa salad - Baked salmon with potatoes and vegetables - Lentils with rice and mushrooms
Session 5 Development	- Explanation of hydration and its role in sports performance, strategies to prevent dehydration, how to distribute fluid intake throughout the day based on physical activity, and how to recognize signs of dehydration. Cooking workshop: Athletes will be divided into four groups to prepare four different types of recovery smoothies: - Banana smoothie - Red berry smoothie - Kiwi and peach smoothie - Avocado and cocoa smoothie
Session 6 Development	- Explanation on how athletes can make healthy food choices when eating away from home (e.g., at restaurants). Guidance will also be provided on food safety, how to store food properly, and how to maintain the plate method when preparing a lunchbox. Lunchbox cooking workshop: Athletes will be divided into four groups, each preparing a different recipe: - Chicken drumsticks with vegetables and quinoa - Bell peppers stuffed with couscous and egg - Chickpea salad - Rice with salmon and vegetable salad

Convention), ratified by Spain, as well as with the ethical principles of the Declaration of Helsinki of the World Medical Association.

Pedagogical Framework

The NEP is grounded in a constructivist and learner-centered pedagogical approach, promoting active participation and experiential learning. The intervention integrates principles of health education and behavior change theory, emphasizing knowledge acquisition, critical thinking, self-efficacy, and practical skill development. Educational strategies are designed to move beyond passive information delivery and instead foster reflective learning, problem-solving, and decision-making skills relevant to real-life sport contexts.

The sessions incorporate interactive components such as group discussions, case-based scenarios, practical workshops, and applied meal-planning exercises tailored to training and competition demands. This approach is consistent with international recommendations for effective nutrition education in athletes and aligns with established sport nutrition guidelines from organizations such as the IOC and the American College of Sports Medicine (ACSM).

The intervention also draws on behavior change principles, including goal setting, self-monitoring (via dietary records), feedback, and reinforcement strategies to enhance adherence and long-term habit formation.

Data Analysis

Data collection will be carried out in an anonymized manner using Microsoft Excel® spreadsheets. The subsequent statistical analysis will be performed with the Statistical Package for the Social Sciences (SPSS®) for Windows. Descriptive statistics will be used to summarize participant characteristics and study variables. Continuous variables will be reported as mean $\pm$ standard deviation (SD) or median (interquartile range), depending on data distribution, while categorical variables will be presented as frequencies and percentages. Normality will be assessed using the Shapiro–Wilk test together with graphical inspection.

Changes between pre- and post-intervention measurements will be evaluated using paired Student's t-tests for normally distributed variables or the Wilcoxon signed-rank test when normality assumptions are not satisfied. Effect sizes will be

estimated using Cohen's *d* for paired samples and interpreted according to conventional thresholds (small ≥ 0.2 , medium ≥ 0.5 , large ≥ 0.8), with corresponding 95% confidence intervals. To account for the repeated-measures structure of the data and potential confounding factors, linear mixed-effects models will be fitted including time (pre/post) as a fixed effect and participant as a random effect. Sex, age group, weekly training hours, and years of skating experience will be considered as covariates where appropriate. This modelling approach allows the inclusion of participants with incomplete follow-up data under the missing-at-random assumption. Categorical outcomes will be analyzed using McNemar's test or generalized linear mixed models as appropriate. Statistical significance will be set at $p < 0.05$, and when multiple comparisons are conducted, false discovery rate adjustment will be applied using the Benjamini–Hochberg procedure. Exploratory subgroup analyses will be by sex and age category (cadet, youth, junior, senior) will be performed when sample size permits, and interaction terms (time $\times$ sex and time $\times$ age group) will be included in mixed-effects models to explore potential differential effects of the intervention.

Missing Data Management

The extent and pattern of missing data will be documented. If missing data are $\leq 5\%$, complete-case analyses will be performed alongside intention-to-treat (ITT) analyses. If missing data exceed 5%, multiple imputation using chained equations (minimum 20 imputations) will be applied under the MAR assumption. Sensitivity analyses comparing imputed and non-imputed datasets will be conducted to evaluate robustness.

RESULTS

As this manuscript presents a study protocol, no empirical results are currently available. The implementation of the NEP is expected to provide a comprehensive overview of the dietary habits, anthropometric characteristics, and eating disorder risk profile of level 11 artistic roller skaters aged 14 years or older.

It is anticipated that the baseline assessment will allow identification of potential areas for improvement in dietary adherence, nutritional knowledge, and awareness of low energy availability risk. The post-intervention evaluation will enable the analysis of changes in Mediterranean diet adherence, eating disorder risk indicators, sport-specific weight pressures, and selected anthropometric parameters.

Although improvements in dietary behaviors and risk awareness are hypothesized, the magnitude and direction of these changes cannot be determined in advance. The findings will contribute to generating preliminary evidence regarding the feasibility and potential effectiveness of a structured nutritional education intervention in this specific sport population. The results derived

from this protocol may inform future controlled studies aimed at strengthening causal inference in aesthetic sports contexts.

DISCUSSION

The present NEP is designed to establish a reference framework for body composition and dietary habits in artistic roller skating athletes in our region. Having sport-specific anthropometric reference values may facilitate the development of individualized nutritional strategies and training programs adapted to the physiological demands of this discipline^{6,7}. Although previous studies have described somatotype and anthropometric characteristics in roller skaters, nutritional intake and energy availability have not been comprehensively investigated in this population.

The protocol is intended for athletes aged 14 years and older, a stage at which adolescents progressively gain autonomy in their dietary choices. Nutritional education during this developmental period may be particularly relevant, as adolescence represents a critical phase of rapid growth, hormonal maturation, and bone mass accrual^{10,11}. Inadequate energy intake during this stage has been associated with potential adverse consequences for reproductive function, bone health, and metabolic regulation¹¹. Therefore, implementing preventive strategies at this age could contribute not only to performance optimization but also to the promotion of long-term health and the reduction of eating disorder risk.

