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Revista Española de Nutrición Humana y Dietética

Spanish Journal of Human Nutrition and Dietetics



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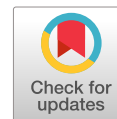
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EDITORIAL

Impulsar el sistema alimentario mediante la transferencia tecnológica: una llamada a la colaboración entre ciencia e industria

➤ Advancing the food system through technology transfer: a call for collaboration between science and industry

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En los últimos años, la producción científica en el campo de la tecnología de alimentos ha experimentado un crecimiento notable. Temas que a priori presentaban un menor interés científico como el desarrollo de ingredientes o alimentos funcionales¹ (alimentos fermentados, compuestos bioactivos, prebióticos, antioxidantes naturales), las proteínas alternativas², las tecnologías verdes de procesamiento³ o la sostenibilidad en la producción⁴, han ganado protagonismo en la literatura científica y en foros internacionales de innovación alimentaria.

Universidades y centros de investigación en Europa y otras regiones han impulsado proyectos que promueven la reformulación saludable de alimentos, valorización de subproductos y desechos orgánicos agroalimentarios, y la optimización de procesos para reducir el impacto ambiental. Sin embargo, la realidad indica que el paso de la teoría a la práctica sigue siendo limitado.

A pesar de su potencial transformador, gran parte de estos avances permanecen en fases de laboratorio, tesis doctorales o publicaciones científicas, sin llegar a convertirse en desarrollos industriales concretos. De hecho, solo una pequeña fracción de la investigación científica se traduce en productos reales o en innovaciones implementadas por la industria alimentaria tradicional. Un ejemplo claro es el uso de desechos orgánicos de cáscara de banana para la fabricación de productos alimentarios que fue probado y aceptado organolépticamente, y a pesar de su potencial académico, no ha podido ser traducido a usos comerciales reales.

Este desfase refleja una problemática estructural: la transferencia tecnológica (entendida como el conjunto de mecanismos que facilitan la aplicación práctica de la investigación científica en el tejido productivo) no está funcionando con la eficacia necesaria. Faltan estructuras intermedias, incentivos adecuados y un lenguaje compartido que permita la colaboración efectiva entre quienes investigan y quienes transforman ese conocimiento en soluciones reales. Además, muchas empresas, especialmente las pequeñas y medianas, carecen del acceso y la capacidad técnica para absorber o escalar nuevas tecnologías.

Ante esta realidad, surgen preguntas fundamentales: ¿Qué obstáculos impiden que los avances en ingredientes funcionales, envases sostenibles o proteínas alternativas lleguen con fluidez a la industria y, en última instancia, al consumidor? ¿Se han establecido canales de comunicación eficaces entre el ámbito académico y el sector empresarial, o persiste una desconexión estructural entre ambos mundos? ¿Qué rol juegan las estructuras institucionales y los ecosistemas de innovación en facilitar, o dificultar, la transferencia tecnológica en el ámbito alimentario? ¿Está la industria realmente dispuesta a asumir riesgos e incorporar avances científicos cuya rentabilidad aún no ha sido probada? ¿Estamos formando profesionales con perfiles híbridos capaces de tender puentes entre la ciencia y la innovación industrial, o seguimos preparando talento en mundos paralelos? Estas preguntas buscan abrir un debate necesario sobre una realidad compleja ya que identificar las barreras es el primer paso

para superarlas. Solo a través de una mirada crítica, colaborativa e interdisciplinaria podremos avanzar hacia un sistema alimentario en el que la innovación científica no se quede en el laboratorio, sino que transforme productos, procesos y, en definitiva, vidas.

A pesar de los desafíos, existen ejemplos alentadores que demuestran que la conexión entre ciencia e industria es posible y puede generar impactos reales. Un ejemplo representativo es el auge de empresas que desarrollan productos plant-based, diseñados no solo para imitar las características sensoriales de los productos animales, sino también para mejorar su perfil nutricional y reducir su huella ambiental. Start-ups como Heura (España)⁵, NotCo (Chile)⁶ o Next Meats (Japón)⁷ han trabajado estrechamente con investigadores para desarrollar matrices proteicas vegetales de alto valor biológico, bajo contenido en grasas saturadas y utilizando tecnologías de extrusión innovadoras.

También han surgido proyectos centrados en la modulación de la microbiota intestinal mediante alimentos funcionales. Empresas como ADM Biopolis⁸ especializada en el desarrollo de cepas probióticas y análisis metagenómico para la formulación de alimentos funcionales y suplementos.

Otro caso notable es el de las tecnologías emergentes como el cultivo celular y la fermentación de precisión, desarrolladas por start-ups como CubiqFoods⁹, en colaboración con universidades y centros tecnológicos. Estas iniciativas buscan crear grasas saludables o carne cultivada sin comprometer sabor, textura o seguridad alimentaria, a partir de rigurosos avances en bioquímica e ingeniería de alimentos.

Todos estos ejemplos presentan un denominador común: la ciencia no solo ha sido el punto de partida, sino el motor continuo de la innovación. La conexión entre el laboratorio y la planta de producción ha sido posible gracias a equipos interdisciplinarios, acceso a financiación orientada al impacto, y, sobre todo, una visión compartida entre investigadores, emprendedores y tecnólogos.

La clave del éxito ha sido identificar problemas reales —como la necesidad de proteínas sostenibles o de mejorar la salud digestiva a través de la dieta— y aplicar el conocimiento científico para ofrecer soluciones viables, escalables y atractivas para el consumidor.

¿Pueden estas experiencias servir de modelo para futuras colaboraciones? ¿Está el ecosistema industrial preparado para escalar este tipo de iniciativas? Parte de la respuesta dependerá de las alianzas que seamos capaces de construir entre ciencia, industria y políticas públicas.

Considerando estas fortalezas, limitaciones, pero también oportunidades, desde el comité editorial de RENHyD invitamos a la comunidad científica y profesional a seguir investigando y compartiendo sus avances en el desarrollo de nuevos alimentos, ingredientes y procesos sostenibles, con el convencimiento de que cada publicación rigurosa puede ser la chispa que inspire a la industria a innovar y transformar el sistema alimentario en beneficio de la salud y del medio ambiente.

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EDITORIAL

Alfabetización alimentaria centrada en las personas mayores desde un enfoque de derechos: la geragogía como desafío para la práctica clínica y comunitaria

➤ Food literacy focused on older adults from a human rights approach: geragogy as a challenge for clinical and community practice

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La población mundial está experimentando un envejecimiento acelerado, proceso natural y progresivo que conlleva alteraciones en diversas funciones fisiológicas del organismo y que se expresa en una pérdida gradual de la funcionalidad, lo que a su vez incrementa la dependencia de los individuos¹. En este escenario, los estilos de vida, y en especial, la alimentación y nutrición, adquieren un papel central, no sólo en términos de salud física, sino también como componentes esenciales de la calidad de vida, la autonomía y la dignidad². Sin embargo, persiste una brecha importante: las intervenciones alimentarias y educativas dirigidas a las personas mayores suelen basarse en modelos verticales y prescriptivos más que participativos³. Esto podría invisibilizar la voz, los significados, los saberes y las trayectorias vitales de quienes envejecen. Frente a esta realidad, la alfabetización alimentaria centrada en la persona mayor y sustentada en un enfoque de derechos ofrece un camino renovado y transformador para el bienestar en este grupo de personas.

La alfabetización alimentaria se define como el conjunto de conocimientos, habilidades y competencias que capacitan a los individuos para tomar decisiones informadas y críticas respecto a su alimentación, independientemente de la etapa del curso de vida en la que se encuentren⁴. Es una consecuencia del proceso educativo y tiene como objetivo centrarse en la persona, en el mensaje que recibe y en los recursos de los que dispone; desde una perspectiva de intervención, deben considerarse tres actores clave: los entornos, los profesionales de la salud y las propias personas⁵. No se trata de entregar información o recomendar conductas, sino de promover procesos de participación activa en los que la persona mayor pueda decidir y co-construir sus necesidades formativas⁶. En este sentido, la alimentación no se concibe sólo como un acto biológico, sino como un fenómeno social y cultural que se entrelaza con identidades, memorias y contextos comunitarios, y que puede influir en las prácticas clínicas y comunitarias, avanzando hacia una atención más humanizada, respetuosa y valorada por las personas mayores.

La educación para la alfabetización alimentaria no puede abordarse con los mismos métodos utilizados en la educación infantil o juvenil. En este punto cobra especial relevancia la andragogía, que enfatiza el aprendizaje adulto y reconoce la experiencia acumulada, la necesidad de pertinencia práctica y la motivación intrínseca de las personas⁷. En el caso de las personas mayores, de manera más reciente, se está acuñando el término "geragogía" para referirse al campo de estudio y práctica educativa centrado en la persona mayor y su proceso de enseñanza y aprendizaje. La geragogía permite reconocer necesidades biopsicosociales propias del envejecimiento, por lo que las estrategias educativas deben fomentar la participación activa, la personalización y la relevancia de los contenidos, así como el desarrollo integral y el fortalecimiento de la autonomía y el bienestar, todo ello adaptado a los contextos reales personales, familiares y comunitarios en este grupo poblacional⁸.

El enfoque de derechos puede situar a la alimentación en un plano normativo y ético, cimentado en el reconocimiento de la

Organización de las Naciones Unidas (ONU) del derecho humano a una alimentación adecuada como principio fundamental⁶. Aplicar este marco en la geragogía, la gerontología y la nutrición, implica superar visiones asistencialistas y reconocer a las personas mayores como titulares de derechos, capaces de exigir condiciones que garanticen su acceso, disponibilidad y disfrute de alimentos culturalmente apropiados y nutritivos⁹. Esto requiere, además, del compromiso de los Estados, instituciones, comunidades y profesionales de la salud en el diseño e implementación de políticas, programas y prácticas inclusivas que no reproduzcan edadismo ni enmascarar las diversidades.

La geragogía, para el logro de sus objetivos, debe responder a una necesidad de alfabetización alimentaria que emane de las personas mayores en un marco de respeto a sus derechos. La aplicación práctica del enfoque de derechos requiere de cambios en la formación y en el quehacer de nutricionistas y otros agentes sanitarios. Estos aprendizajes deben partir de la comprensión de que las acciones destinadas a la enseñanza de una alimentación saludable han de orientarse hacia la co-construcción de saberes, tradiciones y costumbres locales, lo que potencia un aprendizaje dialógico y bidireccional, centrado en la persona mayor y sustentado en un enfoque de derechos.

En la atención clínica, este cambio implica transitar de una prescripción de dietas estandarizadas a la construcción de planes alimentarios personalizados, elaborados en diálogo con la persona mayor y su entorno familiar. Supone también reconocer y validar el papel de los cuidadores y del equipo interdisciplinar, incorporando dimensiones emocionales y sociales vinculadas a la alimentación. En el ámbito comunitario, la alfabetización alimentaria centrada en la persona mayor puede materializarse en talleres participativos, círculos de cocina intergeneracional, programas de compra y consumo responsable, o iniciativas de huertos comunitarios, que refuercen tanto la autonomía como el tejido social.

El rol de los y las nutricionistas-dietistas en los equipos interdisciplinarios debe trascender a la comunicación en estilos de vida saludables y asumir una función facilitadora que promueva la reflexión crítica y el empoderamiento de las personas mayores. Este cambio de paradigma requiere de competencias geragógicas y éticas, además de un compromiso activo con la justicia social y la equidad en salud. Como agentes sanitarios, debemos comprender que las intervenciones basadas en un enfoque de derechos no son opcionales, sino obligaciones derivadas de marcos normativos vigentes en países de Iberoamérica¹⁰.

La Revista Española de Nutrición Humana y Dietética propone fortalecer la práctica profesional mediante una alfabetización alimentaria centrada en las personas mayores y orientada por un enfoque de derechos. Esta perspectiva promueve la innovación en políticas públicas, investigación y colaboración interinstitucional para vincular la alimentación con la inclusión, el bienestar y la ciudadanía en el envejecimiento.

Las personas mayores no deben ser vistas como destinatarios pasivos de programas alimentarios y nutricionales, sino como

protagonistas de su propio proceso de aprendizaje y decisión alimentaria. Integrar el modelo centrado en la persona, el enfoque de derechos, la alfabetización alimentaria y la geragogía constituye una oportunidad única para transformar la práctica clínica y comunitaria en nutrición gerontológica. Se trata de avanzar hacia intervenciones más humanas, participativas y sostenibles, capaces de responder a los desafíos de la longevidad y de garantizar el derecho a una alimentación adecuada en todas las etapas de la vida.

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Todos los autores participaron en la concepción, redacción del manuscrito y aprobaron la versión final del mismo.

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CONFLICTO DE INTERÉS

Los autores son editores asociados de la Revista Española de Nutrición Humana y Dietética (RENHYD).

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ARTÍCULO DE INVESTIGACIÓN

Efectividad clínica de la dieta cetogénica complementada con fórmula en polvo como coadyuvante en niños con epilepsia refractaria: estudio de vida real

Clinical effectiveness of ketogenic diet supplemented with powdered formula as an adjuvant in children with refractory epilepsy: a real-world study

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PALABRAS CLAVE

Epilepsia refractaria
Dieta cetogénica
Pediatria
Crisis epilépticas
Colombia

RESUMEN

Introducción: La epilepsia refractaria en la infancia representa un desafío terapéutico, con alta carga clínica y social. La terapia dietética cetogénica (TDC), incluyendo fórmulas nutricionales con proporción 4:1, ha demostrado eficacia como tratamiento coadyuvante.

Objetivo: Evaluar la efectividad, seguridad y tolerabilidad de la TDC complementada con fórmula cetogénica en polvo (KetoCal® 4:1) durante 12 meses de seguimiento en niños con epilepsia refractaria en un centro especializado en Colombia.

Métodos: Estudio observacional de cohorte retrospectiva. Se incluyeron 25 pacientes pediátricos con epilepsia refractaria, en quienes se indicó TDC como parte del manejo clínico habitual. El desenlace principal fue la reducción en la frecuencia mensual de crisis. Se analizaron también hospitalizaciones, cambios farmacológicos, evolución nutricional y eventos adversos. Se utilizaron pruebas de Wilcoxon, modelos lineales mixtos y correlación de Spearman.

Resultados: La mediana de crisis mensuales disminuyó de 60 a 1 en 12 meses ($p=0,001$). El 60% de los pacientes alcanzó una respuesta excelente ($\geq 90\%$ de reducción) y el 44% obtuvo control total de crisis. Se redujeron hospitalizaciones (de 36% a 16%) y la carga farmacológica (40% de los pacientes). El estado nutricional mejoró en 50% de los casos con desnutrición inicial. Se reportaron eventos adversos leves en el 56%, predominantemente gastrointestinales, sin suspensiones del tratamiento. La alta frecuencia basal de crisis se asoció con mejor respuesta terapéutica ($p=0,01$).

Conclusiones: La TDC complementada con fórmula tecnificada mostró una reducción sostenida en la frecuencia de crisis y fue bien tolerada en pacientes que completaron el seguimiento. Se asoció con beneficios adicionales en hospitalizaciones, manejo farmacológico y estado nutricional. Su implementación es factible en contextos con recursos limitados, siempre que exista un seguimiento especializado y multidisciplinario.

Financiación: Danone Baby Nutrition Colombia financió los costos asociados al análisis de datos y al apoyo editorial proporcionado por la consultora externa EpiThink Health Consulting. Los pacientes incluidos en el estudio fueron atendidos en el centro asistencial FUNDEM IPS. Los patrocinadores no tuvieron participación en el diseño del estudio, el análisis de los datos ni en la redacción del manuscrito.

KEYWORDS

Refractory epilepsy

Ketogenic diet

Pediatrics

Seizure control

Colombia

ABSTRACT

Background: Refractory epilepsy in childhood poses a significant therapeutic challenge, with high clinical and social burden. Ketogenic dietary therapy (KDT), including 4:1 ketogenic powder formula, has shown efficacy as adjunctive treatment.

Objective: To evaluate the effectiveness, safety, and tolerability of KDT supplemented with powdered ketogenic formula (KetoCal® 4:1) over 12 months in children with refractory epilepsy at a specialized center in Colombia.

Methods: Retrospective cohort observational study. Twenty-five pediatric patients with refractory epilepsy receiving KDT were included. The main outcome was the change in monthly seizure frequency. Secondary outcomes included hospitalizations, antiepileptic drug adjustments, nutritional status evolution, and adverse events. Statistical analysis included Wilcoxon tests, linear mixed-effects models, and Spearman correlation.

Results: The median number of monthly seizures decreased from 60 to 1 at 12 months ($p = 0.001$). An excellent response ($\geq 90\%$ reduction in seizure frequency) was achieved in 60% of patients, and 44% achieved complete seizure control. Hospitalizations decreased from 36% to 16%, and 40% of patients reduced their antiepileptic drug burden. Nutritional status improved in 50% of initially malnourished patients. Mild adverse events occurred in 56% of cases, mostly gastrointestinal, with no treatment discontinuations. A higher baseline seizure frequency was significantly associated with a better response ($p = 0.01$).

Conclusions: KDT supplemented with a specialized ketogenic formula achieved sustained seizure reduction and was well tolerated among patients completing follow-up. Additional benefits included fewer hospitalizations, reduced pharmacological load, and improved nutritional status. This strategy is feasible in low-resource settings, provided structured, multidisciplinary follow-up is ensured.

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MENSAJES
CLAVE

1. La suplementación con fórmula cetogénica tecnificada permitió individualizar y sostener la terapia dietética cetogénica en niños con epilepsia refractaria, incluso en contextos de discapacidad neurológica y comorbilidades nutricionales.
2. La alta frecuencia basal de crisis se identificó como un predictor clínico útil de respuesta excelente al tratamiento dietético, lo cual puede orientar la selección de pacientes candidatos a esta intervención.
3. La reducción en la carga farmacológica y en las hospitalizaciones sugiere que la dieta cetogénica puede aportar beneficios más allá del control convulsivo, con potencial impacto en la calidad de vida y en el uso de recursos sanitarios.
4. El protocolo de implementación local, basado en seguimiento multidisciplinario continuo, muestra que esta intervención es viable y segura en entornos de recursos limitados, siempre que se garantice estructura, monitoreo y adaptación individualizada.

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INTRODUCCIÓN

La epilepsia es uno de los trastornos neurológicos más frecuentes en la infancia, con una incidencia particularmente alta en menores de cinco años¹. Hasta un 30–40% de los niños afectados presenta discapacidades cognitivas y funcionales², lo que impacta negativamente el desempeño escolar y la participación en actividades sociales y recreativas³.

Aunque el tratamiento farmacológico constituye la base del manejo de la epilepsia, cerca de un tercio de los niños continúa presentando crisis a pesar del manejo farmacológico adecuado. En estos casos, se define epilepsia refractaria (ER) como la persistencia de crisis tras el uso secuencial de al menos dos fármacos antiepilépticos (FAE) bien indicados, en dosis apropiadas y con buena tolerancia⁴. Este tipo de epilepsia requiere intervenciones complementarias, dado su curso más severo y mayores costos sanitarios⁵.

La terapia con dieta cetogénica (TDC) se ha consolidado en las últimas décadas como una alternativa terapéutica válida para el manejo de la epilepsia refractaria. Esta intervención nutricional se basa en una ingesta elevada de grasas y una restricción significativa de carbohidratos, lo que induce un estado de cetosis en el que los cuerpos cetónicos se convierten en la principal fuente energética⁶. A nivel fisiopatológico, los cuerpos cetónicos atraviesan la barrera hematoencefálica y ejercen efectos anticonvulsivos y neuroprotectores mediante diversos mecanismos: modulación de canales iónicos (como los de potasio), reducción del estrés oxidativo, optimización del metabolismo mitocondrial y regulación de neurotransmisores clave como GABA y glutamato^{7–10}. Además, se ha descrito un efecto modulador sobre la microbiota intestinal, lo que podría contribuir adicionalmente al control de las crisis⁹.

Con el fin de facilitar la inducción y el mantenimiento de la cetosis, especialmente en pacientes con dificultades para adherirse a regímenes estrictos, se han desarrollado fórmulas nutricionales cetogénicas especializadas. En este contexto, el uso de fórmulas en polvo ha demostrado ser una opción eficaz, segura y bien tolerada en lactantes y niños con ER^{11,12}.

Las recomendaciones internacionales destacan la importancia de adaptar estos esquemas a las condiciones del paciente y su contexto y garantizar seguimiento continuo¹³. Esta necesidad es un desafío en las regiones con recursos limitados, donde deben garantizarse requisitos mínimos de factibilidad y viabilidad para la introducción y el seguimiento de la TDC cuando se indique¹⁴. En Colombia existen programas específicos para la implementación de la TDC con varios años de experiencia, sin embargo, la información publicada es escasa.

El objetivo de este estudio es evaluar la efectividad clínica de la terapia dietética cetogénica complementada con fórmula cetogénica 4:1 (KetoCal 4:1®), como tratamiento coadyuvante en niños con epilepsia refractaria, evaluando el cambio en la frecuencia de crisis epilépticas, el perfil de seguridad y la evolución del estado nutricional, en condiciones reales de práctica clínica en un centro especializado en Colombia.

METODOLOGÍA

Se llevó a cabo un estudio observacional de cohorte retrospectiva en un centro especializado en neurología pediátrica en Bogotá (FUNDEM IPS), Colombia, entre junio de 2019 y junio de 2020. La recolección de datos se realizó mediante la revisión de historias clínicas. Se incluyeron pacientes menores de 10 años con diagnóstico de epilepsia refractaria (ER), según los criterios de la Liga Internacional contra la Epilepsia (ILAE)¹⁵, que presentaban falla a dos o más fármacos antiepilépticos (FAE), frecuencia de crisis ≥ 4 por mes, y que recibieron tratamiento con terapia dietaria cetogénica (TDC) complementada con fórmula tecnificada como tratamiento coadyuvante, con un seguimiento clínico mínimo de 12 meses. Se excluyeron los casos con abandono precoz o con historias clínicas incompletas.

La TDC junto con la fórmula tecnificada fue indicada por el médico tratante dentro de la práctica clínica habitual de acuerdo con protocolos institucionales basados en las recomendaciones del Grupo Internacional de Estudio de Dietas Cetogénicas y guías para el manejo de la ER^{13,16} donde se hace énfasis en que la dieta debe ser adaptada individualmente según edad, estado nutricional, tolerancia digestiva y tipo de alimentación. La fórmula coadyuvante utilizada fue KetoCal® 4:1, con una proporción de 4:1 entre grasas y la suma de proteínas y carbohidratos, aportando 700 kcal por cada 100 gramos. La fórmula fue administrada por vía oral o enteral, según requerimiento clínico.

En concordancia con los protocolos institucionales, la evaluación nutricional se realizó con las tablas de crecimiento de la OMS^{17,18} y escalas ajustadas en casos de discapacidad¹⁹. El seguimiento fue efectuado por los equipos de neurología pediátrica y nutrición clínica, aproximadamente cada tres meses, siguiendo los lineamientos institucionales.

El desenlace principal fue el cambio en la frecuencia mensual de crisis, reportado en la historia clínica a partir de la información dada por los cuidadores en los diarios de crisis. Los desenlaces secundarios incluyeron cambios en el uso de FAE, hospitalizaciones por epilepsia, eventos adversos y evolución del estado nutricional. Se registraron variables de caracterización clínica al inicio del tratamiento con TDC, así como los desenlaces de interés a los 3, 6 y 12 meses aproximadamente según los controles realizados habitualmente. Los datos se recolectaron en una base de datos electrónica preestablecida.

Se utilizaron métodos descriptivos y analíticos. La respuesta se categorizó según criterios de Kossoff et al.¹³ y se analizó en términos de frecuencia y proporción. Se estimaron medidas de tendencia central para las variables numéricas según su distribución. Para comparaciones temporales se usó Wilcoxon pareado y modelo lineal de efectos mixtos evaluando tendencia longitudinal. Para explorar factores asociados a una mejor respuesta ($\geq 50\%$ o $\geq 90\%$ de reducción), se aplicó correlación de Spearman entre variables basales y reducción porcentual a los 12 meses. Las comparaciones entre subgrupos (por tipo de crisis, etiología o grupo etario) se realizaron

mediante la prueba exacta de Fisher. Los eventos adversos se describieron por cada punto de seguimiento. El cambio en el estado nutricional entre el inicio y los 12 meses fue analizado mediante la prueba de McNemar, considerando pares de observaciones dentro del mismo paciente. Todos los análisis se realizaron en el software estadístico R (versión 4.4.1, 2024-06-14)²⁰. Se consideró un valor de $p < 0,05$ como indicador de significancia estadística.

El estudio fue aprobado por el Comité de Ética de Investigación Clínica del CAIMED (CEIV-00583-21) y se realizó de acuerdo con la Declaración de Helsinki de 1964 y sus modificaciones posteriores. De acuerdo con las políticas locales y su naturaleza de base documental, este estudio se clasifica como investigación sin riesgo.

RESULTADOS

Se incluyeron 25 pacientes que completaron 12 meses de seguimiento. La edad media fue de 4,43 años (DE: 2,46); 56% eran niñas. La mayoría fue diagnosticada antes de los 3 años. Las crisis focales fueron las más frecuentes (48%), seguidas de generalizadas (28%) y espasmos epilépticos (24%). Las etiologías más comunes fueron estructurales (40%) y genéticas (28%). El 80% presentaba discapacidad asociada. El 56% tenía estado nutricional eutrófico, y el 40% desnutrición. Las características completas de la población se detallan en la [Tabla 1](#).

Tratamiento farmacológico y modalidades de dieta cetogénica

El 80% recibía FAE al inicio; 65% con tres o más fármacos. Los más utilizados fueron levetiracetam, vigabatrina y ácido valproico. Veintidós pacientes siguieron dieta cetogénica clásica (mayoría 2:1) y tres, dieta modificada de Atkins con una razón cetogénica de 1:1 (un gramo de grasa por cada gramo de proteínas y carbohidratos). Todos recibieron fórmula cetogénica KetoCal® 4:1. Las dosis se individualizaron (50 -180 g diarios) según requerimientos energéticos calculados por guías Organización Mundial de la Salud (OMS)¹⁷. Las necesidades proteicas se establecieron con base en las recomendaciones nutricionales para población infantil colombiana¹⁸.

Efectividad observada en el control de crisis epilépticas

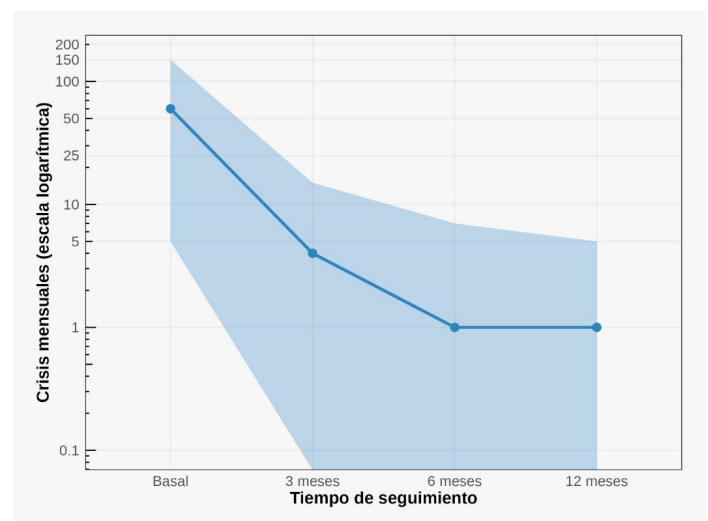
La mediana de crisis mensuales se redujo de 60 (RIC: 5–150) a 4 al tercer mes, y a 1 al mes 6 y 12 ($p < 0,001$). El modelo de efectos mixtos mostró una reducción de 10,2 crisis por trimestre ($p = 0,003$). La reducción porcentual fue de 73,3% (3 meses), 99,4% (6 meses) y 98,3% (12 meses). La evolución temporal de las crisis se ilustra en la [Figura 1](#).

Tabla 1. Características basales de los participantes (N = 25)

Característica	Valor
Edad al ingreso (años), media (DE)	4,43 (2,46)
Sexo femenino, n (%)	14 (56)
Estado nutricional basal, n (%)	
• Eutrofismo	14 (56)
• Desnutrición	10 (40)
• Sobrepeso	1 (4)
Tipo de crisis, n (%)	
• Focal	12 (48)
• Generalizada	7 (28)
• Espasmos epilépticos	6 (24)
Etiología, n (%)	
• Estructural	10 (40)
• Genética	7 (28)
• Infecciosa	2 (8)
• Desconocida	6 (24)
Encefalopatía epiléptica, n (%)	10 (40)
Edad diagnóstico epilepsia (años), media (DE)	2,1 (2,3)
Número de FAE, media (DE)	2,8 (1,1)
Crisis mensuales basales, media (DE)	152,6 (263,8)
Crisis mensuales basales, mediana (RIC)	60 (5-150)
Hospitalización previa, n (%)	9 (36)

DE: desviación estándar; FAE: fármacos antiepilépticos; RIC: rango intercuartílico

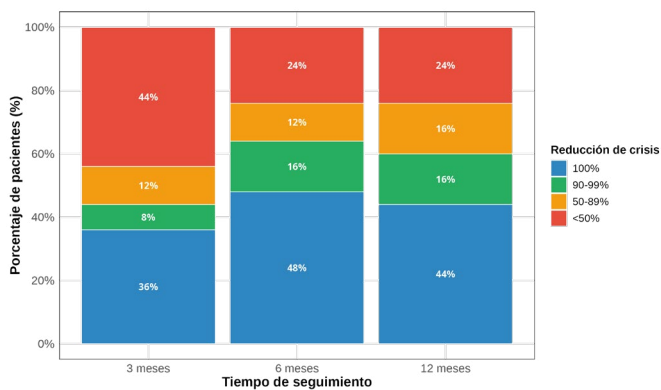
Figura 1. Evolución de la frecuencia de crisis epilépticas durante 12 meses de seguimiento



Respuesta al tratamiento según criterios de efectividad

La respuesta al tratamiento se categorizó siguiendo los criterios establecidos por Kossoff et al. A los 12 meses, 11 pacientes (44%) alcanzaron control total de crisis (reducción del 100%), 4 pacientes (16%) mostraron control alto (reducción 90-99%), 4 pacientes (16%) presentaron control parcial (reducción 50-89%), y 6 pacientes (24%) no respondieron adecuadamente (<50% de reducción). En conjunto, 15 pacientes (60%) lograron una respuesta excelente con reducción igual o superior al 90%. La proporción de pacientes que alcanzó una respuesta favorable (reducción \geq 50%) aumentó progresivamente: 14 pacientes (56%) a los 3 meses, 19 pacientes (76%) a los 6 meses, manteniéndose en 19 pacientes (76%) al final del seguimiento. Esta evolución se presenta en la [Figura 2](#).

