



# Early and High Sport Specialization in a Prepubertal Karate Kata Athlete: An Evidence-Based Case Report

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## ABSTRACT

Early sport specialization is increasingly common, although its independent contribution to injury risk remains uncertain. Its long-term benefits are also unclear and potential risks require individualized clinical interpretation. This evidence-based case report evaluated a highly specialized asymptomatic 10-year-old prepubertal boy (Tanner Stage I, body mass index in the 93rd percentile) who practiced karate kata since age five. A structured search of PubMed, Scopus, and the Cochrane Library was conducted using a Patient-Exposure-Comparison-Outcome (PECO) framework. Reviews comparing specialization with multisport participation or later specialization were screened. Six reviews were included and critically appraised. Quantitative evidence from broader youth-athlete cohorts demonstrated that high specialization significantly increases overuse-injury risk (RR = 1.81, 95% confidence interval [CI] 1.26–2.60) and total-injury risk (RR = 1.37, 95% CI 1.19–1.57). Evidence for performance and psychological outcomes was heterogeneous. Crucially, direct empirical evidence regarding prepubertal karate kata specialists is currently lacking, rendering all applied recommendations indirect. Consequently, the findings are based primarily on indirect evidence from youth sport populations. For this asymptomatic child, the available evidence supports a primary prevention approach rather than sport cessation. Through cautious clinical extrapolation, we recommend a customized risk-management plan that includes periodized participation, planned rest, movement diversification, neuromuscular training, ongoing monitoring, and shared decision-making.

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## INTRODUCTION

Participation in organized youth sports has historically been promoted for its extensive physical, social, and developmental benefits. However, modern youth athletic systems increasingly direct young participants toward intensive year-round training, highly selective development pathways, and demanding competition schedules. This structural shift has accelerated the prevalence of sport specialization among pediatric populations. From a public health perspective, this shift has significant consequences, such as sport dropout rates as high as 70% before age 13, and substantial financial burdens on families (Bell et al., 2019). This is consistent with longitudinal evidence showing a dramatic decrease in youth sport participation from 82% in the 7th grade to just 39% by the 12th grade (Valenzuela-Moss et al., 2024). Indeed, the American Orthopedic Society for Sports Medicine (AOSSM) consensus statement highlights that early sport specialization is not a requirement for success in most sports and is associated with high risks of overuse injury and burnout, while discouraging unstructured free play which is critical for motor and social development (LaPrade et al., 2016). To maintain clinical and methodological clarity, a fundamental distinction must be drawn between early specialization and high specialization. Early specialization primarily refers to the chronological and biological timing at which an athlete begins to focus on a single sport, typically during the prepubertal years. In contrast, high specialization describes the degree of training exclusivity and concentration within that chosen sport (Popkin et al., 2019). In clinical research, this degree of specialization is often operationalized using a three-point scale that evaluates whether an athlete trains year-round for more than eight months, selects a single main sport, and quits other sports to focus on that discipline (Myer et al., 2015). While many health guidelines and consensus definitions, such as those from a multidisciplinary Delphi panel (Bell et al., 2021), describe the general concept of focusing on a single sport to the exclusion of others, they often emphasize the level of exclusivity rather than the specific age of onset.

Within youth sports, karate represents a unique and clinically significant context because its distinct sub-disciplines, kata and kumite, impose vastly different biomechanical and physiological demands. Kumite involves active combat against an opponent, characterized by reactive decision-making, rapid intermittent exchanges, and direct contact exposure. Conversely, kata consists of highly choreographed solo performance sequences judged on technical precision, timing, balance, power expression, and artistic execution. The primary physical demands of kata training involve repetitive execution of sustained deep stances, rapid axial turns, and high-velocity decelerations. While intensive kata practice is essential for technical mastery, executing these highly specialized movement patterns year-round without adequate recovery or athletic diversification can narrow a young athlete motor repertoire and concentrate mechanical loading on immature musculoskeletal tissues (McKay et al., 2019; Myer et al., 2016). Crucially, direct empirical evidence evaluating injury risk, physical function, or psychological outcomes specifically in prepubertal kata specialists is currently absent in the literature (Bell et al., 2018; Luo et al., 2025). Consequently, clinical recommendations for this population cannot be drawn from sport-specific data. Instead, they must be extrapolated from broader pediatric sports medicine research and consensus guidelines and explicitly characterized as being based primarily on indirect evidence (Bell et al., 2018; Herman et al., 2022; Putukian et al., 2026).

