Natural Resources for Human Health

eISSN: 2583-1194

Original Research

Received 09 May 2026
Revised 20 June 2026
Accepted 01 July 2026

Natural Resources for Human Health 2026, Vol. 6 (11s): 521–530

KEYWORDS:
Autism spectrum disorder, Ketogenic diet, GARS-3, Randomized controlled trial.

Ketogenic Diet for Core Symptoms in Children with Autism Spectrum Disorder: A Randomized Controlled Trial

Christine G. Salama[1], Dalia S. Mosallam[1], Aya S. Aly Hassan[1]*, Yasmin F. Elnawawy[2], Marwa A. Ibrahim[1]

[1] Pediatric Clinical Nutrition Unit, Department of Pediatrics, Faculty of Medicine, Cairo University, Cairo, Egypt.
[2] Department of Psychiatry, Faculty of Medicine, Cairo University, Cairo, Egypt. Email: yelnawawy@kasralainy.edu.eg
*Corresponding author: Aya S. Aly Hassan, Pediatric Clinical Nutrition Unit, Department of Pediatrics, Faculty of Medicine, Cairo University, Cairo, Egypt
Emails: aya.s.aly@icloud.com; daliamosalam@hotmail.com; Christine.georges@hotmail.fr; marwaali19841984@gmail.com

ABSTRACT:

Background: Evidence for ketogenic dietary therapy in autism spectrum disorder (ASD) remains limited, particularly from randomized pediatric trials.

Objective: To evaluate the efficacy and short-term safety of a ketogenic diet (KD) for improving core ASD symptoms in children.

Methods: In this single-center randomized controlled trial, 34 children aged 3–10 years with ASD were randomized 1:1 to a KD or individualized balanced diet for 3 months. The KD was gradually titrated from a 1:1 to a 3:1 fat-to-(carbohydrate + protein) ratio. The primary outcome was change in the Gilliam Autism Rating Scale, Third Edition (GARS-3), assessed by a blinded psychologist. Anthropometry, ketosis, and adverse events were also monitored.

Results: GARS-3 scores decreased from 100.76±11.49 to 89.12±11.54 with KD, compared with an increase from 100.35±16.47 to 102.88±13.70 in controls. Percentage change was −11.44±7.10% versus +3.41±9.51% ($P<0.001$). Severity-category improvement occurred in 41.2% versus 5.9% ($P=0.039$). Weight decreased by 2.90% versus increased by 1.51% ($P<0.001$). No significant difference in height change was observed. All KD participants achieved urinary ketosis, with no clinically significant adverse events.

Conclusion: A supervised 3-month KD improved ASD symptom severity and was well tolerated. Larger, longer-term trials are warranted.

Trial registration: Retrospectively registered with Open Science Framework (OSF): https://osf.io/6qhu9/; DOI: 10.17605/OSF.IO/6QHU9.

INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by deficits in social communication and interaction and restricted and repetitive patterns of behavior or interests [1]. Its presentation is heterogeneous and may include language impairment, intellectual disability, feeding difficulties, sleep disturbance, and gastrointestinal symptoms. ASD represents a health burden: the Global Burden of Disease Study 2021 estimated that 61.8 million people, 1 in 127 worldwide,

were autistic in 2021 and ranked ASD among the ten leading causes of non-fatal health burden in people younger than 20 years [2]. In the United States, ASD was identified in 1 in 31 eight-year-old children across 16 ADDM Network sites in 2022 [3]. In Egypt, ASD was identified in approximately 1 in 92 children aged 1–12 years, with a nationwide population-based study reporting a prevalence of 1.1% (455 of 41,640 children) [4]. Its etiology is multifactorial, involving genetic and environmental influences, with mitochondrial dysfunction, oxidative stress, immune dysregulation and gut–brain axis disturbances under investigation.

Management centers on behavioral, developmental and educational interventions. Although medications may be used for associated symptoms, evidence for pharmacological treatment of core ASD symptoms remains limited [5]. This therapeutic gap has encouraged investigation of nutritional approaches. The ketogenic diet (KD) is a high-fat, adequate-protein, and very-low-carbohydrate intervention that induces ketosis and shifts metabolism toward ketone body utilization. Originally established for drug-resistant epilepsy, KD may influence mitochondrial function, neurotransmission, oxidative stress, inflammatory signaling and the gut microbiome [6].

