



Motion Sickness in Children: A Narrative Review

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Abstract Motion sickness (MS) is a common yet often overlooked condition that impacts children, particularly during travel. This review summarizes current research on the prevalence, mechanisms and effective management strategies for paediatric populations. MS usually presents with gastrointestinal and autonomic symptoms, mainly nausea and vomiting, which are responses to movement. School-aged children are most affected, with 40% to 50% experiencing MS. Infants are less likely to develop it, likely because their vestibular systems are still maturing. Additionally, certain medical conditions and paediatric disorders can raise the risk of MS. Factors also influencing MS include sex differences, genetic factors and environmental and social influences. Management strategies include both pharmacological and non-pharmacological approaches. Non-pharmaceutical options, such as behavioural adjustments and appropriate seating positioning, should be prioritized for children. Pharmacological treatments such as antihistamines and anticholinergics are typically reserved for severe, resistant cases. Nevertheless, there is an urgent need for paediatric-specific research to develop effective and safe treatment protocols and innovative therapies tailored for children. Future studies should also focus on refining diagnostic criteria in children, investigating genetic factors and understanding the complexities of comorbid conditions.

Key Words Motion Sickness, Children, Motion Sickness Susceptibility, Vestibular System

INTRODUCTION

Historically, Greek, Roman and Chinese medical traditions have contributed to our understanding of motion sickness (MS) [1]. They viewed it as a discomfort caused by real or perceived movement, referring to it as *nausée* or seasickness. The condition includes gastrointestinal symptoms, neurological reactions and autonomic effects and is regarded as a normal physiological response that can affect nearly all healthy individuals.

Responses to MS are highly variable. Some are susceptible to minimal triggers, while others may not experience symptoms at all, due to a combination of genetic, physiological, psychological and environmental factors [2]. Children are more susceptible to MS, with research indicating that its prevalence peaks in school-aged children, affecting about 40% to 50%, especially during car or bus trips [3,4].

While MS is commonly observed in children and extensive research has been conducted in adults, our understanding of MS in paediatric populations remains limited. Specifically, gaps exist in knowledge about its prevalence, underlying mechanisms and safe treatment options. To fill these gaps, a focused narrative review of childhood MS is needed to synthesize the current evidence.

Our review aims to achieve the following objectives:

- Describe the epidemiological characteristics and determine the prevalence of MS in children
- Explore the key mechanisms behind MS in children
- List the clinical manifestations experienced by children
- Discuss the current treatment options for managing MS in children

Covering these aspects will improve clinical practice for healthcare providers caring for children with MS.

METHODS

This review examines current research on MS in children and young populations. A thorough literature search was conducted across PubMed, Scopus and Web of Science for studies published through December 2025. Only English-language studies were considered. The literature search employed a strategy that integrated keywords with Medical Subject Headings (MeSH). The keywords included “motion sickness,” “kinetosis,” “carsickness,” “seasickness,” “paediatric,” “children,” “infants,” and “adolescents,” along with “susceptibility,” “prevalence,” “epidemiology,” “symptoms,”

“management,” “treatment,” and “therapy.” These terms were combined using Boolean operators (AND, OR) to develop a structured and comprehensive search. References from relevant articles were also manually reviewed to identify additional studies.

Inclusion criteria required that studies provide data on MS in paediatric populations. Given the limited paediatric-specific data, mixed-age studies were also included if they provided data on children or included analyses or developmental comparisons. The eligible study designs encompassed original research such as experimental, observational and clinical studies, as well as review articles. Materials that were non-peer-reviewed, editorials without data or duplicate publications were excluded. Data extraction involved a detailed review of study characteristics, including age ranges, gender differences, risk factors, clinical features and management strategies. Extracted information was then verified through repeated review of the original articles.

Because this study is a review of previously published literature and does not involve animal or human subjects, ethical approval was not required.

THE PATHOPHYSIOLOGICAL MECHANISMS OF MOTION SICKNESS

The sensory conflict theory is a fundamental framework for understanding MS [5-7]. According to this theory, MS happens when the brain receives contradictory signals about movement from different sensory systems, including the visual system, vestibular apparatus and proprioceptive receptors. For example, if a child is in a moving car and focusing on a stationary object like a book, their vestibular system detects movement while their visual system does not. This mismatch can lead to a sensory conflict, causing MS symptoms.