The design of this NEP is aligned with current international recommendations regarding the prevention of LEA and RED-S in weight-sensitive disciplines⁹. According to the 2023 IOC consensus statement, sports in which body composition or aesthetic appearance influence performance evaluation represent high-risk contexts for the development of RED-S and eating disorders^{8,9}. Artistic roller skating shares key characteristics with other aesthetic sports such as figure skating and gymnastics, including subjective scoring systems and emphasis on body shape, factors that may increase weight-related pressures within the sporting environment^{5,12,13}.

Evidence from aesthetic disciplines, particularly in figure skating, has documented restrictive dietary patterns and hypocaloric intake among adolescent athletes¹². Sport-specific pressures related to weight and appearance^{5,13} may further increase vulnerability to LEA and to conditions within the female athlete triad spectrum¹¹.

Athletes presenting eating disorder symptomatology constitute a specific population with distinct clinical and educational needs, requiring targeted preventive strategies within the sporting context²³. Recent evidence has also shown associations between low energy availability, eating disorder risk, and psychological variables such as pre-competitive anxiety in high-performance female athletes²⁴.

From a performance perspective, maintaining an adequate dietary pattern is considered fundamental for optimizing training adaptations, recovery, and competitive outcomes^{14,15}.

Evidence-based guidelines emphasize appropriate macronutrient distribution, nutrient timing strategies, and adequate hydration to reduce fatigue, injury risk, and impaired recovery^{14,15}. In adolescent athletes, these nutritional considerations are further compounded by growth-related energy demands¹⁰.

Systematic reviews suggest that structured, theory-based nutrition education interventions may improve nutrition knowledge and dietary intake in athletic populations¹⁶⁻¹⁸. However, few interventions have been tailored to aesthetic or weight-sensitive sports, and none have been specifically described in artistic roller skating. If successfully implemented, this protocol could contribute to addressing this gap in the literature by integrating anthropometric assessment, validated screening tools (EAT-26 and WPS), and evidence-based educational strategies aligned with IOC recommendations.

In Spanish female athletes participating in aesthetic sports, including artistic roller skaters, Teixidor-Batlle *et al.* (2019)¹³ identified body-related pressures and sport-specific weight monitoring practices as significant risk factors for eating disorders. These findings reinforce the relevance of implementing preventive educational strategies in disciplines where aesthetic demands and external evaluation may normalize restrictive behaviors.

Strengths of the Proposal

This protocol presents several strengths. First, it integrates anthropometric assessment, validated psychometric instruments, and a structured educational intervention within a single comprehensive framework. Second, it is grounded in current international consensus statements on RED-S and evidence-based sport nutrition guidelines. Third, it specifically targets adolescent athletes in a weight-sensitive discipline, a population considered vulnerable to low energy availability and disordered eating behaviors. Additionally, the intervention incorporates an active, learner-centered pedagogical approach, which may enhance engagement and long-term behavioral change.

Limitations

This study follows a quasi-experimental pre-post design without a control group, which introduces inherent limitations in internal validity. Several potential sources of bias must be acknowledged. First, history effects may occur if external events (e.g., competition schedule changes, coaching modifications, or concurrent nutrition advice) influence participants' behaviors during the intervention period independently of the NEP. Second, maturation effects are particularly relevant given the adolescent age range of participants. Natural developmental changes in growth, hormonal maturation, and body composition may influence dietary habits or anthropometric outcomes over time, independently of the intervention. Third, testing effects may arise from repeated administration of questionnaires (KIDMED, EAT-26, WPS), as

participants may become more familiar with the instruments or more aware of socially desirable responses at post-intervention. Additionally, regression to the mean may partially explain changes observed among participants with extreme baseline values, and selection bias may be present due to voluntary participation.

Attrition also represents a potential limitation. Participants may withdraw due to injuries, academic or professional commitments, motivational factors, sports pressure, or lack of family support. Furthermore, the extended study duration increases the likelihood of developmental changes that may independently affect outcomes.

To mitigate these risks, anthropometric assessments will follow standardized ISAK procedures conducted by certified evaluators, data collection conditions will be consistent, and statistical analyses will adjust for age and training exposure. Nevertheless, causal inference will be interpreted cautiously, as the absence of a parallel control group prevents disentangling intervention effects from secular trends. Future research should consider controlled or cluster-randomized designs to strengthen causal inference and external validity.

Periodical follow-up assessments after completion of the NEP may also help evaluate the sustainability of potential behavioral changes. Additionally, although exploratory subgroup analyses by sex and age category are planned, the study may not be sufficiently powered to detect small differences between subgroups. Therefore, these analyses will be considered exploratory and interpreted with caution.

Practical Applications

If implemented successfully, this NEP may provide a structured and reproducible framework for improving nutritional knowledge, dietary habits, and awareness of low energy availability risk among artistic roller skaters. The protocol may serve as a reference model for sport federations, coaches, and sports nutrition professionals working in aesthetic and weight-sensitive disciplines.

Furthermore, the integration of validated screening tools (KIDMED, EAT-26, WPS) alongside anthropometric assessment may facilitate early detection of nutritional risk patterns and weight-related pressures, supporting preventive strategies within youth sport settings.

Future Research Directions

Future studies may expand this protocol to include randomized controlled designs with comparison groups to strengthen causal inference. Long-term follow-up assessments could evaluate the sustainability of behavioral changes and potential effects on performance outcomes.

Future adaptations of the NEP may allow its extension to lower competitive levels (levels 8-10) and potentially to younger athletes, incorporating additional emphasis on nutritional periodization and long-term athlete development. Also, this framework could

be adapted to other artistic roller skating disciplines, such as show groups, solo dance, dance pairs, or artistic pairs, where similar aesthetic and performance demands are present; also to other aesthetic disciplines such as dance or gymnastics. Future research may also explore the inclusion of psychological support components or digital tools to enhance adherence and monitoring.

