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LÍDIA MARIA DE SOUSA FRANÇA

USO DE FÍGADO BOVINO REDUZ ANEMIA EM LACTENTES: UM ENSAIO CLÍNICO RANDOMIZADO

SOBRAL
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Dissertação apresentada ao Programa e Pós graduação em Ciências da Saúde da Universidade Federal do Ceará - campus Sobral, como requisito parcial para obtenção do Título de Mestre em Ciências da Saúde.

Orientador: Dr. Francisco Plácido Nogueira Arcanjo.

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A Deus e à minha mãe.

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"Quando tudo pesa, o amor alivia — e a evolução nos ensina que até o medo pode ser caminho"

RESUMO

Objetivos: Avaliar o impacto de uma intervenção dietética com fígado bovino sobre a anemia ferropriva em crianças de 24 a 36 meses de idade em creches públicas de Sobral, Brasil. **Métodos:** Um estudo randomizado por conglomerados, duplo-cego foi conduzido com crianças, com um grupo de intervenção (n=48) recebendo fígado bovino duas vezes por semana por 4 meses e um grupo controle (n=60) recebendo refeições habituais da escola. As concentrações de hemoglobina (Hb) foram medidas antes e após a intervenção, com anemia definida como Hb inferior a 11,0 g/dL. As análises foram por intenção de tratar. **Resultados:** No grupo de tratamento, a Hb aumentou de 10,73 ± 1,35 para 11,60 ± 0,72 g/dL e a prevalência de anemia diminuiu de 54,2% para 33,3% ($p < .0001$). No grupo controle, a Hb aumentou levemente de 11,66 ± 0,74 para 11,81 ± 0,82 g/dL (p 054) e a prevalência de anemia aumentou de 10% para 15% (p 58). NNT: 9. **Conclusões:** A suplementação com fígado bovino aumentou efetivamente os níveis de Hb e reduziu a prevalência de anemia em lactentes.

Palavras-chave: anemia ferropriva; suplementos dietéticos; fígado bovino; nutrição infantil; hemoglobina; nutrição em saúde pública.

ABSTRACT

Aims: To evaluate the impact of a dietary intervention with beef liver on iron deficiency anaemia in infants aged 24 to 36 months in public day-care centres in Sobral, Brazil. **Methods:** A cluster-randomized, double-blind trial was conducted with infants randomized into a treatment group (n = 48) receiving beef liver twice weekly for 4 months and a control group (n = 60) receiving regular meals. Haemoglobin (Hb) concentrations were measured before and after the intervention, with anaemia defined as Hb <11.0 g/dL. Analyses were by intention to treat. **Results:** In the treatment group, Hb increased from 10.73 ± 1.35 to 11.60 ± 0.72 g/dL ($p < .0001$), and anaemia prevalence decreased from 54.2% to 33.3% ($p = .06$). In the control group, Hb increased slightly from 11.66 ± 0.74 to 11.81 ± 0.82 g/dL ($p = .054$), and anaemia prevalence increased from 10% to 15% ($p = .58$). NNT = 9. **Conclusions:** Beef liver supplementation effectively increased Hb levels and reduced anaemia prevalence in infants.

Keywords: iron deficiency anemia; dietary supplements; beef liver; child nutrition; hemoglobin; public health nutrition.

SUMÁRIO

1 INTRODUÇÃO

Anemia por deficiência de ferro é uma doença hematológica prevalente caracterizado por uma redução substancial da massa de glóbulos vermelhos circulantes, levando a diminuição da concentração de hemoglobina (Hb) e redução do transporte de oxigênio para os tecidos. É uma das deficiências nutricionais mais prevalentes mundialmente, afetando cerca de 30% da população global, chegando a prevalências acima de 60% em algumas regiões, principalmente em países menos desenvolvidos, o que equivale a mais de 2 bilhões de pessoas, com prevalência elevada entre crianças, adolescentes e gestantes (WHO, 2021; Cappellini et. al, 2024). As manifestações clínicas da anemia ferropriva incluem fadiga, palidez, diminuição do desempenho físico e da capacidade de trabalho (Sun, 2018; Theola, 2025; Lozoff *et. al*, 2006). A estratégia primária para controlar e erradicar o quadro de deficiência de ferro envolve a promoção de uma dieta saudável (WHO, 2021; Sun, 2018).