Addressing this need for clinical extrapolation, this evidence-based case report focuses on EAN, a 10-year-old prepubertal boy (Tanner Stage I) presenting with a body mass index in the 93rd percentile, indicating overweight status. He has practiced karate kata as his sole organized sport since the age of five, meeting all criteria for high specialization. Importantly,

because the child is currently asymptomatic and exhibits no active injury, persistent musculoskeletal pain, or exercise intolerance, the clinical scenario is framed strictly as a preventive risk-management encounter. In this context, his overweight status and related lifestyle factors are addressed as contextual health considerations rather than direct outcomes attributable to early sport specialization. While existing systematic reviews and clinical guidelines successfully establish broad population-level relationships between specialization and adverse health outcomes, they rarely address how to apply these generalities to individual asymptomatic athletes. Thus, the novelty and principal contribution of this report lies not in the generation of new empirical evidence, but in the translation and contextual application of the current literature into a highly individualized and patient-centered risk-management framework, utilizing established youth athlete development models (Varghese et al., 2022) tailored specifically to the unique physical and developmental needs of a prepubertal karate kata athlete.

## **METHODS**

### **Clinical Question and Case Framework**

The clinical question for this report was structured using a Patient-Exposure-Comparison-Outcome (PECO) framework to ensure methodological precision. The question was defined as follows: in child and adolescent athletes (Population), how are early specialization, which is characterized by the chronological and biological timing of single-sport focus, and high specialization, which is defined by the degree of training exclusivity and concentration (Exposures), compared with multisport participation, sport sampling, or later specialization (Comparison), associated with musculoskeletal injury, physical function or performance, burnout, and psychological outcomes (Outcomes)? Both early and high sport specializations were treated strictly as modifiable athletic participation patterns and risk factors, rather than as medical diagnoses. Following the structured search and critical appraisal of the literature, the specific clinical case of EAN was analyzed to evaluate the applicability and translation of this population-level evidence to an individual prepubertal athlete in a real-world clinical setting.

### **Search Strategy**

A structured literature search was conducted on April 18, 2026, using PubMed, Scopus, and the Cochrane Library. These databases were selected to cover relevant biomedical, clinical, sports science, and systematic review literature. PubMed was used to identify biomedical and clinical studies, while the Cochrane Library was selected for high-quality systematic reviews. Scopus was included because it provides broad coverage of multidisciplinary research, including sports science and rehabilitation. Although SPORTDiscus and Embase are relevant databases for sports medicine, they were not included. The combination of PubMed for high-level biomedical clinical evidence, the Cochrane Library for gold-standard systematic reviews, and Scopus for broad multidisciplinary sports science coverage was deemed sufficiently sensitive to capture the core literature and minimize publication bias for this clinical case framework.

Search terms were developed based on the PECO framework to capture both physical and psychological outcomes related to sport specialization. The search strategy used combinations of keywords and Medical Subject Headings (MeSH) in PubMed where applicable. The main search terms included "early sport specialization", "sport specialization", "sport sampling", "youth athlete", "pediatric athlete", "child", "child athlete", "overuse injury", "growth", "maturation", "burnout", and "psychological". Terms related to anxiety,

depression, motivation, enjoyment, and dropout were not used as separate search strings but were considered as predefined outcomes during study screening. This approach might have reduced sensitivity for psychological-specific outcomes and was therefore considered as a limitation when interpreting psychological evidence. The database-specific search strategies and initial yields are presented in Table 1.

**Table 1.** Literature Search Strategy and Yield

| Database         | Search Strategy                                                                                                                                                                                                                                                                                                                                          | Records | Included |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------|
| PubMed           | ("early sport specialization"[Title/Abstract] OR "sport specialization"[MeSH Terms] OR "sport sampling"[Title/Abstract]) AND ("youth athlete"[Title/Abstract] OR "pediatric athlete"[Title/Abstract] OR "child"[MeSH Terms]) AND ("overuse injury"[Title/Abstract] OR "growth"[MeSH Terms] OR "burnout"[Title/Abstract] OR "maturation"[Title/Abstract]) | 89      | 4        |
| Scopus           | TITLE-ABS-KEY(("early sport specialization" OR "sport specialization" OR "sport sampling") AND ("youth athlete" OR "pediatric athlete" OR "child athlete") AND ("overuse injury" OR "growth" OR "maturation" OR "burnout" OR "psychological"))                                                                                                           | 164     | 2        |
| Cochrane Library | (sport specialization OR sport sampling) AND (youth OR pediatric OR child) AND (injury OR growth OR burnout)                                                                                                                                                                                                                                             | 22      | 0        |
| Total            |                                                                                                                                                                                                                                                                                                                                                          | 275     | 6        |

*Note.* The search was conducted on April 18, 2026.