A systematic review and meta-analysis of seven randomized controlled trials reported a beneficial effect of dietary therapies on core ASD symptoms; the KD subgroup, based on only two studies, showed a significant effect [7]. However, evidence was limited by small sample sizes, heterogeneous protocols, and variable outcome measures. Safety evidence from pediatric epilepsy supports monitoring gastrointestinal, metabolic, weight, and growth-related adverse effects [8]. Thus, the efficacy and safety of KD in children with ASD remain insufficiently established. This study aimed to evaluate the effect of a 3-month KD, compared with a normal balanced diet, on ASD children.

PATIENTS AND METHODS

Study design and setting

This was a prospective, single-center, two-arm, parallel-group randomized controlled clinical trial conducted at Cairo University Specialized Pediatric Hospital (CUSPH), Cairo, Egypt, between January 2024 and June 2025. Children were recruited from the nutrition, child psychiatry, and general pediatric outpatient clinics of CUSPH and were followed for 3 months after allocation. Participants were assigned in a 1:1 ratio to either a KD intervention or a normal balanced diet control. The present trial report was prepared in accordance with the CONSORT 2025 recommendations for randomized controlled trials, with intervention reporting informed by the Template for Intervention Description and Replication (TIDieR) checklist [9, 10]. This trial was retrospectively registered with the Open Science Framework (OSF). The registration is publicly available at https://osf.io/6qhu9/ and has been assigned the DOI 10.17605/OSF.IO/6QHU9.

Participants and eligibility criteria

Children aged 3–10 years of either sex were eligible if they had a clinical diagnosis of ASD established by a child psychiatrist according to DSM-5/DSM-5-TR criteria [11], with the diagnosis additionally assessed using the Childhood Autism Rating Scale (CARS). CARS-1 is a 15-item clinician-rated observational scale assessing social, emotional, adaptive, communicative, and cognitive features associated with ASD, with each item rated from 1 to 4 and a total score ranging from 15 to 60. In the present study, CARS-1 was administered once at baseline by an experienced pediatric psychologist using an Arabic-language version [12, 13].

Children were excluded if they had diabetes mellitus, hypertension, renal or cardiac disease, phenylketonuria or other metabolic disorders; hyperlipidemia, recurrent hypoglycemia, renal calculi, gastro-esophageal reflux or poor oral intake; chronic metabolic acidosis; pancreatitis, hepatic failure, disorders of fat metabolism; comorbid attention-deficit/hyperactivity disorder; or undernutrition, defined as a BMI-for-age z-score <-2 SD according to WHO growth references [14].

Sample Size Calculation

The sample size was determined *a priori* using MedCalc Statistical Software version 20.215 (MedCalc Software Ltd, Ostend, Belgium). Based on data from El-Rashidy *et al.* (2017) [15], the calculation assumed a clinically relevant between-group difference of 5 points in CARS score, standard deviations of 4.2 and 5.2 in the ketogenic and control groups, respectively, a two-sided α of 0.05, 80% power, and a 1:1 allocation ratio. After allowing for an anticipated 10% attrition rate, the required sample was 34 children (17 per group).

Randomization and allocation concealment

Following baseline assessments, the 34 participants were randomized in a 1:1 ratio to the KD (n=17) or balanced-diet control group (n=17). The allocation sequence was generated using the web-based Research Randomizer, Version 4.0 (Urbaniak and Plous, Social Psychology Network, USA). The official software documentation identifies Version 4.0 as the citable version and describes its use for random assignment in experimental and clinical research.

Blinding

Because the two dietary interventions were readily distinguishable, blinding of participants, caregivers, and clinical nutritionists was not feasible. To minimize ascertainment bias, the GARS-3 was administered at baseline and after 3 months by an experienced psychologist who was blinded to treatment allocation.

KD intervention

Children allocated to the KD group received an individualized KD program for 3 months under the supervision of an experienced clinical nutritionist. Energy intake was individualized according to age- and sex-specific requirements. Before initiation, caregivers received detailed counseling regarding the dietary composition, food selection and preparation, expected benefits, potential adverse effects, and their management. The ketogenic ratio was defined as grams of fat relative to the combined grams of carbohydrate and protein. The diet was introduced gradually, starting at a 1:1 ratio and titrated through 2:1 to a maximum ratio of 3:1, according to individual tolerance and achievement of ketosis. Carbohydrate intake was progressively reduced while dietary fat was increased to facilitate metabolic adaptation and minimize the risk of hypoglycemia. In addition to the prescribed meals, each child received 200 mL/day of a medical-purpose ketogenic milk formula containing predominantly fat and protein. Ketosis was confirmed by urinary acetone testing. Participants attended weekly nutrition clinic visits during the intervention to assess random blood glucose, urinary ketones, dietary adherence, and potential adverse effects. Dietary prescriptions were adjusted according to clinical tolerance and maintenance of ketosis. This individualized, gradually titrated and closely monitored approach is consistent with established pediatric ketogenic-diet practice and with published ketogenic interventions in children with ASD [16, 17].

