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COMPARISON OF THE EFFICACY, SAFETY AND COMPLIANCE OF KETOGENIC DIET WITH MODIFIED ATKINS DIET AND LOW GLYCEMIC INDEX TREATMENT IN CHILDREN WITH DRUG-RESISTANT EPILEPSY

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ABSTRACT

Metabolic dietary therapies serve as a multidimensional intervention for the estimated 30% of pediatric patients with epilepsy who remain refractory to standard antiseizure medications. This review evaluates the clinical utility of the classical ketogenic diet (cKD), modified Atkins diet (MAD), and low glycemic index treatment (LGIT), each utilizing a metabolic shift toward ketogenesis to modulate neuronal excitability and neuroinflammation. While the cKD remains the gold standard for achieving high-level seizure reduction and complete seizure freedom, MAD and LGIT provide robust efficacy for achieving ≥50% responder status with significantly improved palatability. LGIT is associated with the most favorable safety profile and highest patient compliance, particularly among adolescents, due to its less restrictive carbohydrate limits and lower incidence of serious gastrointestinal or metabolic adverse events. Recent advancements in precision medicine highlight the critical roles of genetic etiology, such as variants in SLC2A1 or SCN1A, and gut microbiome composition in predicting individual response to these therapies. With a favorable long-term safety profile when appropriately monitored, these metabolic protocols offer a vital non-pharmacological cornerstone for improving the quality of life for children and their caregivers. Further work is necessary to integrate digital health monitoring and personalized microbiome-targeted strategies to optimize dietary maintenance and therapeutic outcomes.

KEYWORDS

Pediatric Drug-Resistant Epilepsy, Ketogenic Diet, Modified Atkins Diet, Low Glycemic Index Treatment, Metabolic Therapy

CITATION

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1. Introduction

Ketogenic dietary therapies (KDTs) are high-fat, low-carbohydrate metabolic interventions that represent a potential dietary approach for managing pediatric drug-resistant epilepsy. The classical ketogenic diet, modified Atkins diet, and low glycemic index treatment play critical roles in stabilizing neuronal excitability and controlling refractory seizures (Sondhi et al., 2020). KDTs play an essential role in key pathways such as the modulation of neurotransmitter balance, enhancement of mitochondrial bioenergetics, and regulation of neuroinflammation (Liu et al., 2025).

This review examines characteristics of the above therapies and their potential relevance in achieving seizure freedom. It explores the cellular mechanisms of action, effects on seizure frequency reduction, and clinical effectiveness in managing diverse genetic and structural syndromes (Guery & Rheims, 2021). It covers the roles of tolerability and digital health support in improving adherence, positioning metabolic therapy as a well-tolerated solution for both infants and adolescent populations (Sharawat et al., 2025; Xie et al., 2024).

2. Methodology

This review analyzed clinical literature from the past 25 years to assess the comparative efficacy of dietary protocols. The methodology included Database Search: PubMed, Scopus, and the Cochrane Library were searched using keywords such as "ketogenic diet", "modified Atkins diet", "low glycemic index treatment", and "refractory epilepsy"

Inclusion Criteria included randomized controlled trials (RCTs), systematic reviews, and meta-analyses published in English focusing on children and adolescents (≤18 years) with drug-resistant epilepsy.

Exclusion Criteria dismissed studies with weak methodologies, non-English publications, and neonatal management protocols (age <1 month).

3. Results and Discussion

Consolidated evidence from clinical trials and meta-analyses demonstrates that the cKD, MAD, and LGIT are more effective than standard pharmacological care in reducing seizure frequency in children with drug-resistant epilepsy (Sondhi et al., 2020; Devi et al., 2023). However, clinicians must carefully weigh the depth of seizure control required against the patient's and family's ability to maintain strict dietary restrictions (Sondhi et al., 2020; Sharawat et al., 2025).

Clinical Efficacy: Comparative Outcomes

The classical ketogenic diet is considered the most effective dietary therapy for children who need major seizure reduction or complete seizure control. Systematic evaluations indicate that the cKD provides a higher probability of reaching the most stringent control thresholds in seizure reduction, compared to standard care or less restrictive variants (Liu et al., 2025; Devi et al., 2023). This efficacy is particularly evident in infants and young children, who may achieve better outcomes due to higher compliance rates and rapid metabolic adaptation (Kim et al., 2016; Wirrell et al., 2018). While the absolute rates of total seizure freedom remain modest, the cKD offers the best clinical prospect for high-level responder status (Liu et al., 2025).

The modified Atkins diet and low glycemic index treatment have emerged as viable primary alternatives for patients who cannot tolerate the severe restrictions of the classical diet. These protocols demonstrate a robust ability to achieve at least a 50% reduction in seizure frequency, with outcomes that are often comparable to each other in real-world clinical practice (Sharawat et al., 2025; Panda et al., 2024). Although they may be slightly less effective than the cKD in reaching absolute seizure freedom, their enhanced palatability and lower side-effect profiles make them highly effective for the majority of the pediatric population (Sharawat et al., 2025; Sondhi et al., 2020). Recent data also suggest that the efficacy of the LGIT can be maintained over the long term, with some patients who failed the cKD successfully transitioning to and sustaining the LGIT (Sondhi et al., 2020; Sharawat et al., 2025).