Na primeira infância, a anemia ferropriva pode ter efeitos adversos duradouros sobre a saúde física e desenvolvimento cognitivo. Estudos demonstraram que a condição ferropriva durante a infância está associada com déficits irreversíveis no crescimento linear e no desenvolvimento neurocognitivo (Georgieff, 2011; Carter *et. al*, 2010). Crianças que experimentaram o quadro de deficiência de ferro no início da vida exibem desempenho mais baixo no cognitivo, social e funcionamento emocional, mesmo após a correção da anemia (Lozoff *et. al*, 2012). O desenvolvimento socioemocional é particularmente suscetível à condição ferropriva, potencialmente devido a vias neuronais compartilhadas (Sun, 2018). A anemia ferropriva pode também afetar regiões do cérebro associadas à navegação espacial, como o hipocampo (Lukowski, 2010). Além disso, a deficiência de ferro pode impactar o desenvolvimento infantil não apenas de forma direta, mas também por meio das interações mãe-criança. Isso ocorre porque mães com baixos níveis de ferro podem apresentar maior fadiga, irritabilidade e dificuldades emocionais, o que reduz a qualidade da responsividade e do vínculo estabelecido com a criança. Consequentemente, essas limitações nas interações podem afetar negativamente o estímulo cognitivo e socioemocional oferecido à criança, ampliando os efeitos da deficiência de ferro sobre o seu desenvolvimento (Sun, 2018; Lukowski, 2010).

No manejo da anemia ferropriva a intervenção precoce é crucial, pois os efeitos da condição ferropriva sobre o desenvolvimento podem persistir na adolescência e na idade adulta (Lozoff *et. al*, 2012; Lukowski, 2010).

Dentre as estratégias, a alimentação e a nutrição adequadas são determinantes fundamentais para prevenir e controlar as deficiências nutricionais. A anemia ferropriva, condição mais comum de deficiência nutricional, tem como principais causas a baixa ingestão de alimentos ricos em ferro, perdas sanguíneas (como menstruação ou parasitoses intestinais), além de necessidades aumentadas em fases de crescimento e gestação. O tratamento geralmente envolve suplementação de ferro, que embora eficaz, pode estar associado a efeitos secundários como constipação, náuseas, dor abdominal e escurecimento das fezes. Nesse contexto, meta-análises recentes mostram que a dieta representa um fator modificável capaz de melhorar o estado do ferro em crianças com deficiência, reforçando que intervenções dietéticas — como o aumento do consumo de carnes, leguminosas, vegetais verde-escuros e alimentos fortificados, aliados à ingestão de vitamina C para potencializar a absorção — devem ser consideradas na gestão geral da condição ferropriva. Essas estratégias dietéticas podem oferecer vantagens sobre a suplementação isolada, ao reduzir efeitos adversos e promover benefícios adicionais para a saúde global da criança (Sun, 2018).

Mesmo com múltiplos esforços no combate à anemia e à deficiência do ferro uma alta prevalência da condição ferropriva ainda persiste, particularmente em regiões economicamente desfavorecidas, sublinhando a necessidade de abordagens inovadoras e sustentáveis para reduzir a prevalência da anemia ferropriva. Nosso estudo vem acrescentar mais uma estratégia, avaliando o impacto de um programa de alimentação que incorpora o fígado bovino na prevenção e tratamento da anemia ferropriva em crianças com idade entre 24 e 36 meses que frequentam creches.

2 OBJETIVOS

2.1 Objetivo geral

- Avaliar os efeitos de uma dieta com fígado sobre a anemia em crianças de uma creche no município de Sobral, Ceará.

2.2 Objetivos específicos

- Avaliar a concentração de hemoglobina em crianças, após o uso de uma dieta com fígado comparando com um grupo controle.
- Avaliar a prevalência de anemia em crianças, após o uso de uma dieta com fígado comparando com um grupo controle.

3 MÉTODOS

3.1 Desenho do estudo

Este estudo foi um ensaio clínico randomizado por conglomerados, duplo-cego. Creches públicas foram aleatoriamente designadas para o grupo de intervenção ou controle usando uma lista de randomização gerada por computador.