### Eligibility and Selection

Publications were considered eligible for inclusion if they were peer-reviewed, English-language systematic reviews, meta-analyses, rapid reviews, narrative reviews, or clinical reviews. Eligible studies had to evaluate youth athletes under 18 years of age, compare early or high sport specialization with multisport participation, sport sampling, or later specialization, and report at least one prespecified physical or psychological outcome. Narrative and clinical reviews were intentionally retained to capture operational definitions, developmental and biological mechanisms, and clinical recommendations that are often absent in purely quantitative syntheses. However, these narrative sources were utilized strictly to provide clinical context rather than as the primary basis for causal inference. Exclusion criteria comprised original single studies, adult-only investigations lacking youth subgroup data, animal studies, editorials, commentaries, letters, and case reports. Publications published more than 15 years prior to the search date were also excluded, unless they held a seminal role in defining the conceptual framework of pediatric athletic development.

Title and abstract screening, followed by full-text evaluation, was conducted to identify the core evidence set, with the selection process structured and summarized according to the PRISMA 2020 guidelines (Page et al., 2021). Following the selection of the six core reviews, backward citation tracking and targeted literature searches were performed to identify supplementary literature. To prevent selection bias and maintain methodological transparency, strict eligibility parameters were established for all supplementary sources. To qualify for inclusion as supplementary evidence, publications were required to meet at least one of the following criteria: they had to be consensus statements or position papers published by officially recognized international pediatric sports medicine and health organizations, peer-reviewed articles detailing the specific biomechanical and load-

distribution demands of karate kata, or validated training protocols for youth neuromuscular and physical literacy development. These supplementary sources were not counted within the PRISMA selection flow and were not utilized to modify or replace the core risk estimates, serving instead to guide the practical translation of the evidence into clinical recommendations.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only

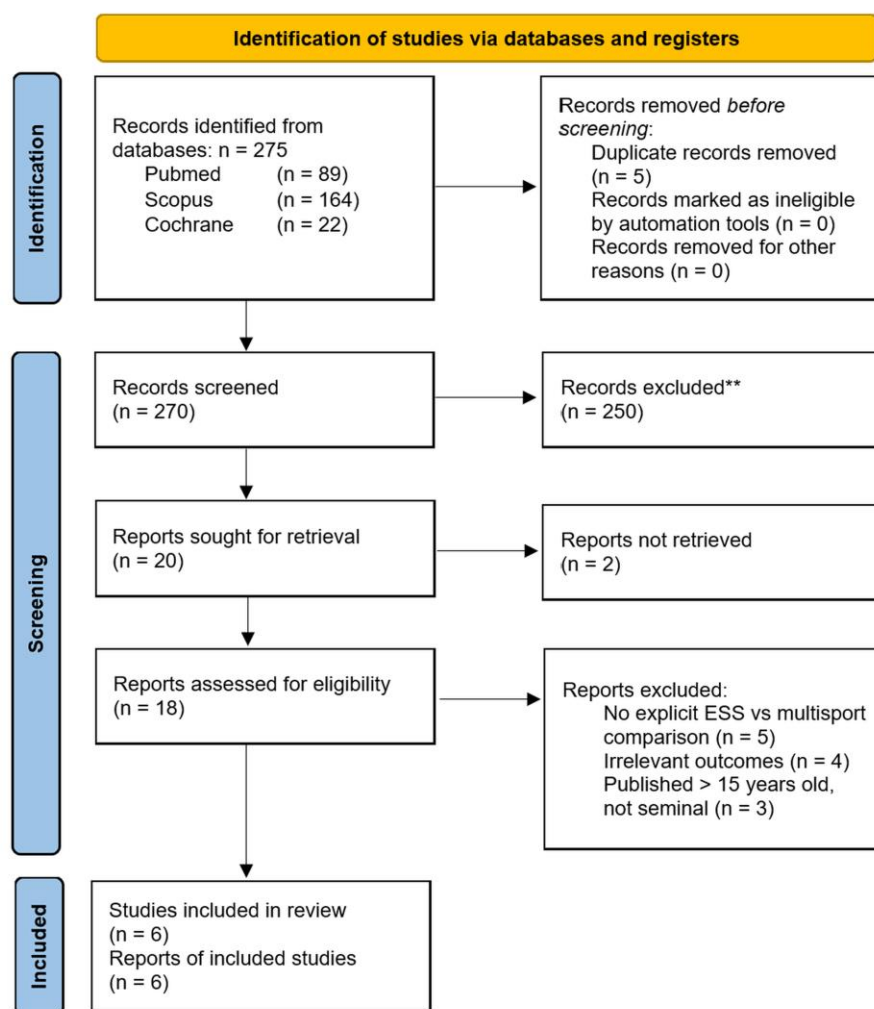


**Figure 1.** PRISMA 2020 Flow Diagram of Study Selection

### Critical Appraisal and Evidence Synthesis

The critical appraisal strategy was designed to align each evaluation instrument with the specific methodological design and intended purpose of the retrieved publications. Systematic reviews and meta-analyses, specifically those by Bell et al. (2018) and Carder et al. (2020), were appraised using A Measurement Tool to Assess Systematic Reviews version 2, known as AMSTAR 2 (Shea et al., 2017). This instrument was also applied pragmatically to the rapid review by Luo et al. (2025), which allowed for a structured identification of the procedural shortcuts, such as single-reviewer data extraction, that are typical of rapid methodologies. For the review by Herman et al. (2022), which functions primarily as a systematic synthesis of clinical practice guidelines, the Appraisal of Guidelines for Research

