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**Quality in Sport. eISSN 2450-3118.**

**Journal Home Page**

**<https://apcz.umk.pl/QS/index>**

**WISOKY, Wiktor, CZAPLA, Natalia, STRUŻYŃSKA, Ewelina, ZIÓLKOWSKA, Weronika, ŁOPIŃSKA, Joanna, MAJCHRZYCKA, Marta, GRACZYK, Martyna, IGNYŚ, Piotr, GRACZYK, Natalia and MAJCHRZAK, Mateusz. Musculoskeletal asymmetries in adolescent fencers: developmental adaptations and injury implications – a narrative review. Quality in Sport. 2026;54:70341. eISSN 2450-3118. <https://doi.org/10.12775/QS.2026.54.70341>**

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).

Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych). © The Authors 2026.

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The authors declare that there is no conflict of interest regarding the publication of this paper.

Received: 28.03.2026. Revised: 30.03.2026. Accepted: 30.03.2026. Published: 05.04.2026.

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**Musculoskeletal asymmetries in adolescent fencers: developmental adaptations and injury implications – a narrative review**

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### **Abstract**

Introduction:

Fencing is an asymmetric sport; when combined with dynamic development in young athletes, in young athletes can contribute to functional imbalances in the musculoskeletal system. In young athletes, unilateral training loads can exacerbate physiological asymmetries associated with growth and puberty, potentially increasing the risk of overload injuries.

Aim of the study:

The aim of this narrative review was to analyse the available literature on the nature of musculoskeletal asymmetries in fencers during their developmental years and their relationship to maturation, and potential injury implications.

Methods:

A review of publications from 2000 to 2025 was conducted using PubMed, Scopus, Web of Science and SPORTDiscus databases. Studies on the population aged 10–18 and works related to biomechanics, biological maturation and injuries in asymmetrical sports, with particular emphasis on fencing, were included.

Results:

The available data indicate that young fencers exhibit asymmetries in muscle strength, range of motion and body segment alignment, especially in the lower limbs, shoulder girdle and spine. Small differences may determine a functional adaptation to the specifics of the discipline, but their magnitude during the pubertal growth spurt may increase the risk of overload injuries, including knee and lower back pain. The limited number of extensive studies makes it difficult to clearly determine cause-and-effect relationships.

Conclusions:

Musculoskeletal asymmetries in young fencers are an adaptive-pathological phenomenon, depending on the stage of biological development and the training load. Early observation of functional parameters and the implementation of correct training should be an integral part of injury prevention in this population.

Keywords:

fencing; youth; musculoskeletal asymmetry; biological maturation; overuse injuries; injury prevention; asymmetrical sport.

## **1. Introduction**

Fencing is a sport with a distinctly asymmetrical biomechanical character. The specificity of this competition is based on a one-sided starting position ('en garde') and the repetitive execution of dynamic lunges, which generate uneven loads on the lower limbs and torso. Biomechanical analyses of lunges indicate significant differences in the generation of ground reaction forces between the lunging and supporting limbs, which can lead to long-term structural and functional adaptations [1,2].

In adult athletes, a certain degree of asymmetry is considered a training adaptation that increases motor efficiency and technical precision [3]. However, adaptive mechanisms may proceed differently during biological maturation. The peak height velocity (PHV) phase is associated with rapid bone growth, while muscle-tendon adaptation may be delayed, leading to temporary muscle imbalance and increased susceptibility to overload [4,5]. The literature emphasises that adolescence is a time of increased risk of overload injuries, especially in sports involving unilateral loading [6].

In addition, hormonal changes during puberty affect body composition, muscle strength and neuromuscular control. Increased sex hormone levels modulate bone mineralisation and muscle tissue remodelling, but at the same time, this period is associated with increased functional instability and impaired motor coordination. As a result, young athletes may be more prone to developing asymmetries that are not only adaptive but also potentially pathological.