Balanced diet control intervention

Children allocated to the control group received an individualized, balanced, normal diet for 3 months under the supervision of an experienced clinical nutritionist. Energy intake was tailored to age- and sex-appropriate requirements, with counseling emphasizing nutritionally balanced meals, adequate vitamin and mineral intake, limiting fast foods, and avoiding both underfeeding and overfeeding.

Primary outcome

The primary efficacy outcome was the change in core ASD symptom severity from baseline to 3 months, assessed using the Gilliam Autism Rating Scale, Third Edition (GARS-3) [18]. GARS-3 is a standardized instrument for individuals aged 3–22 years comprising 56 items across six domains: Restricted/Repetitive Behaviors, Social Interaction, Social Communication, Emotional Responses, Cognitive Style, and Maladaptive Speech. It generates an Autism Index, percentile rank, probability of ASD, and DSM-5 severity level and has demonstrated high internal consistency, test–retest reliability, and inter-rater reliability.

An Arabic-language version of GARS-3 was used. Arabic adaptation of GARS-3 has demonstrated strong psychometric performance, including excellent internal consistency (Cronbach's α=0.971; McDonald's ω=0.972) and satisfactory construct validity [19]. Autism Index scores were interpreted according to the standard GARS-3 severity framework: 55–70, Level 1 (mild/minimal support); 71–100, Level 2 (moderate/substantial support); and ≥101, Level 3 (severe/very substantial support) [20]. GARS-3 was administered at baseline and after 3 months by an experienced psychologist blinded to treatment allocation. The primary treatment effect was evaluated by comparing the change in GARS-3 score between the two randomized groups.

Secondary and exploratory outcomes

Secondary outcomes comprised anthropometric changes and biochemical and clinical safety outcomes. Anthropometric assessment included body weight, height/length, BMI, and head circumference. Weight and height were evaluated at baseline and after 3 months to assess changes during dietary intervention. Anthropometric measurements were interpreted using age-appropriate WHO growth references: the WHO 2006 Child Growth Standards for children younger than 5 years and the WHO

2007 Growth Reference for children aged 5 years and older. Baseline IQ was recorded as an exploratory cognitive characteristic and used to describe the cognitive profile of the randomized groups.

Laboratory and safety assessments

Before initiation of the KD, participants in the intervention group underwent pelvic and abdominal ultrasonography to exclude renal calculi or urinary tract abnormalities. During weekly follow-up, random blood glucose and urinary acetone were monitored, and caregivers were actively questioned regarding adverse effects. Safety surveillance included hypoglycemia, renal calculi, hypotension, and other clinically significant adverse events [17].

Statistical analysis

Data were coded and analyzed using SPSS version 21. Qualitative variables were summarized as numbers and percentages; quantitative variables as mean, standard deviation, median, and interquartile range. Independent-group comparisons used the independent-samples t-test (normally distributed data), the Mann–Whitney U test (non-normally distributed data), and the chi-square or Fisher's exact test (categorical data). Paired pre–post comparisons used the paired-samples t-test or the marginal homogeneity test as appropriate. A two-tailed P value ≤0.05 was considered statistically significant.

RESULTS

Thirty-four children with ASD were randomized equally to the KD and control groups (17 each). Mean age was 5.91±2.04 and 6.87±2.43 years, respectively. Overall, 76.4% were male. Baseline IQ, CARS, and GARS-3 scores were broadly comparable between groups. Most children had normal weight-for-age and BMI, with only two overweight children in the control group **(Table 1)**.

Over 3 months, weight decreased by 2.90±2.15% in the KD group but increased by 1.51±3.54% in the control group, with a significant between-group difference (P<0.001). Height increased slightly and similarly in both groups, with no significant difference (P=0.437). All children were of normal height for age **(Table 2)**.

After 3 months, GARS-3 ASD severity improved significantly in the KD group, with severe cases decreasing from 52.9% to 17.6% and moderate cases increasing from 41.2% to 76.5% (P=0.034). No change occurred in controls (P=1.000), and the between-group difference at 3 months was significant (P=0.016) **(Table 3)**.