CONCLUSIONS

Given the current lack of available evidence, the importance of this project and the NEP will lie in the number of athletes practicing artistic roller skating in Catalonia (Spain) and the interest shown by some of them, especially those at a high-performance level, in nutrition and how it can influence their performance. The intervention has been designed for skaters aged 14 and older at level 11, which is strictly governed by international regulations, and includes athletes who may later qualify for national and international championships.

AUTHORS' CONTRIBUTIONS

All authors contributed to the writing and editing of the study protocol.

FUNDING

The authors declare that no funding was received for the conduct of this study.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding writing this manuscript.

DATA AVAILABILITY

Data will be made available upon reasonable request to the corresponding author. However, this manuscript presents a research protocol that has not yet been implemented.

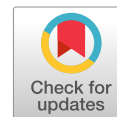
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PROTOCOL

Patrones alimentarios y factores asociados en trabajadores del Mercado Mayorista de Quito: protocolo de estudio transversal

> Food patterns and associated factors among workers of the Mercado Mayorista in Quito: a cross-sectional study protocol

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> RESUMEN

PALABRAS CLAVE

Hábitos alimentarios

Patrones dietéticos

Comportamiento
nutricional

Condiciones laborales

Factores
socioeconómicos

Introducción: Los entornos laborales condicionan los hábitos alimentarios, especialmente en contextos de precariedad laboral y escasa disponibilidad de alimentos saludables. El Mercado Mayorista de Quito, donde convergen comerciantes formales y trabajadores informales en condiciones exigentes, representa un entorno relevante para estudiar la relación entre dieta, trabajo y salud.

Objetivo: identificar los patrones alimentarios predominantes en los trabajadores del Mercado Mayorista de Quito y explorar su asociación con variables sociodemográficas, condiciones laborales, antecedentes de salud e indicadores antropométricos.

Metodología: Estudio observacional, transversal, con enfoque cuantitativo, descriptivo con análisis asociativo de carácter exploratorio. Se aplicarán recordatorios de 24 horas en dos días no consecutivos y se ajustará la ingesta habitual mediante el método Multiple Source Method. Se empleará análisis factorial de componentes principales para identificar patrones alimentarios. Se incluirán variables sociodemográficas, laborales, de salud y antropométricas. La muestra estimada es de 548 personas adultas trabajadoras del mercado, seleccionadas por muestreo no probabilístico por conveniencia. Se aplicarán encuestas estructuradas y procedimientos estandarizados de medición.

Resultados esperados: Se espera identificar patrones alimentarios predominantes y describir posibles asociaciones con características laborales, sociodemográficas y de salud. Dado el diseño del estudio, estas asociaciones se interpretarán como exploratorias, sin inferencia causal ni representatividad poblacional.

Conclusiones: El estudio aportará evidencia descriptiva sobre la relación entre alimentación y condiciones laborales en una población urbana vulnerable, y podrá orientar políticas e intervenciones de salud pública adaptadas.



KEYWORDS

Diet Habits

Dietary Patterns

Nutritional
Behaviour

Working Conditions

Socioeconomic
factors

> ABSTRACT

Introduction: Work environments shape dietary habits, particularly in contexts characterized by job insecurity and limited availability of healthy foods. The Quito Wholesale Market, where formal traders and informal workers converge under demanding conditions, represents a relevant setting to examine the relationship between diet, work, and health.

Objective: To identify predominant dietary patterns among workers at the Quito Wholesale Market and to explore their associations with sociodemographic variables, working conditions, health history, and anthropometric indicators.

Methods: An observational, cross-sectional study with a quantitative approach and a descriptive design including exploratory associative analysis will be conducted. Two non-consecutive 24-hour dietary recalls will be applied, and usual intake will be estimated using the Multiple Source Method. Principal component analysis will be used to identify dietary patterns. Sociodemographic, occupational, health, and anthropometric variables will be included. The estimated sample consists of 548 adult workers, selected through non-probability convenience sampling. Structured questionnaires and standardized measurement procedures will be applied.

Expected results: Predominant dietary patterns are expected to be identified, along with potential associations with occupational, sociodemographic, and health characteristics. Given the study design, these associations will be interpreted as exploratory, without causal inference or population representativeness.

Conclusions: This study will provide descriptive evidence on the relationship between diet and working conditions in a vulnerable urban population and may inform the development of context-specific public health policies and interventions.

MENSAJES
CLAVE

1. Los patrones alimentarios permiten identificar combinaciones reales de consumo y son útiles para entender su relación con enfermedades crónicas no transmisibles.
2. Los entornos laborales informales y precarios pueden limitar el acceso a alimentos saludables y condicionar decisiones dietéticas.
3. El estudio se desarrollará con herramientas validadas para estimar la ingesta habitual y analizar patrones alimentarios en trabajadores expuestos a condiciones de vulnerabilidad laboral.
4. Este protocolo propone una metodología validada para caracterizar la dieta habitual en una población urbana vulnerable de Quito.

CITA

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INTRODUCCIÓN

El análisis de las combinaciones reales de alimentos y hábitos de consumo permite identificar patrones alimentarios desde un enfoque metodológico que evalúa la dieta de forma integral, en contraste con los enfoques tradicionales centrados en nutrientes aislados. Esta perspectiva ha demostrado ser más útil para comprender la relación entre alimentación y enfermedades crónicas no transmisibles, ya que refleja con mayor precisión los comportamientos dietéticos en contextos sociales específicos^{1,2}.

Las dietas inadecuadas constituyen uno de los principales factores de riesgo de mortalidad a nivel mundial, con aproximadamente 11 millones de muertes atribuibles en 2017, superando incluso al tabaquismo. Esta carga está asociada principalmente a dietas pobres en frutas, verduras, cereales integrales, frutos secos y legumbres, así como al elevado consumo de sodio, carnes procesadas y bebidas azucaradas³. Estos datos evidencian la necesidad de estudiar cómo las condiciones estructurales y laborales afectan la calidad de la dieta, particularmente en poblaciones urbanas vulnerables.