Safety and Adverse Events

The safety profile of dietary therapy is a major consideration, as these regimens are associated with various gastrointestinal and metabolic complications (Liu et al., 2025; Sondhi et al., 2020). LGIT is associated with significantly fewer and less severe adverse events than both cKD and MAD (Sondhi et al., 2020; Sharawat et al., 2025). In clinical trials, fewer than one-third of patients on the LGIT reported treatment-related side effects, while more than half of those on the cKD or MAD experienced issues such as vomiting or constipation (Sondhi et al., 2020; Sharawat et al., 2025). Serious metabolic disturbances, including metabolic acidosis and symptomatic hypoglycemia, are primarily linked to the stricter protocols (Guery & Rheims, 2021; Wirrell et al., 2018).

Long-term metabolic concerns for children on stricter diets include dyslipidemia and decreased bone mineral density (osteopenia), often requiring calcium and vitamin D supplementation (Peterson et al., 2025; Sharaf et al., 2025). Growth retardation is a noted risk with the cKD due to limited protein and caloric intake relative to developmental needs (Peterson et al., 2025; Spulber et al., 2025). Conversely, children on the LGIT tend to maintain more stable weight trajectories or even gain weight (Sharawat et al., 2025; Rohani et al., 2025).

Table 1.

Adverse Event	KD Risk/Incidence	MAD Risk/Incidence	LGIT Risk/Incidence
Constipation	37.5% (Liu et al., 2025 [7])	30.97% (Sharawat et al., 2025)	5.5% (Sharawat et al., 2025 [17])
Vomiting	50.9% (Sondhi et al., 2020 [19])	44.8% (Sondhi et al., 2020 [19])	31.6% (Sondhi et al., 2020 [19])
Kidney Stones	RR: 5.24 (Sharawat et al., 2025 [20])	(Reported) (Barañano & Hartman, 2010)	Rare (Sharawat et al., 2025 [17])

Table 1 presents a comparison of the incidence and risk of adverse events among children following the classical ketogenic diet (cKD), modified Atkins diet (MAD), and low glycemic index treatment (LGIT).

Compliance, Tolerability, and Retention

The central challenge in metabolic therapy is the "restrictiveness-compliance" tradeoff. The cKD, while effective, frequently suffers from high attrition rates because of its extreme dietary constraints (Liu et al., 2025; Sondhi et al., 2020). Tolerability is highest with the LGIT, as it permits a wider variety of foods and higher carbohydrate intake (Sondhi et al., 2020; Panda et al., 2024). LGIT is particularly well-tolerated by adolescents (mean initiation age 12.6 years), a population for whom the cKD is often not even considered (Guery & Rheims, 2021; Sharawat et al., 2025).

Compliance is also influenced by the initiation method; traditional hospital-based fasting protocols are increasingly replaced by non-fasting outpatient initiations (Xie et al., 2024; Phoenix Children's Hospital, 2021).

4. Discussion

Precision Medicine and Genetic Etiology

A paradigm shift is occurring in pediatric neurology toward a precision medicine model where genetic testing informs dietary selection (Sjölin et al., 2025; Kim et al., 2018). It is now well-established that the ketogenic diet is the treatment of choice for Glucose Transporter Type 1 (GLUT1) deficiency syndrome, which is caused by pathogenic variants in the SCL2A1 gene (Sjölin et al., 2025; Sharaf et al., 2025). In this condition, the diet provides an alternative fuel source—ketone bodies—that bypasses the defective glucose transport across the blood-brain barrier (Sjölin et al., 2025; Barañano & Hartman, 2010). Similarly, the diet is highly effective for Pyruvate Dehydrogenase Deficiency (PDHD), as it circumvents the underlying metabolic block (Sjölin et al., 2025; Sharaf et al., 2025).

Genetic etiologies significantly influence the overall response to metabolic therapy. Children with variants in SCN1A (associated with Dravet syndrome), SCN2A, KCNQ2, and STXBP1 show significantly higher responder rates compared to those with unknown or structural etiologies (Sjölin et al., 2025; Kim et al., 2018). In a prospective cohort of 226 children, variants in transporter genes, most notably SCL2A1, were associated with the highest likelihood of a positive response (Sjölin et al., 2025). Identifying these genetic markers early allows clinicians to introduce metabolic therapy as a first-line intervention (Sjölin et al., 2025; Kim et al., 2018).