After 3 months, mean GARS-3 scores decreased significantly in the KD group (100.76±11.49 to 89.12±11.54; P<0.001) but showed no significant change in controls (P=0.230). Between-group differences were significant for both final scores (P=0.003) and percentage change (P<0.001). Clinical improvement occurred in 41.2% of the KD group versus 5.9% of controls (P=0.039) **(Table 4)**.

All children in the KD group achieved ketosis. No hypoglycemia, renal stones, hypotension, or other adverse effects were reported during the 3-month intervention, with weekly monitoring of glucose, urinary acetone, dietary adherence, and safety.

DISCUSSION

The principal finding of this randomized controlled trial was that a supervised 3-month KD produced greater improvement in ASD symptom severity than a normal balanced diet. Mean GARS-3 score decreased from 100.76 to 89.12 in the KD group (−11.44%), whereas controls showed a small increase from 100.35 to 102.88 (+3.41%); 41.2% of children receiving KD improved by at least one GARS-3 severity category compared with 5.9% of controls. Severe-category prevalence fell from 52.9% to 17.6% with KD but remained 58.8% in controls. The intervention was also associated with a modest 2.9% mean weight reduction, while height gain was comparable between groups. All KD participants achieved urinary ketosis, with no reported hypoglycemia, renal stones, hypotension, or other adverse effects. These findings support the study's hypothesis and emphasize the need for anthropometric monitoring.

Our findings are broadly concordant with the small but increasingly consistent clinical literature. Evangeliou *et al.* (2003) reported improvement on CARS in 18 of 30 children exposed to a 6-month ketogenic regimen, although tolerability and attrition were important limitations [21]. El-Rashidy *et al.* (2017), studying 45 Egyptian children, found that a modified Atkins KD improved CARS and ATEC outcomes compared with balanced nutrition and produced greater improvement in cognition and sociability than a gluten-free/casein-free diet [15]. Lee *et al.* (2018) subsequently demonstrated improvements in ADOS-2 total and social-affect scores and selected CARS-2 domains after a 3-month modified ketogenic gluten-free/MCT diet, with

improvement persisting among participants reassessed at 6 months [16]. Mu *et al.* (2020), using a related intervention cohort, associated behavioural response with increased circulating ketones and acetyl-carnitine and normalization of selenium concentrations [22]. Earlier case reports by Herbert and Buckley (2013) and Żarnowska *et al.* (2018) also described behavioural improvement during carbohydrate-restricted or ketogenic interventions, although such observations provide low-level supportive evidence [23].

Evidence syntheses support cautious optimism rather than definitive efficacy. Castro *et al.* (2015) found that early human studies generally reported behavioural improvement but concluded that the evidence was insufficient for routine clinical application [24]. Varesio *et al.* (2021) subsequently identified only seven relevant studies and highlighted substantial heterogeneity in study design, dietary formulation and adherence [25]. More importantly, Yu *et al.* (2022) pooled seven randomized dietary trials involving 338 children and found a significant effect on core ASD symptoms; the KD subgroup showed an SMD of −0.67 (95% CI −1.04 to −0.31), although only two KD studies contributed to this estimate [7]. Recent reviews by Öztürk *et al.* (2024), similarly describe encouraging behavioral signals but emphasize small samples, heterogeneous ketogenic protocols, variable adherence and limited long-term evidence [26]. A recent study of 62 children reported greater improvements in CARS and Autism Behavior Checklist scores with modified KD plus rehabilitation than with normal diet plus rehabilitation; however, the currently accessible report is a preprint, so its findings should be interpreted with caution [27].

Not all outcomes across studies have been uniform. Lee *et al.* (2018) found no significant improvement in restricted/repetitive behavior despite improvement in overall ADOS-2 and social-affect scores [16]. This does not necessarily contradict the present findings because GARS-3 and ADOS-2 assess overlapping but non-identical constructs, and the studies differed in age, baseline severity, dietary formulation, MCT exposure, duration, adherence, and design. Thus, the current reduction in global GARS-3 severity should not be interpreted as evidence that all ASD symptom domains respond equally to KD. The heterogeneity of responses has also been emphasized by Li et al. (2021) and in contemporary reviews [28].