Figura 2. Distribución de respuesta al tratamiento por tiempo de seguimiento



Factores predictivos de respuesta

Se observó correlación positiva entre frecuencia basal de crisis y reducción porcentual ($\rho = 0,544$; $p = 0,005$). La respuesta favorable fue del 92,3% en pacientes con >50 crisis/mes, frente al 37,5% con \leq 10 ($p = 0,01$). Las tasas de respuesta excelente fueron mayores en menores de cinco años (66,7%) y en etiologías genéticas (83,3%). No se identificaron diferencias estadísticamente significativas entre estos subgrupos debido al tamaño muestral.

Impacto en el uso de servicios de salud y tratamiento farmacológico

Las hospitalizaciones relacionadas con epilepsia mostraron una tendencia descendente durante el seguimiento. El número de pacientes que requirió hospitalización disminuyó de 9 (36%) al inicio del estudio a 6 (24%) a los 3 y 6 meses, para llegar a 4 (16%) a los 12 meses.

En cuanto al manejo farmacológico, 10 pacientes (40%) experimentaron una reducción en el número o la dosis de medicamentos antiepilépticos durante el seguimiento. Estos ajustes se realizaron de manera gradual y supervisada, basándose en la evolución clínica de cada paciente.

Evolución del estado nutricional

El seguimiento nutricional mostró mejoría en aquellos pacientes que iniciaron con déficit. De los 10 pacientes que presentaron desnutrición al comienzo del estudio, 5 (50%) evolucionaron hacia un estado eutrófico a los 12 meses ($p=0,03$). El paciente que inició con sobrepeso mantuvo esta condición durante todo el período de observación.

Seguridad y tolerabilidad observada

Los eventos adversos se presentaron en 14 de 25 pacientes (56%) durante el seguimiento completo. La distribución temporal mostró variaciones interesantes: 11 pacientes (44%) experimentaron eventos a los 3 meses, 13 pacientes (52%) a los 6 meses, y 9 pacientes (36%) a los 12 meses.

Los síntomas gastrointestinales predominaron entre los eventos reportados. El estreñimiento fue el más común, afectando a 8 pacientes a los 3 meses, 6 a los 6 meses, y solo 2 a los 12 meses. Las náuseas se limitaron a 2 casos durante los primeros 3 meses, sin recurrencias posteriores. El vómito se presentó en 2 pacientes a los 3 meses y en 1 caso a los 6 meses. Todos los eventos se clasificaron como leves y ninguno requirió la suspensión del tratamiento. La tendencia hacia la reducción de estos eventos conforme avanzó el seguimiento se ilustra en la [Figura 3](#).

Los resultados completos del seguimiento longitudinal se presentan en la [Tabla 2](#).

Figura 3. Distribución temporal de eventos adversos durante el seguimiento

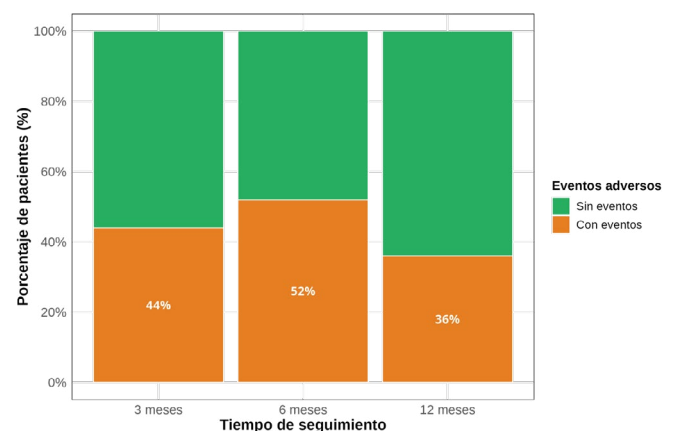


Tabla 2. Resultados longitudinales durante 12 meses de seguimiento

Variable	Basal	3 meses	6 meses	12 meses	p valor*
Crisis mensuales					
Media (DE)	152,6 (263,8)	41,4 (96,2)	13,7 (34,1)	11,9 (29,4)	0,001
Mediana (RIC)	60 (5-150)	4 (0-15)	1 (0-7)	1 (0-5)	
Control de crisis, n (%)					
100%	-	9 (36)	12 (48)	11 (44)	
90-99%	-	2 (8)	4 (16)	4 (16)	
50-89%	-	3 (12)	3 (12)	4 (16)	
<50%	-	11 (44)	6 (24)	6 (24)	
Respuesta \geq 50%, n (%)	-	14 (56)	19 (76)	19 (76)	-
Respuesta \geq 90%, n (%)	-	11 (44)	16 (64)	15 (60)	-
Hospitalización, n (%)	9 (36)	6 (24)	6 (24)	4 (16)	0,08
Reducción FAE, n (%)	-	-	-	10 (40)	-
Mejoría nutricional	-	-	-	5/10 (50%)	0,03

*Wilcoxon pareado comparando cada tiempo vs basal; DE: desviación estándar; RIC: rango intercuartílico; FAE: fármacos antiepilépticos.

DISCUSIÓN

Este estudio observacional retrospectivo evaluó la efectividad clínica de la TDC complementada con la fórmula cetogénica KetoCal® 4:1 como intervención coadyuvante en niños con epilepsia refractaria atendidos en un centro especializado en Colombia. Se evidenció una reducción sustancial y sostenida en la frecuencia mensual de crisis epilépticas, con una respuesta clínica favorable (\geq 50% de reducción) en el 76% de los pacientes, y una respuesta excelente (\geq 90%) en el 60%. El control total de crisis fue alcanzado por el 44% de la cohorte. La mediana de crisis mensuales disminuyó de 60 a 1 en un período de 12 meses, lo que refleja un impacto clínico considerable en condiciones reales de práctica médica.

Los resultados son consistentes con la literatura internacional. Una revisión sistemática de revisiones informó tasas de respuesta \geq 50% en aproximadamente la mitad de los niños con ER tratados con dieta cetogénica²¹, y un metaanálisis reciente confirmó su efectividad en pacientes no candidatos a cirugía²². Los porcentajes superiores observados en esta cohorte podrían atribuirse al protocolo estructurado de atención, el uso sistemático de una fórmula tecnificada como suplemento coadyuvante y el seguimiento multidisciplinario continuo.

En Colombia, un estudio previo con nueve pacientes reportó mejoría parcial en el 88,9% y control total en el 11,1%²³. Aunque existen diferencias metodológicas, ambos estudios respaldan la viabilidad de implementar la TDC en el contexto local, con resultados clínicamente significativos.

Uno de los hallazgos más relevantes fue la identificación de la frecuencia basal de crisis como predictor de respuesta. Los pacientes con más de 50 crisis mensuales al inicio presentaron una tasa de respuesta favorable del 92,3%, frente al 37,5% en aquellos con \leq 10 crisis mensuales ($p=0,01$). Este patrón, también

descrito en otras series¹³, sugiere que la carga convulsiva inicial puede orientar la priorización de esta intervención.

El análisis por grupos de edad mostró tasas similares de respuesta excelente en menores de cinco años (66,7%), mientras que en niños de 5 a 10 años la respuesta fue ligeramente inferior (53,8%). Aunque estas diferencias no fueron estadísticamente significativas, la edad mediana de inicio (4,4 años) fue mayor que la reportada en otras cohortes donde se promueve el inicio temprano para maximizar los beneficios^{12,24}. Esto sugiere la necesidad de mejorar el acceso oportuno a la TDC, especialmente en lactantes.

La intervención fue efectiva en distintos subtipos de crisis: focales (66,7% con respuesta excelente), generalizadas (42,9%) y espasmos epilépticos (50%). Estos resultados son congruentes con estudios previos que respaldan el uso de la TDC en síndromes epilépticos complejos como West o Doose^{25,26}. Además, los pacientes con etiología genética presentaron una mejor respuesta (83,3%) comparado con aquellos de etiología desconocida (52,9%).

Además de la reducción de crisis, la intervención se asoció con una disminución en hospitalizaciones por epilepsia (de 36% a 16%) y con una reducción en la carga farmacológica en el 40% de los pacientes, lo cual puede traducirse en menor exposición a efectos adversos, mejor neurodesarrollo y menor carga familiar asociada. Durante el seguimiento de los pacientes que completaron los 12 meses, el 56% presentó eventos adversos, principalmente gastrointestinales y leves, con tendencia a disminuir en el tiempo. Los eventos más comunes fueron estreñimiento, náuseas y vómitos. No se documentaron interrupciones del tratamiento por efectos adversos entre los pacientes analizados, lo que sugiere buena tolerancia en este grupo.

Sin embargo, se debe señalar que el estudio excluyó a los pacientes que no completaron el seguimiento, lo cual introduce un sesgo de selección. Es posible que algunos de estos casos hayan abandonado

la intervención por intolerancia u otros efectos adversos, lo que podría haber llevado a una subestimación de la incidencia real de eventos relacionados con la dieta. Otras series han reportado tasas de abandono del 20% al 30% por intolerancia o eventos adversos¹⁶. Por otro lado, el estado nutricional mejoró en el 50% de los pacientes con desnutrición al inicio ($p=0,03$), lo que contradice preocupaciones comunes sobre el potencial impacto negativo de la dieta cetogénica en el crecimiento infantil. Estudios previos han demostrado que, con supervisión adecuada, esta dieta puede mantenerse sin comprometer el estado nutricional²⁷, aspecto de especial relevancia en contextos donde las enfermedades neurológicas coexisten con malnutrición.

Las fortalezas del estudio incluyen su diseño basado en condiciones reales de práctica clínica, un protocolo estructurado adaptado a guías internacionales, seguimiento multidisciplinario y evaluación de múltiples desenlaces clínicos durante 12 meses. La inclusión de pacientes con amplio rango etario y perfiles clínicos diversos aporta evidencia en poblaciones poco representadas en ensayos clínicos.

Entre las limitaciones destacan el carácter observacional sin grupo control, que impide establecer relaciones causales definitivas. El tamaño muestral restringe la potencia estadística para análisis de subgrupos y limita la generalización de los hallazgos. La dependencia de diarios de crisis completados por cuidadores introduce una fuente potencial de sesgo subjetivo. Además, la exclusión de pacientes que no completaron el seguimiento de 12 meses impide capturar adecuadamente los casos de intolerancia o abandono, lo que podría haber afectado la evaluación del perfil de seguridad. Finalmente, el estudio fue realizado en un único centro con experiencia especializada, lo que puede limitar su extrapolación a otros entornos.

Los hallazgos respaldan la implementación de la TDC como terapia coadyuvante en niños colombianos con ER, especialmente en aquellos con alta frecuencia basal de crisis. La experiencia documenta que esta intervención puede implementarse de manera segura y efectiva en nuestro contexto, siempre que se garantice seguimiento especializado y multidisciplinario.

Para optimizar la implementación futura, se requieren estudios prospectivos controlados que evalúen la efectividad comparativa frente a otras intervenciones disponibles. La incorporación de herramientas de calidad de vida, análisis de costo-efectividad y biomarcadores de cetosis permitirían una evaluación más integral. El desarrollo de protocolos adaptados a condiciones locales y la capacitación de equipos multidisciplinarios representan áreas prioritarias para mejorar el acceso a estas terapias en poblaciones vulnerables.

CONCLUSIONES

La dieta cetogénica suplementada con fórmula tecnificada fue efectiva para reducir las crisis epilépticas en niños con epilepsia refractaria, con buena tolerabilidad y seguridad. Este estudio demuestra la factibilidad de su implementación en contextos reales de práctica

clínica mediante programas multidisciplinarios estructurados.

Las implicaciones clínicas incluyen la identificación de la frecuencia basal elevada de crisis como predictor de respuesta favorable y la confirmación de esta terapia como alternativa valiosa para reducir la carga de enfermedad.

Se requieren estudios prospectivos controlados que evalúen el impacto integral de la dieta cetogénica y optimicen su implementación en diferentes contextos asistenciales.

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CONTRIBUCIÓN DE AUTORÍA

Todos los autores contribuyeron a la concepción y diseño del estudio. La preparación de materiales, la recolección y el análisis de datos fueron realizados por CEBA, ICO, MSV. Todos los autores comentaron las versiones anteriores del manuscrito, leyeron y aprobaron el manuscrito final.

CONFLICTO DE INTERESES

LHCT trabaja como Asesor Senior de Asuntos Médicos en Danone Baby Nutrition Colombia. Los demás autores declaran no tener conflictos de interés relevantes que puedan influir en los resultados o interpretaciones presentadas en este estudio. La independencia académica de todos los investigadores se mantuvo durante todas las etapas del proceso.

DISPONIBILIDAD DE DATOS

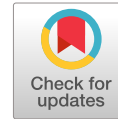
La base de datos utilizada en este estudio está disponible bajo petición razonable al autor de correspondencia.

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RESEARCH ARTICLE

Factors influencing eating behavior among university students in Georgia: a qualitative study

➤ Factores que influyen en la conducta alimentaria entre los estudiantes universitarios de Georgia: un estudio cualitativo

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KEYWORDS

Healthy lifestyle
Healthy eating
Eating behavior
Nutrition knowledge
University students

➤ ABSTRACT

Introduction: A healthy diet is crucial for human well-being and health. Unhealthy eating habits increase the risk of various diseases. University students are exposed to a variety of new personal and environmental influences. This transition period includes changes in physical and social status, along with lifestyle changes, which will affect their eating behavior. While some research has been conducted in Georgia to evaluate university students' eating habits, none has specifically focused on the factors that influence these behaviors. This study aimed to investigate the factors affecting students' eating behavior.

Methodology: The research used a qualitative method and an ecological theoretical framework to analyze the factors influencing students' eating habits. Using a semi-structured question guide, in-depth interviews were conducted with 12 students and 1 expert at Caucasus University. A nonprobability sampling method and its most convenient type, snowball sampling, were used for the respondent selection.

Results: Eating behavior is influenced by individual factors (such as taste preferences), socioeconomic status, living conditions, social groups (friends, peers, family members, and relatives), physical environment (availability and prices), and the macro environment (media and advertising). Early formed incorrect eating habits, limited finances, and time constraints were found to be major barriers to healthy eating for students, shaping their dietary choices significantly.

Conclusions: As students represent a rather delicate social class with limited time and financial resources, the state needs to support and promote healthy eating and living among them. Providing affordable gym memberships and healthy food options in university facilities could help reduce stress and encourage students to establish healthier lifestyles.

RESUMEN

PALABRAS CLAVE

Estilo de vida saludable

Alimentación saludable

Comportamiento alimentario

Conocimientos sobre nutrición

Estudiantes universitarios

Introducción: Una alimentación saludable es fundamental para el bienestar y la salud humana. Los hábitos alimentarios poco saludables aumentan el riesgo de diversas enfermedades. Los estudiantes universitarios se encuentran expuestos a una variedad de nuevas influencias personales y ambientales. Este período de transición incluye cambios en el estado físico y social, así como en el estilo de vida, los cuales afectan su comportamiento alimentario. Aunque en Georgia se han realizado algunas investigaciones para evaluar los hábitos alimentarios de los estudiantes universitarios, ninguna se ha centrado específicamente en los factores que influyen en estas conductas. El presente estudio tuvo como objetivo investigar los factores que afectan el comportamiento alimentario de los estudiantes.

Metodología: La investigación empleó un enfoque cualitativo y un marco teórico ecológico para analizar los factores que influyen en los hábitos alimentarios de los estudiantes. Se realizaron entrevistas en profundidad a 12 estudiantes y un experto de la Universidad del Cáucaso, utilizando una guía de preguntas semiestructurada. Para la selección de los participantes se utilizó un método de muestreo no probabilístico, específicamente el muestreo en bola de nieve por su conveniencia.

Resultados: El comportamiento alimentario está influido por factores individuales (como las preferencias de sabor), el nivel socioeconómico, las condiciones de vida, los grupos sociales (amigos, compañeros, familiares y parientes), el entorno físico (disponibilidad y precios) y el macroentorno (medios de comunicación y publicidad). Se identificaron como principales barreras para una alimentación saludable la presencia de hábitos alimentarios inadecuados formados desde edades tempranas, las limitaciones económicas y la escasez de tiempo, elementos que inciden significativamente en las elecciones dietéticas de los estudiantes.

Conclusiones: Dado que los estudiantes constituyen un grupo social particularmente vulnerable, con recursos de tiempo y económicos limitados, es necesario que el Estado brinde apoyo y fomente la alimentación y el estilo de vida saludables entre esta población. Facilitar el acceso a membresías asequibles para gimnasios y ofrecer opciones alimentarias saludables en las instalaciones universitarias podría contribuir a reducir el estrés y promover estilos de vida más saludables entre los estudiantes.

KEY MESSAGES

1. Respondents held generally similar beliefs about healthy eating, viewing it as a diet rich in proteins, fats, and carbohydrates.
2. Most of the respondents mentioned maintaining good health such as one of the benefits of healthy eating. According to them, healthy eating is one of the best ways to reduce the risk of various diseases.
3. The factors that influence the eating behavior include family, peers, societal traditions, socio-economic status, food accessibility, psychological state, personal willpower, awareness, past eating habits, daily schedules, and levels of physical activity.

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INTRODUCTION

A balanced diet is foundational to a healthy life and disease prevention. Attitudes toward healthy eating can vary by age, gender, socioeconomic status, ethnic-cultural heritage, and lifestyle¹.

Unhealthy eating habits formed early in life may persist into adulthood, increasing the risk of various diseases². It is important to consider the specific social agents - parents, family, and peers. Parents model certain eating behaviors and transmit their attitudes to their children during upbringing³. Students living at home with their parents tend to consume more fruits and vegetables than those living away from their families⁴. When living in student housing, food costs become a key factor, leading to a stronger link between food prices and eating behavior among students living independently. There is a positive correlation between healthy eating and living with parents, as students who spend more time at home generally follow healthier diets⁵. Friends and peers also impact students' eating behavior. The attitudes and behaviors of friends and peers significantly influence adolescents' food choices⁶. Studies show that students with healthy eating habits perform better academically, experience better mental health, and are less likely to develop chronic diseases⁷. Conversely, unhealthy and unbalanced diets contribute to obesity and overweight, leading to serious health issues⁸.

University students are exposed to a variety of new personal and environmental influences⁹. This transition period includes changes in physical and social status, along with lifestyle changes, which will affect their eating behavior¹⁰. To design effective interventions, it is essential to identify the factors that influence students' eating behaviors¹¹. Students are typically engaged in numerous social activities and academic responsibilities, which makes them more likely to choose fast, convenient, affordable, and ready-to-eat food options^{12,13}.

Attitudes and beliefs play a crucial role in shaping dietary decisions at different stages of life. From the perspective of social psychology, attitudes are psychological tendencies that express a certain degree of favorability or disfavor towards food¹⁴. They can be represented in three ways: cognitive component - beliefs or knowledge about food (e.g., "vegetables are healthy food"); affective component - emotions associated with food choices (e.g., liking sweets or aversion to spicy foods); behavioral component - a tendency to act in a certain way (e.g., refusing fast food due to health problems)¹⁵.

Beliefs, on the other hand, are deeply held ideas that individuals accept as true and are shaped by cultural, family, and social influences¹⁶. For example, the belief that "organic food is healthier" can influence purchasing behavior. These attitudes and beliefs determine decisions about food preferences and consumption frequency. They are influenced by factors such as parental, peer, media, and personal experiences¹⁷. Studying these factors in students is important because early intervention can shape long-term habits. Adolescence is a critical period for establishing lifelong dietary patterns. However, many dietary choices are based

on misconceptions (e.g., "Carbohydrates are bad for you"), and educational programs can correct these¹⁸. Understanding attitudes allows for targeted interventions, such as awareness-raising campaigns. Research can, therefore, help develop strategies to address these gaps.

Understanding students' eating behaviors and the factors that shape them is valuable¹⁹. While some research has been conducted in Georgia to evaluate university students' eating habits, none has specifically focused on the factors that influence these behaviors²⁰.

The aim of this qualitative research is to examine students' attitudes toward healthy eating and the factors that influence their eating behaviors.

METHODOLOGY

Theoretical framework

This qualitative research study used an ecological theoretical framework to examine the various factors influencing students' eating habits. This approach considers multiple levels of influence, including individual, social, environmental, and university-related factors, that shape eating behavior among university students.

The ecological framework is particularly effective in understanding how the social environment influences personal choices. For example, individual factors (e.g., taste preferences, self-discipline, time constraints) interact with social networks (e.g., peer influence, family eating habits, parental control), the physical environment (e.g., availability of healthy foods), and the macro-environment (e.g., media and advertising)²¹, as well as university-specific characteristics (exam schedules). By examining these interrelated factors, this qualitative research study provides an understanding of the challenges of healthy eating among university students.

Research design, data collecting

The qualitative in-depth interview method was used for data collection. The target segment consisted of undergraduate students at Caucasus University, one of the reputed universities located in Tbilisi (Georgia). The study involved second-, third- and fourth-year students from different faculties. Given the objectives of the study, students were selected using the snowball sampling method, a purposive nonprobability sampling technique commonly used in qualitative research, where the researcher recruits a few initial volunteers who then recruit others.

The sample size was determined in accordance with the principle of data saturation - reaching the point where new themes or codes do not appear in the interviews. Twelve students participated in the qualitative research. Additionally, one expert was interviewed to provide valuable insights on the research topic. Participants were purposefully recruited for interviews, taking into account their nutritional behavior, experience, practice and perception.

The interview questions were developed collaboratively with experts with relevant experience and were informed by reviewing pertinent literature (Table 1).

In-depth interviews with the respondents were conducted at the university at times convenient for both the students and the researchers. Each interview lasted between 60 and 90 minutes and was conducted over two weeks.

Table 1. Guide for In-Depth Interview Questions

1. Where are you from, and what's your name?
2. Describe a healthy person.
3. What comes to your mind about 'health in university students'?
4. Think back of the last year(s) being a university student. Did your body weight and/or body composition change since you entered university?
5. Did your health related habits change since you entered university?
6. Which factors have caused these changes (or which factors influence current health behaviours)? What barriers and enablers of healthy behaviour can you identify?
7. Which of the previously mentioned factors has had the greatest influence?
8. Do you have any remarks, suggestions, additions?
9. Soon, we will try to help students make healthier choices. Can you give us some advice on how to promote healthy eating behaviours in students?

Data analyses

During the interviews, a voice recorder was used for audio recording. The recorded interviews were transcribed verbatim into Microsoft Word format and then cleaned and checked for precision. All transcriptions were encoded using the qualitative software program NVivo 9. Thematic analysis, chosen for its flexibility and suitability for qualitative studies, was employed to analyze the data²². Using an inductive thematic approach, recurrent instances within the data (quotes) were systematically identified and grouped using a structured coding system. Similar codes were consolidated into broader subcategories, which were subsequently organized into main categories. Thematic analysis ensures a systematic and transparent approach to identifying patterns within qualitative data while maintaining analytical rigor. To enhance the reliability of data interpretation, the analysis was conducted independently by two researchers, reducing potential bias and enhancing the credibility of findings.

Research ethics

Before starting the study, we received approval from the Research and Ethics Committee of Caucasus University (CU 39-21.01.24.). The research participants were informed about the research issue, their participation was completely voluntary and they could refuse to participate in the research at any time. The respondents were aware that the study would be confidential, and they were

informed that their voices would be recorded during the interview and that their opinions and evaluations would be used for analysis. There was no artificial incentive for their participation in the study.

RESULTS

Twelve students participated in the qualitative research, with an equal distribution of healthy and unhealthy eating habits. Using a "self-assessment question," each participant classified themselves into one of two groups. Six respondents identified as eating more healthily, while the other six considered their diets more unhealthy. Gender balance was maintained in each group, and all participants were second-, third-, and fourth-year university students with financial conditions ranging from average to good. Characteristics of participants are shown in Table 2.

Table 2. Characteristics of participants (Mean \pm SD, %, n = 12)

Gender n (%)	
Male	6 (50%)
Female	6 (50%)
Age (yrs)	20.1 \pm 1.5
Body Mass Index (BMI) (kg/m ²)	23.1 \pm 4.2
Underweight (%)	7.5
Normal weight (%)	56.4
Overweight (%)	36.1
Study career (yrs)	3.0 \pm 1.0
Study discipline	
School of Business (%)	46.4
School of Humanities and Social Sciences (%)	22.3
School of Medicine (%)	31.3
Smoking (% smokers)	16.8
Self-reported health (% reporting poor health status)	12.1
Perceived physical activity level (% reporting little physical activity)	53.2
Perceived eating pattern quality (% reporting poor eating pattern)	23.6

Students' Beliefs About Healthy Eating

Respondents held generally similar beliefs about healthy eating, viewing it as a diet rich in proteins, fats, and carbohydrates. Most stressed the importance of balancing these nutrients, eating small portions throughout the day, and incorporating variety. Occasional treats, like sweets and baked goods, were considered acceptable, as students believe this helps the body adapt to different foods given limited access to purely healthy options.

"Eating healthily means balancing healthy foods with what's actually accessible. It's challenging to eat healthy on an average income."

– Male, group 1

"Healthy eating means four small meals with a varied diet, and it's okay to have fast food or sweets occasionally."

– Male, group 1

Those with unhealthier diets emphasized consuming vegetables, fruits, and water but felt that healthy eating required too many sacrifices, such as giving up enjoyable foods. The interviewed expert noted that these beliefs reflect societal stereotypes about healthy eating. According to the expert, a healthy diet doesn't mean monotonous or restrictive eating; instead, it involves balanced consumption and maintaining time intervals between meals.

"Healthy eating means eating lots of fruits and vegetables and avoiding junk food and sweets."

– Female, group 2

"Everything should be low-fat, sugar-free, and salt-free. But for me, that's the enjoyment factor. Without it, food is tasteless, and I don't know if I'll ever make that sacrifice."

– Male, group 2

Based on expert insights, a person who eats healthily typically has a structured diet, sufficient time and resources to prepare balanced meals, eats at regular intervals, and consumes calories that align with daily needs. Most respondents did not consider caloric balance, time intervals, or diet variety. Healthier-eating students were better informed on these aspects, though many still associated healthy eating with less tasty, low-calorie foods.

Social media, television programs, and advice from endocrinologists, nutritionists, and fitness instructors were the most common information sources on healthy eating. Some respondents also cited family and friends as their sources.

Attitude of students toward healthy eating

When discussing the benefits of healthy eating, nearly all respondents first mentioned maintaining good health. According to them, healthy eating is one of the best ways to reduce the risk of various diseases. Based on their experiences, students confidently stated that productivity is closely tied to food intake. As some pointed out, eating healthy leads to feeling more energetic and motivated, which supports daily tasks. Students also recognized that nutrition affects cognitive abilities and behaviors, impacting academic performance.

"Usually, when I eat healthy food, I feel more energetic and train well. If I eat fast food, I feel low energy, sleepy, and lazy."

– Female, group 1

Many students noted that eating healthily fosters self-respect, which enhances self-esteem and supports daily routines. One respondent highlighted that the feeling of self-control was a major motivator for healthy eating, contributing to increased self-esteem. Among female participants, maintaining a desirable body shape was another primary incentive.

"The positive is that you feel good about yourself when you eat healthy, as if you're achieving something and are ahead of others. The feeling of being in control makes a big difference."

– Female, group 1

"The main benefit is staying in good shape, maintaining weight, and looking good."

– Female, group 1

In addition to the physical benefits, students also emphasized the importance of healthy eating for mental health. One respondent noted that while initially challenging, the positive emotional and psychological effects of healthy eating become more apparent over time.

Several participants found it challenging to identify negative aspects of healthy eating. However, they highlighted the practical difficulties, especially the lack of financial and time resources. Healthy food was perceived as more expensive and less accessible than unhealthy options. According to the experts, limited time and financial constraints are major barriers to healthy eating, especially for students. Junk food, which is cheaper, easily accessible, and highly convenient, becomes a tempting choice and can lead to addiction. They observed that this type of food often results in fatigue and self-dissatisfaction, which in turn can cause various psychological issues.

"Eating right and healthy is more expensive. Eating unhealthily is cheaper – for example, I can buy beans, which are tasty and nutritious, for little money. But healthy eating requires ingredients, time, preparation, and a lot of money."

– Female, group 2

"The more you eat unhealthy food, the more your body becomes accustomed to it, and it becomes addictive. When you know it's bad and still eat it, you lose self-love, which negatively impacts self-esteem and can lead to psychological issues."

– Female, group 1

A few students had a different opinion, suggesting that the main drawback of healthy eating is the taste of certain foods. For these respondents, healthy eating is often associated with fruits, vegetables, and grains, and one respondent mentioned that he occasionally follows a healthy diet to lose weight. The interviewed expert noted that for such individuals, healthy eating is often associated with dieting, which may reinforce stereotypes about healthy eating. This view was shared by students who eat more healthily and believe it's a myth that healthy food is tasteless.

"I was eating healthy for a while to lose weight, but it felt like moral stress because healthy food didn't feel enjoyable. I now believe that healthy food can actually taste great."

– Male, group 2

"I've seen many videos showing you can eat healthy and delicious food. The stereotype that healthy food is tasteless is simply not true. The key is knowing the correct cooking techniques."