O estudo foi aprovado pelo Comitê de Ética em Pesquisa da Universidade Federal do Ceará (Protocolo nº 2022269) e realizado no Programa de Pós-Graduação em Ciências da Saúde da Universidade Federal do Ceará. Investigou-se intervenções dietéticas para reduzir a anemia ferropriva em lactentes, em plena conformidade com os princípios éticos estabelecidos pela Resolução nº 466/2012 do Conselho Nacional de Saúde. A participação foi formalizada por consentimento livre e esclarecido por escrito dos responsáveis legais ou pais das crianças. O apoio médico estava disponível mediante solicitação e, após a intervenção, as crianças anêmicas foram encaminhadas para tratamento.

3.2 Local e Participantes

O ensaio foi realizado em creches públicas de Sobral, cidade de médio porte do nordeste do Brasil. Crianças de 24 a 36 meses de idade regularmente matriculadas em quatro creches públicas selecionadas aleatoriamente (duas em cada grupo) foram elegíveis para participar. Os critérios de exclusão incluíram recusa do responsável legal ou dos pais em participar e bebês já recebendo suplementação de ferro.

3.3 Intervenção

A intervenção consistiu em uma intervençao dietetica com fígado para avaliar os niveis de hemoglobina e a prevalencia da anemia. Foi acrescentado no almoço das crianças das creches, duas vezes por semana 80 gramas de fígado bovino por criança. As crianças dos centros de intervenção receberam a refeição regular às segundas, quartas e sextas-feiras, enquanto às terças e quintas-feiras, 80 gramas de fígado foi incluído como componente de carne da refeição. Os lactentes do grupo controle receberam a refeição habitual todos os dias. Todas as refeições foram acompanhadas por massas ou arroz e suco de frutas naturais.

As refeições foram preparadas pelas cozinhas da creche para os grupos de intervenção e controle, com a equipe regular da cozinha supervisionada pelos pesquisadores, foi orientado que se utilizasse o mínimo de temperos possível para que não alterasse a quantidade ou valor nutricional do fígado. O estudo ocorreu de agosto a dezembro de 2024, com início e término de ambos os grupos nas mesmas datas. O consumo alimentar individual não foi mensurado.

3.4 Cálculo do tamanho da amostra

Com base em estudos anteriores realizados no nordeste do Brasil, a prevalência de anemia em lactentes foi estimada entre 40% e 50% (Carvalho, 2010; WHO, 2001). Para alcançar uma redução da prevalência global de anemia de 50% para 25%, com poder de 80% e erro bicaudal tipo I de 5%, representando 10% de perda de seguimento, foi necessário um mínimo de quarenta e três participantes por grupo (Lwanga *et. al*, 1991).

3.5 Medidas

As concentrações de HB foram analisadas antes e após a intervenção usando um hemoglobinometro portátil HemoCue B (Hb 301 - HemoCue AB, Ängelholm, Suécia) por um técnico treinado. A prevalência de anemia foi determinada antes e após a intervenção, utilizando como ponto de corte a concentração de Hb inferior a 11,0 g/dL para definir anemia (WHO, 2023).

3.6 Variáveis

Na linha de base, foram coletados dados sobre idade, sexo, aleitamento materno exclusivo até 6 meses, escolaridade da mãe e renda familiar, com base em informações fornecidas pelos pais ou responsáveis por meio de ficha de dados padronizada. As principais variáveis de desfecho foram a alteração da concentração de Hb (medida em g/dL) e a prevalência de anemia.

3.7 Análise estatística

As comparações intragrupos foram feitas por meio do teste t de Student pareado (bicaudal) para avaliar a diferença na concentração de Hb antes e após a intervenção e do teste exato de Fisher para comparar a ausência ou presença de anemia. Comparações entre grupos foram feitas usando o teste t de Student não pareado (bicaudal) para avaliar a diferença na concentração média de Hb. Os dados foram normalmente distribuídos. Todas as análises foram realizadas utilizando o pacote estatístico SPSS para Windows, versão 24,0 (SPSS Inc., Chicago, IL). A significância estatística foi definida em $p > 0,05$. As análises foram realizadas por intenção de tratar.

4 RESULTADOS

Os resultados estão descritos no artigo Dietary Intervention with Beef Liver Reduces Iron Deficiency Anaemia in Infants: A Cluster-Randomised, Double-Blind Clinical Trial enviado para publicação para a revista Acta Paediatrica ISSN 1651-2227.