Mechanisms of Action: Beyond Ketosis

The traditional view that ketosis is the sole driver of the diet's efficacy is being challenged. While ketone bodies (β-hydroxybutyrate and acetoacetate) are neuroprotective, seizure reduction does not always correlate linearly with ketone levels (Barañano & Hartman, 2010; Zarnowska, 2020). Instead, the therapeutic effect results from parallel mechanisms. KDTs facilitate neurotransmitter modulation by increasing inhibitory GABA while simultaneously reducing excitatory glutamate and directly inhibiting the vesicular glutamate transporter (VGLUT1) to dampen excitatory signaling (Kim, 2022; Rubio et al., 2025).

Furthermore, the diet regulates ion channels by activating ATP-sensitive potassium and two-pore domain potassium channels, which hyperpolarize the neuronal membrane and increase the seizure threshold (Kim, 2022; Rubio et al., 2025). Metabolic signaling is also impacted as ketone bodies inhibit the mTOR pathway, which is frequently overactive in genetic epilepsies such as Tuberous Sclerosis Complex (Rubio et al., 2025; Liu et al., 2025). Finally, KDTs exhibit anti-inflammatory effects by suppressing the NLRP3 inflammasome and reducing the production of reactive oxygen species (ROS) (Kim, 2022; Rubio et al., 2025).

The Gut-Microbiota-Brain Axis

Recent research suggests that the gut microbiome is essential for the antiseizure effects of dietary therapy (Olson et al., 2018; Xie et al., 2024). The diet alters gut flora composition, specifically enriching bacterial genera such as *Akkermansia muciniphila* and *Parabacteroides merdae* (Olson et al., 2018; El-Sharkawy et al., 2024). In experimental models, the co-colonization of these species was found to regulate hippocampal neurotransmission by altering the GABA:glutamate ratio, thereby increasing the seizure threshold (Olson et al., 2018; El-Sharkawy et al., 2024). Fiber content in different formulations can impact these microbial shifts, as fiber-containing diets promote the biosynthesis of neuroprotective pathways (Liu et al., 2025).

Impact on Caregivers and Digital Health Support

Maintaining a child on metabolic therapy requires significant caregiver commitment (Sjölin et al., 2025; Mendonça et al., 2024). To mitigate parental distress, digital health solutions have been integrated into clinical practice. Innovative platforms, such as the "Our Journey™ with Ketogenic Diet Therapy" application and home monitoring tools from the Barrow Neurological Institute at Phoenix Children's, allow families to log seizures and ketone levels in real-time (Phoenix Children's, 2021; Phoenix Children's Hospital, 2021). These tools facilitate rapid communication with the healthcare team, which has been shown to improve retention and safety during outpatient initiation (Phoenix Children's, 2021).

Sequential and Intermittent Strategies

Novel administration strategies are emerging to address long-term compliance challenges. Sequential therapy, involving a "booster" month on MAD followed by maintenance on LGIT, has shown promising results in maintaining responder status at 12 weeks (Panda et al., 2024; Mulyan et al., 2024). Similarly, intermittent LGIT has been shown to be comparable to daily LGIT after 24 weeks (Panda et al., 2024). This flexibility is particularly valuable for the social quotient and overall quality of life of the child (Panda et al., 2024).

5. Conclusions

The management of pediatric drug-resistant epilepsy has been profoundly transformed by the expansion of metabolic dietary therapies. This review demonstrates that while the classical ketogenic diet (cKD) remains the most potent tool for achieving total seizure freedom, its severe restrictiveness often limits its clinical utility over time (Liu et al., 2025; Sondhi et al., 2020). The development of the modified Atkins diet (MAD) and low glycemic index treatment (LGIT) has addressed this limitation, providing families with more sustainable options that still offer significant seizure reduction (Sharawat et al., 2025; Sharaf et al., 2025).

The comparative analysis leads to several clinical conclusions regarding the optimization of therapy. While the cKD is superior for achieving high-level suppression (≥ 90% reduction) and seizure freedom, MAD and LGIT are comparable for the majority of patients who qualify as "responders" with a ≥ 50% reduction in seizure frequency (Liu et al., 2025; Sondhi et al., 2020). From a safety perspective, LGIT is unequivocally the safest option, presenting the lowest incidence of both gastrointestinal side effects and serious metabolic complications (Sondhi et al., 2020; Sharawat et al., 2025). Compliance is heavily influenced by patient age; LGIT and MAD are the preferred choices for adolescents, whereas the cKD remains the preferred first-line dietary choice for infants and children under the age of two (Guery & Rheims, 2021; Kim et al., 2016). Precision medicine and the identification of pathogenic variants such as SLC2A1 (GLUT1 deficiency) or SCN1A (Dravet syndrome) allow clinicians to predict which patients will respond to specific protocols (Sjölin et al., 2025; Xie et al., 2024). The integration of digital health tools, such as the "Our Journey™ with Ketogenic Diet Therapy" application, can significantly reduce caregiver burden and improve sustainability (Phoenix Children's, 2021). Future strategies prioritizing the quality of life for both the child and caregiver will ensure that metabolic therapy remains a vital field in the treatment of neurological disorders.

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All authors have read and agreed with the published version of the manuscript.

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