– Male, group 1

In conclusion, the majority of respondents held positive attitudes toward healthy eating, motivated by maintaining good physical and mental health, achieving a desirable body shape, boosting energy, improving concentration, and increasing self-esteem. Female respondents showed greater interest in nutrition and dietary control compared to males. Nearly all respondents cited limited financial resources as the primary difficulty in maintaining a healthy diet.

Nutritional behavior of students

Eating behavior is a complex phenomenon shaped by various factors, including upbringing, environment, and social influences, as highlighted by an expert interviewed in this study. The research revealed distinct differences in eating habits between groups of respondents. Those who consider themselves healthier reported eating more fruits, vegetables, and protein sources, while those who identified as having less healthy diets leaned towards baked goods, sweets, pizza, beans, khachapuri, processed foods, and sugary treats as staples throughout the week. Few students in this category pay attention to the portion sizes or caloric content of their meals. Conversely, students who consider themselves to eat healthily focus more on balancing their intake of fats, proteins, and carbohydrates throughout the day, rather than strictly counting calories. Only one participant actively tracked calorie intake using an app to ensure their daily calories didn't exceed their energy expenditure. Following a structured eating regimen, which includes regular meal intervals, is challenging for most respondents. The expert recommends eating four times daily with set time intervals, explaining, "The interval between meals must be strictly observed, which is incompatible with the daily routine of most students." Students with less healthy eating habits found following this kind of schedule unrealistic, with some noting they might eat only once or twice a day, if at all. According to the expert, such irregular eating habits can be detrimental to the body and may lead to health issues in the future.

"Based on my schedule, it's just not possible; I can't control it. I don't know exactly what or when I'll eat. An endocrinologist might recommend eating five times daily at specific times with specific foods, but this regimen is nearly impossible for both students and the average person."

– Female, group 2

In contrast, students who identify as healthier eaters make efforts to maintain a consistent diet, typically eating at least three meals daily. Many female participants in this group reported having regular mealtimes and emphasized the importance of breakfast. The expert noted that, in his experience, women generally pay more attention to diet and nutrition than men, observing that most patients with metabolic disorders stemming from poor eating habits are men.

When it comes to planning meals for the week or day, most students reported eating spontaneously based on their schedules, as they find it difficult to predetermine their food choices. This issue is especially pronounced for students who work while attending university, as they rarely have time to prepare meals. These students explained that their diet often depends on the eating habits of the people they live with.

Determining factors of students' nutritional behavior

The study's results identified individual and social factors influencing students' eating behaviors. These include family, peers, societal traditions, socio-economic status, food accessibility, psychological state, personal willpower, awareness, past eating habits, daily schedules, and levels of physical activity.

Eating habits formed in childhood often persist into adulthood, underscoring the role of early-life socialization agents such as parents and family members. When asked about their childhood diets, participants largely attributed their current eating behaviors to their parents' influence. Respondents who ate healthily as children reported a continued sense of responsibility toward balanced eating, whereas those from households with less healthy eating norms struggled to adapt to healthier habits. Most respondents noted that although their parents made efforts to provide nutritious meals, many had misconceptions about what constitutes healthy eating. For instance, some parents equated "home-cooked" with "healthy," even if meals were high in fats, sugars, and salts. Students now aiming for a healthier diet often face challenges in overcoming ingrained habits. They suggested that parental beliefs about nutrition may have been shaped by limited access to nutritional information in the past.

"My parents thought that anything cooked at home was healthy, even if it was high in fat and salt. I think this generation has a different understanding of food."

– Male, Group 1

Students living away from home due to university studies commonly reported significant dietary changes. Many noted a shift towards convenience foods, such as baked goods and processed

items, influenced by a busy schedule, lack of cooking skills, and limited time. University life also brought heightened stress, which many respondents said contributed to irregular eating habits.

“Back at home, I ate healthier. But once I was responsible for my meals, I started eating whatever was quick and easy, especially because I didn’t know how to cook.”

– Male, Group 2

This adjustment was particularly challenging during their first year, a period respondents referred to as a “food adaptation” phase. Due to morning lectures and hectic schedules, many missed meals or turned to inexpensive, easily available food options, finding university cafeterias unaffordable.

“When I started university, I lost control over my diet. The stress of a new environment and responsibilities made nutrition a low priority.”

– Female, Group 1

Male respondents, in particular, noted that their diets were influenced by the eating habits of people they lived with, whether family or roommates. One participant observed that his diet remained unchanged because he still lived with family members who prepared traditional, high-calorie Georgian meals.

“If I lived alone, I’d make healthier choices. But I live with family, so traditional dishes are always part of our meals.”

– Male, Group 2

Social gatherings and celebrations were cited as additional challenges to maintaining healthy eating habits. Financial limitations were another major barrier, with respondents noting that healthy food is often more costly and time-consuming to prepare. Fast, cheap, and tasty options, often unhealthy, were more practical for their student lifestyle. The interviewed expert echoed this view, pointing out that rising food prices in Georgia further hinder access to healthy food.

“The student lifestyle demands quick, affordable food, which usually means unhealthy options.”

– Female, Group 2

A subset of respondents in more favorable financial situations reported better access to healthier diets. For example, one student working part-time noted that his financial independence allowed him to afford meal services offering balanced, ready-to-eat meals. When asked what would help improve their eating habits, respondents cited factors like good habits established in childhood, strong willpower, motivation, and reduced stress. Healthier

students identified family support, exercise, cooking skills, awareness, and self-management as key contributors to their diet. Physical activity, in particular, was a motivator for healthy eating among male students.

“When I work out, I’m more conscious of my diet, so I choose healthier foods.”

– Male, Group 1

Eating behaviors are influenced by a range of factors, including age, gender, socio-economic status, upbringing, and education. According to the expert, higher education tends to promote healthier choices, as it enhances critical thinking and fosters self-care practices. Early socialization, especially by parents, is foundational. When children grow up with varied and balanced diets, they are less likely to develop health issues tied to poor eating habits.

The expert also highlighted a widespread “unhealthy food culture” rooted in households and communities that often passes down to younger generations. Addressing this requires systemic support from national policies that incentivize healthy eating and promote correct dietary habits.

DISCUSSION

A healthy diet is crucial for human well-being and health. It supplies the body with essential nutrients, vitamins, and minerals that play a key role in enhancing the immune system. Family background and economic status influence one’s decision to consume nutritious foods. Participants in this study indicated notable differences in beliefs, attitudes, and behaviors toward healthy eating between students who follow healthy diets and those who do not. Students who lead a healthy lifestyle view a balanced diet as one that includes proteins, fats, and carbohydrates, along with occasional indulgences like baked goods and sweets, consumed in moderation. In contrast, students who consume less healthy foods often feel that healthy eating involves making significant sacrifices. The study suggests that these are misconceptions, as healthy eating does not mean eating bland food; rather, it emphasizes achieving a daily calorie intake that balances or remains below expenditure. Notably, students who follow a healthy diet report experiencing higher self-esteem.

Students who eat healthily also tend to have more knowledge about nutrition than their counterparts who do not. However, expert insights highlight that information about healthy eating is still not widespread among young people, underscoring the need for awareness efforts targeting this demographic.

Parents play a key role in shaping their children’s eating behaviors, passing down specific dietary habits. Participants in this study indicated that students who live at home tend to be more influenced by their parents than those who moved out upon

starting university. Those living with parents reported healthier diets, with a higher intake of fruits and vegetables. Research in other regions, such as a study conducted in Italy, also emphasizes parental influence on dietary habits²³.

Beyond family influence, friends and peers also have a significant impact on eating behaviors, often through shared activities like dining out or snacking. A study in Australia by Pendergast et al. (2017) found that social settings are critical in determining food choices, with peer pressure sometimes leading to unhealthy eating patterns²⁴. Similarly, American research emphasizes the role of social norms and peer behavior in both promoting and deterring healthy eating habits²⁵.

Students consuming less healthy diets often perceive healthy eating as involving sacrifices or bland food, while healthy eaters view it as balanced and enjoyable. A Canadian study by Pelletier et al. (2016) found similar misconceptions among university students, noting that individuals with lower nutrition literacy are more likely to believe healthy eating is restrictive²⁶. This underscores the global need for improved education on the practical and enjoyable aspects of healthy eating.

Economic status impacts access to nutritious food, with healthier diets often associated with higher family income. Studies in low- and middle-income countries found that financial constraints limit access to fresh fruits, vegetables, and lean proteins, leading to reliance on cheaper, less nutritious options.

The study suggests that students' academic backgrounds influence their eating behaviors. Medical school students had greater awareness of diet, nutrition, and health-related issues than business school or humanities and social sciences students. Previous studies have shown that medical students, due to their academic background, have greater nutrition knowledge and are, therefore, more likely to adopt healthy eating habits²⁷. In contrast, students from non-health-related disciplines may have different attitudes and perceptions about nutrition, which may lead to unhealthy food choices²⁸. However, differences in workload and academic pressure across disciplines play an important role in shaping students' dietary habits. For example, medical students often experience intense academic schedules and stress, which may contribute to healthy eating habits due to their knowledge or lead to irregular eating patterns due to time constraints²⁹. On the other hand, students from business or humanities programs may face different lifestyle challenges that affect their food choices. Students eating healthily possess greater nutritional knowledge, but the overall awareness of healthy eating among young people remains low. This finding is echoed by a South Korean study by Kim et al. (2020), which suggests the positive impact of nutrition education on improving students' dietary habits³⁰. However, gaps in awareness among youth are a recurring theme globally, emphasizing the need for targeted health campaigns.

Early exposure to diverse and healthy foods is a strong predictor of healthier eating patterns in adulthood. However, interventions during adolescence and young adulthood can still yield significant improvements in dietary choices.

Limitations of the study

When interpreting the findings of this study, certain methodological limitations should be taken into account. One such limitation is the use of a purposive sampling technique, which resulted in a relatively small sample size. All participants were students from Caucasus University in Tbilisi, so the findings may not be generalizable to other higher education institutions in different regions of the country.

The study used qualitative methods, which provide rich insights but may lack statistical generalizability. While qualitative data help explore students' perceptions in depth, they do not allow for broad conclusions. A mixed-methods approach incorporating quantitative surveys could strengthen the findings.

In addition, various contextual factors, including location, size, structure, and the surrounding environment, can influence university students' eating behavior and dietary intake, which may vary across different institutions. As a result, the findings of this study may not be broadly applicable to other settings. However, the study's primary goal was not to generalize the results but to gain a comprehensive understanding of the factors shaping participants' eating habits. Additionally, this research provides a detailed insight into the key influences on university students' dietary behaviors.

CONCLUSIONS

Our study reflects global trends in factors influencing eating behaviors among university students, particularly regarding family and peer influences, socioeconomic challenges, and the critical role of education. Nonetheless, cultural nuances, such as specific dietary misconceptions and the role of household dynamics, provide unique insights into the Georgian context. Students make deliberate choices from the options available to them in their environment, and various factors, including socioeconomic status and living conditions, influence these choices. Social groups - such as friends, peers, family members, and relatives—also play a crucial role in shaping these choices.

These findings underscore the importance of tailored interventions to address cultural, social, and economic factors in promoting healthier eating among university students worldwide. Given that students are a socially vulnerable group with limited time and financial resources, state support is essential to promote healthy eating and lifestyle habits among them. Providing affordable gym memberships and access to healthy food in university facilities

can help alleviate their stressful environment and increase their motivation to adopt and maintain a healthier lifestyle.

AUTHORS' CONTRIBUTIONS

TV and TP contributed equally to the design and experimental procedures of this study. Both authors have written and accepted the current version of this manuscript.

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CONFLICT OF INTEREST

The authors confirm that there is no conflict of interest in this study.

AVAILABILITY OF DATA

Data available on request to the author of the correspondence.

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ARTÍCULO DE INVESTIGACIÓN

Construcción y validación de un cuestionario sobre prácticas parentales en la etapa de alimentación complementaria: Conductas Instrumentales y Afectivas

Development and Validation of a Questionnaire on Parental Practices During Complementary Feeding: Instrumental and Affective Behaviors

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PALABRAS CLAVE

Malnutrición

Prácticas parentales

Encuestas y cuestionarios

Conducta alimentaria

RESUMEN

Introducción: El estado nutricional en los primeros años de vida es crucial para el desarrollo físico y psicoafectivo. Este estudio tuvo como objetivo construir y validar un cuestionario para evaluar la responsividad en las prácticas parentales de alimentación (PPA) durante la etapa de alimentación complementaria, integrando dimensiones instrumentales y afectivas.

Metodología: Se diseñaron 45 reactivos basados en categorías de un sistema de observación previo, los cuales fueron validados por jueces expertos y cuidadores. El cuestionario final se aplicó a 230 cuidadores de niños de 6 a 40 meses en modalidad presencial y en línea. Se realizó un análisis factorial exploratorio para identificar factores clave y evaluar consistencia interna mediante omega de McDonald.

Resultados: El cuestionario derivó dos instrumentos: uno para conductas instrumentales y otro para ajustes afectivos. El primero mostró tres factores principales (práctica sensible, autonomía y vigilancia del consumo) con una varianza total explicada del 63% ($\omega = 0.76$). El instrumento de ajustes afectivos presentó dos factores (afecto positivo y negativo), explicando el 51.9% de la varianza ($\omega = 0.72$). Las respuestas altas en factores afectivos sugieren posibles sesgos de deseabilidad social.

Conclusiones: El cuestionario aporta una herramienta válida para evaluar PPA durante la alimentación complementaria, abordando aspectos clave para el diseño de intervenciones nutricionales. Futuros estudios deben ampliar las muestras para realizar análisis confirmatorios y explorar su aplicabilidad en contextos diversos.

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KEYWORDS

Malnutrition
Parenting
Surveys and
Questionnaires
Feeding Behavior

ABSTRACT

Introduction: Nutritional status in early childhood is critical for physical and psychosocial development. This study aimed to develop and validate a questionnaire assessing parental feeding practices (PFP) responsiveness during complementary feeding, integrating instrumental and affective dimensions.

Methodology: Forty-five items were derived from an observational system and validated by expert judges and caregivers. The final questionnaire was administered to 230 caregivers of children aged 6–40 months, both in person and online. Exploratory factor analysis was performed to identify key factors, and internal consistency was assessed using McDonald's omega.

Results: The questionnaire produced two independent instruments: one for instrumental behaviors and another for affective adjustments. The first instrument identified three main factors (sensitive practices, autonomy, and consumption monitoring) explaining 63% of the variance ($\omega = 0.76$). The affective adjustments instrument revealed two factors (positive and negative affect), explaining 51.9% of the variance ($\omega = 0.72$). High scores in affective factors suggested potential social desirability bias.

Conclusions: The questionnaire provides a valid tool to evaluate PFP during complementary feeding, addressing key aspects for designing nutritional interventions. Future studies should increase sample sizes for confirmatory analyses and explore applicability in diverse contexts.

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MENSAJES
CLAVE

1. El cuestionario obtenido caracteriza la responsividad en las prácticas parentales de alimentación, incorporando dimensiones instrumentales y afectivas relevantes en la interacción cuidador-infante durante la alimentación complementaria.
2. Los instrumentos derivados son válidos y fiables, explicando hasta el 63% de la varianza en conductas parentales y afectivas, aunque requieren análisis confirmatorios para consolidar su uso.
3. El cuestionario aborda la etapa crítica de la alimentación complementaria, ofreciendo información clave para diseñar intervenciones en contextos de vulnerabilidad nutricional.

CITA

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INTRODUCCIÓN

Gran parte de las preferencias, aversiones y hábitos alimentarios tienen sus raíces en la etapa de introducción de sólidos en la dieta del infante^{1,2}. Este período es fundamental para el desarrollo infantil, ya que la ingesta alimentaria es un factor decisivo en el estado de nutrición (EN), el cual influye en el crecimiento, la evolución del sistema nervioso central, el metabolismo y los procesos de aprendizaje y desarrollo psicoafectivo^{3,4}.

La nutrición infantil está determinada por múltiples factores, como la genética, las condiciones de vida (disponibilidad de alimentos, saneamiento, servicios de salud, educación parental, medios de comunicación, entre otros) y las prácticas de crianza enfocadas en la salud y alimentación del niño^{5,6}. Entre los factores modificables, las prácticas parentales desempeñan un papel crucial, ya que en los primeros años de vida el niño amplía las interacciones con su entorno —incluyendo las experiencias de alimentación— principalmente a través de sus cuidadores^{7,8}.

Analizar las prácticas parentales de alimentación (PPA) permite comprender mejor los procesos que contribuyen a problemas de nutrición en la infancia, tanto por carencias como por excesos. Las PPA pueden evaluarse mediante dos criterios: la modalidad empleada y las dimensiones de las PPA que se abordan. En cuanto a la modalidad, se distinguen la observación sistemática (OS)⁹ y la evaluación indirecta, generalmente mediante instrumentos de auto reporte^{7,10-12}.

La OS se basa en sistemas categoriales que identifican episodios de conducta de manera directa, lo cual ofrece una mayor validez ecológica al reflejar con precisión el entorno real, aunque requiere más recursos económicos, humanos y temporales^{13,14}. Por otro lado, los cuestionarios permiten obtener datos de muestras más amplias con menos recursos; sin embargo, la información puede ser menos precisa debido a factores como la deseabilidad social o sesgos en la memoria y percepción de los cuidadores sobre sus acciones^{15,16}.

En cuanto a las dimensiones de las PPA, se han creado herramientas para medir creencias, actitudes, estilos y acciones específicas. Evaluar cada uno de estos aspectos permite entender el fenómeno y diseñar intervenciones específicas para modificar las PPA. Generalmente, los cuestionarios abordan creencias, actitudes y estilos, mientras que la OS se centra en los estilos y acciones concretas en contextos de alimentación. No obstante, no siempre se encuentra correlación entre la información obtenida de ambos enfoques, salvo cuando los cuestionarios se derivan de sistemas categoriales^{17,18}.

La mayoría de las herramientas de evaluación se basan en el constructo de estilos (autoritario, permisivo, autoritativo y negligente) propuesto por Baumrind¹⁹. Entre los instrumentos más utilizados están el *Infant Feeding Style Questionnaire* (IFSQ)¹², el *Feeding Practices and Structure Questionnaire* (FPSQ-28)¹⁰ y el *Child Feeding Questionnaire* (CFQ)¹¹. Los dos últimos han sido adaptados a la población mexicana^{20,21}, además, en español se desarrolló el *Cuestionario Integral de Prácticas de Alimentación* (CIPA)²². Con

excepción del FPSQ, estos instrumentos se enfocan principalmente en problemas de sobrepeso y obesidad en niños preescolares y mayores, dejando descubierta la etapa de alimentación complementaria y los patrones asociados a la desnutrición infantil. Resulta necesario contar con un cuestionario que refleje la interacción diádica en el contexto de la alimentación, derivado de los constructos de PPA, entendido como las acciones específicas de los adultos para asegurar la vida y el bienestar del niño²³ y de responsividad, definida como aquellas conductas en las que el cuidador identifica y responde a las señales del infante de forma contingente, adecuada y cálida^{24,25}.

Dado lo anterior, el objetivo de este estudio es presentar la construcción y validación inicial de un cuestionario que evalúe la responsividad en las PPA, considerando tanto dimensiones instrumentales como afectivas de la conducta.

METODOLOGÍA

Participantes

Para la validación de contenido se invitó a ocho jueces expertos en el análisis de la interacción cuidador-niño durante la alimentación—dos de ellos con experiencia en orientación alimentaria en la ablactación y en construcción de instrumentos—y a nueve cuidadores de niños de 6 a 40 meses, de entre 18 y 35 años, con niveles educativos de básica, media y media superior. Entre estos, siete eran madres y dos padres; cuatro pertenecían a familias nucleares y tres a familias extendidas. Para la aplicación del cuestionario, se empleó una muestra no probabilística intencional de 230 cuidadores principales (Tabla 1), definidos como la persona responsable del niño y que pasaba la mayor parte del tiempo con él.

Instrumentos

Sistema de Observación de la Interacción Cuidador-Infante en Situaciones de Alimentación (SOICISA). Catálogo de categorías para el análisis de las interacciones adulto-infante en el contexto de la alimentación, agrupadas en tres dimensiones de la conducta parental (Cercanía, Presentación de alimentos y Verbalizaciones) e infantil (Orientación, Consumo de alimentos y Verbalizaciones), más los ajustes afectivos de cada integrante de la diada²⁶.

Cuestionario sobre Prácticas Parentales de Alimentación Complementaria (CPPAC), cuyos 45 reactivos originales, derivados del SOICISA, atendieron las mismas dimensiones de la conducta. Las secciones se presentaron bajo los siguientes rubros: *Cómo le presento los alimentos* (compañía y presentación); *De lo que hablo cuando le doy de comer* (verbalizaciones cuidador); *Cómo me siento* (afecto del cuidador); *A qué atiende mi hijo mientras come* (orientación del niño); *La forma en que come mi hijo*, (consumo); *Comunicación de mi hijo* (verbalizaciones del niño); *Cómo se siente mi hijo a la hora de la comida*; (afecto del niño). Las opciones de respuestas se presentaron con cinco valores dentro de un continuo: 41 en escala Likert, p.e. nunca-

siempre; y cinco en escala de Osgood, p.e. rechazo-aceptación (material suplementario).

Tabla 1. Características de los participantes

	N	Porcentaje
Edad		
Menor de 18 años	3	1.46
Entre 18 y 25 años	52	25.24
Entre 26 y 35 años	96	46.60
Entre 36 y 45 años	48	23.30
Más de 45 años	7	3.40
Sexo		
Mujer	188	91.26
Hombre	18	8.74
Parentesco		
Mamá	177	85.92
Papá	14	6.80
Abuelo / abuela	5	2.43
Tío / Tía	7	3.40
Sin parentesco	3	1.46
Tipo de familia		
Monoparental	101	49.03
Nuclear	53	25.73
Extendida	45	21.84
Otra	6	2.91
Sin información	1	0.49
Escolaridad		
Sin estudios o primaria incompleta	5	2.42
Primaria	22	10.67
Secundaria	72	34.95
Bachillerato o estudios técnicos	89	43.20
Profesional (licenciatura)	17	8.25
Posgrado	1	0.48
Edad de los niños (meses)		
6-9	14	6.80
10-14	15	7.28
15-18	22	10.68
19-24	32	15.53
24-40	123	59.71
Sexo de los niños		
Niño	104	50.40
Niña	102	49.60

PROCEDIMIENTO

Derivación de reactivos

Se utilizaron todas las categorías del SOICISA para derivar los reactivos. En algunos casos, una categoría correspondió directamente a un reactivo; por ejemplo, de la categoría Estar cerca con atención se derivó el reactivo Mientras mi hijo come, estoy cerca y pendiente de él, con opciones de respuesta de En ningún momento a Todo el tiempo. En otros casos, se combinaron dos categorías para formar los extremos de una respuesta, como Come sólidos por sí mismo y Acepta sólidos, de las que se derivó el reactivo Grado de independencia para comer sólidos, con opciones de Con completa asistencia a Sin asistencia. Las 51 categorías dieron origen a 45 reactivos (Tabla 2).

Validación de contenido

A los jueces expertos se les presentaron los reactivos para evaluar si conservaban el sentido de las categorías del SOICISA; la validez se determinó por consenso; cuando hubo discrepancia se llegó a un acuerdo en modificación o supresión de un reactivo. Para la validez de contenido por criterio de los jueces cuidadores, se preguntó sobre la claridad y la facilidad de respuesta de los reactivos. La versión final del instrumento se ajustó mejorando la redacción, opciones de respuesta y eliminando los ítems redundantes o irrelevantes señalados.

El instrumento final se aplicó a 230 cuidadores de niños, tras firmar el consentimiento informado y aviso de privacidad. Se descartaron 24 cuestionarios incompletos. La aplicación fue mixta: remota mediante *Microsoft Forms*, difundida por redes sociales, y presencial en tres Centros de Desarrollo Infantil públicos.

Análisis estadístico

Para la validación de contenido, se calculó la *V* de Aiken para claridad y facilidad de respuesta; el punto de corte para aceptar un reactivo sin modificación fue .89 y para aceptarlo con modificación fue de .77. La consistencia interna se estimó con el *omega* de McDonald, y se realizó un AFE con extracción de componentes principales (valores propios > 1) y rotación ortogonal Varimax. Se obtuvieron las medias y desviaciones estándar de los factores resultantes. Los análisis se efectuaron en Jamovi v. 4.1²⁷.

Consideraciones éticas

La investigación se rigió por los principios éticos de integridad académica, responsabilidad, confidencialidad y privacidad. El protocolo fue aprobado por el Comité de Ética de la UNAM-FES Iztacala con el registro 2066.

Tabla 2. Dimensiones y categorías del SOICISA con el número de reactivos derivados.

Dimensión del Sistema de Observación	Conducta relacionada	Número de Categorías	Número de reactivos originales	Número de reactivos validados
Cuidador				
Compañía	Cercanía física y atención prestada al infante	4	4	4
Presentación	Conducta instrumental para asegurar el consumo del infante	13	12	12
Verbalizaciones	Conducta vocal del cuidador presente en la situación de alimentación	6	7	7
Afecto	Ajustes secundarios que indican satisfacción, insatisfacción o indiferencia	3	6	7
Infante				
Orientación	Atención que presta a los diferentes aspectos de la situación	3	3	3
Consumo	Conducta instrumental relacionada con la ingestión o rechazo de alimentos y bebidas	11	4	4
Verbalizaciones	Conducta vocal y gestual infantil presente en la situación	7	3	3
Afecto	Ajuste secundario que indica el grado de satisfacción con la situación y la vitalidad mostrada	4	5	4

Nota: Muestra el proceso de derivación de reactivos del CPPAC. La columna de reactivos validados muestra los seleccionados mediante la validación de contenido.

RESULTADOS

Validez de contenido

En el proceso de validación de los reactivos se obtuvo un índice *V* de Aiken con valor de 1 en 36 reactivos, .89 en siete y .77 en tres. De acuerdo con las sugerencias de los jueces, se modificó la redacción de los reactivos con valores < 1: se eliminaron dos por ser redundantes; se agregó uno en la dimensión de afecto del cuidador, y se ajustaron los formatos de respuesta de tres reactivos ([Material suplementario 1](#)).

Fiabilidad y reducción de reactivos

Se recodificaron inversamente 16 reactivos que reflejaban prácticas de alimentación no idóneas. Para la consistencia interna, se conservaron los reactivos con una correlación $\geq .30$ con el puntaje total. Así, el cuestionario quedó con nueve reactivos que mostraron correlaciones entre .42 y .74, logrando una fiabilidad de $\omega = .76$. De estos, siete reactivos evalúan la conducta del cuidador y dos, la del niño.

Se aplicó un análisis factorial exploratorio (AFE) con estos reactivos, revelando una estructura de tres factores con saturaciones entre .58 y .87 y una varianza explicada de 63%. Los índices de adecuación fueron favorables: el índice Kaiser-Meyer-Olkin fue $MSA = .74$, y la prueba de esfericidad de Bartlett arrojó $\chi^2_{(36)} = 431$, $p < .01$ ([Tabla 3](#)). Los factores derivados para el cuestionario sobre conducta instrumental (CPPA-I) son los siguientes:

Práctica sensible

Este factor se relaciona con las conductas del cuidador que atienden las señales del niño de saciedad o preferencias e instigan a consumir alimentos o bebidas saludables. Está integrado por tres reactivos; presenta una consistencia interna con un valor omega .74 y 21.9 % de explicación de la varianza.

Autonomía

Este factor describe el fomento de la autosuficiencia por parte del cuidador y el grado de independencia del niño en el consumo de alimentos y bebidas. Se integra por tres reactivos con una fiabilidad de $\omega = .69$ y una varianza explicada del 20.5%.

Vigilancia del consumo

Hace referencia a las acciones del cuidador para asegurar que el infante consuma lo servido. El factor se compone de tres reactivos con un valor $\omega = .65$ explicando el 20.5% de la varianza.

Además de este instrumento, un análisis de componentes principales agrupó dos factores relacionados con los ajustes afectivos del cuidador y del niño, explicando un 51.9% de la varianza con saturaciones factoriales de .42 a .77 ([Tabla 4](#)); conformando el cuestionario sobre ajustes afectivos (CPPA-A). El índice de adecuación de la muestra fue $MSA = .69$, y la prueba de esfericidad de Bartlett mostró $\chi^2(21) = 256$, $p < .01$. El cuestionario alcanzó una consistencia interna de $\omega = .72$, con correlaciones de los reactivos con el puntaje total entre .36 y .58, excepto el reactivo nueve, que tuvo una correlación de .18.

Tabla 3. Propiedades métricas del (CPPA-I)

Reactivo		Saturación factorial	Correlación puntaje-factor
Factor 1: Práctica sensible (varianza explicada 21.9 %, $\omega = .74$)			
P9	Cuando le sirvo algo para tomar: le cambio por comida u otra bebida si es necesario.	.67	.74
P11	Si se niega a comer o beber cuando le doy en la boca, cambio el alimento o bebida.	.81	.58
P15	Si se niega a comer o beber lo servido, le cambio la comida o bebida.	.85	.59
Factor 2: Autonomía (varianza explicada 20.5%, $\omega = .69$)			
P5	Cuando le sirvo alimento sólido, le ayudo a que se lleve la comida a la boca.	.63	.66
C34	Grado de independencia para comer alimentos sólidos.	.87	.48
C35	Grado de independencia para beber líquidos.	.85	.60
Factor 3: Vigilancia del consumo (varianza explicada 20.5%, $\omega = .65$)			
P8	Cuando le sirvo algo para tomar, llamo su atención hacia la bebida y espero a que lo consuma.	.74	.54
P13	Si mi hijo se niega a comer o beber cuando le doy en la boca, lo distraigo con algo y aprovecho para dárselo.	.58	.67
P14	Si mi hijo se niega a comer o beber lo que le sirvo en el plato, biberón o vaso, llamo su atención hacia la comida o bebida y espero a que lo consuma.	.84	.42
ω de Mc Donald = .76			
Varianza Total explicada: 63 %			

Nota: Muestra los reactivos y puntuaciones de los factores extraídos mediante AFE.