and Evaluation II instrument, or AGREE II, was selected as the most appropriate framework (Brouwers et al., 2010). AGREE II represents the international gold standard for assessing the methodological quality, stakeholder representation, and clinical applicability of healthcare guidelines. Narrative and clinical reviews, including Myer et al. (2015) and McKay et al. (2019), were appraised using the Scale for the Assessment of Narrative Review Articles, or SANRA, which evaluates scientific reasoning, literature coverage, and data presentation (Baethge et al., 2019). Appraisal scores were utilized to weight the interpretive confidence of each study rather than to calculate arbitrary quality thresholds.

A standardized evidence table was constructed to extract key data points, including study populations, specialization definitions, specific athletic exposures, and physical or psychological outcomes. Due to the high clinical and methodological heterogeneity across the included literature, no new quantitative meta-analysis was attempted. Instead, a qualitative narrative synthesis was conducted, structured around the core outcome domains of the PECO question. To translate the findings to the clinical case, evidence was critically assessed for its directness to a prepubertal karate kata athlete. Evidence was classified as direct when it evaluated pediatric populations, utilized exposure metrics comparable to the patient schedule, and reported clinically trackable outcomes. In contrast, findings derived from older adolescents, elite talent programs, or different sporting disciplines were classified as indirect evidence. Because no primary studies evaluated prepubertal karate kata specialists directly, the synthesized recommendations were explicitly characterized as clinical extrapolations based on indirect evidence from broader youth-sport populations. Evidence types were interpreted according to their methodological hierarchy. Systematic reviews and meta-analyses were prioritized for quantitative risk estimates, while guideline-oriented reviews were used to support preventive recommendations. Narrative or clinical reviews were used primarily for developmental mechanisms, clinical context, and interpretation.

### **Ethical and Privacy Considerations**

This evidence-based case report was conducted in strict accordance with the ethical principles of the Declaration of Helsinki and local institutional patient privacy policies. Only de-identified clinical information necessary to understand the sports medicine question was included in this report. The original reason for the pediatric clinical visit was unrelated to sport specialization and is not described in detail because it does not contribute to the clinical inference of this study. Prior to the collection of clinical data and the preparation of this manuscript, written parental informed consent was formally obtained from the parent of the patient. This consent explicitly authorized the publication of anonymized case details, including anthropometric measurements and the de-identified growth chart. Furthermore, because this manuscript presents a retrospective analysis of a single, completely de-identified patient case, it was formally determined to be exempt from institutional review board review in accordance with the local policies of the participating institution.

## **RESULTS**

### **Clinical Scenario**

A 10-year-old boy was identified during a pediatric assessment. He was prepubertal (Tanner Stage I), weighed 42 kg, and was 140 cm tall, which corresponds to a body mass index of 21.4 kg/m<sup>2</sup> and falls approximately in the 93rd percentile for his age. He had no history of major sports injuries, persistent musculoskeletal pain, exercise intolerance, or known chronic diseases. Furthermore, no objective assessments of fitness, movement quality, or psychological status had yet been performed. The pediatric assessment identified an

asymptomatic child with no history of active musculoskeletal injuries, persistent pain, or exercise intolerance. Consequently, the clinical focus was directed toward prospective risk identification, baseline monitoring, and appropriate athletic development.

A broader lifestyle assessment identified regular sugar-sweetened beverages, large meal portions, approximately four to five hours of daily screen exposure, delayed sleep onset, and probable sleep duration below the 9–12 hours recommended for school-aged children (Coel et al., 2023). This sleep deficit, often exacerbated by developmental shifts in circadian rhythms, is a critical modifiable factor that can interact with physical loads to increase injury risks in adolescent athletes (Mason et al., 2023). Under the three-item specialization scale, the child met all criteria for high sport specialization, as he practiced karate kata as his single primary organized sport, trained for more than eight months of the year, and had no regular second organized sport (Myer et al., 2015; Post et al., 2017). This classification was further supported by the consensus concept of restricted opportunities, because informal activities such as recreational football and cycling were only occasional and did not constitute structured multisport participation. From a public health perspective, such restricted participation and high exclusivity are associated with high rates of sport dropout, up to 70% of children withdraw from organized sports by age 13, primarily because participation ceases to be fun (Bell et al., 2019).