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Name	Type of File	Size	Page
4 - Manuscript - Dietary Intervention with Beef Liver.docx	Main Document - MS Word	33.4 KB	Page 4
5 - Figure 1 - Dietary Intervention with Beef Liver.docx	Figure	280.1 KB	Page 16
6 - Table 1 - Dietary Intervention with Beef Liver.docx	Table	19.5 KB	Page 17
7 - Table 2 - Dietary Intervention with Beef Liver.docx	Table	401.2 KB	Page 18
8 - Table 3 - Dietary Intervention with Beef Liver.docx	Table	392.5 KB	Page 19

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Cecília Costa Arcanjo Freire: Conceptualization, data curation, formal analysis, investigation, methodology, validation, visualization, writing original draft, writing review & editing.

Myrna Maria Arcanjo Frota Barros: Data curation, formal analysis, investigation, methodology, validation, visualization, writing original draft, writing review & editing.

Lissiana Magna Vasconcelos Aguiar: Data curation, formal analysis, investigation, methodology, validation, visualization, writing original draft, writing review & editing.

All authors participated in validation, visualization, writing original draft, writing review & editing.

Abstract

Aims: To evaluate the impact of a dietary intervention with beef liver on iron deficiency anaemia in infants aged 24 to 36 months in public day-care centres in Sobral, Brazil. **Methods:** A cluster-randomized, double-blind trial was conducted with infants randomized into a treatment group (n = 48) receiving beef liver twice weekly for 4 months and a control group (n = 60) receiving regular meals. Haemoglobin (Hb) concentrations were measured before and after the intervention, with anaemia defined as Hb <11.0 g/dL. Analyses were by intention to treat. **Results:** In the treatment group, Hb increased from 10.73 ± 1.35 to 11.60 ± 0.72 g/dL ($p < .0001$), and anaemia prevalence decreased from 54.2% to 33.3% ($p = .06$). In the control group, Hb increased slightly from 11.66 ± 0.74 to 11.81 ± 0.82 g/dL ($p = .054$), and anaemia prevalence increased from 10% to 15% ($p = .58$). NNT = 9. **Conclusions:** Beef liver supplementation effectively increased Hb levels and reduced anaemia prevalence in infants.

Keywords: Beef liver; Child nutrition; Dietary supplements; Hemoglobin; Iron deficiency anemia.

Introduction

Iron deficiency anaemia (IDA) is a prevalent haematological disorder characterised by a substantial reduction in circulating red blood cell mass, leading to decreased haemoglobin (Hb) concentration and impaired oxygen transport to tissues. IDA affects approximately 30% of the global population, with heightened prevalence among children, adolescents, and pregnant women [1,2] Clinical manifestations of IDA include fatigue, pallor, diminished physical performance, and reduced work capacity [3,4,5] The primary strategy for controlling and eradicating IDA involves promoting healthy dietary habits [1-3].

In early childhood, IDA can have enduring adverse effects on physical and cognitive development. Studies have demonstrated that IDA during infancy is associated with irreversible deficits in linear growth and neurocognitive development [6,7]. Children who experienced IDA in early life exhibit lower performance in cognitive, social, and emotional functioning, even after anaemia correction [5]. Socioemotional development is particularly susceptible to IDA, potentially due to shared neural pathways [3]. IDA can also affect brain regions associated with spatial navigation, such as the hippocampus [8]. Furthermore, IDA may indirectly influence child development through unresponsive mother–child interactions [3,8] Preventive strategies include ensuring adequate maternal iron status, providing iron-rich complementary foods, and promoting responsive caregiving [3,9]. Early intervention is crucial, as the effects of IDA on cognitive development may persist into adolescence and adulthood [5,8]

To address the prevalence of IDA, the Brazilian National Food and Nutrition Policy was established to ensure food quality and promote healthy eating habits for the prevention and control of nutritional disorders [10]. However, high IDA prevalence persists, particularly in economically disadvantaged regions, underscoring the need for innovative, sustainable, and cost-effective strategies to reduce IDA prevalence.

Food and nutrition are fundamental determinants of health promotion and protection; thus, implementing strategies to prevent and control nutritional deficiencies is essential. A recent meta-analysis supports the notion that diet is a modifiable factor capable of improving iron status in children with IDA. Moreover, the study provides evidence that dietary interventions should be considered in the overall management of IDA, potentially offering advantages over iron supplementation by mitigating unnecessary side effects [3].

Therefore, the general objective of this study was to evaluate the impact of a feeding programme incorporating bovine liver on the treatment and prevention of IDA in infants aged 24 to 36 months attending public daycare centres in a medium-sized city in northeastern Brazil. The specific objectives were to assess the difference in Hb levels between the control and treatment groups.