Este instrumento se organizó en dos factores:

Afecto negativo. Este factor describe ajustes afectivos con valencia negativa del cuidador al alimentar al infante. Incluye cinco reactivos inversos que reflejan insatisfacción e impaciencia del adulto. Su consistencia interna es de $\omega = .72$, explicando el 32.3% de la varianza.

Afecto positivo. Este factor aborda ajustes afectivos positivos del cuidador y del niño, asociados con agrado y paciencia en el contexto de la alimentación. Su fiabilidad es de $\omega = .52$ y explica el 19.7% de la varianza.

En el CPPA-I las medias y desviaciones estándar del puntaje total y de sus tres factores fueron similares; en los factores 1 y 2 las medias se ubicaron dentro del rango posible de respuesta, mientras que el factor 3 mostró una media ligeramente mayor, lo que indica una mayor presencia de esas prácticas instrumentales. En el CPPA-A, tanto el puntaje total como las medias de los dos factores fueron prácticamente idénticos y cercanos al valor máximo, con desviaciones estándar también muy similares, sugiriendo niveles consistentemente altos en las prácticas afectivas (Tabla 5).

Todas las respuestas se califican directamente. Se calculan la media de cada factor y la media total; los puntajes más altos reflejan prácticas más responsivas del cuidador. En el caso del CPPA-I, representa un mayor empleo de prácticas instrumentales sensibles, de autonomía y de vigilancia; en el CPPA-A, de prácticas con mayor calidez afectiva.

DISCUSIÓN

Este estudio cumplió con el objetivo de construir y validar un cuestionario para evaluar la responsividad en las prácticas parentales de alimentación (PPA), integrando tanto dimensiones instrumentales como afectivas. El proceso de validación resultó en dos instrumentos independientes: uno enfocado en las conductas instrumentales, mayormente del cuidador, y otro centrado en la dimensión afectiva de la interacción diádica cuidador-infante. En relación con la cobertura conceptual, a pesar de la robustez metodológica, ninguno de los instrumentos logró abarcar completamente el sistema de categorías relevantes en investigaciones previas sobre interacciones alimentarias^{28,29}. Específicamente, las relacionadas con la dimensión compañía/orientación, las verbalizaciones de ambos y la mayoría de las de consumo del niño. Esta limitación podría deberse a la dificultad de los cuidadores para identificar y reportar todas las facetas de sus interacciones durante la alimentación. No obstante, los instrumentos lograron captar los aspectos fundamentales de las PPA responsivas: reconocimiento de señales del niño, respuesta contingente y promoción de la autonomía infantil, elementos consistentes con trabajos previos^{17,25}. Aunque no todas las categorías infantiles se registraron, debe considerarse que las correspondientes al cuidador suponen una interacción con el niño, es decir, son bidireccionales.

Tabla 4. Propiedades métricas del (CPPA-A).

Reactivo		Saturación factorial	Correlación puntaje-factor
Factor 1: Afecto negativo (Varianza explicada: 32.3 %, $\omega = .72$)			
AM25	Me desespera que coma muy lento y lo apuro.	.76	.56
AM27	Me siento cansada cuando le doy de comer.	.70	.42
AM28	Aunque ya puede comer solo, me impacienta y le doy en la boca para que sea más rápido.	.76	.58
AM29	Me molesta cuando se distrae o se ensucia.	.63	.41
Factor 2: Afecto positivo (Varianza explicada: 19.7 %, $\omega = .52$)			
AM30	Le tengo paciencia, aunque se tarde en comer.	.42	.27
AN42	Expresa su gusto por la comida mediante palabras, gritos o balbuceos.	.77	.36
AN45	Nivel de agrado a la hora de comer.	.71	.18
ω de Mc Donald = .72 Varianza Total explicada: 51.9%			

Nota: Muestra los reactivos y puntuaciones de los factores extraídos mediante AFE.

Tabla 5. Descriptivos de la puntuación total y de los factores del CPPA-I y el CPPA-A

	Media	DE	Mínimo	Máximo
CPPA-I				
Puntuación total	2.51	1.33	1.00	0.75
Práctica sensible	2.31	1.04	1.00	5.00
Autonomía	2.16	0.90	1.00	5.00
Vigilancia del consumo	3.06	1.05	1.00	5.00
CPPA-A				
Puntuación total	4.39	0.58	2.14	5.00
Afecto negativo	4.41	0.71	1.0	5.00
Afecto positivo	4.37	0.65	2.3	5.00

En cuanto a las propiedades métricas, el análisis sugiere que los instrumentos son prometedores, pero aún perfectibles. Los índices de fiabilidad ($\omega = 0.76$ para las conductas instrumentales y $\omega = 0.72$ para los ajustes afectivos) son aceptables, aunque factores como *Afecto positivo* muestran una consistencia interna relativamente baja ($\omega = 0.52$). Los análisis factoriales exploratorios explicaron entre el 51.9% y 63% de la varianza, revelando estructuras claras, pero requieren validaciones adicionales mediante análisis factorial confirmatorio.

Adicionalmente, la inclusión exclusiva de reactivos vinculados al afecto positivo ante la conducta infantil en el CPPA-A, junto con las medias elevadas observadas en ambos factores, sugiere posibles sesgos de deseabilidad social o de percepción ante las expresiones infantiles de agrado que podrían limitar la sensibilidad del instrumento para detectar variaciones entre grupos^{15,17}.

Respecto a su fundamento metodológico-conceptual, a diferencia de otros instrumentos, el presente fue construido a partir de una taxonomía de categorías observacionales, el SOICISA, que ya ha

sido ampliamente utilizada en otros estudios^{26,29}, con evidencia de validez ecológica y que discrimina entre prácticas parentales de alimentación en relación distintas condiciones nutricionales, mientras que la mayoría se enfoca solo en la obesidad infantil.

Asimismo, la mayoría de los instrumentos de previamente citados tiene como foco de interés a población infantil arriba de los dos años^{10,11}, edad en la que el consumo de alimentos sólidos está en una etapa avanzada y, en este sentido, las formas de interacción cuidador-infante son cualitativamente diferentes respecto del inicio de la alimentación complementaria. Este aspecto es destacable porque el inicio de la alimentación complementaria es un periodo relevante para la conformación de hábitos alimentarios del infante, y las consecuencias para el estado de salud.

De cara al proceso de validación, considerando que este es un proceso sumativo, donde los estudios iniciales establecen evidencia fundamental que puede ampliarse con investigaciones posteriores, en este estudio se muestra el proceso inicial. Es

importante acumular más evidencia de validez mediante un AFC e incluso aplicaciones futuras enfocadas en la validez convergente, discriminante y predictiva³⁰.

Por otro lado, el análisis de las propiedades métricas indicó que los dos cuestionarios presentados son independientes (**Material suplementario 2**). Sin embargo, se recomienda que se apliquen conjuntamente, aunque sean calificados individualmente, ya que son complementarios.

En cuanto a la interpretación de puntajes, la aplicación de este instrumento proporcionará puntuaciones centradas en la práctica sensible y la autonomía del infante, por lo que mayores puntuaciones, tanto en el ajuste afectivo como en la conducta instrumental, reflejarán prácticas más responsivas. A pesar de presentarse los valores de las medias y desviaciones estándar de los instrumentos y sus factores, estos no indican puntos de corte, ya que no se trata de un estudio de estándares poblacionales.

En términos de aplicabilidad, se recomienda el uso de los instrumentos como herramienta de cribado para identificar a cuidadores con prácticas poco o nada sensibles, a fin de realizar una evaluación más robusta. Debido a que la complejidad de las interacciones dificulta reportar la conducta propia y la del otro, resulta necesario contar con una evaluación multimétodo para el diseño de intervenciones que impacten favorablemente el estado nutricional.

No obstante, la principal limitación que presenta este estudio se relaciona con la representatividad de la muestra para un empleo generalizado de los instrumentos. Aunque el tamaño fue adecuado para el AFE, no permitió dividir la muestra y realizar un AFC, y la proporción de cuidadores de niños de 6 a 14 meses fue menor a la prevista.

Finalmente, se espera que en futuros estudios se amplíe la muestra y se subsanen las limitaciones para fortalecer la evidencia sobre su validez y aplicabilidad.

CONCLUSIONES

Este cuestionario presenta una fortaleza significativa al centrarse en la etapa de alimentación complementaria, un período crítico del desarrollo infantil que ha sido relativamente desatendido en la literatura previa. Este enfoque proporciona una herramienta que podría contribuir al diseño de intervenciones específicas para mejorar las PPA en contextos de vulnerabilidad nutricional.

Futuras investigaciones deberían considerar la verificación de validez concurrente y predictiva del cuestionario, así como su capacidad para evaluar la efectividad de intervenciones dirigidas a optimizar las interacciones diádicas durante la alimentación. Además, sería valioso explorar la aplicabilidad de estos instrumentos en poblaciones diversas, considerando las diferencias culturales y socioeconómicas que influyen en las prácticas de alimentación.

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CONTRIBUCIÓN DE AUTORÍA

A.C.M. Elaboró los protocolos de investigación en que se desarrollaron ambos instrumentos empleados y desarrolló el sistema de categorías del SOICISA, diseñó el plan estadístico, realizó el análisis de datos y escribió el primer borrador. R.H.C. y L.C.D. contribuyeron al diseño del CPPAC, revisaron los reactivos e hicieron los ajustes necesarios; participaron en la interpretación de datos y en la redacción del manuscrito. I.A.S. Participó en la revisión y ajuste de reactivos, captura y análisis de datos. 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

Los datos se encuentran disponibles bajo petición a la autora de correspondencia.

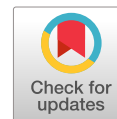
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ARTÍCULO DE INVESTIGACIÓN

Caracterización de merquén, cinética de rancidez y evaluación sensorial de su incorporación en mantequilla

Characterization of Merquén, Rancidity Kinetics, and Sensory Evaluation of Its Incorporation in Butter

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PALABRAS CLAVE

AjÍ
Merquén
Sensorial
Rancidez
Patrimonio
gastronómico.

RESUMEN

Introducción: El merquén es un producto ancestral del pueblo mapuche, que habita en la zona de Araucanía de Chile y Argentina. Se elabora en base a ajÍ deshidratado y ahumado más otros ingredientes. Forma parte del patrimonio gastronómico nacional. Contiene compuestos antioxidantes, aroma y sabor pungente y ahumado que contribuye a un perfil sensorial distintivo.

Metodología: Se caracteriza una muestra de merquén proveniente de la Araucanía en humedad, acidez, contenido de carotenoides y polifenoles totales, recuento microbiológico. Se adiciona merquén en mantequilla en 0,25 - 0,5 - 1,0 - 1,5 % (M1, M2, M3 y M4 respectivamente) manteniendo una muestra control (M0). En estas muestras se midió la acidez durante 4 meses con método volumétrico. En las muestras de mantequilla con merquén se evaluó la aceptabilidad sensorial con escala hedónica de 9 puntos por atributos (aparencia, color, aroma, sabor y textura) y se realizaron dos grupos focales para conocer la opinión de los evaluadores.

Resultados: El merquén contiene humedad de 9,4 g/100g, acidez 0,6 % de ácido cítrico, contiene 203 mg/100g base seca de carotenoides y 136,5 mg AGE/100g base seca de polifenoles totales. El recuento de hongos y levaduras cumple la reglamentación sanitaria. La adición de merquén en mantequilla provoca aumento de acidez en el tiempo, disminuyendo la vida útil. La aceptabilidad sensorial es alta, siendo la muestra con 1% y 1,5% de merquén las favoritas.

Conclusión: Las muestras mejor calificadas desde el punto de vista sensorial son M3 y M4, estas muestras tienen un significativo aumento de acidez a partir del tercer mes de almacenamiento, por lo que se debería declarar la vida útil de 2 meses.

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KEYWORDS

Chili pepper
Merquén
Sensory
Rancidity
Gastronomic heritage

ABSTRACT

Introduction: Merquén is an ancestral product of the Mapuche people in the Araucanía region of Chile and Argentina. It is made from dehydrated and smoked chili peppers and other ingredients. It is part of the national gastronomic heritage. It contains antioxidant compounds, a pungent and smoky aroma, and a delicious flavor.

Methodology: A sample of merquén from Araucanía is characterized by humidity, acidity, carotenoid and total polyphenol content, and microbiological count. Merquén is added to butter at 0.25 - 0.5 - 1 - 1.5 % (M1, M2, M3, and M4 respectively) while maintaining a control sample (M0). In these samples, the acidity was measured for 4 months using the volumetric method. In the butter samples with merquén, the sensorial acceptability was evaluated with a 9-point hedonic scale for attributes (appearance, color, aroma, flavor, and texture), and two focus groups were held to know the opinion of the evaluators.

Results: The merquén contains 9.4 g/100 g of moisture, 0.576% citric acid acidity, 203 mg/100 g dry weight of carotenoids, and 136.5 mg AGE/100 g dry weight of total polyphenols. The count of fungi and yeasts complies with health regulations. The addition of merquén to butter causes an increase in acidity over time, reducing shelf life. The sensorial acceptability is high, with samples 1% and 1.5% merquén being the favorites.

Conclusion: The samples with the highest sensory rating are M3 and M4, these samples have a significant increase in acidity from the 3rd month of storage, so the shelf life of 2 months should be declared.

Funding: School of Nutrition and Dietetics, Faculty of Health, Santo Tomás University, Santiago, Chile.

MENSAJES
CLAVE

1. El merquén contiene carotenoides y polifenoles.
2. Mantequilla adicionada con 1 y 1,5% de merquén tiene alta aceptabilidad sensorial.
3. La incorporación de merquén en mantequilla provoca aumento de la rancidez.

CITA

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INTRODUCCIÓN

El merquén o merkén (merkeñ en mapudungun, lengua del pueblo mapuche) es un aliño tradicional de los pueblos originarios del sur de Chile y Argentina, preparado en base a ají “cacho de cabra” (*Capsicum annuum* var. Longum) un ecotipo local de la Araucanía, seco y ahumado, con semillas de cilantro, sal marina y otros ingredientes. Es un condimento que se produce desde tiempos inmemoriales en Chile y Argentina, creado por la etnia Mapuche. Tradicionalmente preparado por familias para autoconsumo¹, el merquén sigue siendo elaborado de forma artesanal por mujeres de comunidades de la Araucanía. Este condimento, arraigado en las costumbres alimentarias de los chilenos, forma parte del patrimonio gastronómico y sociocultural nacional².

El merquén presenta un aroma y sabor muy característico, pungente y ahumado, que resulta agradable e irresistible. Su principal ingrediente es el ají (*Capsicum annuum* var. Longum), que contiene vitamina C, E y compuestos bioactivos como carotenoides, capsaicinas, polifenoles^{3,4}. Los compuestos capsaicinoides aportan sensación de pungencia o calor cuando se consume⁵. Se caracteriza por su tonalidad roja, aunque existe alta heterogeneidad entre los distintos tipos de merquén que se comercializan en el sur de Chile. Esto se debe a la procedencia del ají, su madurez, concentración y tipos de carotenoides. Además, el calor aplicado durante el “ahumado” podría deteriorar los pigmentos carotenoides alterando el color, también se puede producir decoloración por actividad enzimática⁶. Presenta alta capacidad antioxidante^{3,7,8}, lo que resulta muy apreciable como ingrediente, ya que retardaría la oxidación de los alimentos en los que se incorpora.

El merquén también contiene semillas de cilantro (*Coriandrum sativum* L.), aunque en menor proporción. Estas contienen monoterpenos, tocoles, esteroides, polifenoles y alta proporción de ácidos grasos monoinsaturados. Se le atribuyen efecto antimicrobiano y antioxidante entre otros⁹.

La mantequilla es un alimento lácteo y graso de alto consumo, corresponde a emulsión agua en aceite (W/O)¹⁰. Proviene de la crema de leche, y contiene mayor proporción de ácidos grasos saturados, seguidos de monoinsaturados y baja concentración de poliinsaturados. Dentro de los ácidos grasos saturados, se destacan ácidos de cadena media como ácido láurico, mirístico, esteárico (C12, C14, C18 respectivamente) y con mayor concentración ácido palmítico (C16)^{11,12}. Contiene ácidos grasos esenciales (linoleico y linolénico), ácido butírico, oleico y linoleico conjugado (CLA), vitamina A, carotenoides y tocoferoles. Se caracteriza por un sabor, aroma, color y textura característicos y muy agradables, lo que convierte a la mantequilla en un alimento apetecible, que se debe consumir con moderación¹³. Debido a su naturaleza lipídica, es susceptible de sufrir rancidez, principalmente hidrolítica, lo que provoca aumento de acidez libre junto con sabor y aroma alterado. La mantequilla se puede enriquecer con merquén para potenciar su calidad sensorial e incorporar compuestos bioactivos beneficiosos para la salud, además de mejorar su estabilidad gracias a que el

efecto antioxidante de merquén retardaría procesos de rancidez⁸. El objetivo del presente estudio es caracterizar una muestra de merquén y evaluar su incorporación en mantequilla en diferentes concentraciones, en cuanto a la estabilidad frente a rancidez oxidativa y aceptabilidad sensorial.

METODOLOGÍA

El presente estudio corresponde a un diseño experimental en que la variable independiente es la concentración de merquén adicionado en muestras de mantequilla y las variables respuesta corresponden a acidez y aceptabilidad sensorial de las muestras.

Obtención de materia prima

Se obtuvo merquén en el mercado de Temuco, elaborado por personas de comunidades mapuches, en la Región de La Araucanía, sur de Chile. Las muestras de mantequilla sin sal añadida fueron adquiridas en el mercado local. El Reglamento Sanitario de los Alimentos de Chile¹⁴ define mantequilla como producto lácteo derivado exclusivamente de la crema pasteurizada de leches.

Caracterización de merquén

Se realizaron los siguientes análisis químicos en triplicado:

Humedad: método termogravimétrico de desecación a 105 °C hasta peso constante¹⁵.

Acidez total: método potenciométrico de titulación con NaOH 0.1 N en presencia de fenolftaleína como indicador¹⁵. La acidez se expresó como ácido cítrico.

Carotenoides totales: cuantificación de carotenoides por espectrofotometría UV VIS, descrito por Rodríguez-Amaya¹⁶.

Polifenoles totales: método de Folin-Ciocalteu¹⁷.

Recuento de hongos y levaduras: recuento en placa¹⁸.

Preparación de mantequilla con merquén

Se separaron 4 muestras de mantequilla con adición de merquén: 0,25 - 0,5 - 1 - 1,5 % (M1, M2, M3 y M4 respectivamente) se batió manualmente de forma suave para incorporar el merquén de forma homogénea en la mantequilla. Se dejó una muestra control (M0).

Las muestras de mantequilla se almacenaron en refrigeración (5 °C).

Análisis de mantequilla con merquén

Cinética de Rancidez

Como medida de la rancidez hidrolítica se analizó la acidez titulable de las muestras de mantequilla durante 4 meses. Se aplicó método volumétrico titulando con NaOH 0.1N en triplicado. La acidez se expresó en porcentaje de ácido láctico¹⁵. Se realizaron

los análisis en triplicado y se aplicó análisis de varianza (ANOVA) y prueba de Tukey para establecer diferencias significativas entre las muestras con programa SPSS.

Análisis sensorial

Prueba de aceptabilidad con consumidores mediante escala hedónica de 9 puntos para evaluar los atributos de apariencia, color, aroma, sabor y textura; en que 9 corresponde a la categoría "me encanta" y 1 a "me disgusta extremadamente". Se aplicó la prueba a 90 individuos sanos de ambos sexos, de 18 a 60 años elegidos en función de su consumo habitual de mantequilla. Se aplicó presentación monádica secuencial de las muestras en diferentes sesiones, siguiendo protocolos de norma española UNE-EN ISO 11136¹⁹. Para comparar los resultados entre muestras se calculó el promedio de cada atributo evaluado y se aplicó análisis de varianza (ANOVA) y prueba de Tukey para establecer diferencias significativas entre las muestras ($p < 0.05$) con programa SPSS. El estudio fue aprobado por Comité de Ética de la Universidad (Nº Resolución ERP-11320023) y los evaluadores firmaron consentimiento informado.

Se realizaron dos grupos focales, cada uno conformado por 8 participantes, con el objetivo de recabar información sobre opiniones en torno a las muestras de mantequilla. Esta modalidad de entrevista grupal, utilizada tradicionalmente en estudios de satisfacción con consumidores, permite obtener datos cualitativos sobre actitudes, sentimientos y experiencias a través de interacción y discusión colectiva²⁰. Los participantes seleccionados correspondían a voluntarios sanos, adultos y consumidores habituales de mantequilla. En cada sesión de 60 minutos aproximadamente, se presentaron las distintas muestras de mantequilla (junto a galletas de agua sin sal y pan, además de té como bebida neutralizante); una persona actuó como moderadora dirigiendo las preguntas al grupo valorando las opiniones de cada participante. El análisis de resultados fue cualitativo, reportando la frecuencia de ideas mencionadas por los evaluadores y destacando las opiniones más repetidas²¹.

RESULTADOS

Se observa en la [Tabla 1](#) que la humedad de la muestra es baja, lo que asegura condiciones adversas para desarrollo de microorganismos, lo que coincide con los recuentos de hongos y levaduras analizados. La acidez titulable de 0,6 % expresado como ácido cítrico es más bien bajo. La presencia de polifenoles y carotenos en la muestra de merquén es considerable, lo que debería manifestarse a través de alta capacidad antioxidante en el producto.

El recuento de hongos y levaduras cumple con los límites establecidos por la reglamentación nacional¹⁴ para vegetales desecados o deshidratados.

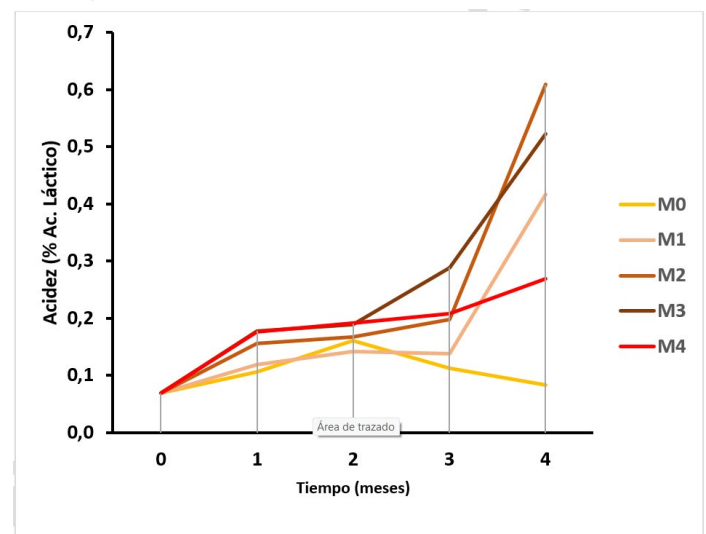
De la [Figura 1](#) se observa que, en 0, 1 y 2 meses no existen diferencias significativas entre las muestras, mientras que en el

mes 3 la muestra M3 si presenta diferencias significativas con las otras muestras y en el cuarto mes existen diferencias significativas ($p < 0,05$) entre todas las muestras. Se observa un claro aumento de la acidez en las muestras adicionadas de merquén.

Tabla 1. Caracterización de muestra de merquén

Análisis	Promedio \pm desviación estándar
Humedad (g/100g)	9,4 \pm 0,7
Acidez titulable (% A. cítrico)	0,60 \pm 0,02
Carotenos totales (mg/100g b.s.)	203,1 \pm 24,4
Polifenoles totales (mg AGE/100 g b.s.)	136,50 \pm 13,02
Recuento de hongos (UFC/g)	$< 1 \times 10^1$
Recuento de levaduras (UFC/g)	$< 1 \times 10^1$

Figura 1. Cinética de rancidez hidrolítica de muestras de mantequilla



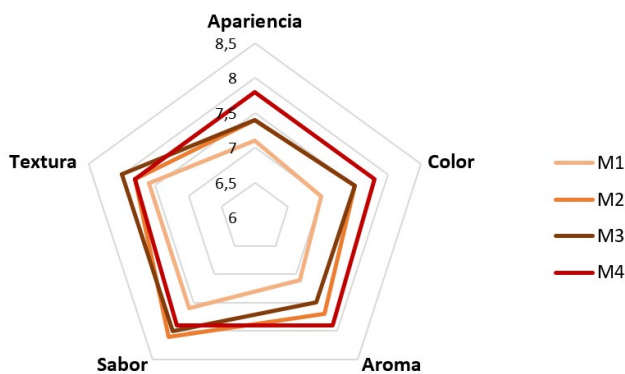
M0: muestra control; M1: mantequilla + 0,25 % merquén; M2: mantequilla + 0,50 % merquén; M3: mantequilla + 1,00 % merquén; M4: mantequilla + 1,50 % merquén

La [Figura 2](#) revela que todas las muestras obtuvieron alta aceptabilidad en los atributos evaluados, sobre el valor de 7 que corresponde a "me gusta" en la escala hedónica de 9 puntos. En todos los atributos evaluados la muestra con menor aceptabilidad fue M1 (con 0,25 % de merquén), y la muestra con mayor aceptabilidad fue M4 (con 1,5 % de merquén). Aunque el sabor de M2 y la textura de M3 presentaron una tendencia hacia una mayor aceptabilidad, no se encontraron diferencias significativas en estos atributos entre las muestras evaluadas.

De la [Figura 2](#) se observa que el puntaje en escala hedónica de apariencia y color es más alto en las muestras con mayor concentración de merquén lo que sugiere una relación positiva

entre la concentración y aceptación visual. El merquén, como se observa en la [Figura 3](#), confiere a la mantequilla una tonalidad suave y ligeramente rojiza, además de pequeñas partículas que resultan visualmente atractivas. El aroma tiene alta aceptabilidad, siendo la muestra M4 la de mayor puntaje en la escala hedónica.

Figura 2. Gráfico radial de calificación en escala hedónica de 9 puntos de muestras de mantequilla con merquén



M1: mantequilla + 0,25 % merquén; M2: mantequilla + 0,50 % merquén; M3: mantequilla + 1,00 % merquén; M4: mantequilla + 1,50 % merquén

La [Tabla 2](#) presenta un resumen de discusión de atributos en el grupo focal. En "formas de consumo", se asocia con eventos sociales y diversas comidas, vino tinto y cerveza (bebidas alcohólicas de alto consumo en Chile). En cuanto a emociones, se declaran nostalgia, recuerdo del sur e invierno, asociado al aroma y sabor ahumado, y al consumo de merquén más propio del sur de Chile.

En la [Tabla 3](#), se presentan opiniones de los sujetos, que manifestaron su agrado por las muestras de mantequilla con merquén y su intención de compra.

Los comentarios recopilados en el grupo focal ofrecieron perspectivas valiosas sobre las preferencias individuales, donde

la muestra M3 fue elogiada por su equilibrio entre mantequilla y merquén, mientras que M4 fue preferida por aquellos que disfrutaban de un sabor más picoso. En términos de compra, M3 resultó ser la opción más atractiva en general, mientras que M4 podría atraer a aquellos que consumen habitualmente ají y están más familiarizados con el sabor pungente.

DISCUSIÓN

En la elaboración del merquén, el ají y los demás ingredientes se secan de forma natural y luego se ahúman. Las condiciones de temperatura y tiempo de deshidratación y ahumado no se conocen con exactitud, dado que el proceso se realiza de manera artesanal, lo que provoca una variabilidad según el elaborador y las condiciones climáticas. Los resultados obtenidos muestran que el merquén analizado presenta una humedad de 9,4 g/100 g, un valor ligeramente superior al reportado por Palo-Tejada et al.²² para ají deshidratado en secador solar de aire por convección forzada a 55°C, el cual alcanzó 8 % de humedad.

La acidez del merquén es de 0,58 % Ac. Cítrico, valor superior al promedio de 9 variedades de *Capsicum* de Perú reportado por Gamarra²³ con 0,29 % Ac. Cítrico, y rango de 0,12 a 0,45 %. Por su parte, Martínez et al.²⁴ determinaron valores similares de acidez en híbridos de *Capsicum chinense*.

En la elaboración del merquén, el ají se seca y se somete a ahumado, lo que produce aumento de acidez, además de aromas y sabores característicos, ya que durante el ahumado se descomponen compuestos orgánicos en compuestos de cadena corta por reacciones de oxidación e hidrólisis, y aumentan las sustancias volátiles.

Los resultados presentados en la [Tabla 1](#) indican que la concentración de carotenos totales en merquén es de 203,1 mg/100g b.s., valores similares a los que determinaron Topuz y Ozdemir²⁵ en distintos cultivares de *Capsicum annum* de Turquía y similares también a los que reportan Tundis et al.⁴ en Italia. Moreno-Escamilla et al.²⁶ determinaron carotenoides en ají Jalapeño (*Capsicum annum* L.) sometido a ahumado para transformarse en "ají chipotle"; hasta el tercer día de ahumado,

Figura 3. Merquén y muestras de mantequilla con merquén



M1: mantequilla + 0,25 % merquén; M2: mantequilla + 0,50 % merquén; M3: mantequilla + 1,00 % merquén; M4: mantequilla + 1,50 % merquén

Tabla 2. Resumen de resultados de discusión de atributos de grupo focal

Color	Aroma	Sabor	Sensación de boca	Formas de consumo	Emoción
Amarillo/rojizo	Ahumado	Salado	Picor	Cóctel	Nostalgia
Puntos rojos	"a sur" A ají	Sabroso Apetitoso Familiar	Pungente	Preparaciones Reunión social Con huevo revuelto, puré, pollo, pescado. Con vino tinto Con cerveza	Recuerdo del sur Invierno

Tabla 3. Resumen de declaraciones entregadas en grupos focales**¿Qué muestra de mantequilla les gustó más? ¿por qué?**

- Creo que la M2 es mi favorita porque se siente más la mantequilla y al final el merquén, pero la M3 es como para cuando quiero algo más picoso, podría ser. Por eso estoy entre esas dos.
- La M3 me parece el equilibrio perfecto entre el sabor de la mantequilla y los distintos tonos del merquén, el final de boca es picoso pero agradable, yo me quedo con la M3.
- En proporción, la M3 es perfecto, pero a mí que me gusta más picoso me quedo con la M4. La medida justa de sabor entre mantequilla y merquén al final de boca, la M3.