Several mechanisms may plausibly contribute to behavioral improvement. Ketosis modifies cerebral substrate utilization and mitochondrial energetics and may influence GABAergic–glutamatergic balance, oxidative stress, inflammatory signaling, mTOR pathways, and gut microbial metabolism [26, 28]. Human mechanistic data provides preliminary support. Mu *et al.* (2020) demonstrated metabolomic changes associated with behavioral response, including differences in β-hydroxybutyrate and selenium, while Allan *et al.* (2024) reported reductions in IL-12p70 and IL-1β, altered gut microbial pathways, increased butyrate-kinase expression, and changes in BDNF-associated microRNAs after modified KD [22]. These findings provide biological plausibility but do not establish causality, particularly because the cohorts were small and these mechanisms were not measured in the present trial.

Clinically, KD should therefore be considered a potential adjunctive intervention, rather than a replacement for established developmental, behavioral or educational care. The observed 2.9% weight reduction is particularly relevant in growing children. Safety evidence is substantially stronger in pediatric epilepsy: Cai *et al.* (2017), reviewing 45 prospective studies, identified gastrointestinal disturbances and hyperlipidemia as common adverse effects and recommended monitoring for growth disturbance and renal stones [29]. An overview of 24 systematic reviews by Ruan *et al.* (2022) similarly identified gastrointestinal effects, weight loss, and metabolic disorders as recurring concerns [8]. Furthermore, Lu *et al.* (2023) found reduced height z-scores during longer-term ketogenic therapy, particularly in younger children and those receiving classical KD [30]. Accordingly, the preserved linear growth and absence of reported adverse effects in our 3-month trial are reassuring for short-term tolerability only, and structured medical and nutritional supervision remains essential, consistent with International KD Study Group recommendations [17].

Strengths of the present study include randomized allocation, an active balanced-diet comparator, blinded GARS-3 assessment, objective confirmation of ketosis, gradual ketogenic-ratio titration and close nutritional monitoring. Baseline cognitive distribution was also comparable between groups. Limitations include the small sample of 34 children, single-center setting, 3-month follow-up, inability to blind families and dietitians, absence of detailed longitudinal laboratory results among the reported outcomes, and lack of mechanistic biomarkers. The study also cannot establish persistence of benefit after KD discontinuation or identify which ASD phenotypes are most likely to respond. The thesis itself recognizes the need for larger samples, longer follow-up and broader study settings. These limitations reduce precision and generalizability but do not eliminate the randomized between-group signal.

CONCLUSION

A supervised 3-month KD improved GARS-3 symptom severity compared with a balanced diet, while preserving linear growth despite modest weight loss. These findings support KD as a potential adjunctive therapy for selected children with ASD, although larger, longer-term trials are needed to confirm efficacy, safety, mechanisms, and predictors of response.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional Research Ethics Committee (approval code: MD-203-2024). Written informed consent was obtained from the legal caregiver of each participating child before enrolment.

Consent for publication

Not applicable.

Availability of data and materials

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

Competing interests

None.

Funding

None.

Authors' contributions

All authors contributed to the study conception and design, data acquisition and interpretation, and preparation and critical revision of the manuscript. All authors read and approved the final manuscript.

Acknowledgements

None.

Generative AI Declaration

During the preparation of this manuscript, the authors used ChatGPT (GPT-5.6) solely for language editing and improvement of clarity and readability.

REFERENCES

[1] American Psychological, A., *Diagnostic and statistical manual of mental disorders: DSM-5*. 2013: American Psychiatric Association.

[2] Collaborators, G.B.o.D.S.A.S., *The global epidemiology and health burden of the autism spectrum: findings from the Global Burden of Disease Study 2021*. Lancet Psychiatry, 2025. **12**(2): p. 111-121.

[3] Shaw, K.A., *Prevalence and early identification of autism spectrum disorder among children aged 4 and 8 years—Autism and Developmental Disabilities Monitoring Network, 16 Sites, United States, 2022*. MMWR. Surveillance Summaries, 2025. **74**.

[4] Metwally, A.M., et al., *Mapping autism in Egypt: population-based insights into prevalence, risk determinants, and severity among children aged 1–12 years*. Molecular Autism, 2025. **16**(1): p. 32.

[5] Siafis, S., et al., *Pharmacological and dietary-supplement treatments for autism spectrum disorder: a systematic review and network meta-analysis*. Mol Autism, 2022. **13**(1): p. 10.

[6] Zhu, H., et al., *Ketogenic diet for human diseases: the underlying mechanisms and potential for clinical implementations*. Signal Transduct Target Ther, 2022. **7**(1): p. 11.

[7] Yu, Y., et al., *Efficacy and Safety of Diet Therapies in Children With Autism Spectrum Disorder: A Systematic Literature Review and Meta-Analysis.* Front Neurol, 2022. **13**: p. 844117.