The problem of asymmetry in youth sports is attracting growing interest in scientific literature. In many disciplines involving asymmetric movement, such as tennis or baseball, there is a connection between chronic unilateral strain and an increased risk of overload injuries,

especially in the spine, knee joints and shoulder complex. In fencing, however, data on young fencers is limited. Most studies focus on adults or the analysis of movement biomechanics without taking developmental aspects into account. The lack of clear information on the long-term consequences of established asymmetries during periods of intensive growth makes it difficult to develop precise preventive guidelines.

While asymmetry is a natural element of sport, excessive or persistent asymmetry during adolescence may increase the risk of posture disorders, soft tissue overload as well as the development of pain. Therefore, it is crucial to distinguish between functional asymmetry, which supports athletic performance, and asymmetry that can potentially lead to pathology.

The aim of this study was to analyse the literature on musculoskeletal asymmetry in young fencing athletes, with particular focus on developmental adaptations occurring during adolescence and their implications for injury. The review aims to identify the biomechanics that contribute to the development of asymmetry and to estimate their significance in the context of prevention and monitoring of young athletes.

## **2. The biomechanics of fencing and the development of asymmetry**

Fencing is a discipline with a distinctly unilateral movement pattern, in which asymmetry is a functional element of the technique. The repetition of specific positions and movement sequences leads to a fixed, uneven load on the musculoskeletal structures, which in the long term may result in structural and functional adaptations [1,2].

### **2.1 The “en garde” position**

The basic starting position in fencing is the ‘en garde’ stance, characterised by one leg forward and the torso rotated relative to the line of attack. Biomechanical analyses indicate that even in a static position, there is an uneven distribution of muscle tension and load on the hip and knee joints [1,7]. The front limb remains bent at the knee and hip joints, while the rear limb performs a stabilising function and generates the force that initiates movement. The position of the pelvis and the rotation of the shoulder girdle relative to the body axis further reinforce the unilateral nature of the load. Maintaining this position for a long time may contribute to the development of postural asymmetries, especially in the population of young athletes undergoing intensive specialized training [5,6].

### **2.2 Step forward and weight bearing on the forward limb**

The lunge is a key offensive element in fencing and is a movement that generates high ground reaction forces [1,2,8]. The acceleration phase is initiated mainly by the rear limb, while the braking and energy absorption phase primarily loads the lunging limb. Studies using dynamometric platforms have shown significant differences in maximum vertical forces between the front and rear limbs [1].

Repetitive eccentric loading of the quadriceps muscle and knee joint structures can lead to differences in strength, range of motion and neuromuscular stabilisation between the limbs

[9,10]. In young athletes during periods of intensive growth, unilateral overload may further exacerbate the temporary musculoskeletal imbalances characteristic of the pubertal growth spurt [4,5].

### **2.3 Torso rotation**

Fencing technique requires maintaining a rotational position of the torso in relation to the opponent, which involves asymmetrical engagement of the oblique abdominal muscles and back extensors [7]. During offensive actions, dynamic axial rotation occurs, generating uneven load on the lumbar spine. The literature on asymmetrical sports indicates that chronic rotational loads can lead to the development of functional spinal asymmetries and an increased risk of lower back pain [11]. During puberty, when bone and muscle structures undergo intensive remodelling, repetitive rotational loads may contribute to the consolidation of unfavorable postural patterns [5,6].

### **2.4 Unilateral upper limb work**

Operating a weapon requires precise and repetitive movement of one upper limb, involving rapid extension of the elbow joint and controlled rotation of the shoulder joint. Dominance of one side leads to differences in strength, muscle mass and range of motion between the dominant and non-dominant limbs [12,13]. Studies conducted in unilateral sports (e.g. tennis, baseball) indicate that long-term dominance of one upper limb may result in shoulder girdle muscle imbalance and altered internal/external shoulder rotation [12,13]. Similar mechanisms may also occur in young fencers, especially with high training volume and early specialisation.