¿Cómo consumiría estas mantequillas?

- En un picoteo
- Con otras cosas como aceitunas, ramitas, cosas saladas.
- Para acompañar con cerveza o vino tinto.

¿Compraría alguna de estas mantequillas?

- Sí, yo me imagino tenerla en la casa cuando quiera comer algo picoso.
- Esa es la gracia del merquén, que le baja un poco este tono grasoso y pesado a la mantequilla, queda más suave, por eso la compraría.
- Sí, yo compraría la M3.

¿Prefieren una mantequilla sola o una mantequilla con merquén?

- En este caso con merquén y no son comparables, son distintas, pero en una experiencia social, con merquén.
- Con merquén, más sabrosa, más colorida.

la concentración de carotenoides aumentó, para descender posteriormente a un valor similar a la inicial de 204 mg/100g b.s. valor muy semejante al determinado en merquén.

El proceso de ahumado en alimentos afecta su estructura, propiedades químicas y nutricionales. Los factores que afectan estos fenómenos son temperatura, tiempo y el tipo de madera usada para el proceso de ahumado²⁷.

En cuanto a los polifenoles totales, se determinó una concentración de 136,5 mg AGE/100 g b.s., valor más bajo que el determinado por Muñoz-Concha et al.²⁸ "en ají cacho de cabra" de la región del Maule con 325 mg AGE/100 g. Ponder et al.²⁹ determinaron polifenoles totales en diferentes variedades de ají, de cultivo orgánico y convencional, y los valores promedio encontrados son de 264,8 y 432,8 mg/100g b.s. En el estudio de Moreno-Escamilla et al.²⁶, la concentración de polifenoles totales aumentó en muestras de ají sometido a ahumado, de 13,91 a 19,0 mg AGE/g b.s.; los autores

lo atribuyen a la adsorción de polifenoles provenientes de la leña que se liberan durante la combustión, como ácidos fenólicos que son parte de la lignina. Por otra parte, se produce la inhibición de la enzima polifenoloxidasas, que degrada compuestos fenólicos.

El recuento de hongos y levaduras indica que el producto es inocuo y seguro para su consumo. Aunque no se determinó directamente, los bajos recuentos microbianos sugieren bajo riesgo de contaminación con ocratoxinas, un metabolito secundario sintetizado por algunos hongos pertenecientes al género *Aspergillus* y *Penicillium* que es posible encontrar en muestras de merquén, aunque han disminuido los casos en los últimos años⁶.

La rancidez hidrolítica, representada por acidez en la [Figura 1](#) aumenta en el tiempo en las muestras adicionadas con merquén. Debido a la presencia de compuestos bioactivos con capacidad antioxidante en merquén (provenientes del ají y semillas de cilantro) se esperaría el comportamiento contrario al exhibido. En

general, la adición de hierbas y especias en alimentos (en forma de extractos, aceites esenciales u otras), retarda procesos oxidativos. Farag et al.³⁰ adicionaron 0,02 % de aceite de comino y tomillo en mantequilla y la rancidez disminuyó respecto a muestra control; por su parte, Ayar et al.³¹ incorporaron extractos de salvia, romero y orégano en mantequilla y sus mezclas en concentraciones de 0,02 y 0,05 %, y demostraron que la acidez disminuía respecto a la mantequilla control excepto con extracto de salvia 0,02 %, de romero 0,02 % y 0,05 %, mezcla de orégano y romero al 0,02 %. En el estudio de margarinas de Serra et al.³², se adicionaron diferentes plantas, siendo romero, cúrcuma, pebrerola y tomillo las que demostraron efecto de estabilizar la oxidación de las margarinas, pero diente de león y anís estrella tuvieron un efecto contrario, los autores atribuyeron este efecto a que sus compuestos fenólicos no eran solubles en medio no-polar como la margarina.

El aumento de rancidez provocado por merquén se puede atribuir a que al adicionarlo se incorpora humedad, lo que cataliza la reacción de hidrólisis de triglicéridos en la mantequilla; si bien es cierto que la mantequilla contiene agua, está incorporada en la emulsión, no así la que se ingresa con el merquén. Por otra parte, algunos antioxidantes polares como polifenoles pierden su actividad porque se disuelven parcialmente en la fase acuosa o se acumulan en la interfase aceite-agua por lo que no pueden ejercer la función antioxidante esperada, los polifenoles son muy efectivos para retardar la rancidez oxidativa, no así la rancidez hidrolítica⁸.

El merquén contiene ají principalmente, que si bien es cierto contiene compuestos bioactivos con capacidad antioxidante asimismo contiene ácidos grasos poliinsaturados que se oxidan con gran facilidad y por lo tanto aumentan la rancidez³³. Por otra parte, el merquén presenta acidez (0,576 % ácido cítrico) siendo un factor que favorece la reacción de hidrólisis de triglicéridos liberando ácidos grasos.

La rancidez en mantequilla surge cuando la humedad se dispersa de manera desigual en la preparación³¹, por lo tanto, al adicionar merquén y batir se puede haber producido este fenómeno.

La evaluación sensorial de las muestras de mantequilla con merquén presentada en la [Figura 2](#) demuestra alta aceptabilidad principalmente en M2, M3 y M4.

Al analizar los datos diferenciando a los evaluadores por edad, en las personas con más de 50 años existe una tendencia al aumento de la aceptabilidad al aumentar la concentración de merquén. En cuanto a la apariencia, color y aroma, las personas entre 18 y 29 años demuestran una aceptabilidad levemente mayor que los de 30 a 49 años. El atributo sabor tiende a mayor aceptabilidad en sujetos de 18 a 29 años seguido por mayores de 50 años.

Al analizar los resultados entre hombres y mujeres, se observa que los hombres mostraron más aceptabilidad por las muestras de mantequilla con mayor concentración de merquén en color; las

mujeres presentaron una tendencia de mayor aceptabilidad en el aroma, sabor y textura de las muestras de mantequilla con merquén.

CONCLUSIONES

La incorporación de merquén a mantequilla presenta ventajas desde el punto de vista sensorial y composicional (carotenoides), ya que el merquén aporta carotenoides. El producto resulta novedoso y atractivo. De acuerdo con los resultados de respuesta sensorial de consumidores, la concentración más adecuada de merquén adicionada a mantequilla corresponde a 1 % y 1,5 %. No obstante, estas muestras tienen un significativo aumento de acidez a partir del tercer mes de almacenamiento, por lo que se debería declarar la vida útil de 2 meses.

CONTRIBUCIÓN DE AUTORÍA

V.Q., M.F., V.S. contribuyeron a la creación y diseño del estudio. M.F., J.A., V.O., V.S., V.Q. realizaron experimentos químicos y sensoriales, analizaron datos y redactaron discusiones. M.F., V.Q. participaron en la escritura del manuscrito. Todos los autores revisaron el manuscrito.

FINANCIACIÓN

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CONFLICTO DE INTERESES

Los autores y autoras no presentan conflicto de interés.

DISPONIBILIDAD DE DATOS

Los datos están disponibles para quien los solicite mediante ofrecimiento de datos bajo petición al autor/a de correspondencia.

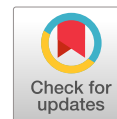
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RESEARCH ARTICLE

From pre-competition prep to recovery: analysing cyclists' dietary choices and gastrointestinal health in an endurance competition

De la preparación previa a la competición hasta la recuperación: análisis de las elecciones dietéticas y la salud gastrointestinal de los ciclistas en una competencia de resistencia

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ABSTRACT

Introduction: In recent years, long-distance events and mountain biking or MTB have seen a growth in both the number of events organised and number of participants. In this type of endurance event, proper nutritional and hydration planning is essential to maintain optimal sporting performance and reduce the incidence of gastrointestinal problems. This study aims to determine the dietary intake and compliance with nutritional recommendations of athletes in two endurance competitions at different times: pre-competition, during competition and post-competition, and as well, assess the incidence of gastrointestinal discomfort.

Methods: An observational and cross-sectional study was carried out on the consumption of liquids, food, and supplements in 40 MTB athletes participating in Gran Fondo Sierra de Alcaraz (Castilla la Mancha, Spain), in two different distances: Long-distance (143 km) and Marathon (64 km). The mean age was 44.21 ± 11.88 years, and body mass was 74.05 ± 11.86 kg. Data was registered by self-completing a validated questionnaire (NIQEC) by each participant after completing the competition.

Results: The mean intakes during the competition were 186.2 ± 92.3 kcal/h for energy, carbohydrate (CHO) 41.1 ± 21.2 g/h, fluids 516.6 ± 177.7 ml/h and sodium 181.9 ± 175.6 mg/h. Significant differences were found, with energy, CHO, and sodium intake being higher in the long-distance group. Additionally, a trend toward a negative correlation was observed in the long-distance group between CHO intake during the race and finishing time.

Conclusions: Mean intakes of CHO and sodium were lower than scientific recommendations but higher in the long-distance competitors, but fluids intake met these recommendations in both groups.



PALABRAS CLAVE

Nutrición

Resistencia

Suplementos deportivos

Alimentos

Ciclistas

NIQEC

RESUMEN

Introducción: En los últimos años, las pruebas de larga distancia y de ciclismo de montaña o BTT han experimentado un crecimiento tanto en el número de eventos organizados como en el número de participantes. En este tipo de pruebas de resistencia, una adecuada planificación nutricional y de hidratación es esencial para mantener un rendimiento deportivo óptimo y reducir la incidencia de problemas gastrointestinales. El objetivo de este estudio es determinar la ingesta dietética y el cumplimiento de las recomendaciones nutricionales de los deportistas en dos competiciones de resistencia en diferentes momentos: pre-competición, durante la competición y post-competición, así como evaluar la incidencia de molestias gastrointestinales.

Metodología: Se realizó un estudio observacional y transversal sobre el consumo de líquidos, alimentos y suplementos en 40 deportistas de MTB participantes en la prueba Gran Fondo Sierra de Alcaraz (Castilla la Mancha, España), en dos distancias diferentes: Larga distancia (143 km) y Maratón (64 km). La edad media fue de 44.21 ± 11.88 años y la masa corporal de 74.05 ± 11.86 kg. Los datos se registraron mediante la autocomplimentación de un cuestionario validado (NIQEC) por cada participante tras finalizar la competición.

Resultados: Las ingestas medias durante la competición fueron de 186.2 ± 92.3 kcal/h de energía, hidratos de carbono (CHO) 41.1 ± 21.2 g/h, líquidos 516.6 ± 177.7 ml/h y sodio 181.9 ± 175.6 mg/h. Se encontraron diferencias significativas, siendo la ingesta de energía, CHO y sodio mayor en el grupo de larga distancia. Además, se observó una tendencia hacia una correlación negativa en el grupo de larga distancia entre la ingesta de CHO.

Conclusiones: La ingesta media de CHO y sodio fue inferior a las recomendaciones científicas, pero superior en los competidores de larga distancia, aunque la ingesta de líquidos cumplió con estas recomendaciones en ambos grupos.

KEY MESSAGES

1. Proper planning of carbohydrate (CHO), fluid, and sodium intake before, during, and after mountain bike (MTB) competitions is essential to optimize athletic performance and reduce gastrointestinal complaints.
2. Cyclists participating in the Gran Fondo Sierra de Alcaraz consumed CHO and sodium levels below scientific recommendations during the competition, which could limit their performance capacity in prolonged events.
3. A negative trend was observed between CHO intake during the competition and finishing time among long-distance cyclists, suggesting that higher consumption could improve performance outcomes.
4. Long-distance cyclists showed greater awareness of the importance of pre-competition fluid and CHO intake but still faced challenges in meeting intra-competition recommendations.

CITATION

Castillo-Martínez M, Jiménez-Alfageme R, Ayala-Guzmán CI, Martín Hernández S, Sospedra I, Norte A, Romero-García D, Herrera-Puche L, Martínez-Sanz JM. From pre-competition prep to recovery: analysing cyclists' dietary choices and gastrointestinal health in an endurance competition. Rev Esp Nutr Hum Diet. 2025; 29(3): e2458. doi: <https://doi.org/10.14306/renhyd.29.3.2458>

INTRODUCTION

Cycling is the second most popular sport in Spain according to the 2022 sports habits survey¹. In terms of competitive cycling the Real Federación Española de Ciclismo (RFEC) registered 73,496 licenses at the end of the year 2023². The Union Cycliste Internationale (UCI) recognises 11 competition disciplines: Road, Track, Mountain Bike (MTB), BMX freestyle, BMX Racing, Indoor cycling, Trials, Cyclo-cross, Gravel, Cycling Esports and Para-cycling³. MTB is a discipline off-road with a wide variety of terrain and obstacles like rocks, branches, ruts, and tree roots⁴. There are some disciplines of MTB, based in the distance and specific characteristics of the track (i.e.: XCO-Olympic cross country, XCM-Cross country marathon, XCUM-Cross country ultramarathon ...) each one with individual rules of the RFEC⁵.

Optimal physiological conditioning for the cyclists is essential for a good performance because all three energy energetic pathways are used: phosphagen (explosive efforts up to 6s), glycolytic (medium intensity efforts >6s up to 1 min) and oxidative phosphorylation (efforts >1 min)⁶. It has been widely scientific evidence about the glycogen paper in endurance athletes, as a fuel source and its depletion as a limiting factor in performance⁷. In submaximal long-distance cycling events there will be varied intensities from moderate (i.e. 65% VO_2max) to high intensity exercise (85% VO_2max), caused by changes in environmental conditions, terrain, peloton race dynamics and in the final sprint which imply an increase in the use of muscle and liver glycogenesis, making carbohydrates (CHO) metabolism predominant⁸.

Diet and timing play special role in a cyclist's nutritional preparation. The importance of CHO consumption prior to a competition or training has been widely established⁹. Current guidelines recommend a high-CHO-containing meal of ~1-4g/kg >60 min prior to exercise⁹, considering important factors the amount, type of CHO and avoid fat or protein to minimise the risk of gastrointestinal (GI) discomfort¹⁰. The recommendations when cycling at a high intensity for more than 120-150 min, recent research suggests to consume 120g/hour of exercise with CHO from different sources (glucose, fructose, solid, liquid or semisolid) to optimise their absorption and subsequent utilisation⁶. However this requires athletes to train their digestive system to avoid GI discomfort¹¹. Post-exercise recommendations for CHO intake are aimed for maximally replenishing glycogen stores, the recommended amount of CHO post-exercise is 1-1.2 g/kg, in case that cyclist cannot reach this amount, is interesting the co-ingestion of protein to complete the recovery meal (i.e.: 0.8 g CHO/kg and 0.4 g protein/kg)¹².

Another important aspect in terms of performance is the state of hydration. Sweat rates can reach 5L/h in fit athletes but 0.5-1.5L/h is more common⁶. The recommended volume and rate of fluid consumption during exercise are dependent on the athlete's individual sweat rate, but the American College of Sports Medicine (ACSM) recommends 4 hours prior to exercise small and slowly

drink beverages (~5-7 mL/kg). In addition, is recommended to consume 0.4 to 0.8 L/h with 300-600 mg/h of sodium during prolonged exercise of more than 2 hours, in order to reduce the risk of dehydration and prevent hyponatraemia¹³. It is also recommended post-exercise to consume 150% of the fluid lost based on body mass, taking into account the incorporation of sodium (>60 mmol/L) to facilitate greater fluid retention¹³.

The use of ergogenic aids could improve the performance in MTB, being caffeine one with most scientific evidence in dose of 3-6 mg·BM⁻¹ 45-60 before exercise or in smaller doses throughout the ride¹⁴. Considering the high nutritional demands of endurance cycling and all the factors surrounding peak performance, including dietary habits, ergogenic aids consumption, timing and hydration, the present study aimed to determine the dietary intake and compliance with nutritional recommendations of cyclists in two MTB-endurance competitions at different times: pre-, during and post-competition, as well as assess the incidence of GI complaints.

METHODOLOGY

Study Design

This is an observational and cross-sectional study on the consumption of nutrients, fluids, and supplements and the occurrence of gastrointestinal discomfort by cyclists participating in the MTB Gran Fondo Sierra de Alcaraz, Spain (October 2023). The competition consisted in two MTB competitions: Gran Fondo with 140 km distance (5h 30 min to 9 hours); MTB Marathon with 62km distance (2h 30 min to 5 hours)¹⁵. The manuscript is presented according to the STROBE-nut guidelines for nutritional epidemiology, an extension of the general STROBE recommendations for observational research.

Study Population

The study population was selected by non-probability, non-injury, convenience sampling, as participants were recruited by email from the organising institutions. The eligibility criteria established were 1) Participants must have completed the competitions in one of its two distances (143 or 64 km); 2) -Not suffered from any injuries or illnesses in the six months prior to the survey; 3) complete the NIQEC questionnaire.

Procedure

To select the study sample organisers of the MTB Gran Fondo Sierra de Alcaraz 2023 were contacted by e-mail to inform them of the characteristics of the study and to request their collaboration. After agreeing to participate, the cyclists could fill the questionnaire voluntarily, electronically and anonymously. The questionnaire was sent out at two time points: on the race day (5 October 2023) and

two days later via race's newsletter. With the cooperation of the event organisers, the link reporting to the NIQEC questionnaire with instructions on how to fill it in was made available to the participants.

Study Variables - Instruments

A online self-administered NIQEC questionnaire, developed specifically to obtain fluid, food, and supplement intake and to determine the incidence of gastrointestinal complaints in endurance competitions, was used¹⁶. The questionnaire consists of 50 questions and contains five main sections: (1) sociodemographic data; (2) sports data; (3) food, liquid, and supplement intake in the hour before, during, and in the hour after the competition; (4) possible gastrointestinal complaints; and (5) dietary-nutritional planning of the test. The coding of the variables and the estimation of energy and macronutrients was carried out by a trained dietitian-nutritionist, using the Spanish Database of Food Composition (BEDCA) and following the guide to perform the nutritional estimation from the NIQEC questionnaire developed by the authors of the questionnaire¹⁷.

Statistical Analysis

The statistical analysis was run with the statistical package STATA 15 (College Station, TX). Only completed questionnaires were analysed with no imputation for missing data. The mean and standard deviations of the variables were calculated. Normality of the variables was verified by the Shapiro Wilk test. To analyse differences according to finishing time, Anova or Kruskal Wallis tests were used, depending on the normality of the variables. An alpha level of $p < 0.05$ was established. The relationship between finishing time with demographics, training characteristics, and pre-, intra-, and post-competition intake on each distance, was evaluated using Pearson's correlation coefficients. The effect sizes were calculated as Cohen's d and interpreted using sport-specific thresholds for highly trained population: 1 trivial (< 0.25), small (0.25-0.5), moderate (0.5-1.0), and large (> 1.0). For variables that showed asymmetric distribution, the median and Mann-Whitney U test were used. The effect size was estimated with the rank-biserial correlation coefficient and interpreted as follows: 2 small = 0.10-0.29, medium = 0.30-0.49, large = > 0.50 .

RESULTS

A total of 210 athletes were invited to participate across two endurance competitions. Of these, 40 male cyclists (20 to 67 years old) participants voluntarily completed the full questionnaire and met the inclusion criteria. Table 1 provides participants characteristics information on the age, basic anthropometric characteristics, years of sporting experience and competition finishing times of the study participants.

Regarding nutritional advice and planning, GI problems and the type of CHO consumed are shown in Table 2. Half of the participants had a nutrition plan before the competition. Most of the male cyclists did not have nutrition counselling before the competition and had a pre-, intra-, or post-competition intake strategy. Less than a quarter of athletes reported a gastrointestinal problem during competition, such as gases, urge to defecate, stomachache, and mushy stool or diarrhoea were the most common referred symptoms. Pre-, intra- and post-competition CHO intake from solids, liquids or semi-liquids are also shown in table 2.

Findings related to nutritional intake in the 60 minutes prior to competition are displayed in Table 3.

Participation in the long competition was associated with elevated levels of total fluid consumption, ml/kg body mass, total CHO consumption and g CHO/kg body mass. ($p < 0.05$). No significant differences were found in the rest of the nutrients analysed. Significant differences were found between groups in the recommended nutrient ranges for the fluids ($p = 0.014$). Despite body mass-relative caffeine intake (i.e., relative to body mass, g/kg) was not different between marathon distance and long-distance cyclists ($p = 0.509$), it was observed ($d = 0.66$).

The nutritional intakes per hour during the competition are exhibited in Table 4. The long-distance cyclists ingested more fluids (i.e., relative to body mass, ml/kg), protein and fat (i.e., relative to body mass, g/kg), and total or body mass relative energy, carbohydrates and sodium (Table 4, $p < 0.050$). The effect size was large for protein and fluids intake ($d = 0.51$ and 0.81 , respectively), and medium for fat intake ($d = 0.41$, respectively). The effect size was large for protein and fluids intake ($d = 0.51$ and 0.81 , respectively), and medium for fat intake ($d = 0.41$, respectively). The total energy intake showed a large effect size ($d = 1.17$), while body mass relative energy intake showed a trivial effect size ($d = 0.14$). The carbohydrate intake showed a large effect size ($d = 1.17$ to 2.61). Sodium intake showed a moderate to large effect size ($d = 0.44$ to 0.70).

Nutritional intakes during the hour following the competition are displayed in Table 5. Despite body mass relative fluids and caffeine post-competition intake was not different between marathon and long-distance ($p > 0.050$), it was observed a moderate effect size ($d = 0.62$ and 0.72 , respectively).

In consideration of the correlations between the finishing time of the competition and the variables analysed, a positive correlation was identified for the athletes participating in the marathon distance with respect to age ($p = 0.000$), body mass ($p = 0.007$), BMI ($p = 0.000$) and time in the sport modality ($p = 0.001$). Regarding the nutrients analysed, only a negative trend was found between of caffeine per hour intake during the competition and the finishing time ($p = 0.090$), and a negative correlation between the fluids intake (ml/kg body mass) in the following hour and the finishing time ($p = 0.000$).

Regarding the long-distance category, negative correlations were found between the finishing time and the frequency of weekly exercise ($p = 0.004$), the intake of caffeine per hour during the

Table 1. Descriptive characteristics of the participants in the study.

	Overall (n=40)		Cycling modality race		p
	n	%	Marathon distance (n= 20)	Long-distance(n= 20)	
			%	%	
BMI (kg/m²)					
LW/NW	25.0	62.5	60.0	65.0	0.744
OW/OB	15.0	37.5	40.0	35.0	
Age (yrs)					
20 - 39	12.0	30.0	30.0	30.0	0.524
40 - 44	13.0	32.5	25.0	40.0	
>45	15.0	37.5	45.0	30.0	
Allergy diagnosis					
No	39.0	97.5	95.0	100.0	0.311
Yes	1.0	2.5	5.0	0.0	
Federated athlete					
No	25.0	62.5	80.0	45.0	0.022
Yes	15.0	37.5	20.0	55.0	
Sports experience					
PARL	34.0	85.0	90.0	80.0	0.376
NL	6.0	15.0	10.0	20.0	
Exercise frequency (s/w)					
1 – 3	13.0	32.5	45.0	20.0	0.116
4 – 6	26.0	65.0	50.0	80.0	
≥7	1.0	2.5	5.0	0.0	
Exercise time (h/w)					
1 – 8	12.0	30.0	45.0	15.0	0.115
9 – 10	16.0	40.0	30.0	50.0	
≥11	12.0	30.0	25.0	35.0	
Double training session					
No	28.0	70.0	65.0	75.0	0.490
Yes	12.0	30.0	35.0	25.0	
	n	Mean ±SD	Mean ±SD	Mean ±SD	p
Age (yrs)	40.0	45.0 ±11.9	46.4 ±13.9	43.5 ±9.5	0.455
Height (m)	40.0	1.75 ±0.05	1.75 ±0.05	1.74 ±0.05	0.335
Body mass (kg)	40.0	74.1 ±11.7	76.5 ±14.6	71.7 ±7.4	0.199
BMI (kg/m²)	40.0	24.2 ±3.4	24.7 ±3.9	23.8 ±2.9	0.404
TSM (yrs)	40.0	11.2 ±7.8	11.5 ±7.6	8.5 ±8.0	0.349
Exercise frequency	40.0	4.1 ±1.3	4.0 ±1.6	4.0 ±1.1	0.167
Exercise time (h/w)	40.0	9.4 ±2.6	8.9 ±2.9	9.9 ±2.3	0.214

Abbreviations: BMI, body mass index; LW/NW, low and normal body mass; OW/OB, overweight or obese; PARL, provincial, autonomous or regional level; NL, national level; SD, standard deviation; h/w, hours per week.

Table 2. Nutrition planning and counseling, nutrition timing and gastrointestinal problems of male cyclists sample.

	Overall (n=40)		Cycling modality race		p
	n	%	Marathon distance (n= 20)	Long- distance(n= 20)	
			%	%	
Special planning	12.0	30.0	10.0	50.0	0.006
Nutrition planning	20.0	50.0	40.0	60.0	0.206
Nutrition counselling					
Coach	2.0	5.0	5.0	5.0	0.834
Internet	3.0	7.5	5.0	10.0	
Nutritionist	1.0	2.5	0.0	5.0	
Friend	2.0	5.0	5.0	5.0	
None	32.0	80.0	85.0	75.0	
Pre-competition intake	39.0	97.5	95.0	100.0	0.311
Intra-competition intake	40.0	100.0	100.0	100.0	-
Post-competition intake	38.0	95.0	90.0	100.0	0.147
GIP during competition					
GIP	9.0	22.5	10.0	35.0	0.058
Burps	2.0	5.0	0.0	10.0	0.147
Bloating	2.0	5.0	0.0	10.0	0.147
Gases	5.0	12.5	5.0	20.0	0.151
Flatulence	1.0	2.5	0.0	5.0	0.311
Stomachache	3.0	7.5	10.0	5.0	0.548
Urge to defecate	3.0	7.5	10.0	5.0	0.548
Mushy stool or diarrhoea	3.0	7.5	10.0	5.0	0.548
	n	Mean ±SD	Mean ±SD	Mean ±SD	p
Pre-competition (1 h, g)					
CHO from liquids	23.0	27.3 ±17.6	22.8 ±16.2	31.4 ±18.5	0.249
CHO from semiliquids	8.0	33.7 ±32.9	28.5 ±41.2	22.0 ±4.0	0.177
CHO from solids	26.0	47.6 ±23.2	38.0 ±15.1	57.3 ±26.2	0.030
Intra-competition (g/h)					
CHO from liquids	33.0	18.7 ±12.1	14.4 ±9.1	17.3 ±13.9	0.610
CHO from semiliquids	36.0	19.0 ±15.8	10.5 ±13.0	17.4 ±17.9	0.373
CHO from solids	32.0	10.7 ±6.4	8.9 ±4.4	11.7 ±7.3	0.235
Post-competition (1 h, g)					
CHO from liquids	34.0	35.7 ±26.5	26.1 ±18.3	35.0 ±30.5	0.106
CHO from semiliquids	2.0	21.0 ±1.4	21.0 ±1.4	-	-
CHO from solids	30.0	57.7 ±37.6	48.8 ±41.5	65.6 ±33.2	0.228

Abbreviations: GIP, gastrointestinal problems; CHO carbohydrates

Table 3. Pre-competition fluids, energy, and nutrient intake of a sample of male cyclists.

	Overall (n=40)		Cycling modality race		p	Effect size
	n	Mean \pm SD	Marathon distance (n= 20) Mean \pm SD	Long-distance (n= 20) Mean \pm SD		
Pre-competition intake						
Fluids (ml)	38.0	550.0 \pm 292.2	430.0 \pm 186.1	658.2 \pm 330.6	0.014	0.85 ^a
Fluids (ml/kg)	38.0	7.5 \pm 4.4	5.6 \pm 2.5	9.2 \pm 4.9	0.009	0.93 ^a
Energy (kcal)	35.0	375.3 \pm 227.1	342.0 \pm 211.7	410.5 \pm 243.7	0.381	0.30 ^a
Energy (kcal/kg)	35.0	5.1 \pm 3.3	3.2 \pm 3.1	5.8 \pm 3.4	0.324	0.23 ^b
Carbohydrates (g)	33.0	65.1 \pm 37.4	53.4 \pm 34.4	79.1 \pm 37.1	0.047	0.72 ^a
Carbohydrates (g/kg)	33.0	0.90 \pm 0.54	0.72 \pm 0.50	1.10 \pm 0.54	0.044	0.73 ^a
Protein (g)	34.0	10.8 \pm 9.3	11.6 \pm 11.0	8.5 \pm 7.0	0.309	0.43 ^b
Protein (g/kg)	34.0	0.15 \pm 0.13	0.12 \pm 0.15	0.11 \pm 0.09	0.480	0.12 ^b
Fat (g)	33.0	9.4 \pm 9.0	7.5 \pm 8.6	7.1 \pm 9.6	0.815	0.04 ^b
Fat (g/kg)	33.0	0.13 \pm 0.12	0.09 \pm 0.12	0.09 \pm 0.13	0.942	0.01 ^b
Sodium (mg)	35.0	269.9 \pm 241.0	211.5 \pm 257.2	210.7 \pm 230.4	0.895	0.02 ^b
Sodium (mg/kg)	35.0	3.8 \pm 3.7	2.5 \pm 4.2	2.8 \pm 3.2	0.973	0.00 ^b
Caffeine (mg)	19.0	108.8 \pm 76.5	133.7 \pm 101.8	80.0 \pm 41.8	0.332	0.22 ^b
Caffeine (mg/kg)	19.0	1.4 \pm 0.9	1.5 \pm 1.1	1.1 \pm 0.5	0.509	0.66 ^a
	n	%	%	%	p	
Fluids						
<5 ml/kg	12.0	31.6	50.0	15.0	0.014	
5 - 7 ml/kg	6.0	15.8	22.2	10.0		
>7 g/kg	20.0	52.6	27.8	75.0		
Carbohydrates						
<1 g/kg	20.0	60.6	72.2	46.7	0.135	
\geq 1 g/kg	13.0	39.4	27.8	53.3		
Caffeine						
<1 mg/kg	5.0	26.3	37.5	18.2	0.089	
1 - 3 mg/kg	12.0	63.1	37.5	81.8		
>3 mg/kg	2.0	10.5	25.0	0.0		

Note: The effect size was based on Cohen's d^a or rank-biserial correlation coefficient^b

Table 4. Intra-competition fluids, energy and nutrient intake per hour of a sample of male cyclists.