Age is also a key factor in MS susceptibility. Research shows that school-age children are at greater risk than younger children and infants, likely because infants' vestibular systems are still maturing [3,4,8]. On the other hand, visual cues may contribute less, as blind individuals generally show reduced susceptibility to MS, mainly because they rely less on visual cues, which helps lessen sensory conflict [9]. However, since their vestibular and somatosensory systems remain intact, they can still experience MS, especially during intense or unfamiliar movements.

Despite this, the mechanisms of MS in infants are not yet fully understood. One theory suggests that the negative reinforcement mechanism, which drives individuals to avoid harmful motion, is not activated in infants until they reach a particular developmental stage [10]. Additionally, factors such as their underdeveloped sensorimotor skills, existing medical conditions and habituation may contribute to their lower susceptibility to MS. This area offers opportunities for further research, emphasizing the complexity of MS and the need to explore neurophysiological factors and individual differences more thoroughly.

EPIDEMIOLOGY IN THE PAEDIATRIC POPULATION

Influence of Age on Disease Distribution in Children

Evidence shows that MS follows a clear age-related pattern, forming an inverse U-shaped curve across a person's life

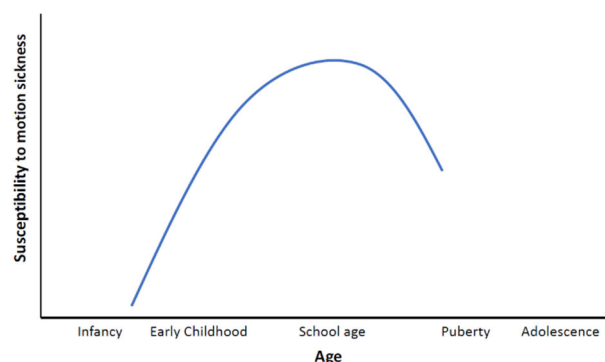


Figure 1: Age-related susceptibility to motion sickness in children [3,4]

[3,4]. It is uncommon in infants, who tend to be resistant, probably due to immature sensory integration, as mentioned earlier [3,4,8]. Susceptibility then increases rapidly after age two, peaking during the school-age and prepubertal years and decreases after puberty Figure 1 [3,4].

Sex Differences in Susceptibility

Females are generally more susceptible to MS than males, both in childhood and adulthood [4,11,12]. Hormonal fluctuations throughout the menstrual cycle may significantly increase the likelihood of MS in females after menarche [13-15]. Susceptibility tends to peak around menstruation and ovulation, probably due to changes in oestrogen and other reproductive hormones.

Interestingly, prepubertal children also exhibit a clear sex difference in MS, suggesting that factors beyond hormones might be involved [4]. This gender disparity in MS persists across all ages, even when physical activity levels are similar.

Genetic research has broadened our knowledge by uncovering sex-specific genetic variants that may heighten risk in females [16,17]. A large-scale study involving over 80,000 participants identified several variants, particularly those associated with the development of the inner ear and the nervous system [17]. Notably, some of these variants have effects in females that are up to three times stronger, pointing to a sex-specific genetic influence on susceptibility. Nevertheless, the precise genetic mechanisms, especially those involving sex chromosomes, are still largely unknown, presenting a valuable opportunity for future investigation.

Genetic and Hereditary Susceptibility

Previous reports show a consistent relationship between heredity and family history and the risk of MS in children [17-19]. These genetic and family patterns are essential to consider when assessing a child's susceptibility. Notably, twin studies reveal that monozygotic twins show significantly higher concordance rates than dizygotic twins [18,19].

Large-scale research has estimated the heritability of MS to be between 57% and 70%, suggesting that genetic influences are more significant in younger people and tend

to diminish with age [18]. Additionally, a comprehensive genome-wide association study (GWAS) identified 35 genetic variants associated with MS, many of which are linked to genes related to balance, inner ear function and neurological development [17]. Interestingly, some of these variants have a more substantial effect in females, aligning with the higher susceptibility often observed in girls. Future genetic research is important for identifying specific variants and broadening our understanding.

Type of Transport

The mode of transportation significantly influences the likelihood of children experiencing MS. Observations show that MS occurs more frequently in cars and buses than in other modes of transport. A large population study of 831 children aged 7 to 12 found notable differences in the prevalence of MS across transport modes [3]. Specifically, 43.4% of children reported symptoms when riding in cars and 43.2% did so on buses. Meanwhile, only 11.7% experienced symptoms on park swings and 11.6% on Ferris wheels. The higher risk of MS in ground vehicles, especially cars and buses, likely stems from complex sensory interactions related to linear motion.