His athletic specialization reflects an exposure pattern rather than a medical pathology, overtraining syndrome, or burnout. Similarly, his overweight status and lifestyle habits represent independent physical and environmental variables rather than consequences of his athletic training. The clinical objective of this encounter was to identify modifiable training and lifestyle risks while preserving his athletic participation, enjoyment, and familial sporting goals. None of the six core reviews specifically evaluated prepubertal karate kata athletes. Consequently, the application of population-level evidence to this patient represents a clinical extrapolation based primarily on indirect evidence from broader youth-sport cohorts.

### **Study Selection and Evidence Synthesis**

The structured literature search retrieved a total of 275 records. Ultimately, six reviews were selected for inclusion after PRISMA screening, consisting of two systematic reviews with meta-analyses, one systematic review of healthcare organization guidelines, one rapid review, and two narrative or clinical reviews (Table 2). A preliminary evaluation of these six included publications revealed substantial heterogeneity across the evidence base in terms of study designs, population demographics, age distributions, operational definitions of sport specialization, and reported outcomes. Consequently, the synthesized evidence cannot be interpreted as a uniformly consistent body of literature. The strongest and most consistent findings relate to musculoskeletal and overuse injury risk, whereas outcomes concerning physical performance, neuromuscular function, and psychological health exhibit greater methodological and conceptual heterogeneity.

**Table 2.** Characteristics and Main Findings of The Six Included Reviews

| Study                | Design and Population                                                                                                                   | Main Findings Relevant to The PECO Question                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bell et al. (2018)   | Systematic review and meta-analysis, five studies, youth athletes 18 years or younger (n = 3,005 to 3,601 depending on the comparison). | Highly specialized athletes had an 81 percent higher risk of overuse injury compared with low specialization peers (RR = 1.81; 95% CI 1.26 to 2.60). Moderate specialization also carried a greater risk than low specialization (RR = 1.39; 95% CI 1.04 to 1.87), while high specialization carried a greater risk than moderate specialization (RR = 1.18; 95% CI 1.05 to 1.33). The results demonstrated a clear stepwise increase in overuse injury risk. |
| Herman et al. (2022) | Systematic review of clinical practice guidelines, 11 international health and sports organizations.                                    | Convergent global guidance recommended to delay intensive single-sport specialization until age 15 or 16, limit primary sport participation to less than 8 months per year, incorporate consecutive rest of 2 to 3 months, and monitor weekly training volume so it does not exceed the child chronological age. Psychological recommendations were less consistently represented across the evaluated guidelines.                                            |
| Carder et al. (2020) | Systematic review and meta-analysis, six studies, 5,736 athletes aged 7 to 18 years (mean age 14.6 years).                              | Specialized athletes had a 37 percent higher risk of total injury (including both acute and overuse injuries) compared with sport samplers (RR = 1.37; 95% CI 1.19 to 1.57). Moderate specialization carried a 21 percent higher total injury risk than samplers (RR = 1.21; 95% CI 1.14 to 1.29), and highly specialized athletes had a 9 percent higher risk than the moderate group (RR = 1.09; 95% CI 1.04 to 1.14).                                      |
| Luo et al. (2025)    | Rapid review, 93 studies, 62,327 pediatric athletes (mean age 15.9 years).                                                              | Adverse specialization outcomes were reported in 44.4 percent of injury studies, 50.0 percent of physical function and performance studies (poorer coordination, neuromuscular control, and landing mechanics), and 38.9 percent of psychological studies (increased burnout, anxiety, and depression). No definitive long-term performance advantage for elite-level career success was found.                                                               |
| Myer et al. (2015)   | Clinical review (non-systematic), youth athletes across sports.                                                                         | Highly specialized athletes had 2.25 times greater odds of serious overuse injury compared with minimally specialized peers (OR = 2.25; 95% CI 1.27 to 3.99). Described a practical three-point specialization scale and training-volume guidelines, noting increased injury risks when weekly organized training hours exceeding the child age. Associated early specialization with elevated burnout and dropout rates.                                     |
| McKay et al. (2019)  | Narrative review, youth athletes approximately 10 to 18 years.                                                                          | Overuse injuries account for a substantial proportion of pediatric musculoskeletal complaints. Changing biomechanics and immature skeletal structures (including the physis, apophysis, and articular cartilage) are highly vulnerable to repetitive mechanical loading during pubertal growth spurts. Athletic attrition reached 70 to 80 percent among athletes specializing prior to age 15.                                                               |