	Overall (n=40)		Cycling modality race		p	Effect size
	n	Mean \pm SD	Marathon distance (n= 20)	Long-distance (n= 20)		
			Mean \pm SD	Mean \pm SD		
Intra-competition intake						
Fluids (ml/h)	40.0	516.6 \pm 177.7	525.9 \pm 193.1	507.4 \pm 165.8	0.786	0.04 ^b
Fluids (ml/kg)	40.0	38.2 \pm 19.8	22.8 \pm 7.9	47.8 \pm 16.1	0.000	0.81 ^b
Energy (kcal/h)	40.0	186.2 \pm 92.3	139.3 \pm 76.3	233.0 \pm 84.0	0.000	1.17 ^a
Energy (kcal/kg)	40.0	15.4 \pm 11.7	6.4 \pm 3.8	24.4 \pm 9.8	0.000	0.14 ^a
Carbohydrates (g/h)	40.0	41.1 \pm 21.2	30.3 \pm 17.2	51.9 \pm 19.6	0.000	1.17 ^a
Carbohydrates (g/kg)	40.0	3.4 \pm 2.5	1.4 \pm 0.8	5.3 \pm 2.0	0.000	2.61 ^a
Protein (g/h)	36.0	1.7 \pm 2.0	0.41 \pm 1.9	1.5 \pm 2.0	0.091	0.28 ^b
Protein (g/kg)	36.0	0.15 \pm 0.21	0.02 \pm 0.11	0.15 \pm 0.26	0.002	0.51 ^b
Fat (g/h)	34.0	1.4 \pm 1.8	0.25 \pm 1.4	0.96 \pm 2.1	0.270	0.19 ^b
Fat (g/kg)	34.0	0.13 \pm 0.21	0.01 \pm 0.08	0.10 \pm 0.26	0.015	0.41 ^b
Sodium (mg/h)	40.0	181.9 \pm 175.6	74.8 \pm 134.9	204.0 \pm 195.4	0.005	0.44 ^b
Sodium (mg/kg)	40.0	15.5 \pm 18.7	3.5 \pm 5.9	20.3 \pm 21.8	0.000	0.70 ^b
Caffeine (mg/h)	24.0	27.4 \pm 23.6	37.2 \pm 37.8	24.2 \pm 17.0	0.252	0.44 ^a
Caffeine (mg/kg)	24.0	2.2 \pm 1.7	1.7 \pm 1.6	2.4 \pm 1.7	0.344	0.46 ^a
	n	%	%	%	p	
Fluids						
<400 ml/h	12.0	30.0	35.0	25.0	0.702	
400 - 800 ml/h	25.0	62.5	60.0	65.0		
> 800 ml/h	3.0	7.5	5.0	10.0		
Carbohydrates						
<30 g/h	11.0	27.5	40.0	15.0	0.019	
30 - 60 g/h	20.0	50.0	55.0	45.0		
60 - 90 g/h	9.0	22.5	5.0	40.0		
Sodium						
<300 mg/h	34.0	85.0	90.0	80.0	0.517	
300 - 600 mg/h	5.0	12.5	10.0	15.0		
>600 mg/h	1.0	2.5	0.0	5.0		
Caffeine						
0 mg/kg	16.0	40.0	70.0	10.0	0.001	
<1 mg/kg	8.0	20.0	15.0	25.0		
1 - 3 mg/kg	8.0	20.0	5.0	35.0		
>3 mg/kg	8.0	20.0	10.0	30.0		

Note: The effect size was based on Cohen's d^a or rank-biserial correlation coefficient^b

Table 5. Post-competition fluids, energy and nutrient intake of a sample of male cyclists.

	Overall (n=40)		Cycling modality race		p	Effect size
	n	Mean ±SD	Marathon distance (n= 20)	Long-distance (n= 20)		
			Mean ±SD	Mean ±SD		
Post-competition intake						
Fluids (ml)	38.0	933.7 ±416.0	806.0 ±271.7	1,048.5 ±491.6	0.072	0.61 ^a
Fluids (ml/kg)	38.0	12.9 ±6.1	11.0 ±4.4	14.7 ±7.1	0.067	0.62 ^a
Energy (kcal)	37.0	628.8 ±402.0	543.5 ±322.4	701.4 ±454.5	0.239	0.40 ^a
Energy (kcal/kg)	37.0	8.8 ±5.8	4.4 ±5.4	8.7 ±6.1	0.437	0.13 ^b
Carbohydrates (g)	37.0	80.7 ±49.0	52.7 ±41.8	86.3 ±52.5	0.175	0.22 ^b
Carbohydrates (g/kg)	37.0	1.1 ±0.7	0.75 ±0.74	1.3 ±0.74	0.135	0.24 ^b
Protein (g)	36.0	31.4 ±23.8	27.9 ±24.3	34.5 ±23.6	0.411	0.15 ^b
Protein (g/kg)	36.0	0.44 ±0.34	0.24 ±0.38	0.48 ±0.31	0.350	0.28 ^a
Fat (g)	33.0	13.2 ±12.0	9.8 ±10.1	10.7 ±13.5	0.612	0.09 ^b
Fat (g/kg)	33.0	0.18 ±0.17	0.11 ±0.15	0.16 ±0.18	0.638	0.08 ^b
Sodium (mg)	36.0	517.3 ±445.8	300.4 ±309.9	590.1 ±523.9	0.117	0.26 ^b
Sodium (mg/kg)	36.0	7.2 ±6.4	3.4 ±4.7	8.5 ±7.4	0.132	0.25 ^b
Caffeine (mg)	9.0	70.5 ±61.8	33.2 ±27.0	54.8 ±73.4	1.000	0.00 ^b
Caffeine (mg/kg)	9.0	0.94 ±0.82	0.60 ±0.27	1.11 ±0.97	0.417	0.72 ^a
Carbohydrates/protein	36.0	7.2 ±14.9	2.9 ±21.1	2.7 ±2.8	0.623	0.08 ^b
	n	%	%	%	p	
Carbohydrates						
<0.8 g/kg	15.0	40.5	58.8	25.0	0.082	
0.8 – 1.2 g/kg	4.0	10.8	11.8	10.0		
>1.2 g/kg	18.0	48.6	29.4	65.0		
Protein						
<0.2 g/kg	10.0	28.6	43.7	15.8	0.170	
0.2 – 0.4g/kg	7.0	20.0	12.5	26.3		
>0.4 g/kg	18.0	51.4	43.7	57.9		

Note: The effect size was based on Cohen's d^a or rank-biserial correlation coefficient^b

competition ($p=0.027$) and a strong negative trend with the intake of CHO per hour during the competition ($p=0.062$). Furthermore, a positive correlation was found between pre-competition fluid intake (ml/kg body mass) and finishing time ($p=0.012$).

DISCUSSION

Food intake, supplements, fluids, and gastrointestinal discomfort experienced in 40 MTB athletes participating in the Gran Fondo Sierra de Alcaraz event, were assessed in this study, comprised two modalities and two different distances: MTB Long Distance (143 km) and Marathon (64 km). Information was collected using a validated questionnaire, NIQEC questionnaire¹⁶.

In terms of pre-competition time, every group met the recommendations of CHO (1 g/kg) and liquids (5–10 mL/kg or 400–600 mL)^{18,19}, similar data to other endurance sports (trail runners and triathletes) was observed by Jiménez-Alfageme et al.²⁰.

During the competition, the study results showed that cyclists CHO intake was below current recommendations, which suggest that athletes should consume between 90–120 g/h of CHO during events exceeding 2.5 hours, using both SGLT1 and GLUT5 (glucose and fructose) transporters to facilitate absorption^{21,22}. This average intake (4.1 g/h) is comparable to, though marginally higher than, that documented for other endurance athletes such as trail runners over various distances in several studies (31 g/h, 35 g/h)^{21,23} or marathoners (35 g/h)^{24,25}. However, it was lower than that reported

for middle- and long-distance triathletes in several studies (47 g/h, 62 g/h, 65 g/h, or 71 g/h)^{21,25}.

Regarding hydration, participants were (average 0.5 mL/h) in the recommended range established by the ACSM (0.4-0.8 L/h)¹³, higher intake than that found in studies on trail runners and middle-distance triathletes (447.1 and 422.5 mg/h, respectively)²⁰ and marathon runners (466 and 354 mL/h)^{24,25}, but lower than that reported for long-distance triathletes and cyclists (between 643 and 794 mL/h)²⁵.

Following the hydration data during event, the sodium average consumed by total sample (181.9 mg/h) was considerably below the recommendations for long-duration endurance events (300-600 mg/h), which could increase the risk of hyponatremia, especially in high-temperature conditions¹³. This results were similar to what reported in previous studies on marathon runners (118 and 192 mg/h)^{24,25}, but lower than in trail runners and middle- and long-distance triathletes (between 269.5 and 444 mg/h)^{21,25}. Concerning the post-competition period, no significant differences were observed between nutrition intake of participants in both distances, but CHO intake in the short-distance group did not meet suggested recommendations of 0.8-1 g/kg²⁶, it seems that this is also observed in other endurance sports such as triathlon and trail running²⁰.

To conclude the discussion on the nutrient and energy part of the issue, a comparative analysis revealed significant differences in nutritional intake based on competition distance. Long-distance participants (140 km) exhibited significantly higher consumption of kilocalories, CHO, and sodium during competition ($p < 0.05$), as well as greater fluid and CHO intake in the pre-competition period. These results were similar to the study by Martinez et al.²³ which documented similar patterns in mountain ultramarathon runners, identifying a direct relationship between competitive distance and CHO intake. This convergence of findings across different endurance disciplines reinforces the hypothesis of a natural adaptation of nutritional strategies according to effort duration, possibly as a compensatory mechanism for greater glycogen depletion in prolonged events²¹.

In addition to dietary intake data, the study analysed possible gastrointestinal complaints perceived by the participants, and results of less than 25% were lower than compared to other endurance events, where rates could range between 30% and 90% of participants according to various studies²⁷. Paradoxically, the relatively low CHO intake observed in this study (41.1 g/h) could partially explain the lower prevalence of digestive problems, albeit at the cost of potentially suboptimal performance. These findings align with Pfeiffer et al.'s 2012 study²⁵ which found a positive correlation between CHO intake and the incidence of gastrointestinal problems in endurance athletes, demonstrating that intakes exceeding 60 g/h were associated with higher rates of gastrointestinal distress.

As regards ergogenic aids a key finding of the study was the negative correlation between caffeine consumption and finishing

time in both distances, suggesting an ergogenic effect of this compound. This is consistent with the ISSN Position Stand¹⁴ and a 2022 meta-analysis²⁸ which state that caffeine's effects are particularly relevant in disciplines such as MTB, concluding that caffeine could improve endurance performance by 1.1% to 2.7%, a margin considered relevant in elite competitions.

Finally, some aspects related to performance were analysed. On the one hand a not statistical significance negative correlation ($p = 0.062$) was also identified between CHO intake per hour and finishing time in the long-distance event, but even not statistical significance they were consistent with various endurance sports studies^{25,29} which observed performance improvements associated with higher CHO intake during prolonged exercise. On the other hand, Different performance predictors were also identified based on race distance. In the Marathon modality (62 km), anthropometric factors (body mass, BMI) and age showed significant positive correlations with finishing time, while in the long-distance category, weekly exercise frequency emerged as a negative predictive variable. This dichotomy has been supported by Allen and Hopkins' research³⁰ which established that in shorter events, body composition has greater influence, whereas metabolic efficiency parameters become more relevant in ultra-endurance competitions.

On another note, a concerning finding of the study was that only half of the participants had an established nutritional plan for the day prior to competition, and most did not receive specialized nutritional advice. Similar trends have been reported in other endurance sports, such as marathon running, where a higher percentage of pre-competition nutritional planning was observed, yet the lack of professional guidance persisted. This absence of tailored nutritional support and planning may partly explain the suboptimal CHO and sodium intake recorded during the race, leading to conclusions similar to those of Burke et al. (2017)¹⁸, who found that personalized nutritional interventions significantly enhance performance.

Limitations

The use of the NIQEC instrument in this study responds to the need for systematic tools that allow for the structured and formative collection of nutritional intake data in competitive contexts, without the intention of measuring latent constructs or psychological dimensions. It is a descriptive-type questionnaire, in which each item has individual, non-aggregable informational value referred to as formative indicators, as opposed to reflective or latent indicators³¹. In such instruments, internal consistency measures and factor analyses are not appropriate, as the items are not required to correlate with each other in order to be considered valid³². Although the questionnaire was developed through a Delphi process involving expert judgement, formal indices of content validity such as the Content Validity Index (CVI) were not calculated, which constitutes a relevant methodological limitation³³. Similarly, the absence of inter-rater reliability analyses,

such as the Kappa coefficient or the Intraclass Correlation Coefficient (ICC), prevents confirmation of the instrument's stability across different observers. In order to provide support for the instrument's validity, cognitive interviews were conducted with athletes during the NIQEC development process²⁷. The purpose of these interviews was to assess the comprehensibility and feasibility of the questionnaire, including the clarity of items and instructions, the response format, and example answers.

The observational and cross-sectional design prevents the establishment of causality between variables. The sample size of 40 male cyclists limits generalization to female athletes and other endurance profiles. Due to the nature of convenience sampling, the study was underpowered, where a participation of 19% of the cyclists who completed the competition was obtained. In addition, self-reported post-event data could introduce recall bias, which can lead to errors in the quantity and type of information reported (food, supplements, fluids, or gastrointestinal problems). However, the questionnaire used was developed for content, applicability, structure, and presentation, unlike other studies where unvalidated or non-consensual questionnaires were employed. Additionally, endurance athletes tend to be highly concerned about their diet and training, as their performance depends on it, making them more likely to accurately recall their intake compared to the general population.

The psychometric validation of the NIQEC instrument represents another limitation. As it is a formative questionnaire with a descriptive nature, it is not appropriate to assess its internal consistency using Cronbach's alpha or to conduct structural validity analyses, since the items do not reflect a unifying construct³¹. On the other hand, although the development of the questionnaire was based on expert consensus through a Delphi process, no quantitative indices of content validity, such as the Content Validity Index (CVI), were calculated³³, which limits the empirical evidence supporting its validity. Taken together, these aspects should be addressed in future stages of the instrument's development in order to consolidate its reliability and validity for use in clinical and sports practice.

Strengths

The study employed the NIQEC questionnaire, which has been specifically validated for endurance competitions. Although the sample size calculation was performed to ensure adequate statistical power for the primary outcome, the final sample was determined by the number of athletes who voluntarily completed the questionnaire during the competitions. As such, the study reflects a convenience sample with sufficient statistical power, but future studies should consider broader recruitment strategies to enhance representativeness and generalisability. Nutritional assessments at three time points (pre-, during, and post-competition) provide a comprehensive overview, and comparing distances enables specific adaptations according to competitive demands to be identified.

CONCLUSIONS

The present study observed that CHO and sodium intake were below the recommended levels for endurance events of this nature. However, fluid consumption met the established guidelines.

The results revealed that only 50% of participants had a structured nutritional plan, and the majority did not receive specialised nutritional counselling.

A negative correlation was identified between caffeine intake and finishing time, and a trend towards a negative correlation in the long-distance group between CHO intake during the competition and finishing time.

These findings highlight the need to improve nutritional planning. Optimising CHO and sodium intake in mountain cyclists is essential, with gastrointestinal tract training emerging as a recommended strategy. Nutritional strategies should be adapted according to the competitive distance.

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AUTHOR CONTRIBUTIONS

MCM: methodology, formal analysis, visualization, writing—original draft preparation; RJ-A: Conceptualization, methodology, visualization, writing—original draft preparation; CIA-G: methodology, data curation, formal analysis, writing—original draft preparation; SMH: data curation, formal analysis, writing—original draft preparation; IS: Conceptualization, methodology, visualization, project administration, writing—review and editing; AN: methodology, data curation, visualization, writing—review and editing; DR-G: data curation, formal analysis, writing—original draft preparation; LH-P: data curation, formal analysis, writing—original draft preparation; JMMS: Conceptualization, methodology, visualization, project administration, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY

Data from this study are available upon request from the corresponding author. Raw data is available via the following link: <https://doi.org/10.5281/zenodo.15825477>

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the ethics committee of the University of Alicante with the file number UA-2022-02-01 and followed the World Medical Association codes and Declaration of Helsinki for research in humans.

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RESEARCH ARTICLE

Body mass index adjusted calf circumference as phenotypic criterion to diagnose malnutrition in cardiac patients admitted in intensive care unit

➤ **Perímetro de la pantorrilla ajustado por el índice de masa corporal, como criterio fenotípico, para el diagnóstico de malnutrición en pacientes cardíacos ingresados en la unidad de cuidados intensivos**

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Malnutrition

➤ ABSTRACT

Introduction: Early screening malnutrition risk at hospital admission is crucial. However, the aim of the present study is to assess Body Mass Index (BMI) adjusted calf circumference (CC) as GLIM (Global Leadership Initiative on Malnutrition) phenotypic criterion to diagnose malnutrition in cardiac patients admitted to an intensive care unit due to lack of reports on it.

Materials and Methods: Cross-sectional, descriptive study approaching cardiac patients admitted to an intensive care unit (ICU). Age, BMI (kg/m²) and CC (cm) were measured. CC was adjusted based on BMI categories. Nutritional Risk Screening (NRS 2002) and GLIM methods were used to assess malnutrition risk and diagnose, respectively. Statistical analysis included descriptive techniques.

Results: Thirty-six patients were assessed, 22 of them belonged to the male sex and 14, to the female sex. Most patients were elderly (n=22, 61.11%), recorded normal BMI weight (n=15, 41.66%), CC below the recommended cut-off point (n=19, 52.77%). BMI-adjusted CC was below the recommended cut-off point - males (n=12, 54.54%) and females (n=9, 64.28%). NRS 2002 ≥ 3 points (n=36, 4.05 ± 1.12). Patients scoring ≥ 3 were assessed based on GLIM criteria. GLIM: n=9 (25%) showed malnutrition, when BMI was used as a phenotypic criterion. Malnutrition was observed in most cases (n=19, 52.77%) when CC was the criterion. BMI-adjusted CC criterion resulted in malnutrition in 21 (58.33%) assessed patients (male, n=12, 54.54%; female, n=9, 64.28%). APACHE II score was ≥ 10 (n=36) and the mortality risk reached 55.50 ± 21.00% in the assessed patients.

Conclusions: All patients showed nutritional risk (NRS 2002). Malnutrition prevalence varied when BMI, calf circumference (CC) and BMI-adjusted CC were used as phenotypic criterion through GLIM diagnosing; it was higher in case of BMI-adjusted CC. Similarly, BMI-adjusted CC allowed diagnosing malnutrition through the GLIM method applied in overweight patients.

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PALABRAS CLAVE

Circunferencia de la pantorrilla

Índice de masa corporal

Unidad de cuidados intensivos

Malnutrición

RESUMEN

Introducción: La detección precoz del riesgo de desnutrición en el momento del ingreso hospitalario es fundamental. Debido a la escasez de estudios, el presente trabajo tuvo como objetivo evaluar la circunferencia de la pantorrilla (CP) ajustada por el índice de masa corporal (IMC) como criterio fenotípico para el diagnóstico de malnutrición en pacientes con enfermedades cardiovasculares ingresados en una unidad de cuidados intensivos (UCI).

Metodología: estudio transversal en pacientes cardíacos admitidos en una UCI. Se recopilieron datos sobre edad, IMC (kg/m^2) y CP (cm). La CP fue ajustada según las categorías de IMC. Para la evaluación del riesgo nutricional y el diagnóstico de desnutrición, se aplicaron los criterios del Nutritional Risk Screening 2002 (NRS-2002) y del Global Leadership Initiative on Malnutrition (GLIM).

Resultados: Se evaluaron 22 hombres y 14 mujeres, con una mayoría de adultos mayores ($n = 22$; 61,1%). La mayor parte presentó IMC dentro de los valores normales ($n = 15$; 41,7%) y CP por debajo del valor recomendado ($n = 19$; 52,8%). Al considerar la CP ajustada por IMC, los valores se encontraron por debajo de lo recomendado en 12 hombres (54,5%) y 9 mujeres (64,3%). Todos los pacientes presentaron puntuación ≥ 3 en el NRS-2002. GLIM: IMC como criterio fenotípico, se diagnosticó malnutrición en 9 pacientes (25%). Este porcentaje aumentó al 52,8% ($n = 19$) cuando se utilizó la CP, y alcanzó el 58,3% ($n = 21$) al aplicar la CP ajustada por IMC.

Conclusiones: Todos los pacientes presentaron riesgo nutricional. La prevalencia de malnutrición varió dependiendo del criterio fenotípico utilizado en el marco del diagnóstico GLIM, siendo más elevada cuando se empleó la CP ajustada por IMC. Estos hallazgos sugieren que este parámetro puede ser especialmente útil para detectar malnutrición en pacientes con sobrepeso, lo que refuerza su aplicabilidad clínica en unidades de cuidados intensivos.

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KEY MESSAGES

1. Older age can be a risk factor for worst prognosis in ICU patients, regardless of nutritional status.
2. Malnutrition prevalence reached 25%, 52.77% and 58.33% when BMI, calf circumference (CC) and BMI-adjusted CC were used as phenotypic criteria through GLIM diagnosing, respectively.
3. BMI-adjusted CC was the most promising method for overweight cardiac patients diagnostic in ICU.

CITATION

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INTRODUCTION

Malnutrition is a risk factor presenting poor clinical outcomes, mainly in patients with cardiovascular disease admitted to the herein assessed hospital.¹ Catabolism is significantly enhanced and anabolism is weakened in critically ill cardiac patients in intensive care unit (ICU), mainly due to inflammatory responses that result in muscle loss and increased nutritional risk.^{2,3} Hence, early malnutrition risk screening at hospital admission is crucial.⁴ Although no specific nutritional score has been validated for ICU use, nutritional risk screening (NRS 2002) accounts for the best predictive values when it comes to mortality; therefore its daily application is recommended.⁵ NRS 2002 includes three parts: nutritional status, disease severity and age; and the score ranges from 0 to 7 - ≥ 3 points highlight malnutrition risk.⁴ Studies carried out with cardiac patients pointed out higher nutritional risk associated with more severe symptoms, according to the NRS 2002, regardless of 1-year re-hospitalization or long-term mortality risk factors.^{1,6,7}

NRS 2002 is the first Global Leadership Initiative on Malnutrition (GLIM) step to identify patients who need nutritional support. The second GLIM step can be adopted when NRS 2002 shows nutritional risk (≥ 3 points).^{8,9} Secondary assessment and malnutrition diagnoses are recommended; there should be at least 1 etiological (inflammation and disease burden) and phenotypic (low body mass index (BMI) and muscle mass loss) index recorded.^{10,11} According to Vico¹², Kootaka and Cols.¹³ and Yamaguchi and Cols.¹⁴ prognosis, low physical function and increased all-cause mortality were associated with GLIM criteria in patients with cardiovascular disease.

Muscle mass loss is a phenotypic criterion to GLIM diagnosing. Calf circumference (CC), in its turn, is an alternative low-cost measurement¹⁰ applicable to estimate muscle mass. Evidence has highlighted CC prognostic value as predictor of adverse outcomes such as prolonged hospital stay and mortality risk.^{15,16} However, BMI-adjusted CC was recommended to replace raw CC due to subcutaneous adipose tissue depots.¹⁷ Excess adiposity can be associated with false normal CC values and mask muscle mass loss, despite its detrimental effect on CC prognostic value.¹⁶ Miyahara and Cols.¹⁸ assessed older adults in a Geriatrics and Gerontology Hospital, and suggested BMI-adjusted CC as good alternative to assess GLIM-based malnutrition. However, the aim of the present study was to determine malnutrition prevalence in cardiac patients admitted to an intensive care unit based on BMI-adjusted CC as phenotypic criterion through GLIM diagnosing due to lack of reports on it.

METHODOLOGY

Cross-sectional study carried with a convenience sample comprising cardiac patients admitted to an intensive care unit (ICU) located in the Recôncavo Baiano region. Data collection

was carried out between August and December 2019. The study was approved by the Ethics Committee of the Federal University (CAAE: 7118618.2.0000.0056).

All participants signed the informed consent form. Exclusion criteria were age (< 20 years), pregnancy, amputations, advanced terminal illness, patients readmitted to the ICU, patients admitted to the ICU with diagnosis unrelated to heart disease. The following data were collected from the patients within their first 72 ICU-admission hours: age; estimated height [according to the following equations: men = $(2.02 \times \text{knee height [KH, cm]} - (0.04 \times \text{age [years]}) + 64.19)$ and women = $(1.83 \times \text{KH [cm]} - (0.24 \times \text{age [years]}) + 84.88)$]; estimated body mass [according to the following equations: men = $(\text{KH [cm]} \times 1.09) + (\text{arm circumference [AC, cm]} \times 3.14) - 83.72)$ and women = $(\text{KH [cm]} \times 1.24) + (\text{AC [cm]} \times 2.81) - 82.48$].¹⁹ Knee height (KH, cm) was measured with the aid of a non-stretchable measuring tape, based on the distance between the heel and the top of the thigh, with patient in supine position, and knee and ankle bent at 90° angle. Arm circumference (AC, cm) was measured with the aid of a non-stretchable measuring tape at the midpoint between the acromion and the olecranon.²⁰

Body mass index (BMI, kg/m^2) was calculated based on the estimated height and body mass. The cut-off point used to classify BMI was proposed by the World Health Organization for adults and the by the Pan American Health Organization for elderly individuals (≥ 60 years).^{21,22} Calf circumference (CC, cm) was measured with the aid of a non-stretchable measurement tape at the widest calf point, with patient in supine position. The cut-off point adopted to classify CC was higher than 34 cm in males and 33 cm in females.²³ Subsequently, CC was adjusted based on BMI categories before comparing CC to the suggested sex-specific cut-off point, namely: $< 18.5 \text{ kg/m}^2$ (original CC value), $18.5\text{-}24.9 \text{ kg/m}^2$ (original CC value), $25\text{-}29.9 \text{ kg/m}^2$ (-3 cm), $30\text{-}39.9 \text{ kg/m}^2$ (-7 cm) and $\geq 40 \text{ kg/m}^2$ (-12 cm).^{3,23,24,25}

The Nutritional Risk Screening (NRS 2002) method was used to assess malnutrition risk. Total score ranged from 0 to 7 points. Nutritional status, disease severity and age were assessed - ≥ 3 suggested nutritional risk and ≥ 5 pointed towards very high risk.²⁶ Patients scoring ≥ 3 was assessed based on GLIM (Global Leadership Initiative on Malnutrition) criteria. Inflammation was the etiological criteria applied to all patients.²⁷ The following phenotypic criteria were used to diagnose malnutrition: BMI reduction or lean mass decrease (assessed through calf circumference).

Glasgow Coma Scale data (GSC. Score range 3 – deep coma to 15 – full consciousness),²⁸ approximate mortality risk (%), and Acute Physiology and Chronic Health Evolution (APACHE II score > 10 indicates a high risk of nutritional deficiency, in context of the NRS 2002)^{26,29} were collected from the medical records.

Data were analyzed in Graph Pad Prism (Version 5.0, 2007, San Diego, CA, USA) and Microsoft Excel software based on column statistics and expressed as means \pm standard deviation, minimum and maximum value, absolute frequencies and percentages. Shapiro Wilk test was used to assess numerical data normality. Student's t-Test or Mann Whitney test were adopted to compare numerical data depending on normality results. Paired t-test or Wilcoxon test

were used to compare CC vs. BMI adjusted CC. Chi-square or Fisher's exact tests were used to assess the association between numerical variables. All testes followed the 5% significance level.

RESULTS

Thirty-six (n=36) cardiac patients admitted to the ICU were herein assessed: twenty-two (n=22) male and fourteen (n=14) female patients. Most patients were elderly (n=22) presenting normal BMI weight (n=15) and they were followed by underweight elderly (n=12). Mean CC recorded for most patients (n=19) showed CC below the recommended cut-off point. Mean CC was below the recommended cut-off point in most assessed male (n=12) and female (n=9) patients when CC was adjusted based on BMI categories. GCS score was associated with full consciousness. APACHE II score was ≥ 10 (n=36) and mean mortality risk reached 55.50 ± 21.00 % in the assessed patients. Furthermore, the comparison between CC and BMI-adjusted CC showed significant difference; BMI-adjusted CC was lower than CC (p-value < 0.0001, paired t-test) (Table 1).

Table 2 shows data of patients admitted to an intensive care unit based on CC or BMI-adjusted CC classification. There was no significant difference in the assessed parameters, except for BMI in CC – patients presenting the aforementioned classification recorded higher BMI (p = 0.030). This difference was not observed when this parameter was assessed in BMI-adjusted CC (p-value = 0.317).