Diversos estudios han demostrado que los determinantes sociales y laborales como la informalidad, las largas jornadas, los ingresos bajos y la limitada disponibilidad de alimentos saludables en el entorno inmediato pueden condicionar los patrones dietéticos, favoreciendo dietas monótonas, con alta proporción de carbohidratos simples y alimentos ultraprocesados, y baja diversidad nutricional^{4,5}.

En este contexto, los mercados mayoristas en América Latina cumplen un rol clave como nodos logísticos del sistema alimentario urbano y, al mismo tiempo, como espacios de alta concentración de empleo precario o informal. La Food and Agriculture Organization of the United Nations (FAO) ha señalado que estos entornos, pese a ser fundamentales para el abastecimiento de alimentos, presentan condiciones laborales que dificultan el acceso a dietas saludables para sus trabajadores, quienes suelen quedar fuera de las políticas públicas alimentarias tradicionales⁶.

El Mercado Mayorista de Quito (MMQ) representa un ejemplo claro de esta realidad. Este centro alberga a una diversidad de trabajadores en funciones físicamente exigentes, como comercio, carga y transporte. Entre ellos, se encuentran comerciantes registrados que, si bien cuentan con puestos asignados y licencias municipales, muchas veces operan bajo esquemas de semiformalidad, sin afiliación al sistema de seguridad social. Paralelamente, un número importante de prestadores de servicios como estibadores, tricicleros y transportistas trabajan en condiciones de informalidad, sin contratos ni cobertura de salud ocupacional⁷. Estas condiciones estructurales, unidas a largas jornadas laborales, escaso tiempo de descanso y limitada oferta de alimentos saludables dentro del recinto, constituyen factores relevantes que pueden influir en las decisiones alimentarias de los trabajadores⁶.

Desde una perspectiva conceptual, se plantea que los patrones alimentarios de esta población resultan de la interacción entre

determinantes sociodemográficos y condiciones laborales. Variables como edad, sexo, nivel educativo, ingresos y condiciones de vivienda actúan como determinantes distales que influyen en el acceso y selección de alimentos. A su vez, la ocupación, la duración de la jornada y los horarios de trabajo configuran el entorno alimentario inmediato, el tiempo disponible para comer y los hábitos de sueño, actuando como mediadores proximales del comportamiento alimentario. En este protocolo, los patrones alimentarios constituyen la variable principal, y las demás variables serán analizadas como factores asociados medidos en un mismo momento de observación.

En este marco, el objetivo de este protocolo es identificar los patrones alimentarios predominantes en los trabajadores del Mercado Mayorista de Quito y explorar su asociación con variables sociodemográficas, condiciones laborales, antecedentes de salud e indicadores antropométricos.

METODOLOGÍA

Diseño del estudio

Se desarrollará un estudio observacional, transversal, de tipo descriptivo con análisis asociativo de carácter exploratorio, orientado a caracterizar los patrones alimentarios en una población laboral urbana en situación de vulnerabilidad. Se estimará la ingesta habitual de alimentos y se explorarán asociaciones entre los patrones alimentarios identificados y variables sociodemográficas, laborales, de salud y antropométricas.

Dado el diseño propuesto, las relaciones observadas serán interpretadas exclusivamente en términos asociativos, sin establecer direccionalidad temporal ni causalidad, ni inferencia poblacional, debido al carácter no probabilístico del muestreo.

El modelo conceptual del estudio se presenta en la [Figura 1](#).

El flujo metodológico general se presenta en la [Figura 2](#).

Población y selección de la muestra

La población objetivo comprende personas adultas con actividad laboral continua en el Mercado Mayorista de Quito. Inaugurado en 1981, este centro opera como nodo estratégico del sistema alimentario urbano, con 126.885 m² de extensión, 1.119 comerciantes registrados en secciones de abastos, frutas, tubérculos, hortalizas, cárnicos y productos complementarios, y 535 prestadores de servicios logísticos (estibadores, tricicleros y transportistas)⁷.

Se tomó un tamaño muestral inferencial basado en 1.199 comerciantes censados, por ser la única subpoblación con datos demográficos verificables y ante la ausencia de parámetros específicos para patrones alimentarios en esta población. Utilizando la calculadora para estudios poblacionales del Centro de métodos cuantitativos (CEMEQ)⁸, con población finita, margen de error del 5% y nivel de confianza del 95%, y considerando las prevalencias de sobrepeso y obesidad reportadas en la Encuesta

Figura 1. Modelo conceptual de los determinantes de los patrones alimentarios en trabajadores del Mercado Mayorista de Quito. Las flechas sólidas representan la vía principal hipotética: los determinantes sociodemográficos y socioeconómicos condicionan el tipo de ocupación y las condiciones laborales, las cuales configuran el entorno alimentario, el tiempo disponible para comer y el sueño, que actúan como mediadores proximales de los patrones dietéticos. Las flechas discontinuas representan efectos directos no mediados por factores laborales. El estado nutricional (IMC y circunferencia de cintura) se plantea como variable consecuente analizada de forma asociativa en un diseño transversal.