Interestingly, the previous report found that children experience less MS when traveling by ship or plane, likely because they seldom do so [3]. Although MS during air and sea travel is known, more research on children's experiences is needed. Such studies could compare ground and non-ground travel, helping develop better strategies to reduce MS and improve travel for young passengers and families.

Common Paediatric Comorbidities

Some children are more prone to MS due to specific medical conditions. For example, children with migraines, vestibular disorders, vasovagal syncope and Tourette's syndrome often experience higher rates of MS than the general population [20-24].

One study revealed that 45% of children with migraines experienced MS, whereas only 5-7% of other groups did [20]. Similarly, research by Sophie Lipson *et al.* confirmed these findings, showing that 47.8% of children with MS also had a migraine variant [21]. Moreover, M. Abouzari *et al.* identified a significant association between childhood MS scores and the presence of definite vestibular migraine, suggesting a possible link between these conditions in children [22]. This suggests a meaningful relationship between the two. Therefore, recognizing MS may serve as a potential diagnostic indicator for childhood migraines [23].

While these findings provide valuable insights into the relationship between MS and specific medical conditions in children, the small sample sizes underscore the need for larger studies to validate these links and investigate additional contributing factors.

Clinical Presentation and Diagnosis in Children

MS in paediatric patients manifests a range of autonomic and neurovegetative symptoms, with nausea and vomiting being the most commonly reported and often most distressing for

children [4]. Nausea typically emerges first, frequently followed by vomiting, which can sometimes be quite intense. During these episodes, children may exhibit signs such as pallor and clamminess.

Currently, standard criteria for diagnosing MS in children are not well-established. However, the Bárány Society consensus criteria, as presented by Cha *et al.* [26], offer a valuable framework that emphasizes essential clinical features applicable across all age groups. Diagnosis is based on symptoms such as nausea, vomiting, pallor, sweating, dizziness and drowsiness during motion exposure. Notably, these symptoms typically subside with the cessation of motion and may reemerge upon repeated exposure. It is crucial to exclude other vestibular, neurological or gastrointestinal conditions as potential causes. Additionally, the authors classify MS into three distinct subtypes: classic motion sickness (CMS), resulting from actual physical movement; visually induced motion sickness (VIMS), elicited by perceived motion in virtual reality (VR) or screen-based environments; and motion sickness disorder (MSD), characterized by persistent hypersensitivity leading to functional impairment [26].

It is important to recognize that previous diagnostic criteria were primarily designed for adults and have not been systematically validated for younger populations. The lack of definitive diagnostic criteria for MS in children arises from several challenges. Children experience rapid developmental changes in anatomy, pathophysiology, neurology and psychosocial factors, resulting in a broader spectrum of symptoms than in adults [4,8,27].

Moreover, younger children may struggle to articulate their experiences, complicating accurate clinical assessments. For example, preschool-aged children may predominantly report headaches and significant instability, such as balance difficulties or falls, while exhibiting fewer autonomic symptoms like nausea, compared to older children and adults [27]. Establishing a standardized approach to diagnosing MS in children would greatly enhance clinical understanding and treatment efficacy. Further research and validation are essential to develop criteria that address the unique experiences of younger patients.

In terms of assessment, several validated self-report tools can significantly improve the objective evaluation of MS. For instance, the Motion Sickness Susceptibility Questionnaire (MSSQ), created by Golding, measures lifetime susceptibility to physical motion sickness [28]. The Motion Sickness Assessment Questionnaire (MSAQ), developed by Gianaros *et al.* [29], evaluates symptom distribution across the gastrointestinal, peripheral, central and somatogenic domains. For quicker assessments, the Motion Sickness Severity Scale (MSSS) uses a six-item questionnaire to measure symptom severity accurately [30].

Cybersickness can be considered a specific subtype of MS primarily triggered by visual or VR stimuli. Children can experience cybersickness similarly to adults and research indicates that short-term, supervised use of VR by children generally leads to mild, temporary symptoms [31]. A systematic review of VR safety in children under 14 found

that, while VR may cause mild symptoms such as nausea and dizziness, these are typically not severe enough to deter children from engaging with VR technology [32].