[8] Ruan, Y., et al., *Ketogenic diet for epilepsy: an overview of systematic review and meta-analysis.* Eur J Clin Nutr, 2022. **76**(9): p. 1234-1244.

[9] Hopewell, S., et al., *CONSORT 2025 statement: updated guideline for reporting randomised trials.* The Lancet, 2025. **405**(10489): p. 1633-1640.

[10] Hoffmann, T.C., et al., *Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide.* Bmj, 2014. **348**.

[11] First, M.B., et al., *DSM-5-TR: overview of what's new and what's changed.* World Psychiatry, 2022. **21**(2): p. 218-219.

[12] Moon, S.J., et al., *Accuracy of the Childhood Autism Rating Scale: a systematic review and meta-analysis.* Dev Med Child Neurol, 2019. **61**(9): p. 1030-1038.

[13] El-Defrawi, M.H., A. Atef, and M. Arafa, *Infantile autism in Egyptian children. Assessment and clinical correlates.* Egypt J Psychiatry, 1998. **21**: p. 58-93.

[14] World Health, O., *Levels and trends in child malnutrition child malnutrition: UNICEF/WHO/World Bank Group Joint Child Malnutrition Estimates: Key findings of the 2023 edition*. 2023: World Health Organization.

[15] El-Rashidy, O., et al., *Ketogenic diet versus gluten free casein free diet in autistic children: a case-control study.* Metab Brain Dis, 2017. **32**(6): p. 1935-1941.

[16] Lee, R.W.Y., et al., *A modified ketogenic gluten-free diet with MCT improves behavior in children with autism spectrum disorder.* Physiol Behav, 2018. **188**: p. 205-211.

[17] Kossoff, E.H., et al., *Optimal clinical management of children receiving dietary therapies for epilepsy: Updated recommendations of the International Ketogenic Diet Study Group.* Epilepsia Open, 2018. **3**(2): p. 175-192.

[18] Minaei, A. and S. Nazeri, *Psychometric properties of the Gilliam Autism Rating Scale–Third Edition (GARS-3) in individuals with autism: A pilot study.* Journal of exceptional children, 2018. **18**(2): p. 113-122.

[19] Alasmari, M., et al., *Predicting language, cognition, and social skills in individuals with Autism spectrum disorder using the Arabic validation of Gilliam Autism Rating scale-Third Edition.* Appl Neuropsychol Child, 2024: p. 1-14.

[20] Kong, X., et al., *Early Screening and Risk Factors of Autism Spectrum Disorder in a Large Cohort of Chinese Patients With Prader-Willi Syndrome.* 2020. **Volume 11 - 2020**.

[21] Evangeliou, A., et al., *Application of a ketogenic diet in children with autistic behavior: pilot study.* J Child Neurol, 2003. **18**(2): p. 113-8.

[22] Mu, C., et al., *Metabolic Framework for the Improvement of Autism Spectrum Disorders by a Modified Ketogenic Diet: A Pilot Study.* J Proteome Res, 2020. **19**(1): p. 382-390.

[23] Herbert, M.R. and J.A. Buckley, *Autism and dietary therapy: case report and review of the literature.* J Child Neurol, 2013. **28**(8): p. 975-82.

[24] Castro, K., et al., *Effect of a ketogenic diet on autism spectrum disorder: A systematic review.* Research in Autism Spectrum Disorders, 2015. **20**: p. 31-38.

[25] Varesio, C., et al., *Ketogenic Dietary Therapies in Patients with Autism Spectrum Disorder: Facts or Fads? A Scoping Review and a Proposal for a Shared Protocol.* Nutrients, 2021. **13**(6).

[26] Öztürk, E., et al., *Ketogenic diet as a therapeutic approach in autism spectrum disorder: a narrative review.* Metab Brain Dis, 2024. **40**(1): p. 67.

[27] Liu, L., et al., *Therapeutic Efficacy of a Modified Ketogenic Diet in Autism Spectrum Disorder: A Randomized Controlled Trial.* 2025.

[28] Li, Q., et al., *A Ketogenic Diet and the Treatment of Autism Spectrum Disorder.* Front Pediatr, 2021. **9**: p. 650624.

[29] Cai, Q.Y., et al., *Safety and tolerability of the ketogenic diet used for the treatment of refractory childhood epilepsy: a systematic review of published prospective studies.* World J Pediatr, 2017. **13**(6): p. 528-536.

[30] Lu, S., et al., *Impact of ketogenic diet therapy on growth in children with epilepsy.* Epilepsy Res, 2023. **190**: p. 107076.