### **Interpretation of Injury and Performance Risks**

Quantitative evidence from clinical case-control studies has established that single-sport specialization and intensive training are independent risk factors for overuse injury, with highly specialized youth athletes being more likely to suffer serious overuse injuries (Jayanthi et al., 2015). The meta-analysis of Bell et al. (2018) confirmed a stepwise increase in overuse injury risk with higher levels of specialization (high vs. low RR = 1.81; moderate vs. low RR = 1.39). Furthermore, a high degree of sport specialization coupled with training volume exceeding a child chronological age is strongly associated with a prior history of overuse injuries (Post et al., 2017). In terms of performance and sport success, the evidence exhibits substantial heterogeneity. Systematic review and meta-analysis of early talent promotion programs indicate that early specialization and intensive training do not correlate with long-term senior success, while most elite adult athletes are specialized later in their careers (Güllich & Barth, 2024). This is supported by specific sport cohorts, such as youth basketball players, which demonstrate no significant direct relationship between early specialization prior to age 14 and basketball-related injury, suggesting that success and injury risks vary significantly by sport and training behaviors (Meisel et al., 2022).

### **Growth, Maturation, and Biological Vulnerability**

The biological explanation for the elevated risk of overuse injuries during childhood lies in the unique vulnerability of the immature pediatric skeleton. McKay et al. (2019) emphasize that growth-related structures, including the physis, apophysis, and articular cartilage, are highly susceptible to repetitive mechanical stress. This vulnerability is particularly pronounced during the pubertal growth spurt, where skeletal growth often outpaces the functional adaptation of muscle-tendon units, resulting in temporary motor clumsiness, strength imbalances, and joint stiffness. Repetitive and sport-specific physical demands, such as the highly choreographed and precise movement sequences of karate kata, channel monotonic mechanical loads onto specific immature tissues. Without athletic diversification or sufficient recovery, these repetitive forces exceed the physiological remodeling capacity of the bone and surrounding soft tissues, providing the biological substrate for overuse injuries. In particular, biological maturation status is a key predictor, with early-maturing athletes exhibiting up to a two-fold increase in injury risk under specialized training loads (Rejeb et al., 2019).

### **Critical Appraisal**

The critical appraisal of the six included reviews revealed substantial variation in methodological quality. Under AMSTAR 2, Bell et al. (2018) received a high confidence rating, whereas Carder et al. (2020) was rated as low due to incomplete duplicate screening procedures, and Luo et al. (2025) was rated as critically low due to rapid review procedural shortcuts. Under the AGREE II framework, Herman et al. (2022) demonstrated exceptional strength in Scope and Purpose and Stakeholder Involvement, but achieved moderate scores in Rigour of Development and low scores in Applicability and Editorial Independence due to a lack of community-level implementation metrics. Narrative reviews Myer et al. (2015) and McKay et al. (2019) scored high on SANRA (11/12 and 10/12, respectively) and were utilized primarily for biological mechanisms and clinical context (Table 3).

**Table 3.** Critical Appraisal and Evidence Weighting

| Study                | Appraisal                  | Interpretive Weight in This EBCR                                                                                                            |
|----------------------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Bell et al. (2018)   | AMSTAR 2: High             | Primary quantitative basis for the conclusions regarding overuse injury risk.                                                               |
| Herman et al. (2022) | AGREE II: Moderate quality | Primary basis for convergent, organization-level preventive recommendations and guidelines.                                                 |
| Carder et al. (2020) | AMSTAR 2: Low              | Supportive quantitative evidence, not used as the sole basis for causal conclusions.                                                        |
| Luo et al. (2025)    | AMSTAR 2: Critically low   | Used to map broad multi-domain outcomes and literature gaps, risk estimates interpreted with caution.                                       |
| Myer et al. (2015)   | SANRA: 11/12               | High-quality clinical context and operational framework, lower clinical hierarchy because of non-systematic search.                         |
| McKay et al. (2019)  | SANRA: 10/12               | Developmental, biological, and mechanistic context regarding maturation, lower clinical hierarchy because search strategy was not reported. |