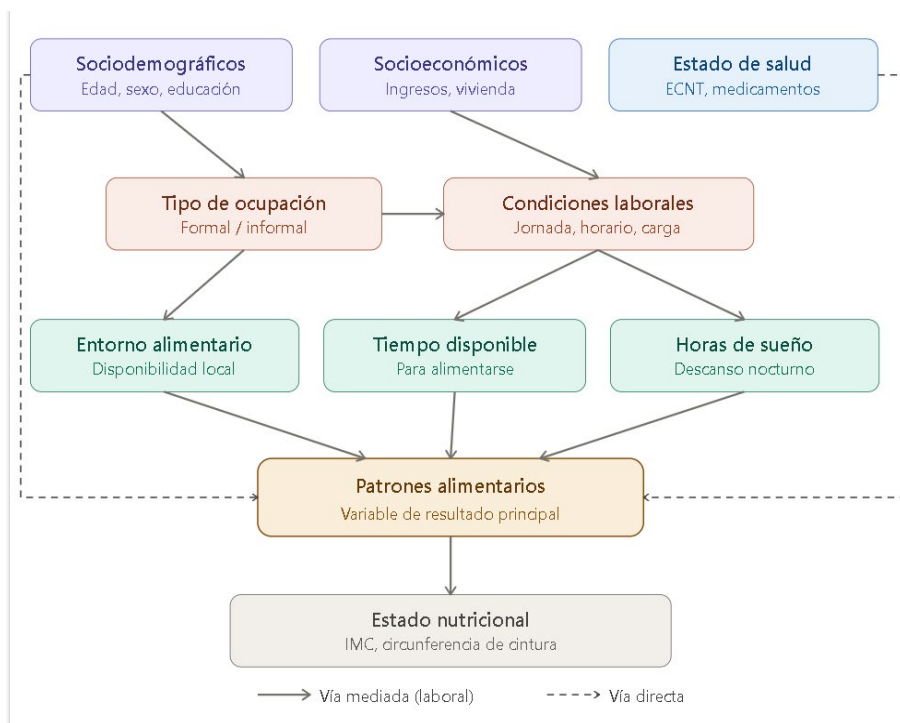
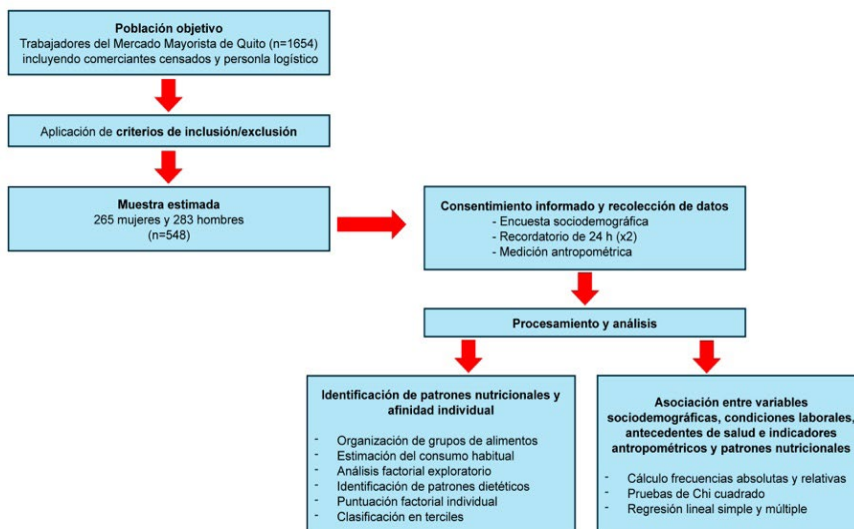


Figura 2. Esquema del flujo metodológico propuesto para el estudio



STEPS Ecuador 2018 (67,4% en mujeres; 59,7% en hombres)⁹, se obtuvo una muestra de 265 mujeres y 283 hombres (n=548).

No obstante, dado que la variable principal corresponde a patrones alimentarios derivados de análisis factorial exploratorio, la suficiencia muestral se fundamenta principalmente en criterios de estabilidad factorial. Con 18 grupos de alimentos preespecificados como variable de entrada¹⁰, la relación sujeto-variable proyectada es de 30:1, superando el umbral recomendado de 10:1 y clasificándose como “muy buena” para la estabilidad factorial según Hair. et al¹¹. La adecuación muestral será confirmada formalmente mediante el índice Kaiser-Meyer-Olkin (KMO) y la prueba de esfericidad de Bartlett una vez completada la recolección de datos.

Dado que no existe un marco muestral nominal completo que incluya al personal logístico informal, se empleará muestreo no probabilístico por conveniencia. Para reducir la sobrerrepresentación de un único subgrupo ocupacional, el reclutamiento se organizará considerando los principales grupos ocupacionales y distintas franjas horarias de actividad.

La muestra no pretende ser estadísticamente representativa, sino capturar la variabilidad existente en los principales grupos ocupacionales del mercado. En consecuencia, los resultados no serán interpretados como estimaciones representativas de toda la población trabajadora ni extrapolables a otros contextos. Los análisis de asociación tendrán carácter exploratorio y no inferencial, tal como se detalla en la sección de limitaciones.

Criterios de inclusión y exclusión: Se incluirán trabajadores adultos del Mercado Mayorista de Quito que desarrollen actividad laboral continua en el recinto y que otorguen su consentimiento informado por escrito para participar en el estudio.

Se excluirán trabajadoras embarazadas, debido a que esta condición puede modificar los patrones alimentarios y los requerimientos nutricionales, así como trabajadores que presenten limitaciones físicas o cognitivas que impidan proporcionar información válida para las variables de estudio.

Procedimientos

Reclutamiento: El reclutamiento se realizará in situ durante jornadas previamente planificadas. Se invitará a participar a los trabajadores presentes en el recinto que cumplan con los criterios de inclusión. A cada participante se le explicará el propósito del estudio, los procedimientos a realizar y las condiciones de participación. Posteriormente, se solicitará la firma del consentimiento informado por escrito. Solo se incluirán en la muestra aquellos trabajadores que acepten participar voluntariamente y autoricen la recolección de sus datos.

Evaluación sociodemográfica: Se aplicará una encuesta estructurada de elaboración propia, diseñada a partir de variables utilizadas en estudios previos de patrones alimentarios en población ecuatoriana¹⁰, adaptada al contexto laboral del Mercado Mayorista de Quito. El instrumento será sometido a prueba piloto previa para

evaluar comprensión, pertinencia y consistencia interna.

Este instrumento recogerá información sociodemográfica (edad, sexo, nivel educativo, estado civil, tipo de vivienda e ingresos económicos), laboral (ocupación, horario, jornada diaria y semanal) y de salud (horas de sueño, presencia de enfermedades crónicas no transmisibles autorreportadas, uso habitual de medicamentos y antecedentes familiares de enfermedades crónicas). La aplicación será realizada por personal capacitado, en un espacio habilitado dentro del recinto, garantizando privacidad.