List of Legends

Figure 1. CONSORT Flow Diagram

Table 1. Baseline Characteristics of Children According to Dietary Intervention Group

Table 2. Changes in Weight and Height During the 3-Month Dietary Intervention

Table 3. GARS-3 Severity Categories at Baseline and After 3 Months

Table 4. GARS-3 Scores and Symptom Trajectory During the 3-Month Intervention

Table 1: Baseline characteristics of children according to dietary intervention group

Characteristic	Ketogenic diet group (n=17)	Control diet group (n=17)
Age, years	5.91 ± 2.04	6.87 ± 2.43
Weight, kg	21.26 ± 6.65	27.57 ± 13.15
Height, cm	111.47 ± 12.43	120.12 ± 17.60
Normal weight-for-age, n (%)	17 (100.0)	15 (88.2)
Overweight by weight category, n (%)	0 (0.0)	2 (11.8)
Underweight, n (%)	0 (0.0)	0 (0.0)
Normal BMI category, n (%)	12 (70.6)	13 (76.5)
Overweight BMI category, n (%)	5 (29.4)	4 (23.5)
IQ, score	56.35 ± 7.83	57.76 ± 12.81
Mild intellectual disability, n (%)	13 (76.5)	13 (76.5)
Moderate intellectual disability, n (%)	4 (23.5)	4 (23.5)
CARS score	37.71 ± 8.72	42.47 ± 10.48
GARS-3 score	100.76 ± 11.49	100.35 ± 16.47

Data are presented as mean ± standard deviation or number (%). ASD, autism spectrum disorder; BMI, body mass index; CARS, Childhood Autism Rating Scale; GARS-3, Gilliam Autism Rating Scale, Third Edition; IQ, intelligence quotient; SD, standard deviation.

Table 2: Changes in weight and height during the 3-month dietary intervention

Anthropometric outcome	Ketogenic diet group (n=17)	Control diet group (n=17)	*P* value†
Weight at baseline, kg	21.26 ± 6.65	27.57 ± 13.15	—
Weight at 3 months, kg	20.65 ± 6.48	27.68 ± 12.53	—
Weight change, %	−2.90 ± 2.15	+1.51 ± 3.54	**<0.001**
Height at baseline, cm	111.47 ± 12.43	120.12 ± 17.60	—
Height at 3 months, cm	112.47 ± 12.28	121.24 ± 17.53	—
Height change, %	+0.92 ± 0.39	+0.96 ± 0.36	0.437

Natural Resources for Human Health
eISSN: 2583-1194

Data are presented as mean ± SD. Percentage change was calculated relative to baseline. †P values shown are the between-group comparisons of percentage change. The corresponding reported Z statistics were −3.652 for weight percentage change and −0.777 for height percentage change. SD, standard deviation.

Table 3: GARS-3 severity categories at baseline and after 3 months

GARS-3 category	KD baseline, n (%)	KD at 3 months, n (%)	Control baseline, n (%)	Control at 3 months, n (%)
Mild	1 (5.9)	1 (5.9)	2 (11.8)	2 (11.8)
Moderate	7 (41.2)	13 (76.5)	5 (29.4)	5 (29.4)
Severe	9 (52.9)	3 (17.6)	10 (58.8)	10 (58.8)

Statistical comparison	KD group	Control group
Within-group baseline-to-3-month change, *P* value	**0.034**	1.000

Between-group comparison at 3 months: Fisher's exact test=7.590; **P=0.016**.

Values are numbers (%). GARS-3, Gilliam Autism Rating Scale, Third Edition; KD, ketogenic diet.

Table 4: GARS-3 scores and symptom trajectory during the 3-month intervention

Outcome	Ketogenic diet group (n=17)	Control diet group (n=17)	Between-group P value
GARS-3 at baseline	100.76 ± 11.49	100.35 ± 16.47	—
GARS-3 at 3 months	89.12 ± 11.54	102.88 ± 13.70	**0.003**
GARS-3 percentage change	−11.44 ± 7.10	+3.41 ± 9.51	**<0.001**
Mean baseline-to-3-month difference	11.65 ± 7.47	−2.53 ± 8.36	—
95% CI for paired difference	7.80 to 15.49	−6.83 to 1.77	—
Within-group P value	**<0.001**	0.230	—
Improved, n (%)	7 (41.2)	1 (5.9)	
Unchanged, n (%)	9 (52.9)	15 (88.2)	**0.039†**
Worsened, n (%)	1 (5.9)	1 (5.9)	

Data are mean ± SD or number (%). The baseline-to-3-month difference was calculated as the post-intervention GARS-3 minus the baseline GARS-3; therefore, a positive value represents a reduction in the GARS-3 score. †P=0.039 represents the overall Fisher's exact test comparing the three symptom-trajectory categories between groups, rather than an individual category. The reported test statistic was 6.101. The between-group GARS-3 percentage-change comparison had Z = -4.152 and P < 0.001. CI, confidence interval; GARS-3, Gilliam Autism Rating Scale, Third Edition; SD, standard deviation.