To address visually induced motion sickness (VIMS), researchers often use the Visually Induced Motion Sickness Susceptibility Questionnaire (VIMSSQ) [33]. Additionally, the modified Simulator Sickness Questionnaire for children (Peds SSQ) is employed to assess MS in young children during VR sessions [34]. Leveraging these tools can enhance diagnostic accuracy and facilitate more effective symptom recognition.

MANAGEMENT

Non-Pharmacological Interventions

Behavioural and Environmental Strategies: Behavioural interventions are universally considered the foundation of paediatric MS management. They are easy for caregivers to implement during everyday travel. The central aim of these measures is to reduce the sensory conflicts that drive symptoms while also addressing psychological triggers, such as anticipatory anxiety.

Seating Position

Making a few simple adjustments and implementing practical strategies can significantly improve travel experiences, turning them from stressful to manageable. While most current research focuses on adults or mixed groups, these methods are helpful and easy to use, even for children, though more specific evidence is still needed [35,36].

Studies indicate that looking out the window toward the horizon can help alleviate MS, especially for those who are more susceptible to it [35]. Clear visual information helps the brain anticipate motion, reducing sensory conflict.

Additionally, seating arrangements affect comfort during car journeys; facing backward or having a restricted view increases the likelihood of MS [36]. Forward-facing seats with an unobstructed view of the road provide the most relief, but more research on children is needed to optimize travel comfort.

Another potential method to reduce MS in children focuses on increasing their sense of control during vehicle travel. Active engagement, such as anticipating or simulating vehicle movement, can reduce discomfort. A study by Chang *et al.* found that children who interacted with virtual vehicle controls experienced less MS [37]. While these scenarios don't perfectly mirror real-world situations because children aren't actually driving, the results emphasize the benefits of incorporating interactive or predictive features, such as virtual simulations or gamified tasks, to foster anticipatory awareness and reduce sensory mismatch for young travellers.

Trip-Related Modifications

Several proposed behavioural and environmental modifications may be beneficial, although it is essential to note that paediatric-specific trials have not yet validated all of these strategies [38,39]. Some suggested advice includes:

taking breaks every one to two hours, maintaining an upright posture with proper head support, avoiding leaning forward, ensuring good ventilation and avoiding strong odours [38]. Additionally, limiting activities such as reading or using devices can help reduce the risk of visual-vestibular conflict, which may lead to nausea [38]. Ongoing research is essential to assess the preventive effectiveness of these interventions better and to support their use in paediatric care.

Cognitive Factors

Parents' support and outlook can shape a child's perception of their symptoms. Research indicates that children who expect to feel ill are more likely to do so, highlighting the importance of parental guidance in preventing symptoms [40]. Therefore, parents should aim to frame trips positively, avoid repeatedly inquiring about symptoms and use distractions such as music, conversation or games. Conversely, providing predictability about motion can significantly reduce symptoms and promote more enjoyable trips [41]. Although most evidence comes from adult studies, similar mechanisms likely apply to children as well.

Vestibular Rehabilitation and Habituation Training

Vestibular rehabilitation is increasingly recognized as a valuable treatment for children with vestibular disorders or vestibular migraine [42]. However, evidence supporting its effectiveness in reducing MS in healthy children is limited. These exercise-based programs aim to improve balance, reduce dizziness and enhance the quality of life for individuals with various vestibular disorders. It typically includes exercises targeting gaze stabilization, balance, gait and habituation [42,43].

There is potential to develop standardized guidelines for the "dose" of vestibular rehabilitation in paediatric MS. The French Society of Otorhinolaryngology endorses its early use in children with vestibular dysfunction [44]. It favours personalized, symptom-driven approaches over fixed protocols. Additionally, it recommends that exercises be adapted to age and developmental stage, though details on session numbers or durations remain open for discussion. More research is needed to evaluate its effectiveness in healthy children with MS and to determine the best protocols and doses for this group.

Habituation exercises, part of vestibular rehabilitation, offer a non-pharmaceutical method for reducing MS in both adults and children [45]. Repeated, controlled exposure to motion stimuli initially provokes symptoms but leverages the vestibular system's ability to adapt, resulting in desensitization and greater tolerance. Evidence indicates that this exposure can produce long-term reductions in MS, with some individuals experiencing relief for as long as 18 weeks [46]. Although most studies focus on adults, children are also affected and may benefit since research shows a post-pubertal decline in MS linked to habituation [4]. A cautious, gradual approach starting with short vehicle rides is recommended.