## **3. Development adaptations of the musculoskeletal system in adolescents**

Adolescence is a critical stage in the development of the musculoskeletal systems, characterised by dynamic bone growth, changes in body proportions and the remodelling of muscle and connective tissues [5,6]. During this time, a temporary imbalance between the rate of bone growth and the adaptation of muscles and tendons is observed, which may affect neuromuscular control and segmental stability [4,6]. In young athletes practising asymmetrical sports, including fencing, the unilateral nature of training loads may exacerbate natural functional and structural differences, leading to the perpetuation of asymmetry [9,14]. These adaptations may be physiological in nature – as the body's response to the specific biomechanical requirements of the discipline – but under certain conditions (excessive training volume, lack of training compensation, pubertal growth spurt) they may be the starting point for the development of overload pathologies [6,5].

### **3.1 Muscle force asymmetries**

Long-term unilateral loads contribute to differences in muscle strength and endurance between the dominant and non-dominant sides [9]. In fencing, the difference in lower limb strength is particularly noticeable – the leading limb is subjected to repetitive eccentric loads during the braking phase of the lunge, while the trailing limb is mainly responsible for generating propulsive force [1,2]. During puberty, there is an increased susceptibility to strength imbalances, which results from uneven muscle mass development and variable motor control.

Persistent strength differences exceeding 10–15% between the limbs may be a risk factor for lower limb injuries, including patellofemoral pain syndrome and overload injuries [10]. However, it should be emphasised that moderate strength asymmetry may be a functional adaptation to the specifics of the discipline and is not always associated with pathology [9]. The degree of asymmetry and its progression over time are of key importance.

### **3.2 Differences in range of motion**

The unilateral nature of movements in fencing contributes to differences in range of motion (ROM) between the sides of the body. Within the shoulder joint, there may be a reduction in internal rotation on the dominant side, a phenomenon also described in other unilateral sports [12]. In the lower limbs, differences in the flexibility of the hamstring muscles and dorsiflexion of the ankle joint are observed [7].

During the growth spurt, rapid bone lengthening can lead to temporary functional shortening of muscles and tendons, which increases the risk of range of motion limitations and tendon attachment overload. While slight differences in ROM may be part of sports adaptation, significant mobility limitations – especially when combined with weakened neuromuscular control – may contribute to the development of overload injuries [4,5,6].

### **3.3 Spinal and pelvic adjustments**

Fencing requires maintaining an asymmetrical starting position ('en garde') and repetitive torso rotation, which can lead to changes in the position of the pelvis and spine [1,7]. Adolescents, whose ossification process is not yet complete, are more susceptible to the development of functional postural asymmetries [14]. Adaptations within the spine may include increased rotation in the lumbar region and asymmetrical tension in the paraspinal muscles. The literature on asymmetrical sports indicates that chronic unilateral loads may contribute to the perpetuation of functional scoliosis or increased segmental rotation. Under physiological conditions, these changes may reflect sport-specific adaptation; however, in the absence of appropriate compensatory exercises, they can lead to chronic lower back pain [6,11].

### **3.4 The role of the puberty surge period**

Peak Height Velocity (PHV) is a stage of intensive linear growth during which susceptibility to musculoskeletal imbalance increases [4,6]. During this period, there is a temporary deterioration in motor coordination, increased stiffness of muscle-tendon structures and greater sensitivity of growth plates to overload [15]. In combination with the unilateral load characteristic of fencing, this may contribute to increased asymmetry and an increased risk of overload injuries, such as apophysitis or knee pain syndromes [10,15]. Therefore, the PHV period should be treated as a phase of special monitoring of young athletes, both in terms of the development of functional asymmetries and the volume of training loads.

### **3.5 Neuromuscular asymmetry and motor control in adolescent fencers**

In addition to structural and strength-related differences, neuromuscular control plays a crucial role in the development and consequences of musculoskeletal asymmetries. Neuromuscular

control refers to the ability of the nervous system to coordinate muscle activation in order to maintain joint stability, postural control, and efficient movement execution.

In asymmetric sports such as fencing, repetitive unilateral movement patterns lead not only to differences in muscle strength but also to the development of side-dominant motor strategies. Adolescent fencers often exhibit preferential muscle activation on the dominant side, particularly during complex movements such as lunges and rapid changes of direction. This may result in altered timing of muscle activation, reduced proprioceptive accuracy, and impaired interlimb coordination [9,10]. Over time, these neuromuscular adaptations may become ingrained, leading to persistent asymmetrical movement patterns that extend beyond sport-specific tasks and influence general motor function.