Natural Resources for Human Health
eISSN: 2583-1194

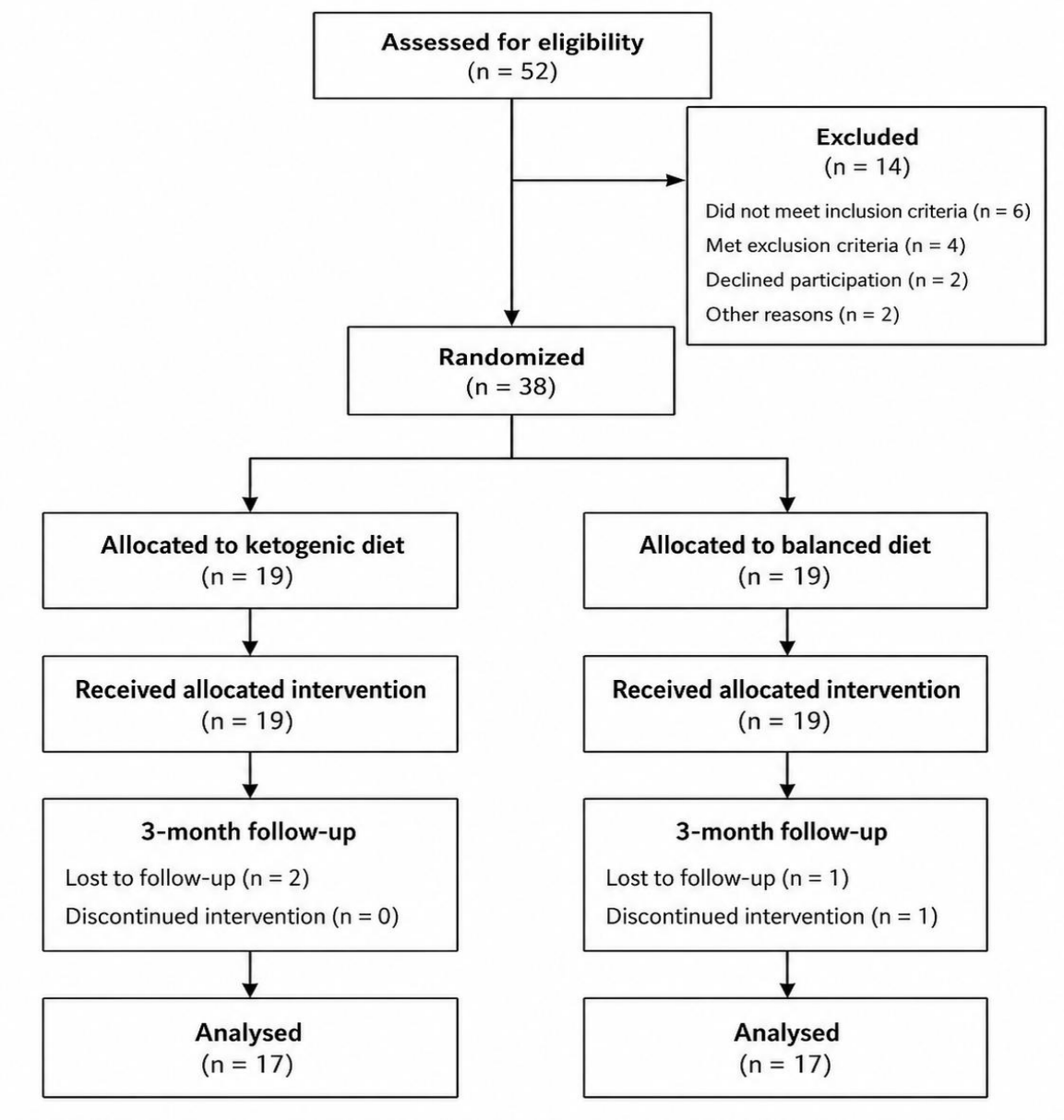

Figure 1: CONSORT flowchart.