Habituation effects are usually specific to the motion type and training setting. Desensitization to one motion (such as linear acceleration) doesn't necessarily reduce symptoms from another (such as angular acceleration) or from more intense exposures [47]. Habituation also doesn't transfer well between virtual and real environments [48].

Dietary and Herbal Approaches

Growing interest exists in nutritional and herbal remedies for managing MS, especially among adults [39]. Ginger, in particular, has been extensively studied [49-53]. However, there is a lack of high-quality randomized controlled trials in children that definitively demonstrate its effectiveness for MS compared with standard pharmacological treatments. In other paediatric conditions, ginger has a good safety profile [54]. It is a well-tolerated natural remedy, with only mild gastrointestinal side effects [52]. Families seeking alternatives when pharmaceutical options are limited may find it helpful. Future paediatric studies are necessary to better understand its efficacy and safety for this purpose.

Ginger's potential benefits in alleviating MS may stem from its effects on gastric motility, plasma vasopressin levels and modulation of histamine and acetylcholine within the vestibular system, as well as its role in metabolic regulation [55,56].

Other Alternative Methods

Acupressure, a complementary therapy, has shown potential to reduce symptoms of various conditions by applying pressure to the Neiguan point (P6) on the anterior wrist, often using a wristband [57]. Other acupoint sites have also been studied in paediatric patients. This technique has been examined in children, providing relief from nausea and vomiting associated with several paediatric illnesses [57]. Its non-invasive, simple and low-risk approach makes it an attractive option. However, there is currently no direct paediatric trial specifically examining acupressure for MS. More research is needed to confirm its effectiveness.

Electronic neuromodulation bands that deliver gentle electrical stimulation are increasingly marketed. For example, galvanic vestibular stimulation (GVS) shows promise and has been used in adults, including trials addressing MS [58]. There is no direct clinical evidence in children and safety and optimal dosing for paediatric use are not established.

Emerging technologies such as VR-based therapy and training show promise but remain experimental and insufficiently tested, particularly regarding paediatric MS. Recent vestibular rehabilitation guidelines explicitly recommend against using virtual reality to treat children and young adolescents with vestibular dysfunction [44].

Pharmacological Interventions

While behavioural measures and environmental adjustments are the primary strategies for preventing and managing MS, pharmacologic treatment may be necessary for individuals with severe or resistant cases. Healthcare providers often

find prescribing these medications challenging because many are used "off-label" in children, outside their approved indications. Consequently, medication decisions should be made cautiously, considering variable effectiveness and the potential for significant side effects that require careful monitoring in paediatric patients.

Antihistamines

Antihistamines, especially first-generation H₁ antagonists such as dimenhydrinate, meclizine, cinnarizine and promethazine, are effective in preventing MS in adults, particularly in those prone to seasickness or airsickness [59].

They act by blocking central H₁ receptors in the vestibular nuclei and vomiting centre, reducing nausea and vomiting signals [60]. These older medications cross the blood-brain barrier, enhancing their benefits but also causing side effects such as sedation in over 50% of patients, which can impact learning and alertness in children [59,61,62]. Additional side effects include drowsiness, fatigue, dizziness and anticholinergic effects like dry mouth and blurred vision [59].

In contrast, newer antihistamines, which cross the blood-brain barrier less readily, are less sedating but ineffective for MS [63]. First-generation antihistamines remain beneficial for certain patients who can manage sedation. A Cochrane review of nine trials confirmed their efficacy, estimating a 40% reduction in MS risk compared with 25% with placebo, but highlighted the need for more research on their safety and effectiveness in children under 18 [62]. These medications are more effective as prophylaxis, as they tend to be less helpful once symptoms appear.

While off-label use in children as young as 2 is common, careful monitoring is essential due to potential adverse effects. A significant need remains for well-controlled paediatric studies to enhance our understanding of the efficacy and safety of these medications in younger individuals.

Anticholinergics

Scopolamine is a well-established anticholinergic used primarily to prevent MS in adults and children 12 years of age or older [64-68]. As a nonselective anticholinergic, it effectively inhibits the vestibulo-visual reflex, blocks signals to the vomiting centre and provides central antimuscarinic effects [66,68].