Methods

Study Design

This study is a cluster-randomised, double-blind clinical trial aimed at preventing and treating IDA in infants through a dietary intervention. Public day-care centres were randomly assigned to either the intervention or control group using a computer-generated randomisation list.

The study was approved by the Research Ethics Committee of the Federal University of Ceará (Protocol No. 2022269) and conducted within the Postgraduate Program in Health Sciences at the Federal University of Ceará. It investigated dietary interventions to reduce iron deficiency anaemia in infants, in full accordance with the ethical principles established by Resolution No. 466/2012 of the Brazilian National Health Council. Participation was formalised by written informed consent from the infants' legal guardians or parents. Medical support was available upon request, and after the intervention, anaemic infants were referred for treatment.

Setting and Participants

The trial was conducted at public day-care centres in Sobral, a medium-sized city in the northeast of Brazil. Infants aged 24 to 36 months who were regularly enrolled in four randomly selected public day-care centres (two in each group) were eligible to participate. The exclusion criteria included refusal by the legal guardian or parent to participate and infants already receiving iron supplementation.

Intervention

Meals were prepared by the day-care centre kitchens for both the intervention and control groups, with regular kitchen staff overseen by researchers. Infants in the intervention centres received the regular meal on Mondays, Wednesdays, and Fridays, while on Tuesdays and Thursdays, 80 g of beef liver per infant was included as the meat

component of the meal. Infants in the control group received the regular meal every day. All meals were accompanied by pasta or rice and natural fruit juice. The study took place from August to December 2024, with both groups starting and ending on the same dates. Individual food consumption was not measured.

Sample Size Calculation

Based on previous studies conducted in the northeast of Brazil, the prevalence of anaemia in infants was estimated to be between 40% and 50% [11-13]. To achieve a reduction in the global prevalence of anaemia from 50% to 25%, with 80% power and a two-tailed type I error of 5%, accounting for 10% loss to follow-up, a minimum of forty-three participants per group was required [14].

Measures

Hb concentrations were analysed before and after the intervention using a portable HemoCue B-haemoglobin photometer (Hb 301 - HemoCue AB, Ängelholm, Sweden) by a trained technician. Anaemia prevalence was determined before and after the intervention using an Hb concentration of <11.0 g/dL as the cutoff point to define anaemia [15].

Variables

At baseline, data were collected on the child's age, gender, exclusive breastfeeding up to 6 months, mother's education level, and family income, based on information provided by parents or legal guardians using a standardised data sheet. The main outcome variables were the change in Hb concentration (measured in g/dL) and the prevalence of anaemia.

Statistical Analysis

Within-group comparisons were made using the paired Student's t-test (two-tailed) to assess the difference in Hb concentration before and after the intervention, and Fisher's exact test to compare the absence or presence of anaemia. Between-group comparisons were made using the unpaired Student's t-test (two-tailed) to assess the difference in mean Hb concentration. Data were normally distributed. All analyses were conducted using the SPSS statistical software package for Windows, version 24.0 (SPSS Inc., Chicago, IL). Statistical significance was set at $p < 0.05$. Analyses were performed byintention-to-tr

Results

At baseline, eighteen preschoolers were excluded prior to blood analysis. Before the second biochemical evaluation (conducted at the end of the intervention), there were two dropouts from Group A and four from Group B (Figure 1).