During the fencing lunge, precise neuromuscular coordination is required to synchronize force generation in the rear leg with controlled load absorption in the lead leg. Disruptions in this coordination may lead to inefficient force transfer and increased mechanical stress on joints, particularly the knee and ankle of the lead limb [1,7]. Furthermore, repeated execution of suboptimal movement patterns may result in cumulative microtrauma and progressive overload of passive structures. In adolescent athletes, these deficits may be further exacerbated by a temporary decrease in motor control observed during periods of rapid growth [3].

Neuromuscular asymmetry is also closely associated with postural control. Studies in youth athletes indicate that asymmetric loading patterns may impair balance and stability, particularly during single-leg tasks [9,14]. In fencing, where athletes maintain a staggered stance and perform rapid forward and backward movements, reduced postural symmetry may increase the risk of instability and injury. Additionally, deficits in trunk stabilization and core control may lead to compensatory movement strategies, further increasing mechanical load on distal segments of the kinetic chain.

Importantly, neuromuscular deficits are not always detectable through traditional assessments of strength or range of motion. Functional tests, such as single-leg hop tasks or movement quality assessments, have been shown to be more sensitive in identifying asymmetries in motor control [9,18]. These tools allow for the evaluation of dynamic stability, coordination, and movement efficiency, which are critical in sports involving rapid and complex actions. Therefore, incorporating functional and neuromuscular assessments into regular monitoring protocols may improve early detection of maladaptive patterns. From a developmental perspective, adolescence represents a critical period for motor skill refinement. However, during the peak height velocity phase, temporary disruptions in coordination may occur due to rapid changes in body proportions and neuromuscular adaptation [3]. This phenomenon, sometimes described as “adolescent awkwardness,” may reduce movement efficiency and increase variability in motor performance. When combined with repetitive asymmetric loading, this may contribute to the persistence of maladaptive movement patterns and increase susceptibility to injury.

Another important consideration is the interaction between fatigue and neuromuscular control. In conditions of accumulated fatigue, the ability to maintain symmetrical movement patterns

may be compromised, leading to greater reliance on the dominant side and increased asymmetry. This is particularly relevant in fencing, where training sessions often involve repeated high-intensity actions with limited recovery. Fatigue-related alterations in neuromuscular coordination may therefore represent an additional mechanism contributing to injury risk.

Therefore, neuromuscular asymmetry should be considered a key factor in the continuum from functional adaptation to injury. Early identification and targeted training interventions—such as proprioceptive training, balance exercises, and neuromuscular control drills—may improve movement efficiency, enhance coordination, and reduce injury risk in adolescent fencing athletes. Integrating these strategies into regular training programs may help maintain an optimal balance between sport-specific adaptation and overall musculoskeletal health.

### **3.6 Long-term musculoskeletal consequences of asymmetry**

While a certain degree of asymmetry may represent a functional adaptation to the specific demands of fencing, prolonged exposure to unilateral loading patterns during adolescence may have long-term consequences for the musculoskeletal system. The persistence of asymmetrical movement patterns and structural adaptations beyond the developmental period may contribute to chronic alterations in biomechanics and movement efficiency later in life.

In sports characterized by repetitive unilateral actions, long-term adaptations have been associated with altered joint loading, muscle imbalances, and asymmetrical distribution of mechanical stress [11,14]. In fencing, repeated loading of the lead leg during lunges may result in cumulative stress on the knee joint, potentially contributing to patellofemoral dysfunction or degenerative changes over time. At the same time, the rear leg, primarily responsible for force generation, may develop distinct neuromuscular and mechanical characteristics, further reinforcing interlimb asymmetry.

The spine represents another region particularly susceptible to long-term asymmetric loading. The rotational demands of fencing, combined with a consistently staggered stance, may lead to persistent changes in spinal alignment and muscle activation patterns. Evidence from asymmetric sports suggests that unilateral loading is associated with an increased prevalence of postural deviations and chronic low back complaints [11,14]. Over time, these adaptations may influence spinal mechanics and contribute to long-term musculoskeletal discomfort.