Disease severity (APACHE ≥ 10), age (cut-off 70 years) and nutritional risk were assessed through the NRS 2002 questionnaire supported by nutritional status (BMI) data. Patients showed NRS 2002 ≥ 3 points (n=36), nutritional risk ranging from 3 to 4 points in most male (n=15) and female (n=8) patients. Very high risk (5 – 7 points) was observed in 13 of the assessed patients. According to the GLIM questionnaire, most patients (n=27) did not show malnutrition when BMI was used as a phenotypic criterion. However, the CC criterion was associated with malnutrition in most patients (n=19). CC adjusted based on BMI categories resulted in malnutrition in 21 patients: in 12 male and in 9 female participants (Table 3).

Nutrition Risk Screening (NRS), Global Leadership Initiative on Malnutrition (GLIM) score based on CC or on BMI-adjusted CC classification, are shown in Table 4. There was significant association between GLIM (vs. BMI-adjusted CC, criterion), and CC and BMI-adjusted CC, in other words, there were more malnutrition cases, based on both classifications, when CC was above the limit.

DISCUSSION

The NRS 2002 and GLIM should not be limited to Scientific Research projects. Actually, larger numbers of trained health professionals are needed to implement protocols aimed at assessing malnutrition risk and diagnosing in patients admitted to ICUs. According to the study, all the assessed patients recorded score ≥ 3 points based

on the NRS 2002 for nutritional risk. The BMI-adjusted CC allowed diagnosing malnutrition through the GLIM method in overweight patients. NRS 2002 and GLIM are low-cost questionnaires that help reducing in-hospital malnutrition and muscle loss, and worsening prognosis risk in ICU patients.

Most cardiac patients in the present study were over 60 years old. According to Herberger and Cols.¹ cardiac cachexia is closely associated with old age in chronic heart failure patients, and it can have nutritional risk implications. It is mainly true in patients in the age group ≥ 70 years, since it represents additional score (in NRS 2002) for higher susceptibility to malnutrition and lean body mass loss.⁴ Older age can be a risk factor for worst prognosis in ICU patients regardless of nutritional status, because all the assessed cardiac patients recorded APACHE > 10 (score = 3 points in the NRS 2002).

Milanez and Cols.³⁰ and Athayde and Cols.²⁷ observed malnutrition prevalence equals 68.9% and 57.6%, respectively, in Brazilian studies carried out with critical patients that have taken inflammation as criterion for all ICU patients at admission time. The same etiological criterion was used. However, weight loss was not taken into consideration to assess malnutrition prevalence based on phenotypic criteria due technical limitations linked to information collection in ICUs.

Malnutrition prevalence reached 25% in the present study when BMI was taken as phenotypic criterion. However, according to ESPEN nutrition guidelines for ICU⁵ patients, BMI does not accurately reflect malnutrition. Overweight patients have lower malnutrition diagnostic and BMI, alone, is contraindicated to assess nutritional status.^{5,26,27} Therefore, calf circumference (CC) was used as phenotypic criterion to reduce muscle loss: malnutrition prevalence reached 52.77%. CC (vs. BMI) enabled more cardiac patients to get a malnutrition diagnosis.

Overweight and malnutrition can coexist, and BMI-adjusted CC can work as complementary exam.^{5,27} Miyahara and Cols.¹⁸ suggest BMI-adjusted CC as alternative when technical measurements such as dual-energy X-ray absorptiometry are not available. Jensen and Cols.¹⁰ recorded 60% malnutrition prevalence, and it is considered an independent predictor for longer hospital stay and for mortality in older patients presenting high BMI.^{10,16} In total, 58.33% of cardiac patients admitted in the herein assessed ICU showed malnutrition when BMI-adjusted CC was adopted. This finding corroborated what Alves and Cols.³ had previously mentioned, namely: BMI-adjusted CC was the most promising method to for overweight cardiac patients' diagnostic in the herein assessed ICU.

It was almost accurately impossible measuring height and body mass in the intensive care unit, and these were limitations of the present study. There is no consensus about the best method to measure height and body mass in critically ill patients, and it may lead to likely bias for BMI and, consequently, for BMI-adjusted CC and malnutrition diagnosis through the GLIM method. Lack of robust methods for muscle loss analysis like dual-energy absorptiometry, bioelectrical impedance, computed tomography or magnetic resonance imaging is another study limitation.

Table 1. Data of the patients admitted to an intensive care unit.

Parameters	Patients (n=36)	Male (n=22)	Female (n=14)	p-value
Age (years):	60.86 ± 11.16 (33 – 82)	59.73 ± 11.71 (33 – 79)	62.64 ± 10.39 (47 – 82)	0.453
Adult	14 (38.88%)	8 (36.36%)	6 (42.85%)	0.482
Elderly	22 (61.11%)	14 (63.63%)	8 (57.14%)	
BMI (kg/m ²):	23.81 ± 5.58 (11.87 – 36.96)	23.58 ± 5.46 (11.87 – 36.96)	23.74 ± 5.97 (13.26 – 33.89)	0.942
Underweight	12 (33.33%)	7 (31.81%)	5 (35.71%)	0.636
Normal weight	15 (41.66%)	9 (40.90%)	6 (42.85%)	
Overweight	6 (16.66%)	5 (22.72%)	1 (7.14%)	
Obesity	3 (8.33%)	1 (4.54%)	2 (14.28%)	
CC (cm):	34.22 ± 4.76 (27 – 45)	34.81 ± 5.21 (27 – 45)	33.30 ± 3.96 (27.9 – 40)	0.364
Below	19 (52.77%)	12 (54.54%)	7 (50%)	0.530
Above	17 (47.22%)	10 (45.45%)	7 (50%)	
BMI-Adjusted CC:	32.56 ± 3.68 (25.66 – 40)	33.17 ± 3.74 (27 – 40)	31.59 ± 3.50 (25.6 – 36.9)	0.191
Below	21 (58.33%)	12 (54.54%)	9 (64.28%)	0.411
Above	15 (41.66%)	10 (45.45%)	5 (35.71%)	
GCS score	14.83 ± 0.61 (12 – 15)	14.71 ± 0.78 (12 – 15)	15.00 ± 0.00 (15)	0.110
APACHE II	23.75 ± 6.82 (13 – 40)	22.86 ± 6.85 (13 – 40)	25.14 ± 6.79 (17 – 39)	0.336
RM (%)	55.50 ± 21.00 (18.51 – 91.33)	54.00 ± 20.40 (18.51 – 91.33)	57.85 ± 22.49 (23.24 – 88.73)	0.602

Adult (< 60 years), Elderly (≥ 60 years); BMI, Body Mass Index; CC, Calf Circumference; GCS, Glasgow Coma Scale; APACHE, Acute Physiology and Chronic Health Evaluation; RM, Risk of mortality. Numerical variables: Student's t-test; categorical variables: Chi-square test or Fisher's exact test.

Table 2. Data of the patients admitted to an intensive care unit based on CC or BMI-adjusted CC classification.

Parameters	CC		p-value	BMI-adjusted CC		p-value
	Below (n=19)	Above (n=17)		Below (n=21)	Above (n=15)	
Age (years):	61.72 ± 2.25 (45-79)	59.06 ± 3.04 (33-82)	0.367	61.70 ± 2.06 (42-79)	58.73 ± 3.41 (33-82)	0.341
Adult	6 (31.58%)	8 (47.06)	0.272	7 (33.33%)	7 (46.67%)	0.321
Elderly	13 (68.42%)	9 (52.94)		14 (66.77%)	8 (53.33%)	
BMI (kg/m ²):	22.06 ± 1.15 (12-32)	26.06 ± 1.42 (18-37)	0.030*	23.20 ± 1.30 (12-34)	25.07 ± 1.42 (18-37)	0.317
Underweight	7 (36.84%)	5 (29.41%)	0.639	7 (33.33%)	5 (33.33%)	1.000
Normal weight	9 (47.37%)	6 (35.29%)		9 (42.86%)	6 (40.00%)	
Overweight	2 (10.53%)	4 (23.53%)		3 (14.29%)	3 (20.00%)	
Obesity	1 (5.26%)	2 (11.77%)		2 (9.52%)	1 (6.67%)	
GCS score	14.83 ± 0.17 (12-15)	14.82 ± 0.13 (13-15)	0.963	14.75 ± 0.15 (12-15)	14.80 ± 0.15 (13-15)	0.817
APACHE II	26.06 ± 1.75 (15-40)	21.65 ± 1.34 (13-35)	0.080	25.55 ± 1.64 (15-40)	21.73 ± 1.47 (13-35)	0.136
RM (%)	59.78 ± 5.29 (23-91)	50.47 ± 4.69 (19-89)	0.175	58.85 ± 4.91 (23-91)	50.47 ± 5.15 (19-89)	0.226

Adult (< 60 years), Elderly (≥ 60 years); BMI, Body Mass Index; CC, Calf Circumference; GCS, Glasgow Coma Scale; APACHE, Acute Physiology and Chronic Health Evaluation; RM, Risk of mortality. Numerical variables: Student's t-test; categorical variables: Chi-square test or Fisher's exact test; *p<0.05.

Table 3. Nutrition Risk Screening (NRS), Global Leadership Initiative on Malnutrition (GLIM) score.

Parameters	Patients (n=36)	Male (n=22)	Female (n=14)	p-value
NRS 2002:	4.05 ± 1.12 (3 – 6)	3.95 ± 1.04 (3 – 6)	4.21 ± 1.25 (3 – 6)	0.389
3 - 4 points	23 (63.88%)	15 (68,18%)	8 (57.14%)	0.374
5 -7 points	13 (36.11%)	7 (31.81%)	6 (42.85%)	
GLIM (BMI criterion):				
No malnutrition	27 (75%)	16 (72.72%)	11 (78.57%)	0.506
Malnutrition	9 (25%)	6 (27.27%)	3 (21.42%)	
GLIM (CC criterion):				
No malnutrition	17 (47.22%)	10 (45.45%)	7 (50%)	0.530
Malnutrition	19 (52.77%)	12 (54.54%)	7 (50%)	
GLIM (vs. BMI-adjusted CC, criterion):				
No malnutrition	15 (41.66%)	10 (45.45%)	5 (35.71%)	0.411
Malnutrition	21 (58.33%)	12 (54.54%)	9 (64.28%)	

NRS, Nutritional Risk Screening; GLIM, The Global Leadership Initiative on Malnutrition; BMI, Body Mass Index; CC, Calf Circumference. Numerical variables: Student's t-test; categorical variables: Fisher's exact test.

Table 4. Nutrition Risk Screening (NRS), Global Leadership Initiative on Malnutrition (GLIM) score based on CC or on BMI-adjusted CC classification.

Parameters	CC		p-value	BMI-adjusted CC		p-value
	Below (n=19)	Above (n=17)		Below (n=21)	Above (n=15)	
NRS 2002:	4.17 ± 0.26 (3 – 6)	3.94 ± 0.28 (3 – 6)	0.473	4.05 ± 0.25 (3 – 6)	4.07 ± 0.30 (3 – 6)	0.940
3 - 4 points	12 (63.16%)	11 (64.70%)	0.599	14 (66.7%)	9 (60.00%)	0.474
5 -7 points	7 (36.84%)	6 (35.30%)		7 (33.3%)	6 (40.00%)	
GLIM (BMI criterion):						
No malnutrition	13 (68.42%)	14 (82.35%)	0.283	15 (71.4%)	12 (80.0%)	0.427
Malnutrition	6 (31.68%)	3 (17.65%)		6 (28.6%)	3 (20.0%)	
GLIM (vs. BMI-adjusted CC,criterion):						
No malnutrition	0 (0.00%)	15 (88.24%)	<0.0001***	2 (9.5%)	15 (100.00%)	<0.0001 ***
Malnutrition	19 (100.0%)	2 (11.76%)		19 (90.5%)	0 (0.00%)	

NRS, Nutritional Risk Screening; GLIM, The Global Leadership Initiative on Malnutrition; BMI, Body Mass Index; CC, Calf Circumference. Numerical variables: Student's t-test; categorical variables: Fisher's exact test; ***p<0.0001.

However, these methods are not available in most nutritional assessment and research settings.

CONCLUSIONS

The use of low-cost questionnaire should be routine to assess and diagnose malnutrition risk in cardiac patients admitted to the assessed ICU since it help reducing in-hospital malnutrition, muscle loss and worst prognosis risk in ICU patients. Malnutrition prevalence varied when BMI, calf circumference (CC) and BMI-

adjusted CC were used as phenotypic criterion for GLIM diagnosing, and it was higher when BMI-adjusted CC was adopted. Similarly, BMI-adjusted CC allowed diagnosing malnutrition through the GLIM method applied in overweight patients.

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AUTHORS' CONTRIBUTIONS

J.S-B, A.J-S, P.C-R, D.B-A, V.G-S, T.B-S, B.S-B and M.F-M were responsible for extracting and interpreting the results. A.D-P, A.P-B and C.A-C were responsible for designing and writing the final version of manuscript.

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CONFLICTS OF INTEREST

The authors state declare no conflicts of interest.

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RESEARCH ARTICLE

Culture and Eating Behaviour of Nursing Students of the University of Granada: A Cross-sectional Study

➤ **Cultura y comportamiento alimentario de los estudiantes de enfermería de la Universidad de Granada: un estudio transversal**

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➤ ABSTRACT

Introduction: The university period involves moving away from the family, which influences eating habits. Health is considered a key criterion in food choices, although it varies according to social and cultural context. The study focused on describing and correlating the eating behaviours of university students in the health field on the Melilla campus, with special attention to cultural influence.

Methods: with a convenience sampling approach, 192 nursing students enrolled in the Faculty of Health Sciences of Melilla at the University of Granada were selected to investigate the status of eating behaviours, food consumption preferences, and healthy food using descriptive and inferential analysis with correlational statistical techniques.

Results: the most Christians prepare their meals themselves (60.5%), while 70.3% of Muslims report that it is their parents who prepare them. Muslim were the group most likely to remove all visible meat fat (82.2%). A significant association was found between this behaviour and gender ($\chi^2 = 10.955$, $p = 0.012$) as well as religion ($\chi^2 = 15.890$, $p = 0.014$). Preference for consumption of vegetables, fish, and seafood is higher among Muslims, while consumption of alcohol and ultra-processed food is higher in Christians. These findings were statistically significant ($p < 0.001$ for alcohol consumption; Kruskal-Wallis test, $H = 58.264$, $p < 0.001$).

Conclusions: health science students at the Melilla Campus exhibit unhealthy eating habits influenced by cultural differences, highlighting the need for educational programs on nutrition for future healthcare professionals as community leaders.

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RESUMEN

PALABRAS CLAVE

Comportamiento alimentario

Estudiantes de enfermería

Salud

Cultura

Educación

Introducción: el periodo universitario implica un alejamiento de la familia que influye en los hábitos alimentarios. La salud se considera un criterio clave en la elección de alimentos, aunque varía según el contexto social y cultural. El estudio se centró en describir y correlacionar los comportamientos alimentarios de estudiantes universitarios del área sanitaria en el campus de Melilla, con especial atención a la influencia cultural.

Metodología: con un enfoque de muestreo por conveniencia, se seleccionaron 192 estudiantes de enfermería matriculados en la Facultad de Ciencias de la Salud de Melilla de la Universidad de Granada para investigar el estado de las conductas alimentarias, las preferencias de consumo de alimentos y la percepción de alimentos saludables utilizando un análisis descriptivo e inferencial con técnicas estadísticas correlacionales.

Resultados: la mayoría de los cristianos preparan ellos mismos sus comidas (60.5%), mientras que el 70.3% de los musulmanes afirman que son sus padres quienes se las preparan. Las mujeres musulmanas fueron el grupo con mayor probabilidad de eliminar toda la grasa visible de la carne (82,2%). Se encontró una asociación significativa entre este comportamiento y el género ($\chi^2 = 10,955$, $p = 0,012$) así como la religión ($\chi^2 = 15,890$, $p = 0,014$). La preferencia por el consumo de verduras, pescado y marisco es mayor entre los musulmanes, mientras que el consumo de alcohol y alimentos ultraprocesados es mayor en los cristianos ($p < 0.001$ para el consumo de alcohol; prueba de Kruskal-Wallis, $H = 58.264$, $p < 0.001$).

Conclusiones: los estudiantes de ciencias de la salud en el Campus de Melilla presentan conductas alimentarias poco saludables, influenciadas por diferencias culturales, lo que evidencia la necesidad de programas educativos en nutrición para futuros profesionales sanitarios como referentes comunitarios.

Financiación: Los autores/as declaran que no ha existido financiación para realizar este estudio.

KEY MESSAGES

1. Health is presented as a value that influences consumers' food choices.
2. Food selection differs according to individuals' social and cultural environments.
3. Health-oriented education is highly important for future nurses within community-based care models

CITATION

Fernández-Gómez E, Luque-Vara T, López-Olivares M, Navarro-Prado S, Sánchez-Ojeda MA, Mohatar-Barba M, Enrique-Mirón C. Culture and eating behaviour of nursing students of the University of Granada: A cross-sectional study. Rev Esp Nutr Hum Diet. 2025; 29(3): e2502.

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INTRODUCTION

Food and certain dietary habits influence the development of several diseases, such as cardiovascular disease, type 2 diabetes and cancer¹. Eating behaviour includes all actions related to the choice, preparation and consumption of what we eat².

Today, individuals are increasingly aware of self-care and seek products that promote health; nevertheless, in recent decades, what we know as an eating pattern has been mostly altered in developed countries, thus affecting, among others, adolescents³.

The university period is mainly characterised by distance from family; as a result, consumption habits are undoubtedly modified⁴. However, despite this growing responsibility for health, certain groups, such as university students, are especially vulnerable to adopting risky eating behaviours, which can lead to chronic disease⁵. University students show characteristic physiological changes, typical of young people, coupled with sociological and cultural changes, as a consequence of the commencement of university studies, the beginning of adult life, etc. These factors have a direct impact on food practices, which, in most cases, will be present throughout adolescents' lives⁶.

College students are at greater risk for eating disorders, so it is crucial to promote healthy habits that will impact their future health. In addition, students in health-related fields should be knowledgeable about balanced nutrition, as they influence the promotion of healthy habits in the population⁷.

Eating behaviour is not only a nutritional phenomenon, but also a cultural and social one. Beliefs, values and traditions, including religion, influence the acceptance or rejection of certain foods⁸. Religion establishes rules about what should be consumed and also affects the practice of fasting or dietary restrictions. In turn, factors such as gender and customs influence dietary decisions, which impacts eating habits, especially in a multicultural university environment⁹. Likewise, there are numerous studies that examine the impact of social and cultural characteristics on diet in Spain, which have studied eating behaviour from the point of view of sociology or anthropology¹⁰.

Most studies on adolescent eating behaviour focus on sexuality and addictions, not on the promotion of healthy habits. Hence, this study aims to contribute data to the investigation on this very current and important topic¹¹.

Understanding the relationship between diet and health in university students is key to designing programs and policies that improve lifestyle and prevent disease. To do this, it is necessary to understand their eating behaviours and adapt nutrition education to the cultural and religious context¹², as religion influences both restrictions and the times and ways of eating¹³.

The main objective of this study is to describe the eating behaviours of university students in the health area of the Melilla campus, and to analyse the cultural factors that influence their dietary choices.

METHODS

Design of study

A diagnostic, descriptive, and cross-sectional study was utilised, where information was collected by means of a validated questionnaire. For the selection of subjects, non-probability convenience sampling was conducted.

Instrumentation

The "Student Eating Behaviours Questionnaire"¹⁴, validated for university students in the health field, was used, with 30 multiple-choice items plus sociodemographic variables. It is divided into three sections: eating behaviour, consumption preferences, and food perception, addressing aspects such as schedules, preparation, label reading, eating out, satiety, diets, beliefs, and barriers to change. Preferences (items P11-P22) were measured on a scale from 1 ("I dislike it very much") to 5 ("I like it very much"). The questionnaire was administered in paper format in Spanish and then translated into English. [Table 1](#) presents the distribution of items across the aforementioned blocks.

Table 1. Thematic blocks and number of items

Thematic blocks	Number (Items)
Sociodemographic	6
Eating behaviours	8 (P4-P10, P25)
Consumption preferences	16 (P1, P3, P11-P24)
Healthy food perception	6 (P26-P30, P2)

Study variables

Sociodemographic or identification variables were established as independent variables, namely gender, age, religion, origin, and cohabitation. Dependent variables are the answers given to the measured items making up the questionnaire, that is eating behaviours, consumption preferences, and food perception.

Data collection and selection criteria

Non-probability sampling was used with nursing students from the Faculty of Health Sciences of Melilla (University of Granada) between September and November 2022. Those who were not enrolled, were not nursing students, did not understand Spanish, or did not give consent were excluded. Participation was voluntary and anonymous, with a possible self-selection bias, which was attempted to be reduced by including students from different classes.

Data analysis and treatment

The data were analysed using SPSS 24.0. Descriptive statistics (frequencies and percentages) and association tests were used: chi-square for categorical variables (gender, religion), together with Cramér's V to measure the strength of the relationship. For non-parametric numerical variables, the Mann–Whitney U test (comparison between genders) and the Kruskal–Wallis test (comparison between religions) was applied, after checking for non-normality with Kolmogorov-Smirnov test.

Effect sizes were calculated using Cohen's d for the gender variable (small ($0.2 < d \leq 0.5$), medium ($0.5 < d < 0.8$), or large ($d \geq 0.8$) effect size) and the "Eta squared, η^2 " statistic for the religion variable (small ($0.01 < \eta^2 \leq 0.06$), medium ($0.06 < \eta^2 < 0.14$), or large ($\eta^2 \geq 0.14$)). Cohen's d helps to determine whether the differences between groups are practically significant, and Eta squared (η^2) for the religion variable, which provides an estimate of the variance in the dependent variable explained by religion.

Ethical aspects

Participation was anonymous and voluntary, with informed consent and in accordance with the Declaration of Helsinki. Permission was granted by the Ministry of Education, Culture, and Sport (MECD) to provide questionnaires to university students at the Faculty of Health Sciences of Melilla and its approval corresponds to the number 201802658.

RESULTS

To determine the study sample, the total population of 382 nursing students was considered, with 192 participants in total. The sampling error was 5%, with a confidence level of 95%. Every student was from different nursing graduate studies with a mean age of 22.5 (SD=4.77), the minimum being 18 and the maximum 49. Characteristics of the sample are reflected in Table 2.

The objective of the study was addressed considering the three blocks making up the questionnaire to assess university students' eating behaviours.

Block I: Eating behaviours

With respect to the most usual way of preparing food, 51.4% of participants answered that they prefer roasted or grilled food. Fried food was chosen by 19.3% and casserole and sauté food by 15.7%. The least predominant ways of cooking food are oven-cooked (3.6%) and boiled (10%). This variable is closely related to gender ($\chi^2=11.239$, $p=0.024$) and religion ($\chi^2=21.704$, $p=0.002$) although, in both cases, the effect size determined by Cramér's V is small ($V=0.283$, $p=0.005$ and $V=0.278$, $p=0.005$, respectively). It is mostly Christian women who prefer, on a significant basis,

Table 2. Sociodemographic characteristics of the sample (n = 192)

Variables	Frequency (%)	
Gender	Male	34 (17.9%)
	Female	158 (82.1%)
Origin	Melilla	73 (37.9%)
	Andalusia	88 (45.8%)
	Morocco	8 (4.3%)
	Other provinces	23 (12%)
Religion	Christian	111 (57.9%)
	Muslim	51 (26.4%)
	Agnostic	30 (16.0%)
Cohabitation	Parents	96 (50%)
	Partners or friends	71 (36.4%)
	Other relatives	11 (5.7%)
	Alone	14 (7.1%)

roasted and grilled food. As regards visible meat fat, 82.2% remove it completely, while 11.4% only remove a little. Only 6.4% do not remove any fat at all. There is a significant statistical dependence association between such behaviour and the gender ($\chi^2=10.955$, $p=0.012$; $V=0.280$, $p=0.012$) and religion ($\chi^2=15.890$, $p=0.014$; $V=0.238$, $p=0.014$) variables, in this case being women, in particular Muslims, who remove all visible fat.

Almost half of students (47.9%) report that they prepare their own food, compared to 40% who indicate that their parents prepare it. There is a significant statistical association with the religion variable ($\chi^2=25.117$, $p<0.001$; $V=0.300$, $p<0.001$). It is mostly Christians who prepare their own food (60.5%), while 70.3% of Muslim students report that food is prepared by their parents. Among healthy habits, from a nutritional point of view, it is important to follow a schedule for intake; however, this is not always the case, especially among university students. In this sense, only 45.7% answered that they do follow a schedule as opposed to 32.1% who do not have a schedule established for meals. Having or not having an eating schedule is related to the gender variable significantly ($\chi^2=11.253$, $p=0.024$; $V=0.284$, $p=0.024$), with women having a schedule established.

In general, eating is a social action, which is why most people prefer to do it in company. Among our university students, 78.6% eat with others regularly, while 20.7% do so on occasion. When asked if they eat out, most of them (72.9%) answered that they do so sometimes, while 13.6% do it on a regular basis. The same percentage (13.6%) report that they do not usually do it. Finally, the percentage of students recognising that they stop eating when they feel full is 79.3%. However, there is a small percentage (5.7%) who find it difficult to stop eating, and 4.3% continue eating despite feeling bad for doing so.

Block II: Food consumption preferences

Taste is the determining factor for food consumption (54.3%) as opposed to nutritional content (33.6%). Likewise, it is taste determines food restrictions (47.9%) rather than personal health (33.6%). Neither case has an association with the gender or religion variables. Cold or room temperature water is the usual beverage throughout the day for 80.7% of participants. There is some dependence between this variable and religion, although the effect size is small ($\chi^2=23.194$, $p<0.001$; $V=0.288$, $p<0.001$). Christian students drink water more frequently in between meals, while Muslims prefer juice or tea.

Lastly, mass-produced pastries (24.3%) and fruits and vegetables (22.1%) are the foods chosen in between meals. A similar percentage (20.7%) report not consuming anything. There are statistically significant differences as regards gender in the consumption of meat and chicken and alcoholic drinks, with men preferring them (Table 3). Regarding religion, there are statistically significant differences when it comes to preference for vegetables and alcoholic drinks, with agnostics preferring vegetables and Muslims disliking alcoholic drinks very much (Table 4).

Block III: Healthy food perception

Food labels on packaged food are established by legislation. Such information must help us perform a logical selection to guide our eating habits. Nevertheless, labels are infrequently read, as reported by respondents; 37.1% indicate that they do not read them out of laziness, while 2.1% state that they do not understand them, as opposed to 48.6% who read and understand them.

When asked about what they do or would do to take care of their

body, 50.7% indicate that taking care of their diet and working out as opposed to 4.3% who prefer to follow a special diet, and only 0.7% choose to have dietary supplements. Personal motivation and commitment are the factors deemed necessary to improve diet (50.7%), and time is another important factor (18.6%), while information, money, and social support are barely significant.

Finally, 62.2% consider their diet to be different every day or sometimes per week, and most respondents (75%) feel capable of using nutritional advice to improve their health condition. No significant differences were found in this block with respect to gender or religion for neither of the items that make it up.

DISCUSSION

The sample obtained for the study is mostly female. Such data agree with different studies with such gender-based difference in participants, with mostly women studying this field of knowledge. Women are more comfortable performing tasks related to emotions, feelings, and care, which explains why the number of female students is higher¹⁵.

Half of participants live with their parents. Food habits of adolescents may be related to their parents' food habits, hence the importance of the promotion of health not only be targeting adolescents but also the family¹⁶. Cooking is more frequently related to healthier eating habits among university students. In this research, we observe that almost half of students prepare their meals. However, it was determined that preparation is virtually based on opening packages and combining several ingredients¹⁷.

There is a considerable percentage of participants who report

Table 3. Significance of food preferences (P11-P22) and gender

	Gender			U	Z	p	Effect size
	Total (n=192)	Female (n=158)	Male (n=34)				
	Mean (DS)	Mean (DS)	Mean (DS)				
Fruits	4.31(.80)	4.33(.81)	4.24(.77)	1321.5	-.692	.489	.81
Vegetables	3.75(1.13)	3.83(1.11)	3.36(1.18)	1083.5	-1.953	.051	1.12
Meat and chicken	4.44(.73)	4.37(.76)	4.76(.43)	1018	-2.581	.010**	.72
Fish and seafood	4.14(.91)	4.13(.93)	4.16(.80)	1406	-.111	.911	.91
Dairy products	4.07(.96)	4.04(.98)	4.25(.89)	1188	-1.013	.311	.96
Bread, omelettes, pasta, cereals	4.40(.70)	4.38(.72)	4.48(.65)	1328.5	-.589	.556	.71
Pulses	3.42(1.03)	3.41(1.04)	4.48(1.04)	1354	-.475	.635	1.04
Sweets	4.24(.92)	4.24(.93)	4.24(.87)	1411	-.157	.875	.92
Eggs	4.04(.84)	4.02(.85)	4.17(.76)	1266.5	-.674	.500	.84
Nuts	4.06(.79)	4.04(.81)	4.16(.68)	1343.5	-.548	.584	.79
Alcoholic drinks	2.70(1.26)	2.57(1.26)	3.28(1.13)	993	-2.513	.012*	1.24
Processed food	3.18(.99)	3.19(.99)	3.12(1.05)	1423.5	-.080	.936	1.00

U de Mann Withney Test, $p^* < .05$; $p^{**} < .01$; $p^{***} < .001$

Table 4. Significance of food preferences (P11-P22) and religion

	Religion				H	p	Effect size
	Total (n=192)	Christian (n=111)	Muslim (n=51)	Agnostics (n=30)			
	Mean (DS)	Mean (DS)	Mean (DS)	Mean (DS)			
Fruits	4.31(.80)	4.22(.837)	4.51(.692)	4.32(.839)	3.359	.186	.029
Vegetables	3.75(1.13)	3.53(1.242)	3.92(.983)	4.27(.703)	7.455	.025*	.063
Meat and chicken	4.44(.73)	4.46(.822)	4.41(.551)	4.41(.666)	1.609	.422	.004
Fish and seafood	4.14(.91)	4.00(.941)	4.41(.798)	4.18(.907)	5.266	.070	.043
Dairy products	4.07(.96)	4.05(.992)	4.14(.845)	4.05(1.090)	.073	.970	.002
Bread, omelettes, pasta, cereals	4.40(.70)	4.45(.727)	4.41(.599)	4.18(.795)	2.311	.261	.018
Pulses	3.42(1.03)	3.38(1.067)	3.32(1.132)	3.73(.703)	2.197	.404	.021
Sweets	4.24(.92)	4.30(.980)	4.24(.796)	4.05(.899)	1.852	.294	.019
Eggs	4.04(.84)	4.06(.913)	3.94(.715)	4.14(.774)	1.401	.859	.006
Nuts	4.06(.79)	4.12(.765)	3.92(.862)	4.09(.750)	1.484	.502	.027
Alcoholic drinks	2.70(1.26)	3.25(.994)	1.30(.702)	3.05(1.113)	58.264	<.001***	.446
Processed food	3.18(.99)	3.31(.944)	2.89(.906)	3.18(1.259)	5.519	.063	.032

Kruskal Wallis Test, p* < .05; p** < .01; p*** < .001

not having eating schedules. Findings suggest that focusing on eating schedules may help prevent bad health results¹⁸. Most of our university students eat in company. A positive relationship has been demonstrated between frequency of eating together with relatives and a healthy diet¹⁹. Having healthy eating behaviours at home is related to healthier food choices²⁰.