Ingesta alimentaria: La evaluación del consumo dietético se realizará mediante recordatorios de 24 horas (IR24), administrados en formato presencial por personal capacitado. A cada participante se aplicarán dos recordatorios en días no consecutivos, incluyendo deliberadamente un día de semana y un día de fin de semana, dado que la ingesta varía sistemáticamente entre ambos períodos. Cada recordatorio seguirá el método de múltiples pasos de cinco etapas: (1) listado rápido de todos los alimentos y bebidas consumidos, (2) sondeo de alimentos olvidados, (3) organización por tiempo y ocasión de consumo, (4) recolección detallada y cuantificación de porciones mediante el manual fotográfico validado para Ecuador¹², y (5) revisión final para recuperación de omisiones. Este enfoque mejora la precisión del reporte dietético y reduce el subregistro.

La ingesta habitual será estimada mediante el Método de Múltiples Fuentes (MSM)^{13,14}, que corrige la variabilidad intraindividual a partir de los recordatorios de 24 horas. Como control de calidad, se realizará entrenamiento estandarizado del personal previo al trabajo de campo, aplicación de una encuesta piloto, supervisión directa durante las primeras jornadas de recolección y doble entrada de datos para verificación de consistencia. La concordancia inter-encuestador en mediciones antropométricas se evaluará mediante el coeficiente de correlación intraclase (CCI).

Dado el diseño del estudio, no se realizará una corrección específica del subregistro energético; sin embargo, este será considerado en la interpretación de los resultados como una limitación inherente al método de recordatorio de 24 horas.

Valoración antropométrica: La evaluación antropométrica incluirá la medición del peso corporal, la talla y la circunferencia de cintura. Estas mediciones se realizarán siguiendo protocolos estandarizados, utilizando equipos calibrados y validados.

El **peso corporal** se registrará con una balanza digital marca SECA® modelo 874, con precisión de 100 gramos, ubicada en superficie plana y nivelada. Los participantes serán medidos sin calzado y con ropa ligera. La **talla** se medirá utilizando un tallímetro portátil de la misma marca modelo 213, con una precisión de 0,1 cm, asegurando que el participante esté en posición anatómica correcta (posición de Frankfort). A partir de estas mediciones se calculará el índice de masa corporal (IMC).

La **circunferencia de cintura** se tomará con una cinta métrica inextensible, posicionada en el punto medio entre el borde inferior de la última costilla y la cresta ilíaca, al final de una espiración normal. Las mediciones se realizarán por duplicado, y si hay discrepancias mayores a 0,5 cm (en talla o cintura) o 0,1 kg (en

peso), se tomará una tercera medición. Se utilizará el promedio de las dos mediciones más cercanas¹⁵.

Todos los procedimientos serán realizados por personal entrenado, en condiciones de privacidad y siguiendo medidas de bioseguridad. Los datos se registrarán en formularios estructurados y serán integrados en una base de datos única para su análisis.

Variables del estudio

La variable principal del estudio será el patrón alimentario, definido a partir de la ingesta habitual de grupos de alimentos estimada mediante recordatorios de 24 horas y derivada mediante análisis factorial exploratorio (componentes principales). Los patrones serán expresados como puntuaciones factoriales continuas y categorizados en terciles para su análisis descriptivo.

Como variables asociadas se considerarán variables sociodemográficas, laborales, de salud y antropométricas, seleccionadas en función del modelo conceptual del estudio. Estas variables permitirán caracterizar a los participantes y explorar su relación con los patrones alimentarios identificados.

Las variables sociodemográficas (edad, sexo, nivel educativo, ingresos y tipo de vivienda) se considerarán determinantes distales; las variables laborales (ocupación, horario y carga de trabajo) actuarán como factores intermedios; y las variables de salud y antropométricas (horas de sueño, enfermedades crónicas, índice de masa corporal y circunferencia de cintura) serán analizadas como variables concurrentes dentro del diseño transversal.

La [Tabla 1](#) presenta el conjunto de variables incluidas en el estudio y su definición operacional, de acuerdo con las dimensiones consideradas.

Plan de análisis

Los datos recogidos en formularios físicos serán ingresados en una hoja de cálculo mediante doble entrada para verificación de consistencia. Para la identificación de patrones nutricionales se aplicarán los siguientes procedimientos: 1) Se organizarán grupos de alimentos según su valor nutricional o lógica de consumo. 2) Se utilizará el método Múltiple Source Method (MSM) que permite estimar el consumo habitual ajustando la variabilidad intraindividual a partir de los recordatorios de 24 horas^{13,14}. 3) Las variables de entrada al PCA serán estandarizadas a puntajes z. 4) Previo al análisis factorial, se evaluará la adecuación muestral mediante el índice KMO y la prueba de esfericidad de Bartlett. 5) Se aplicará análisis factorial exploratorio mediante componentes principales con rotación Varimax¹⁶. 6) El número de factores a retener se determinará combinando tres criterios: eigenvalor >1,5, gráfico de sedimentación (*scree plot*) y plausibilidad interpretativa^{11,16,17}. 7) Se conservarán en cada factor los grupos de alimentos con cargas factoriales $\geq 0,25$ ¹⁷. 8) Las puntuaciones factoriales individuales se calcularán mediante el método de Bartlett¹⁷ y se clasificarán

en terciles para determinar la afinidad de cada participante con cada patrón¹⁷. 9) Como análisis de sensibilidad se compararán soluciones con dos, tres y cuatro factores retenidos.