## DISCUSSION

### Kata Biomechanics and Clinical Translation

The primary findings of this report demonstrate a consistent association between high sport specialization and elevated overuse injury risks, although the independent impact of early initiation remains less clear. To apply this to the patient, the mechanical demands of karate kata must be carefully considered. Kata consists of highly choreographed solo sequences involving repeated deep stances, rapid axial turns, and high-velocity decelerations. Executing these specialized movement sequences year-round without adequate recovery can concentrate mechanical loads on immature growth-related structures, such as the physis, apophysis, and articular cartilage, which are highly vulnerable to repetitive stress. In this context, the patient overweight status (BMI in the 93rd percentile) acts as a significant contextual physical variable. While not caused by his sport participations, his excess body mass physically increases the baseline compressive loads transmitted through his lower-extremity joints during weight-bearing activities. Clinically, this increased mass compounding the repetitive forces of kata may increase lower-extremity mechanical demand. Given the distinct vulnerability of immature growth-related structures, longitudinal monitoring of the athlete growth velocity is crucial. Anticipating the onset of Peak Height Velocity (PHV) allows clinicians to proactively modify training loads, thereby mitigating the heightened risk of apophysitis and physeal injuries that typically emerge during periods of rapid skeletal growth and transient altered biomechanics. This physical convergence underscores the value of prospective movement monitoring and targeted primary prevention over automatic sport cessation.

### Targeted Neuromuscular Training

Importantly, early specialization is generally considered necessary only for a limited number of early-peak sports where peak performance occurs before physical maturity, such as gymnastics, figure skating, and diving (Brenner, 2016; Myer et al., 2015). Karate does not fall into this category and there is no sport-specific evidence requiring specialization from early childhood. To mitigate these risks while preserving kata technical progress, we recommend integrating targeted integrative neuromuscular training (INT) exercises tailored to the biomechanics of kata stances. Specifically, to control dynamic knee valgus during rapid

stance transitions (such as moving into a deep zenkutsu-dachi or forward stance), the patient should perform single-leg squats, eccentric step-downs, and band-resisted side-steps to strengthen the hip abductors and external rotators. To address core-pelvic stability during rapid axial rotations, the training plan should incorporate Swiss ball exercises, such as a Swiss ball bridge, which challenges the transverse abdominis and gluteal complexes to maintain a level pelvis under dynamic arm movement.

### **Psychological Safeguards and Shared Decisions**

The clinical management plan must also address psychological well-being. The meta-analysis by Giusti et al. (2020) found higher scores in all three domains of burnout, emotional/physical exhaustion, reduced sense of accomplishment, and sport devaluation, among specializing adolescent athletes compared with sport samplers. These findings are supported by broader literature showing that specialized youth athletes face an increased risk of anxiety, depressive symptoms, and social restriction (Daley et al., 2023). However, longitudinal evidence suggests that while sport specialization tends to increase as athletes transition from middle to high school, average burnout levels can remain relatively stable over time (Valenzuela-Moss et al., 2024), indicating that the psychological trajectory of each specializing athlete is highly individualized. EAN family background of active karate participation can be a strong source of social support, but it may also create subtle, unintentional pressure that makes it difficult for a ten-year-old child to express a desire for rest (Sawyer & Opel, 2024). To prevent early dropout, clinical management should use shared decision-making that actively includes the child perspective rather than focusing solely on competitive achievements (Sawyer & Opel, 2024). Securing the child assent is an important ethical step that supports his growing sense of autonomy (McKay et al., 2019). Simple, age-appropriate questions should be asked during follow-up visits to evaluate his enjoyment, motivation, and comfort in reporting pain. To ensure psychological monitoring is objective and trackable over time, clinicians should consider incorporating brief validated pediatric tools, such as a modified age-appropriate Athlete Burnout Questionnaire (ABQ) or a simple visual analog scale for sport enjoyment and perceived fatigue, during routine follow-up visits (Giusti et al., 2020).

### **Parental Counseling and Cultural Alignment**

Communicating these recommendations to highly involved parents with a martial arts background requires specific supportive techniques to avoid defensiveness. Martial arts traditions deeply respect the values of discipline and repetitive dedication. Therefore, clinicians should avoid framing recommendations as a restriction or a break. Instead, training adjustments should be presented as proactive elite physical preparation strategies designed to optimize long-term career success and technical mastery. The clinician should explain that incorporating periodized recovery and cross-training builds a broader physical foundation (following the Japanese principle of continuous improvement or kaizen), which ultimately prevents performance plateaus, enhances technical movement quality in kata, and safeguards the child from premature athletic retirement. To ensure this plan is practical, the clinician should coordinate with the child coach to align the planned rest periods with the local competition calendar (Putukian et al., 2026).