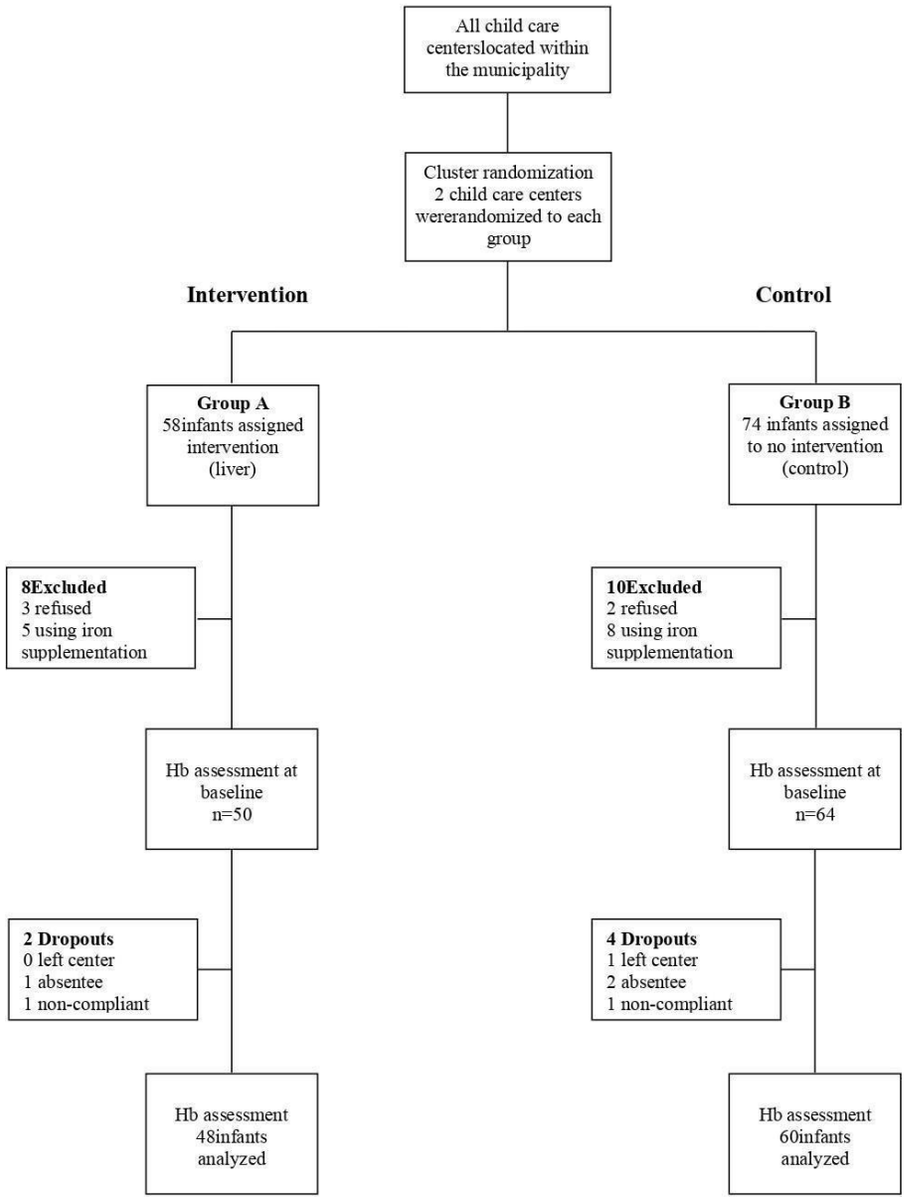

Figure 1. Flowchart of the study design.

At baseline, mean Hb concentration and other study variables were analysed. The mean Hb concentration was 10.73 ± 1.35 g/dL in the intervention group and 11.60 ± 0.72 g/dL in the control group ($p < 0.0001$). However, no statistically significant differences were observed between the groups for the other study variables (Table 1)

Table 1. Baseline characteristics of study participants, by intervention group and control

Variables	**Group A**(n=50) *Liver*	**Group B** (n=64) *Controle*	p-value
Age (months) *Mean±SD*	33.4±3.50	34.2±2.80	.18[a]
Hemoglobin (g/dL)	10.73±1.35	11.60±0.74	.0001[a]
Gender M:F	22:28	30:34	.85[b]
EBF	18	27	.56[b]
Mother with ≥9y schooling	15	24	.43[b]
Family income ≥300USD	27	33	.55[b]

All numbers are absolute
SD standard deviation
M:F male:female
EBF exclusively breastfed up to 6 months of age
[a]Based on unpaired t test
[b]Based on Fisher's exact test

In Group A (intervention), the mean Hb concentration increased from 10.73 ± 1.35 g/dL before the intervention to 11.60 ± 0.72 g/dL after the intervention ($p < 0.0001$). Anaemia was present in 26 out of 48 participants (54.2%) at baseline, and in 16 (33.3%) following the intervention ($p = 0.06$).

In the control group (Group B), the mean baseline Hb concentration was 11.66 ± 0.74 g/dL, increasing slightly to 11.81 ± 0.82 g/dL post-intervention ($p = 0.054$). Anaemia was present in 6 out of 60 participants (10.0%) at baseline, rising to 8 (15.0%) at the end of the study ($p = 0.58$).