Para explorar las asociaciones entre las variables sociodemográficas, condiciones laborales, de salud e indicadores antropométricos con los patrones alimentarios: 1) Se calcularán frecuencias absolutas y relativas de las variables de interés. 2) Se empleará la prueba Chi cuadrado para analizar diferencias en la distribución de características según terciles de adherencia a los patrones. 3) Se utilizarán modelos de regresión lineal para explorar asociaciones entre variables explicativas y las puntuaciones factoriales. Todas las variables con $p < 0,20$ en el análisis bivariado se incluirán en el modelo multivariado¹⁸. La construcción de modelos seguirá la jerarquía conceptual establecida en el modelo teórico del estudio ([Figura 1](#)), distinguiendo determinantes distales, variables intermedias mediadoras y factores laborales. Se evaluarán los supuestos del modelo: normalidad de residuos (Shapiro-Wilk), homocedasticidad (Breusch-Pagan) y multicolinealidad (VIF, umbral >10). 4) Como análisis secundario se realizará estratificación por sexo. 5) El análisis principal se realizará sobre casos completos; se reportará el número y características de los participantes excluidos por datos faltantes para evaluar el potencial sesgo de selección. Los análisis estadísticos se realizarán utilizando el lenguaje de programación R¹⁹.

Consideraciones éticas

El estudio se conducirá conforme a los principios establecidos en la Declaración de Helsinki y la normativa nacional vigente.

Todos los participantes firmarán un consentimiento informado por escrito antes de su inclusión en el estudio, garantizando su participación voluntaria y su derecho a retirarse en cualquier momento sin repercusiones.

Los datos recolectados serán tratados con estricta confidencialidad y utilizados exclusivamente con fines de investigación. En caso de identificarse hallazgos relevantes para la salud, los participantes serán informados y referidos a servicios de atención médica o nutricional, sin que esto sustituya la atención clínica formal.

Los datos serán almacenados en formato digital con acceso restringido mediante contraseña y respaldo en servidor institucional seguro. Los formularios físicos serán resguardados bajo llave en la Universidad Central del Ecuador. Cada participante será identificado mediante un código numérico, garantizando la seudonimización de la información y la disociación entre identidad y datos de investigación.

Los datos se conservarán durante cinco años tras la publicación del estudio. El acceso a la base de datos estará disponible bajo solicitud justificada a la autora de correspondencia, sujeto a evaluación ética y a las restricciones derivadas de la naturaleza sensible de la información recolectada.

Tabla 1. Variables del estudio y su operacionalización en trabajadores del Mercado Mayorista de Quito

Dimensión	Variable	Definición operacional	Tipo de variable
Nutricional (variable principal)	Patrón alimentario	Conjunto de patrones dietéticos identificados a partir del análisis factorial exploratorio aplicado a la ingesta habitual de alimentos y nutrientes	Continua (puntuación factorial) y categórica (terciles)
Sociodemográfica	Edad	Años cumplidos al momento de la encuesta	Continua
Sociodemográfica	Sexo	Sexo biológico autorreportado (hombre/mujer)	Categórica dicotómica
Sociodemográfica	Nivel educativo	Sin instrucción / Primaria / Secundaria / Superior	Ordinal
Sociodemográfica	Estado civil	Soltero/a / Casado o unión libre / Separado, divorciado o viudo	Categórica
Sociodemográfica	Ingresos económicos	Ingreso económico mensual autorreportado	Continua / categórica
Sociodemográfica	Tipo de vivienda	Tipo de vivienda habitual del participante	Categórica
Laboral	Ocupación	Tipo de actividad desempeñada dentro del mercado (comerciante, personal logístico u otros)	Categórica
Laboral	Horario de trabajo	Horario habitual de inicio y finalización de la jornada laboral	Categórica
Laboral	Jornada laboral diaria	Número de horas trabajadas por día	Continua
Laboral	Jornada laboral semanal	Número total de horas trabajadas por semana	Continua
Salud	Horas de sueño	Promedio de horas de sueño por noche autorreportadas	Continua
Salud	Enfermedades crónicas no transmisibles	Presencia autorreportada de diagnóstico médico previo de enfermedades crónicas no transmisibles	Categórica dicotómica
Salud	Uso habitual de medicamentos	Consumo regular de medicamentos al momento del estudio	Categórica dicotómica
Salud	Antecedentes familiares	Antecedentes familiares autorreportados de enfermedades crónicas relevantes	Categórica
Antropométrica	Peso corporal	Peso corporal medido en kilogramos según protocolo estandarizado	Continua
Antropométrica	Talla	Estatura medida en centímetros según protocolo estandarizado	Continua
Antropométrica	Índice de masa corporal (IMC)	Relación entre peso (kg) y talla (m ²)	Continua / categórica
Antropométrica	Circunferencia de cintura	Medida en centímetros tomada en el punto anatómico estandarizado	Continua

Nota: Salvo indicación contraria, todas las variables se obtendrán mediante encuesta sociodemográfica estructurada. Las variables antropométricas se medirán con equipos calibrados según protocolo estandarizado.

RESULTADOS ESPERADOS

Se espera identificar uno o más patrones alimentarios predominantes en los trabajadores del Mercado Mayorista de Quito, a partir del análisis de la ingesta habitual de alimentos estimada mediante recordatorios de 24 horas. Estos patrones se definirán mediante análisis factorial exploratorio con rotación ortogonal, y las puntuaciones factoriales permitirán caracterizar a los participantes según su afinidad a cada patrón.

Asimismo, se espera describir posibles asociaciones entre los patrones alimentarios identificados y variables sociodemográficas (edad, sexo, nivel educativo, estado civil, ingresos y tipo de vivienda), laborales (ocupación, tipo y duración de jornada laboral), de salud (horas de sueño, enfermedades crónicas no transmisibles, uso de medicamentos y antecedentes familiares) y antropométricas (índice de masa corporal y circunferencia de cintura).

Dado el carácter exploratorio del estudio, estas asociaciones serán interpretadas como relaciones observadas en un mismo momento de medición, sin inferencia causal ni representatividad poblacional. Los resultados permitirán caracterizar el perfil alimentario de una población laboral expuesta a condiciones de vulnerabilidad y generar evidencia descriptiva útil para orientar futuras investigaciones y el diseño de intervenciones adaptadas a contextos similares.