Upper limb asymmetry may also have lasting implications. Continuous dominance of one arm in weapon handling can lead to muscular imbalances within the shoulder girdle, altered joint kinematics, and side-to-side differences in range of motion [12,13]. In other unilateral sports, such adaptations have been associated with overuse conditions, including tendinopathies and functional limitations. Although fencing involves different movement patterns than overhead sports, similar mechanisms related to unilateral loading and motor dominance may be present.

Importantly, asymmetries developed during adolescence may persist into adulthood if not appropriately addressed. During growth, the musculoskeletal system is highly adaptable, allowing both beneficial and maladaptive changes to occur. However, this period is also

associated with increased vulnerability to overload and long-term consequences of repetitive stress [5,6]. If asymmetrical loading patterns and compensatory movement strategies are repeatedly reinforced, they may become ingrained in long-term motor behavior and structural organization.

Another important factor influencing long-term outcomes is training history, including early specialization and cumulative exposure to asymmetric loading. Young athletes exposed to high volumes of sport-specific training without adequate compensatory strategies may be more likely to develop persistent asymmetries [5]. These long-term adaptations may not only influence performance but also contribute to altered movement patterns and musculoskeletal complaints later in life.

It should be noted that long-term consequences of asymmetry in fencing remain insufficiently explored, and much of the available evidence is derived from other asymmetric sports. This highlights the need for longitudinal studies specifically investigating fencing athletes across different stages of development.

Therefore, understanding the long-term implications of asymmetry is essential for both clinicians and coaches working with young fencers. Preventive strategies should aim not only to reduce short-term injury risk but also to limit the persistence of asymmetrical patterns into adulthood and support balanced musculoskeletal development. Evidence suggests that targeted neuromuscular training and structured injury prevention programs may effectively reduce injury risk and improve movement quality in youth athletes [19,20]. Integrating corrective exercises, monitoring asymmetry over time, and adapting training loads to the athlete's developmental stage may help mitigate the potential negative effects of prolonged asymmetric loading.

#### **4. Traumatic implications**

The unilateral nature of training loads in fencing, combined with the dynamic developmental changes of adolescence, can lead to an increased risk of both acute and overuse injuries. The literature emphasises that young athletes are particularly susceptible to musculoskeletal imbalances, which under certain conditions may contribute to the development of pathologies [6,15].

##### **4.1 Most common injuries among young fencers**

Available epidemiological studies indicate that lower limb injuries are most common in fencing, especially in the ankle and knee joints [3,16]. The lunge mechanism, involving rapid acceleration and deceleration, generates significant ground reaction forces that strain the ligamentous structures and the musculotendinous apparatus [1,2].

An increased incidence of lower back pain is also observed in the adolescent population, which may be related to repetitive trunk rotation and maintaining an asymmetrical starting position

[11,14]. Although many injuries are acute (e.g. ankle sprains), a significant proportion are overload changes that develop gradually.

#### **4.2 Overload injuries**

Overuse injuries are particularly relevant in the context of young people, as bone structures and growth plates are more susceptible to repetitive microtrauma [6,15]. Among young athletes practising asymmetrical sports, an increased risk of patellofemoral pain syndrome, apophysitis (e.g. Osgood-Schlatter disease) and lumbar spine overload has been described [15].

In fencing, repetitive stress on the leading limb can lead to the accumulation of microtraumas in the knee joint, while unilateral work of the shoulder girdle can lead to rotator cuff overload and limited range of motion [12]. The severity of these changes may be particularly evident during the pubertal growth spurt, when the muscle-tendon structures cannot keep up with the dynamic growth of the bones [4,5].