Between-group comparison showed that the mean increase in Hb concentration was significantly greater in the intervention group than in the control group (0.88 ± 1.29 vs. 0.16 ± 0.61 g/dL, $p = 0.0002$) (Table 2).

Table 2. Effects of beef liver and control interventions on haemoglobin levels and anaemia prevalence among all participants, before and after the intervention.

Variables	**Group A**(n=48) *Liver*			**Group B** (n=60) *Control*		
	Before	After	*p*	Before	After	*p*
Hb *Mean±SD*	10.73±1.35	11.60±0.90	**<.0001**[a]	11.66±0.74	11.81±0.82	.054[a]
CI	10.33,11.12	11.34,11.86		11.46,11.85	11.60, 12.02	
Mean increase in Hb *Mean±SD*		0.88±1.29			0.16±0.61	**.0002**[b]
CI		0.50, 1.25			0.00, 0.31	
Anemic[c]	26 (54.2)	16 (33.3)	.06[d]	6 (10.0)	8 (15.0)	.58[d]

All numbers are absolute except numbers in brackets, which represent percentages
Hb Hemoglobin(g/dL)
SDstandard deviation
CI 95% Confidence interval
[a]Based on paired Student's *t*-tests (two-tailed)
[b] Based on unpaired Student's *t*-tests (two-tailed)
[c] Anemia defined as Hb concentration <11.0 g/dL
[d]Based on Fisher's exact test (two-tailed)

In the second analysis, only participants who were anaemic at baseline were considered. In Group A (n = 26), the mean Hb concentration increased from 9.82 ± 1.08 g/dL at baseline to 11.39 ± 0.66 g/dL following the intervention ($p < 0.0001$). Of the 26 dIn the control group (n = 6), the mean Hb concentration increased from 10.40 ± 0.44 g/dL at baseline to 11.35 ± 1.15 g/dL at the end of the study ($p = 0.022$), with three participants (50%) remaining anaemic.

Both groups showed an increase in mean Hb concentrations, which was greater in the intervention group (1.57 ± 1.14 vs. 0.95 ± 0.71 g/dL); however, the difference between groups was not statistically significant ($p = 0.28$) (Table 3).

Table 3. Effects of beef liver and control interventions on haemoglobin levels and anaemia prevalence in anaemic preschoolers, before and after the intervention.

Variables	**Group A**(n=26) *Liver*			**Group B** (n=6) *Control*		
	Before	After	*p*	Before	After	*p*
Hb *Mean±SD*	9.82±1.08	11.39±0.66	**<.0001**[a]	10.40±0.44	11.35±1.15	**.022**[a]
CI	9.38, 10.25	11.12, 11.65		9.94, 10.86	10.14, 12.56	
Mean increase in Hb *Mean±SD*		1.57±1.14			0.95±0.71	<.28[b]
CI		1.11, 2.03			0.20, 1.70	
Anemic[c]	26	10(38.5)	**<.0001**[d]	6	3 (50.0)	.18[d]

All numbers are absolute except numbers in brackets, which represent percentages
Hb Hemoglobin(g/dL)
SD standard deviation
CI 95% Confidence interval
[a] Based on paired Student's *t*-tests (two-tailed)
[b] Based on unpaired Student's *t*-tests (two-tailed)
[c] Anemia defined as Hb concentration <11.0 g/dL
[d]Based on Fisher's exact test (two-tailed)

In this study, among participants who were anaemic at baseline, outcomes were compared between the intervention group (Group A) and the control group (Group B), classified as either favourable (absence of anaemia) or adverse (persistence of anaemia). At the endpoint, an adverse outcome was observed in 38.5% of participants in Group A and 50.0% in Group B. The absolute risk reduction (ARR) in the intervention group was 11.5%. The 95% confidence interval for this difference ranged from -32.6% to 55.7%. The number needed to treat (NNT) was calculated as 9 (data not shown).

Discussion

This study assessed the impact of a dietary intervention with beef liver on Hb levels and anaemia prevalence in preschoolers. The results indicated a significant improvement in Hb concentration in the intervention group (Group A), with a mean increase of 0.88 ± 1.29 g/dL, compared to 0.16 ± 0.61 g/dL in the control group (Group B). This difference was statistically significant ($p = 0.0002$), suggesting that the dietary inclusion of beef liver had a beneficial effect on Hb levels.