### **Clinical Management and Monitoring**

The main goal of clinical management for the patient is to create a safe and balanced training routine that protects his bones and muscles while supporting his growth, without forcing him to quit karate. The structured and patient-centered clinical recommendations and their corresponding monitoring parameters, classified by evidence strength and directness, are systematically summarized in Table 4. First, we recommend documenting 4 to 6 weeks of training frequency, duration, session-RPE, competitions, extra practices, and rest. Health guidelines suggest that a child should not train more hours per week than their chronological age (Myer et al., 2016). Second, we recommend periodized rest, including 1 to 2 days off from karate each week, and taking 2 to 4 months off annually from competition and intense single-sport training (Brenner, 2016; Herman et al., 2022; Putukian et al., 2026). Third, to offset repetitive loading, the child should engage in alternative physical activities or free play during lower-karate periods. Finally, we recommend neuromuscular training (INT) tailored to kata biomechanics. Resistance training in youth has been shown to reduce sports-related injury risks by up to 68% and serve as a positive catalyst for the development of physical literacy to offset the impact of early specialization (Zwolski et al., 2017). Multimodal injury prevention programs that combine strength, balance, and landing mechanics have consistently demonstrated significant protective effects across various pediatric cohorts (Faude et al., 2017; Steib et al., 2017). Specifically, a dose-response analysis suggests that 10–15 minute neuromuscular sessions performed 2 to 3 times per week yield the largest preventive effects (Steib et al., 2017). Additionally, targeted neuromuscular programs have been successfully implemented to reduce specific overuse conditions such as medial tibial stress syndrome in youth athletes (Mendez-Rebolledo et al., 2021).

**Table 4.** Individualized Clinical Recommendations and Monitoring Plan

| Domain                 | Patient-Centered Recommendation                                                                                                                                                                                                                                                                                              | Monitoring                                                                                                   | Evidence Strength and Directness                                                                                          |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Training Exposure      | Document 4 to 6 weeks of frequency, duration, session-RPE, competitions, extra practice, and rest.                                                                                                                                                                                                                           | Weekly review of load, pain, fatigue, and recovery.                                                          | Moderate but indirect evidence (load monitoring principles derived from youth-sport literature).                          |
| Periodization          | Maintain karate with 1 to 2 karate-free days per week and a defined period away from competition or intensive single-sport training.                                                                                                                                                                                         | Calendar adherence, symptoms during load transitions.                                                        | Moderate and convergent guidance (clinical consensus, indirect to prepubertal karate kata).                               |
| Diversification        | Introduce child-selected organized sport or free play during lower-karate periods.                                                                                                                                                                                                                                           | Enjoyment, participation, and whether other activities are being displaced.                                  | Moderate and indirect evidence (supported by youth athlete development literature).                                       |
| Neuromuscular Training | Add 10 to 15 minutes, 2 to 3 times per week of INT tailored to kata biomechanics; include single-leg squats, eccentric step-downs, and band-resisted side-steps for knee valgus control during stance transitions (such as zenkutsu-dachi), and Swiss ball exercises (such as Swiss ball bridges) for core-pelvic stability. | Correct joint alignment during stance transitions, pelvic levelness during rotations, and any pain response. | Indirectly supported but clinically relevant (kata-specific extrapolation from neuromuscular injury prevention evidence). |

| Domain                          | Patient-Centered Recommendation                                                                                                                                                                                         | Monitoring                                                                                                                             | Evidence Strength and Directness                                                                     |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Physical & Psychological Health | Establish baseline pain, ROM, strength, balance, movement quality, enjoyment, motivation, pressure, and burnout symptoms.                                                                                               | Reassess at 6 to 8 weeks, track growth velocity for PHV, and use validated visual scales for sport enjoyment, motivation, and burnout. | Lower-certainty and heterogeneous evidence (psychological outcomes require cautious interpretation). |
| Lifestyle                       | Reduce sugar-sweetened beverages, improve portion awareness, protect sleep, and limit screen time. Initiate basic sports nutrition counseling to optimize body composition and manage lower-extremity mechanical loads. | Serial anthropometry, sleep timing and duration, dietary history, and clinical metabolic review.                                       | Contextual health considerations, not ESS-specific interventions.                                    |

### Methodological Limitations

As a primary limitation, this single-case report cannot validate or establish causal associations at the population level. While the clinical scenario of EAN provides a valuable real-world context for applying and interpreting existing pediatric sports medicine literature, it cannot independently prove that early or high sport specialization caused, or will inevitably cause, an overuse injury in this specific child. Furthermore, the lack of serial objective movement analysis, quantitative training-load data, and longitudinal physiological assessments restricts our ability to monitor subclinical changes over time.

### CONCLUSION

High-level sport specialization among young athletes has been shown to increase the risk of overuse injuries, although the independent impact of the age at which specialization begins remains uncertain. Given the lack of direct empirical evidence regarding prepubescent karate kata specialists, clinical recommendations should be applied cautiously as preventive measures rather than grounds for unilaterally stopping the sport. Karate training for children can be maintained by integrating training periodization, planned rest, movement diversification, neuromuscular training (INT) tailored to kata biomechanics, and periodic clinical monitoring, alongside a shared decision-making process involving clinicians, parents, and coaches.

### AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirm that the manuscript is original, free of plagiarism, and has not been published or submitted elsewhere.

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