#### **4.3 Relationship between asymmetry and risk of injury**

Sports literature increasingly analyses the relationship between functional asymmetry and injury risk. It has been shown that significant differences in strength or motor control between limbs may increase the likelihood of injury, especially in sports requiring dynamic changes in direction [9,10]. Although slight asymmetry may be a functional adaptation, exceeding a certain threshold (e.g. >15% difference in strength between limbs) is associated with an increased risk of overuse injuries [9]. In adolescents, an additional risk factor is neuromuscular instability during puberty, which can exacerbate the effects of existing imbalances [4,5]. In the context of fencing, it is important to note that structural asymmetries (e.g. in the pelvis or spine) can lead to compensatory changes in the kinematic chain, increasing the load on adjacent body segments [11,14].

#### **4.4 The mechanism of ‘adaptation to pain’**

The process of transition from physiological adaptation to pathology can be presented as a continuum. Initially, unilateral loading leads to beneficial adaptive changes – increased strength, improved specific performance and movement efficiency. In the absence of adequate training compensation and excessive load volume, asymmetry and musculo-fascial imbalance may become permanent [9].

During puberty, when neuromuscular control is temporarily reduced, the risk of overloading passive structures such as ligaments and intervertebral discs increases [4,11,15]. Repetitive microtraumas can lead to chronic inflammation, pain and functional limitations, which in the long term may result in interruptions in training or premature termination of a sporting career [6]. Understanding the mechanism of ‘adaptation to pain’ is crucial for the early detection of adverse changes and the implementation of preventive strategies in young athletes [6,17].

## **5. The importance of monitoring and prevention**

Early identification and control of musculoskeletal asymmetries in young fencers is a key element of injury prevention. Due to the dynamic changes occurring during puberty and the unilateral nature of training loads, systematic monitoring of functional parameters can limit the progression of adverse adaptations and reduce the risk of overload [9,17].

The literature emphasises that an effective prevention strategy in youth sport should include both functional assessment and appropriate modifications to the training programme [17].

### **5.1 Early detection of asymmetry**

Regular assessment of strength asymmetry, range of motion and neuromuscular control allows for the identification of athletes at increased risk of injury [9,10]. Studies on asymmetrical sports have shown that significant differences between limbs (especially exceeding 10–15%) may be associated with an increased risk of overuse injuries [9].

During the growth spurt, monitoring should be carried out more frequently, as rapid bone lengthening and temporary deterioration in coordination may exacerbate functional imbalances [4,5]. In practice, this means that athletes need to be assessed periodically (e.g. every 3–6 months), especially during the intensive growth phase.

### **5.2 Functional tests**

When evaluating young athletes, it is recommended to use simple diagnostic tools. The most commonly used may include:

- single-leg hop tests,
- assessment of isometric or isokinetic strength symmetry,
- analysis of range of motion in the hip, knee and shoulder joints,
- assessment of trunk control and core stability.

Studies indicate that functional tests can detect neuromotor deficits that may not be apparent in static posture assessment [9,10]. In youth sports, it is also recommended to use a battery of movement quality assessments (e.g., movement pattern tests) to identify compensation and asymmetrical movement strategies [18].

In the context of fencing, it is particularly important to monitor differences in lower limb strength and torso rotation control, as these segments are most stressed during lunges and returns to the starting position [7].

### **5.3 Bilateral and compensatory training**

One of the basic elements of prevention is the introduction of compensatory exercises and bilateral strength training aimed at reducing excessive imbalances between the sides of the body [8,9]. The literature emphasises that programmes involving core stabilisation exercises, gluteal

muscle strengthening and proprioception training can effectively reduce the risk of lower limb injuries in adolescents [17].

In the case of young fencers, the following are of particular importance:

- strengthening the non-dominant limb,
- pelvic and trunk stabilisation training,
- exercises to improve ankle and hip joint mobility,
- controlled eccentric training.

The introduction of symmetrical exercises is not intended to eliminate discipline-specific adaptations, but to reduce their potential pathological consequences.