The medication can be administered via various routes, including oral and non-oral methods [69]. Non-oral options, such as transdermal patches, intranasal sprays and gels, offer advantages, including fewer side effects and less impact on the gastrointestinal system, making them suitable for individuals with MS and gastric issues [70-72]. Transdermal patches are the most common delivery method [70,71]. When applied to the mastoid area, they usually begin to work within 4 to 8 hours and last up to 72 hours. The patch can be replaced as needed for extended relief. Intranasal sprays can offer faster relief for MS [72].

Orally, scopolamine is effective in adults at doses of 0.3 to 0.6 mg, with children requiring smaller amounts [73]. Oral doses take effect within 30 minutes and last about four to six hours, making them suitable for short trips [73]. Combining oral and transdermal patches may improve relief for longer journeys. Safety in children under 12 isn't fully established, so caution is advised. Evidence from other contexts suggests potential. For instance, a study shows that transdermal scopolamine is effective and tolerable for children with sialorrhea, indicating possible broader off-label use [74].

When using scopolamine for MS, be aware of safety concerns related to its anticholinergic effects. Common side effects include dry mouth, constipation, urinary retention and ocular symptoms [70,71]. Neurological effects range from restlessness and drowsiness to hallucinations and euphoria [70,71]. Rare cases in children have involved delirium and psychosis from transdermal use during long trips [75]. Although rare, these cases highlight the need for careful monitoring of side effects.

Given the neuropsychiatric effects of scopolamine in children and limited evidence of safety and efficacy, exploring alternatives for MS prevention is wise. Behavioural and non-pharmacologic methods should be the first choice. Medication, such as first-generation antihistamines, may be used for severe cases unresponsive to initial strategies. If scopolamine is needed, it should be used under medical supervision with careful dosing and monitoring. Research is vital to better understand its safety and establish paediatric guidelines.

Neuroleptics

Phenothiazines are neuroleptic derivatives with antiemetic effects, but haven't been studied in children and adolescents for MS [76]. Their routine use isn't recommended due to unpredictable, sometimes severe toxicity. Safer options are preferred for paediatric patients.

Serotonin Antagonists

Ondansetron is an example of an antiemetic commonly used for a variety of clinical conditions characterized by vomiting and nausea [77,78]. Its favourable safety profile and effectiveness make it a valuable option in these cases. However, no published studies specifically examine its efficacy in treating MS among children. This suggests an opportunity for further research to assess the potential benefits of ondansetron in this area.

Medications for Related Comorbidities

When treating children with MS, it's essential to recognize its frequent association with other clinical conditions and comorbidities. These may include vestibular disorders, various migraine types, particularly vestibular and abdominal migraines, irritable bowel syndrome and other hypersensitivity disorders [20-22]. These conditions often share interconnected underlying mechanisms, primarily involving abnormalities in central vestibular processing

regions, particularly in serotonergic and dopaminergic pathways, which affect spatial awareness and autonomic responses.

MS may not only occur in isolation but can also precede or accompany migraines, indicating its role within a broader vestibular–migraine spectrum rather than being a standalone issue. This connection suggests that strategies targeting these shared neurobiological foundations could offer additional benefits. Future clinical trials are essential to assess the effectiveness of these approaches and to establish safe, age-appropriate treatments for children with comorbidities.

CONCLUSIONS

Motion sickness is common in children, especially during travel and peaks in school-aged children. It is more common among those with a family history or other comorbidities. Several treatment methods exist. Generally, non-pharmacological interventions and behavioural therapies are preferred for children because they are safer and easier to implement. Despite existing research, there is a pressing need for further studies on specific aspects of motion sickness in children. These studies should aim to refine diagnostic criteria, explore the impact of comorbidities and develop innovative treatments through targeted randomized controlled trials. Addressing these gaps can help healthcare providers improve care, ensuring better travel experiences and overall well-being for children.

Limitations

This review highlights several factors that may influence the interpretation of findings. Many studies involve small sample sizes or include mixed age groups, which can limit their applicability to paediatric populations and may not fully capture children's unique physiological and developmental needs.

Furthermore, some studies rely on self-reported data, which can introduce bias, especially because younger children may struggle to articulate their symptoms. The lack of standardized diagnostic criteria for MS in children also complicates assessments and may lead to inconsistent experiences.

Furthermore, although various management strategies are evaluated, the efficacy of behavioural and pharmacological interventions can differ significantly among children due to factors such as age and health status. Current research emphasizes the necessity for additional high-quality studies and randomized controlled trials focusing on paediatric populations. Acknowledging these limitations underscores the importance of ongoing research to enhance understanding of MS in children and to develop practical management approaches.

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