The main reason for selecting food is taste²¹. Likewise, in this study, taste is the determining factor for the consumption of certain food as opposed to nutritional value. Cold or room temperature water is the usual beverage throughout the day for most participants. A study shows that sugar-containing beverages contribute substantially to university students' daily calorie intake²².

As regards intake of food, published studies reveal that young people (including healthcare-field university students) show unhealthy consumption, with an excessive consumption of saturated fat and refined sugar from processed food and sugar-containing beverages and foods with a low nutritional quality²³. Reducing the consumption of foods high in saturated fats, trans fatty acids, or free sugars is important for everybody but especially for children and adolescents. Nutrition research reveals a deficiency in the consumption of vegetables, fruits, and fish, showing a preference for fried food and snacks, which leads to eating in between meals and consumption of sugar-containing beverages²⁴. In this study the results are along the same lines.

In this investigation, body care mainly involved working out and following diets to keep in good shape. Research noted that a high percentage of participants read labels²⁵. In our research, the results are in line with the abovementioned study. Most participants feel capable of using nutritional advice to improve their health status. Nutrition education may improve university students' daily intake²⁶.

Several authors affirm that factors such as lack of time may play a significant role when it comes to consuming healthy food, and they highlight the importance of designing programmes with effective strategies to encourage university students to improve their eating behaviours²⁷. In this research, lack of motivation and time are deemed the main factors that must be addressed to improve dietary habits.

With respect to religion, it is worth noting that Catholicism establishes less demanding eating rules than other monotheistic religions, which focus on regulating, with fasting, the consumption of food at a certain time. Furthermore, according to Islamic belief, the consumption of pork is deemed a sin, as well as drinking alcohol among other foods or products specified as forbidden (*haram*)²⁸. This study shows results along the same lines. Fish, according to Islam, are deemed *halal* (permissible), and in the results we observe that Muslims like fish and seafood very much, compared to Christians. Muslims drink more soft drinks, juices, or tea than Christians. Consumption of sugar-containing beverages is related to culture, among other factors. Such data coincide with other studies conducted among the Islamic population, in which the consumption of tea is very common²⁸. In general, a study shows similar results with the prevalence of bad eating habits in adolescents and insist on the need to implement interventions to improve these eating behaviors²⁹.

Most instruments assess dietary intake quantitatively, without considering eating behaviors³⁰. Combining both approaches provides a more comprehensive view. In this study, an eating behaviours questionnaire was used, which is useful for guiding nutritional interventions toward healthier habits¹⁴.

The study has limitations: sampling was convenience-based and not stratified, so it only represents Catholics and Muslims,

with a predominance of women, which is common in healthcare careers. As it is cross-sectional, it does not allow causality to be established, requiring longitudinal studies. It highlights the need to include university nutrition education to prevent long-term health problems. As a strength, it provides a little-studied view of food from a cultural perspective in a multicultural city.

CONCLUSIONS

University students in the health field in Melilla exhibit mixed eating behaviours: they prepare food properly and read nutrition labels, but they lack schedules, eat out, and have a high preference for sweets and alcohol. Although they watch their diet and exercise, they acknowledge a lack of motivation to improve. Differences are observed by gender (women remove more fat from meat, men consume more meat and alcohol) and by religion (Muslims reject alcohol, consume more tea and juices, and remove more fat from meat; Christians prepare more of their own food, consume more alcohol, and reject fish and seafood more). In general, unhealthy habits persist, highlighting the importance of nutrition education, especially among future healthcare professionals, to prevent long-term diseases and further investigate the cultural influence on diet.

AUTHOR CONTRIBUTION

E.F-G, T.L-V, and M.L-O contributed to the creation and design of the study. S.N-P and M.A.S-O designed the statistical plan and interpreted the data. M.M-B conducted the literature search. C.E-M performed the analyses and wrote the first draft with the help of E.F-G, and T.L-V. All authors critically reviewed this and previous versions of the paper.

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CONFLICT OF INTEREST

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

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PROTOCOL

Challenges and Strategies in Metabolic Modulation Diets for Longevity: Protocol for the Validation of the FusionMed Antiaging Model

Retos y estrategias en dietas de modulación metabólica para la longevidad: Protocolo para la validación del modelo FusionMed Antiaging

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KEYWORDS

Metabolic regulation
Mediterranean diet
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FusionMed Antiaging model

ABSTRACT

Introduction: To develop and propose the validation of the FusionMed Antiaging (FMA) model, which combines principles from the Mediterranean (MD) and DASH diets with moderate caloric restriction and cultural adaptations to improve adherence and promote longevity and metabolic health.

Methods: A 12-week randomized controlled clinical trial is proposed with three groups: Standard Mediterranean Diet, Standard DASH Diet, and the experimental FMA model. Metabolic markers, adherence measures, and general well-being variables will be assessed using descriptive and inferential analyses. The intervention focuses on combining evidence-based principles, such as moderate caloric restriction and a personalized approach, to overcome cultural, economic, and behavioral adherence barriers, facilitating implementation in various settings. A total of 120 adults aged 40 to 70 years, with mild overweight (BMI between 25–30) and no severe metabolic diseases, randomly divided into three intervention groups

Results: The FusionMed Antiaging group is expected to show significant improvements in insulin sensitivity, systemic inflammation, body composition, and adherence compared to the control groups.

Conclusions: The FMA model presents itself as a promising and adaptable proposal to improve metabolic health and promote healthy aging. Its experimental validation will determine its efficacy and sustainability across diverse contexts and populations.



PALABRAS CLAVE

Regulación metabólica

Dieta Mediterránea

Dieta DASH

Longevidad

FusionMed Antiaging model

RESUMEN

Introducción: El objetivo es desarrollar y proponer la validación del modelo FusionMed Antiaging (FMA), que combina principios de las dietas Mediterránea (MD) y DASH con restricción calórica moderada y adaptaciones culturales para mejorar la adherencia y promover la longevidad y la salud metabólica.

Metodología: Se propone un ensayo clínico controlado aleatorizado de 12 semanas con tres grupos: Dieta Mediterránea estándar, Dieta DASH estándar y el modelo experimental FusionMed Antiaging. Se evaluarán marcadores metabólicos, medidas de adherencia y variables de bienestar general mediante análisis descriptivos e inferenciales. La intervención combina principios basados en evidencia, como la restricción calórica moderada y un enfoque personalizado, para superar barreras culturales, económicas y conductuales, facilitando su implementación en diversos entornos. La población objetivo serían 120 adultos entre 40 y 70 años, con sobrepeso leve (IMC entre 25–30) y sin enfermedades metabólicas graves, distribuidos aleatoriamente en tres grupos de intervención.

Resultados: Se espera que el grupo FusionMed Antiaging muestre mejoras significativas en la sensibilidad a la insulina, la inflamación sistémica, la composición corporal y la adherencia en comparación con los grupos de control.

Conclusiones: El modelo FusionMed Antiaging se presenta como una propuesta prometedora y adaptable para mejorar la salud metabólica y promover el envejecimiento saludable. Su validación experimental determinará su eficacia y sostenibilidad en diversos contextos y poblaciones.

KEY MESSAGES

1. The FusionMed Antiaging (FMA) model integrates metabolic modulation principles, moderate caloric restriction, and personalized strategies to improve adherence, making it a promising alternative for promoting longevity and metabolic health across diverse populations.
2. The proposed randomized clinical trial will evaluate FMA's efficacy and applicability, aiming to inform policies that reduce the burden of aging-related chronic diseases through scientifically validated dietary interventions through increased dietary adherence, cultural adaptation and sustainability that could improve metabolic markers

CITATION

Murillo-Cancho AF, Nievas-Soriano BJ, Martín-Latorre MM, Lozano-Paniagua D. Challenges and Strategies in Metabolic Modulation Diets for Longevity: Protocol for the Validation of the FusionMed Antiaging Model. Rev Esp Nutr Hum Diet. 2025; 29(3): e2395.

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INTRODUCTION

Caloric restriction (CR) involves reducing caloric intake without causing malnutrition. It is a widely studied strategy due to its benefits for health and longevity¹. In preclinical models, CR has been shown to extend lifespan and improve health by inducing metabolic and cellular adaptations that protect against chronic diseases associated with aging¹.

In humans, caloric restriction (CR) has been shown to modulate key metabolic pathways such as AMPK and mTORC1, mechanisms also associated with cellular regeneration and autophagy. Furthermore, dietary modulation of amino acid intake—particularly branched-chain amino acids and methionine—has been linked to reduced mTORC1 activation, supporting metabolic regulation and healthy aging outcomes².

In animals, CR activates pathways such as AMPK and mTORC1, promoting autophagy, a critical mechanism for cellular regeneration³. Additionally, the limitation of amino acids, such as branched-chain amino acids and methionine, reduces mTORC1 activity, enhancing cellular health and metabolism².

In humans, while direct evidence of CR's impact on longevity is limited, it has been shown to improve insulin sensitivity, regulate circulating lipids, and reduce inflammation, thereby decreasing the incidence of chronic diseases such as type 2 diabetes, cancer, and cardiovascular diseases^{4,5}. Studies like CALERIE have linked CR with improvements in metabolic markers, such as lower LDL cholesterol, reduced inflammation, and greater insulin sensitivity^{5,6}.

CR has also been observed to reduce oxidative stress and improve sleep and mood in older adults, although it may cause adverse effects like decreased bone density, highlighting the importance of adequate monitoring⁷.

Culturally, the Okinawan diet exemplifies the benefits of moderate energy restriction, with a caloric intake 15-20% lower than the Japanese average. This is associated with greater longevity and a lower incidence of degenerative diseases¹. This example demonstrates how a balanced hypocaloric diet can enhance quality of life.

CR also increases the activity of sirtuins and promotes mechanisms such as autophagy and mitophagy, protecting against oxidative damage and the accumulation of senescent cells³. This contributes to reducing chronic inflammation and improving immune and metabolic function.

In conclusion, CR is an effective intervention for promoting health during aging, but its application faces challenges such as individual variability and low long-term adherence. It is essential to explore sustainable dietary patterns, such as the Mediterranean Diet (MD) and DASH, which combine the benefits of CR with a more accessible approach^{4,5}.

In this context, this study introduces the FusionMed Antiaging (FMA) model, which integrates principles of the MD and DASH with metabolic modulation strategies. The main objective is to develop and validate an innovative dietary model that promotes longevity

through a sustainable and customizable approach. Through a randomized clinical trial, the effects of FMA on metabolic markers, adherence, and overall well-being will be evaluated, positioning it as a promising alternative for healthy aging.

Challenges in the Implementation of Energy-Restrictive Dietary Patterns

Energy-restrictive diets and fasting patterns, while beneficial for longevity and health, face significant adherence challenges due to social, cultural, and behavioral factors. Food fulfills nutritional needs but is also a source of pleasure, tradition, and socialization, which can conflict with the perceived "deprivation" associated with caloric restriction, especially in contexts where food abundance is deeply rooted in cultural activities^{1,3} impacting long-term sustainability. These barriers are less evident in animal models, where interventions are applied under controlled conditions, free from cultural or social influences, allowing for the observation of benefits such as metabolic improvements and increased longevity². In humans, genetic variability, diverse lifestyles, and food traditions complicate the standardization and adaptation of caloric restriction (CR) and fasting to individual contexts. Moreover, metabolic factors, such as reduced leptin and increased ghrelin levels, intensify hunger, further complicating adherence⁶.

The pleasure derived from foods rich in fats and refined carbohydrates, which activate brain reward centers, makes the transition to hypocaloric diets more challenging. Changes in dietary habits also disrupt eating rhythms, causing discomfort and leading to abandonment of these regimens⁷.

Finally, dietary habits shaped by culture, tradition, and environment hinder the adoption of restrictive patterns. Changing established routines requires significant behavioral restructuring, generating resistance in societies with food abundance⁸.

In summary, cultural, social, economic, and metabolic factors affect adherence to restrictive patterns. This highlights the need for sustainable metabolic modulation approaches tailored to individual lifestyles to foster prolonged and effective adherence^{5,7,8}.

Metabolic Regulation and Anti-Aging Dietary Design

Metabolic modulation involves adjusting nutrients to activate or inhibit key molecular pathways that promote longevity and health during aging while avoiding malnutrition. By manipulating macronutrient intake and energy-restrictive patterns, this strategy aims to replicate the benefits observed in animal models and apply them practically to humans. Its objectives include reducing oxidative stress, improving mitochondrial health, and decreasing cellular senescence without requiring pharmacological interventions^{1,2}.

This nutritional approach affects metabolic pathways such as AMPK and mTOR, promoting adaptive cellular responses. AMPK, activated by low energy availability, regulates glucose and lipids, inhibits mTORC1, and fosters autophagy, which is essential for cellular renewal^{2,3}. In contrast, excessive activation of mTOR

accelerates cellular damage, while its inhibition through amino acid and carbohydrate restriction promotes autophagy, reduces inflammation, and mitigates oxidative stress³.

Patterns like the Mediterranean Diet (MD) and DASH have shown significant benefits. The MD, rich in fruits, vegetables, legumes, fish, and healthy fats, reduces animal proteins in favour of plant-based proteins, limiting branched-chain amino acids and inhibiting mTOR¹⁴. The DASH diet, designed to reduce hypertension, emphasizes plant-based foods, whole grains, and low-fat dairy products, improving insulin sensitivity and regulating mTOR^{1,5}.

Studies like PREDIMED have highlighted that the MD reduces cardiovascular and neurodegenerative risks due to its antioxidant and bioactive compound content^{5,6,9}. Similarly, DASH improves blood pressure, lipid profiles, and insulin sensitivity, reducing the risk of metabolic and neurodegenerative diseases^{5,6,7,10}.

Another notable example is the Okinawan Diet, characterized by a caloric intake 15–20% lower than the Japanese average, with foods rich in antioxidants and nutrients, which is associated with greater longevity and a lower incidence of chronic diseases^{11,12}. Additionally, Blue Zone diets share principles such as moderate caloric restriction and anti-inflammatory profiles, which are strongly linked to longevity^{13,14,15,16}.

In summary, metabolic modulation through patterns like MD, DASH, and the Okinawan Diet improves metabolic markers and activates anti-aging mechanisms like autophagy. However, their effectiveness depends on sustainability and adaptability to real-world contexts, underscoring the need for personalized dietary designs to maximize adherence and anti-aging benefits.

Development of the FusionMed Antiaging (FMA) Model

The personalization of dietary design is crucial to optimizing adherence to anti-aging interventions. Adapting diets to metabolic needs, cultural preferences, and individual lifestyles enhances both their feasibility and effectiveness, maximizing long-term benefits. Strategies such as caloric restriction (CR) and intermittent fasting (IF) are effective in preventing chronic diseases and delaying aging but face barriers related to cultural restrictions, food enjoyment, and inherited eating behaviors¹. Designing interventions tailored to individual preferences and cultural contexts increases their likelihood of success, while nutritional education and continuous support improve understanding of their benefits and foster motivation to maintain them.

IF and time-restricted feeding (TRF) are complementary strategies to CR. TRF limits food intake to 8–10 hours daily, promoting prolonged fasting periods that regulate glucose, reduce insulin levels, and improve cardiovascular biomarkers by aligning meals with circadian rhythms to enhance cellular regeneration^{16,17,18}. Meanwhile, IF alternates normal days with restricted periods, activating metabolic pathways such as autophagy and mTOR regulation, which improve insulin sensitivity and reduce

inflammation^{8,19}. Although these approaches are flexible and promising, long-term adherence remains challenging.

Combining these strategies with established patterns like the Mediterranean Diet (MD) and DASH offers a sustainable and personalized approach. The FusionMed Antiaging (FMA) model integrates these strategies, also drawing inspiration from Blue Zone diets and principles of moderate caloric restriction to optimize longevity and health.

FMA prioritizes plant-based foods (80–90% of total intake), including fruits, vegetables, legumes, whole grains, and nuts, rich in bioactive compounds like polyphenols, which optimize metabolic health. It also incorporates wild plants (nettle, purslane, samphire) that add nutritional and culinary value. Protein intake is slightly reduced, favouring plant-based sources such as legumes, nuts, and seeds, while maintaining fish for its omega-3 content and limiting red meat to 5–6 servings per month^{4,5}. High-glycemic-index carbohydrates are reduced, added sugars are eliminated, and healthy fats like extra virgin olive oil are prioritized.

This formula proposes moderate energy restriction tailored to individual needs, ensuring adequate intake of nutrients, antioxidants, and fiber essential for combating oxidative damage and inflammation. For example, older adults maintain higher protein intake to prevent sarcopenia, while younger populations emphasize caloric flexibility to avoid negative effects on basal metabolism.

FMA also prioritizes environmental sustainability. The use of artisanal fishing and reduced consumption of processed meats minimizes ecological impact, positioning it as an adaptable and scalable model that addresses both individual needs and global challenges.

Although based on theoretical principles and evidence from established patterns like MD and DASH^{20,21}, the application of FMA requires empirical validation. Experimental studies are needed to evaluate its metabolic effects, impact on longevity, and acceptance. In this context, an experimental design is proposed to validate the model's efficacy in a controlled setting, providing initial data for its future implementation.

METHODOLOGY

Validation of the FusionMed Antiaging Proposal

The aim of this clinical trial is to evaluate the metabolic efficacy, adherence, and practical viability of the FMA model. This analysis seeks to determine whether the model provides superior benefits in regulating key metabolic markers, improving body composition, and enhancing general well-being, while ensuring high acceptance and long-term adherence in a diverse population.

To achieve this, a randomized controlled trial²² is proposed to compare the impact of the FMA model with two standard diets: the Mediterranean Diet and the DASH diet. Participants will be randomly assigned to one of three intervention groups, ensuring the validity of the results.

This design allows for a direct comparison of FMA's efficacy against established dietary patterns, minimizing biases and maximizing internal validity. The selection of participants with homogeneous characteristics (age, BMI, and metabolic health) ensures that the results are attributable to dietary interventions rather than external factors.

The study will provide preliminary evidence on the model's applicability within a representative population, laying the groundwork for larger and longer-term studies.

A population sample will be selected and divided equally into three groups. Recruitment will be conducted through primary care centers and public calls, ensuring representativeness of the target group. Population according to defined criteria (see [Table 1](#)).

Study Design

A 12-week randomized controlled clinical trial is proposed to compare the effects of the FusionMed Antiaging (FMA) model against two standard dietary patterns: the Mediterranean Diet (MD) and the DASH diet. The study includes an initial two-week baseline phase, a twelve-week intervention phase, and a final reassessment phase. The objective is to evaluate the metabolic efficacy, adherence, and practical feasibility of the FMA model in a population of adults with mild overweight.

Target Population

The study will include 120 adults (40 per group), aged between 40 and 70 years, recruited through primary care centers and open calls. Participants must have a body mass index (BMI) between 25 and 30, and no severe metabolic diseases. Random allocation will ensure group comparability and minimize bias.

Inclusion and Exclusion Criteria

The criteria are presented in [Table 1](#) and ensure a homogeneous sample in terms of baseline metabolic health. Individuals

with advanced chronic diseases, severe food allergies, or pharmacological treatments that interfere with metabolism (e.g., corticosteroids, antipsychotics) will be excluded.

Interventions

Group 1 (Control - Standard Mediterranean Diet):

- Validated diet rich in fruits, vegetables, legumes, whole grains, and nuts.
- Extra virgin olive oil (EVOO) as the primary fat source.
- Moderate consumption of fish, poultry, and dairy products.
- Limited intake of red meat, processed foods, and added sugars.
- Moderate consumption of red wine or beer.

Group 2 (Control - Standard DASH Diet):

- Validated diet emphasizing fruits, vegetables, whole grains, and low-fat dairy products.
- Includes lean meats, fish, and legumes.
- Sodium limited to <2300 mg/day, with restrictions on saturated fats, added sugars, and processed foods.

Group 3 (Experimental - FMA):

- Moderate caloric restriction (15–20% below maintenance caloric needs), tailored to individual requirements.
- Low-glycemic-index carbohydrates and plant-based proteins (legumes, nuts, seeds), with reduced reliance on animal proteins.
- Controlled inclusion of small fish rich in omega-3 and low-fat dairy products.
- Use of healthy fats (EVOO).
- Reduction of processed and refined foods and inclusion of bioactive-rich foods.

Each group will receive a personalized weekly menu and participate in biweekly educational sessions to ensure understanding and adherence to the assigned dietary pattern. Evaluation variables are detailed in [Table 2](#).

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Adults aged 40 to 70 years	Pregnancy or breastfeeding
Body Mass Index (BMI) between 25 and 30 (mild overweight)	Diagnosis of advanced chronic diseases (renal or hepatic insufficiency)
Absence of uncontrolled severe metabolic diseases	Pharmacological treatments that may alter metabolism or body weight (steroids, antipsychotics)
Ability to attend regular follow-up sessions during the study	Severe food allergies or dietary restrictions incompatible with the studied diets
Willingness to follow the assigned dietary plan	Participation in another clinical trial within the past six months

Table 2. Variables measured and evaluation guidelines.

Category	Variables	Details
Metabolic Markers	Insulin Sensitivity (HOMA-IR) ⁽²⁶⁾ Lipid Profile: Total cholesterol, LDL, HDL, triglycerides ⁽²⁷⁾ Systemic Inflammation: CRP, IL-6 ⁽²⁸⁾ Oxidative Stress: MDA, GSH	HOMA-IR assesses insulin resistance and type 2 diabetes risk. Lipid profile is associated with cardiovascular diseases. CRP and IL-6 are key indicators of systemic inflammation. MDA and GSH are markers of oxidative stress and cellular antioxidant capacity.
Adherence Measures	Food Frequency Questionnaires (FFQ) Weekly Dietary Records Satisfaction Scale Body Composition: Weight, BMI, fat/muscle mass	FFQ estimates adherence to dietary patterns. Weekly records monitor compliance. Likert scale measures diet acceptance. Bioimpedance assesses body composition.
General Well-Being	Sleep Quality (Pittsburgh Index) Mood (SF-36, emotional well-being) Perceived Energy (VAS scales)	Pittsburgh Index evaluates sleep quality. SF-36 measures emotional well-being. VAS quantifies perceived energy levels.
Sociodemographic	Age Sex Socioeconomic Level Educational Level	For subgroup analysis.

Procedure

Initial phase (2 weeks):

- Baseline evaluation of metabolic variables, adherence, and body composition.
- Random assignment to one of the three groups.

Intervention (12 weeks):

- Supervised diets with personalized weekly menus.
- Biweekly group sessions to promote adherence and address questions.
- Follow-up phase: Reevaluation of all variables.

Final phase (2 weeks):

- Comprehensive reassessment of all measured variables and comparison of results among groups

During the intervention, specific strategies will be implemented to improve adherence:

- Nutritional education focused on the metabolic and longevity benefits of the model, including techniques such as motivational interviewing²³.
- Social and family support through peer networks and enabling environments.
- Cultural flexibility by incorporating local foods and traditional preparations.
- Promotion of sustainable behavioral change practices, such as mindful eating, short-term goal setting with incentives, and continuous professional monitoring of dietary records.
- Use of technological tools, including mobile applications for dietary tracking, online consultations with professionals, and gamification elements to foster motivation^{24,25}.

Variables and Measurements

The main variables include: (See [Table 2](#))

- Metabolic markers: insulin sensitivity (HOMA-IR)²⁶, lipid profile (total cholesterol, LDL, HDL, triglycerides)²⁷, systemic inflammation (CRP, IL-6)²⁸, and oxidative stress and oxidative stress markers, including malondialdehyde (MDA) and reduced glutathione (GSH).
- Adherence: food frequency questionnaires (FFQ), weekly dietary records, satisfaction scale, and body composition (BMI, fat and lean mass via bioimpedance).
- General well-being measures: sleep quality (Pittsburgh Index), mood (SF-36, emotional dimension), and perceived energy (VAS scales).
- Sociodemographic variables: age, sex, educational level, and socioeconomic status.

Statistical Analysis

Descriptive statistics will be used to characterize the sample and compare baseline variables. Post-intervention comparisons between groups will be conducted using ANOVA or ANCOVA, adjusting for confounding variables. Regression models will identify predictors of adherence and outcomes. A qualitative analysis of satisfaction and perceived feasibility of the model will complement the results. All analyses will be performed using a two-tailed significance level of $p < 0.05$, with both intention-to-treat and per-protocol approaches depending on adherence and dropout rates.

RESULTS AND DISCUSSION

Expected Results.

The experimental group (FMA) is expected to show significant improvements in metabolic markers and greater adherence compared to traditional diets, preliminarily validating the model as a viable alternative for promoting longevity and metabolic health. The experimental design will provide initial data on FMA's efficacy and adherence, supporting its practical viability and potential inclusion in healthy aging guidelines. Compared to MD and DASH, the model aims to optimize metabolic parameters and foster adherence through moderate caloric restriction and cultural personalization. The analysis will help identify necessary adaptations, such as adjustments in macronutrients, incorporation of traditional foods, and behavioral strategies, positioning FMA as a scalable solution for diverse populations.

Strategies to Improve Adherence

- Nutritional education²³: Programs explaining the metabolic and longevity benefits of the model using tools aimed at dietary behavior change, such as motivational interviewing.
- Social support: Networks for sharing experiences and enhancing motivation.
- Family involvement: Creating an environment that supports adherence.
- Cultural flexibility: Incorporating local foods and adjusting to different contexts and sustainable Practices for Habit Changes
- Mindful eating: Teaching participants to recognize hunger and satiety signals.
- Rewards: Short-term goals with incentives to maintain motivation.
- Professional monitoring: Use of dietary records reviewed by professionals, use of Technology to Support Adherence²⁴: Mobile applications for meal planning, food intake tracking, and immediate feedback; Online consultations in a continuous way and personalized support with specialists; and gamification²⁵ for incorporating challenges and motivational games.

Clinical Practice Implications

Cultural Contexts Adaptation: For mediterranean participants, adjust nutrients aligned with the MD model, prioritizing legumes and vegetables; for Asian participants, the incorporation of healthy fats and whole-grain versions of traditional cereals, and, for anglo-saxon cultures the gradual changes, such as reducing animal proteins.

Demographic Subgroups Adaptation: Older adults, menus with soft textures, rich in plant-based proteins and calcium. Low-income populations prioritize affordable and local foods; and for

people with dietary restrictions offers alternatives to meet specific nutritional needs.

Practical Approach: Personalized menus and adaptation of recipes: adapted to each region or subgroup with the use of local ingredients. Along with educational workshops supported by culinary professionals to promote the pattern.

These strategies will facilitate acceptance in different contexts, providing a framework for future studies evaluating adherence and metabolic outcomes.

A key strength of this study is its innovative design: to our knowledge, it represents the first randomized controlled trial to directly compare the Mediterranean diet, the DASH diet, and the novel FusionMed Antiaging model in terms of both metabolic efficacy and dietary adherence. This comparative framework enhances the relevance, originality, and potential clinical impact of the findings in the field of nutritional strategies for healthy aging. The expected outcomes will contribute to refining the FusionMed Antiaging model and establishing a foundation for its integration into evidence-based dietary recommendations for aging populations

Study Limitations

While this study would provide valuable data, there are limitations:

- The duration (12 weeks) does not allow for evaluating long-term changes in chronic diseases or sustained adherence.
- The sample size (40 participants per group) limits generalization.
- Focus on adults aged 40–70 excludes other age groups.
- These limitations highlight the need for larger and longer studies.

Considerations for Future Studies

Macronutrient proportions should be individually adjusted. Reducing proteins in middle age to inhibit mTOR and increasing complex carbohydrates could favour longevity. Circadian modulation represents a promising field. Preliminary studies suggest that eating early optimizes metabolism and improves lipid profiles^{29,30}. Additionally, modulation appears to influence longevity processes such as autophagy and DNA repair. Further studies are essential to confirm its impact on health and longevity³⁰.

CONCLUSION

Metabolic modulation based on MD and DASH, combined with moderate caloric restriction, is promising for promoting longevity. These diets activate key metabolic pathways, improving cellular health and preventing diseases.

The FMA model, based on sustainable and cultural principles, represents an accessible and personalized approach. Incorporating

techniques such as time-restricted feeding improves adherence without imposing extreme restrictions. However, long-term studies are needed to evaluate its impact on quality of life and longevity. Ultimately, these strategies could form the foundation of sustainable dietary interventions, optimizing quality of life and longevity in diverse populations.

AUTHORS CONTRIBUTIONS

Study design, data collection: AM. Writing – original draft preparation: AM, BN and DL. Data analysis; AM, BN and DL. Writing – review and editing. All authors have read and approved the final manuscript.

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CONFLICTS OF INTEREST

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

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