#### **5.4 Training volume control**

Excessive training volume and intensity are significant risk factors for overuse injuries in young people [5,6]. Combining high-frequency training with the pubertal growth spurt, when bone structures and growth plates are more susceptible to overload, is particularly dangerous [4,5,15]. It is recommended to gradually increase training loads and monitor fatigue and pain indicators. In coaching practice, this means avoiding sudden increases in training volume, planning recovery periods, and individualising training programmes according to biological age rather than chronological age alone. Research on injury prevention in youth sports indicates that comprehensive programmes combining load monitoring with neuromotor training can significantly reduce the incidence of injuries [17].

#### **5.5 Practical significance for trainers**

When working with young fencers, it is crucial to monitor and control daily training process. The coach, in a contact with a physiotherapist or doctor, should:

- regularly assess the functional symmetry of the athletes,
- adapt the training programme to the stage of maturation,
- respond to early symptoms of pain,
- include compensatory exercises as a regular part of the training unit.

This approach allows asymmetry to be treated not only as a structural problem, but as a variable parameter requiring systematic monitoring and control.

### **6. Limitations of the study and directions for future analysis**

Despite growing interest in functional asymmetry in sport, the available literature on adolescent fencers remains limited. Most studies focus on adult athletes or include mixed age groups without a clear distinction between stages of biological maturation [3,16]. As a result, the

possibility of directly transferring the results to the youth population is limited, especially in the context of the specific nature of the pubertal growth spurt [4,5].

Another significant methodological problem is the predominance of cross-sectional studies. Single-time analyses do not allow for the assessment of the dynamics of asymmetry changes over time or for the determination of cause-and-effect relationships between the development of functional imbalances and the occurrence of injuries [9]. There is a lack of prospective studies that would monitor young athletes over several years of training, especially during periods of intensive growth.

Another limitation is the lack of standardisation of asymmetry assessment methods. Various measurement tools are used in the literature (isometric and isokinetic strength tests, jump tests, range of motion assessment), as well as different interpretation thresholds defining 'significant' asymmetry [9,10]. This makes it difficult to compare results between studies and to formulate clear clinical recommendations.

Future analyses should include longitudinal studies covering the period before, during and after the growth spurt, taking into account biological age (e.g. PHV index) rather than just chronological age [4], developing uniform criteria for assessing functional asymmetry, and integrating biomechanical assessment with analysis of training loads and injury frequency.

Further research in this area may contribute to a better understanding of the mechanisms of transition from physiological adaptation to overload pathology and enable the development of more precise prevention strategies in the population of young fencers.

## **7. Conclusions**

Available data indicate that musculoskeletal asymmetries in young fencers are a multifactorial phenomenon resulting from both physiological growth and maturation processes and specific, unilateral loads characteristic of this discipline. Moderate functional differences may reflect the body's adaptation to the demands of sport, but their excessive intensity, especially during the pubertal growth spurt, may increase the risk of developing overload injuries.

A review of the literature indicates that puberty is a phase of increased susceptibility to musculoskeletal imbalances resulting from dynamic bone growth and transient changes in neuromuscular control. Combined with high training volume and a lack of compensatory exercises, this can promote a transition from physiological adaptation to overload pathology, manifested by pain, functional limitations and increased injury frequency.

From a clinical point of view, systematic monitoring of functional asymmetries, taking into account the assessment of strength, range of motion and postural control, is of key importance. Early identification of unfavourable imbalances and implementation of appropriate corrective measures – such as bilateral training, core stabilisation or training volume control – can significantly reduce the risk of overload in young fencers.

Early intervention should be an integral part of the sports training process, and cooperation between the coach, physiotherapist and sports medicine doctor is the basis for effective prevention. This approach allows asymmetry to be treated not only as a structural problem, but as a dynamic parameter requiring continuous assessment in the context of the athlete's biological development.

## **Disclosure**

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**Project administration:** Weronika Ziółkowska, Piotr Ignys, Ewelina Strużyńska **Receiving funding:** not applicable

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

**Funding statement:** The study did not receive external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflicts of interest.

**Declaration of generative AI and AI assisted technologies in the writing process:** In preparing this work, the authors used ChatGPT (OpenAI) for the purpose of language editing and grammar correction only. After using this tool, the authors reviewed and edited the text as needed and accept full responsibility for the substantive content of the publication.

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