Furthermore, a significant reduction in the prevalence of anaemia was observed in the intervention group, with only 10 out of 26 participants (38.5%) remaining anaemic post-intervention ($p < 0.0001$). In contrast, the control group exhibited a slight increase in anaemia prevalence, with 50% of participants remaining anaemic at the end of the study, though this change was not statistically significant ($p = 0.18$).

The absolute risk reduction (ARR) for anaemia in the intervention group was 11.5%, with a Number Needed to Treat (NNT) of nine, indicating that for every nine children treated with the beef liver intervention, one case of anaemia would be prevented.

These findings suggest that dietary interventions, specifically with iron-rich foods such as beef liver, can be an effective strategy for improving iron status and reducing anaemia in preschool-aged children.

The findings of this study are consistent with several previous studies that have highlighted the effectiveness of dietary interventions in improving iron status and reducing anaemia in children. A study by Moshe et al. (2017) [16] revealed that children who seldom consumed red meat had a fourfold higher risk of iron deficiency compared to those who consumed red meat at least twice a week (OR: 3.98; 95% CI: 1.21–13.03; P = 0.023). The study concluded that low red meat intake is linked to higher rates of anaemia and iron deficiency in young children, supporting the notion that dietary iron can be an effective alternative to supplementation in certain populations. Similarly, a meta- analysis of six studies encompassing a total of 676 children with IDA found that dietary interventions, particularly those involving iron-rich animal products, are effective in increasing Hb levels among anaemic children [3].

In the pursuit of alternatives to reduce the prevalence of anaemia, our study also aligns with existing research indicating that iron supplementation can have beneficial effects in lowering anaemia rates. A systematic review and meta-analysis of 129 randomised trials by Andersen et al. (2023) confirmed that iron supplementation has been widely effective in treating anaemia in children across various age groups and settings [17]. However, our findings suggest that dietary interventions with whole foods, like beef liver, may provide a more sustainable, side-effect-free alternative to iron supplements, which are commonly associated with gastrointestinal issues [18].

Furthermore, the observed reduction in anaemia prevalence in the intervention group of our study (from 54.2% to 33.3%) is in line with other studies that have evaluated the impact of iron-rich diets on anaemia outcomes. A study conducted in Brazil by Arcanjo et al. (2012) reported a similar reduction in anaemia prevalence following an intervention with iron-fortified foods, further supporting our conclusion that dietary strategies can be effective in tackling anaemia [19].

Overall, our findings contribute to the growing body of evidence that dietary interventions, particularly those including iron-rich foods like beef liver, are a valuable tool in the prevention and treatment of anaemia in young children.

This study has several limitations that should be acknowledged. First, numerous confounding factors could influence Hb concentrations and anaemia prevalence, with the most common being illness, inconsistent eating habits, and periods of rapid growth. Second, infants from one of the day-care centres, located on the outskirts of the municipality, had lower mean Hb concentrations. However, in keeping with the cluster randomisation design, this day-care centre was not excluded from the trial. To account for this difference, researchers focused not only on the mean Hb concentrations before and after the intervention but also on the mean change in Hb levels. Finally, another important limitation is that this study relied solely on Hb concentrations to measure outcomes, without considering serum ferritin levels or soluble transferrin receptors, which are better indicators of iron stores in the body.

Despite these limitations, the study provides valuable insights into the potential of food-based interventions for tackling anaemia. The significant improvements in Hb levels in the intervention group and the reduction in anaemia prevalence underscore the importance of integrating iron-rich foods, like beef liver, into the diet of young children. This approach could serve as a sustainable and cost-effective alternative to iron supplementation, particularly in settings where access to supplements is limited or where their use is associated with adverse side effects. It is worth noting that our intervention had a weekly cost of only 14 US dollars to provide meals for 50 children.

In conclusion, incorporating iron-rich foods into children's diets can be a highly effective, sustainable, and cost-efficient approach to reducing anaemia, especially in resource-limited settings. Healthcare providers should consider advocating for dietary interventions that include iron-rich foods like beef liver as part of efforts to prevent and treat anaemia in young children. Public health programmes in schools and day-care centres could integrate such interventions to reduce the burden of anaemia in the population. Future research should also investigate the impact of other locally available iron-rich foods and evaluate the feasibility of implementing such interventions on a broader scale. Moreover, studies should assess the cost-effectiveness of food-based strategies compared to traditional iron supplementation.

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