DISCUSIÓN

Los entornos laborales determinan no solo las condiciones de vida, sino también los hábitos alimentarios de la población económicamente activa. Esta influencia es especialmente marcada en contextos donde se combinan precariedad laboral, exigencia física y escasa disponibilidad de alimentos saludables, como ocurre en los mercados mayoristas de América Latina^{5,6}. Sin embargo, pese a su importancia estratégica en el sistema alimentario urbano, estos espacios han sido poco estudiados desde la perspectiva de la nutrición poblacional.

Diversos estudios han demostrado que los patrones alimentarios están fuertemente modulados por factores estructurales, especialmente los determinantes sociales y laborales^{4,20}. En poblaciones con condiciones laborales precarias, como las que enfrentan inseguridad alimentaria, bajos ingresos o jornadas extensas, la dieta tiende a caracterizarse por baja diversidad alimentaria, particularmente en el consumo de frutas y verduras, menor ingesta de proteínas de alto valor biológico y micronutrientes como hierro, zinc y vitaminas del complejo B, y predominio de hidratos de carbono simples procedentes de cereales refinados, pan y bebidas azucaradas⁵. Estas características no solo limitan el acceso físico y económico a alimentos saludables, sino que reflejan inequidades estructurales que influyen directamente en el estado nutricional y metabólico de los trabajadores.

Desde el punto de vista metodológico, se propone el uso del recordatorio de 24 horas (IR24) administrado en días no consecutivos, ajustado mediante el método Multiple Source Method (MSM), el cual permite estimar la ingesta habitual corrigiendo la variabilidad intraindividual^{13,14}. Combinado con el análisis factorial de componentes principales, este enfoque permite identificar patrones dietéticos presentes en esta población, y ha sido ampliamente utilizado en estudios de epidemiología nutricional^{16,17}.

El uso del manual fotográfico de porciones validado para el contexto ecuatoriano¹² y la capacitación estandarizada del personal de campo contribuyen a reducir la variabilidad en la estimación de porciones, aunque no eliminan el sesgo de recuerdo ni el subregistro diferencial inherentes al método de recordatorio de 24 horas.

Esta metodología ha sido validada en poblaciones latinoamericanas y en otro grupo poblacional del Ecuador¹⁰, y se adapta a entornos con recursos limitados, como el presente caso.

El presente estudio presenta limitaciones que deben considerarse al interpretar sus resultados. En cuanto a la validez interna, el recordatorio de 24 horas está sujeto a sesgo de recuerdo, que se mitiga mediante el método de múltiples pasos con sondeo activo de alimentos olvidados, aunque no puede eliminarse completamente. El posible subregistro diferencial de la ingesta según IMC constituye una limitación adicional: dado que el estudio no contempla medición objetiva del gasto energético, este sesgo no puede cuantificarse directamente y podría afectar de forma diferencial las variables de entrada al análisis factorial en participantes con obesidad. Respecto a la confusión residual, si bien el modelo conceptual pre-especificado (Figura 1) orienta la construcción jerárquica de los modelos de regresión, variables no medidas como preferencias alimentarias previas, cultura alimentaria familiar o acceso a comedores externos al recinto no podrán controlarse en este diseño. En cuanto a la validez externa, el muestreo no probabilístico por conveniencia limita la generalización a los trabajadores disponibles durante las jornadas de recolección, sin posibilidad de extrapolación a otros contextos. Adicionalmente, el tamaño muestral se calculó sobre la base de los comerciantes formales censados, mientras que la selección incluirá también personal logístico informal; esta discrepancia implica que el n calculado podría no representar óptimamente la heterogeneidad ocupacional del recinto, por lo que los resultados referentes al personal informal deberán interpretarse con cautela. Dado el diseño transversal y el muestreo no probabilístico, los hallazgos deberán interpretarse como asociaciones exploratorias observadas en un mismo momento de medición, sin inferencia causal ni representatividad poblacional.

Por tanto, se espera que este estudio no solo caracterice los patrones alimentarios predominantes entre los trabajadores del Mercado Mayorista de Quito, sino que también contribuya a visibilizar una realidad poco documentada, generando evidencia útil para la planificación de intervenciones adaptadas a entornos urbanos vulnerables en América Latina.

La literatura actual respalda la efectividad de estrategias de intervención en el entorno laboral para promover hábitos saludables y reducir el riesgo metabólico²¹. De esta manera, este protocolo se enmarca en una agenda de salud pública que reconoce la alimentación como un derecho socialmente condicionado, y el trabajo como un determinante clave del entorno nutricional⁵.

CONCLUSIONES

Este protocolo plantea un estudio necesario para caracterizar los patrones alimentarios y sus factores asociados en una población laboral urbana expuesta a condiciones de vulnerabilidad estructural. A través de una metodología validada y contextualizada, se espera aportar evidencia descriptiva sobre la relación entre alimentación, condiciones laborales y salud nutricional en trabajadores del Mercado Mayorista de Quito.

Dado el diseño del estudio, los hallazgos se interpretarán como asociaciones exploratorias, sin inferencia causal ni representatividad poblacional. Los resultados podrán servir como base para el diseño de intervenciones adaptadas al entorno laboral y para la formulación de políticas públicas que aborden las desigualdades alimentarias en contextos similares.

CONTRIBUCIÓN DE AUTORÍA

P.T-P., C.D. y S.V-M. participaron en la conceptualización y diseño general del estudio. P.T-P. y S.V-M. elaboraron el plan de análisis estadístico. J.M. y M.J.C. contribuyeron al diseño de instrumentos y a la planificación logística del estudio. C.D. gestionó los trámites administrativos necesarios para la aprobación del protocolo. K.H. facilitó el acceso al entorno de estudio y brindó apoyo institucional clave. Todos los autores participaron en la búsqueda bibliográfica. P.T-P. redactó el primer borrador del manuscrito. Todos los autores revisaron críticamente el contenido y aprobaron la versión final.

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CONFLICTO DE INTERESES

Los autores expresan que no existen conflictos de interés al redactar el manuscrito.

DISPONIBILIDAD DE DATOS

Ofrecimiento de datos bajo petición a la autora de correspondencia.

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