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Analysis of the Causes and Preventive Intervention Measures for Sports Injuries in Adolescents

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Abstract: Adolescents demonstrate high enthusiasm for sports participation, yet they are prone to sports injuries such as stress fractures and acute muscle strains due to immature physical development, higher risk preference than risk awareness, imbalanced training loads, and inadequate sports supervision. To effectively prevent and promptly intervene, it is essential to organize daily training aligned with individual developmental patterns, dynamically adjust training loads, and provide targeted risk education. Additionally, addressing deficiencies in facilities, equipment, and medical supervision is crucial to ensure adolescents can enjoy sports safely and healthily.

Keywords: Adolescent sports injuries; Injury causes; Prevention and intervention

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1. Introduction

In recent years, the General Administration of Sport of China and other departments have issued documents such as the “20 Guidelines for Scientific Fitness for Children and Adolescents” and organized events like the “Run, Youth! National Youth Sunshine Sports Conference.” These initiatives aim to address issues such as obesity, myopia, physical weakness, and anxiety among adolescents, promoting their active participation in sports. Against this backdrop, physical education curricula and extracurricular sports guidance have been optimized nationwide, leading to increased enthusiasm for physical exercise among adolescents. However, this has been accompanied by a rise in instances of blind exercise and training despite injuries. According to the “White Paper on the Prevention of Sports Injuries in Adolescents” released by the Chinese Medical Doctor Association by the end of 2025, the incidence rate of sports injuries among adolescents in China reached 18.7%. Therefore, to ensure more active and effective participation in sports, it is imperative to objectively analyze the causes of sports injuries in adolescents and implement targeted preventive and intervention measures [1].

2. Common sports injuries in adolescents

According to relevant research, common sports injuries in adolescents primarily include overuse injuries to the epiphysis and growth plates, joint ligament and tendon injuries, stress fractures, and acute muscle strains and delayed-onset muscle soreness. The first category of injuries is most prevalent among adolescents aged 10–14, with a significantly higher incidence rate among boys. Adolescents frequently engaged in running, jumping, and shuttle sports are particularly susceptible to micro-tears, congestion, edema, pain, and swelling at the tibial tuberosity growth plate junction. The second category of injuries typically occurs in specific scenarios. For example, during an 800-meter race, a slight unevenness on the track edge may cause an individual to lose their footing, leading to an instant inward inversion of the ankle and subsequent severe pain on the lateral side of the ankle. The third category of injuries is common among adolescents aged 12–16: boys are more prone to tibial stress fractures due to long-term participation in high-intensity weight-bearing sports like basketball and football, while girls are more susceptible to metatarsal stress fractures due to relatively weaker lower limb muscle strength. The last category of injuries varies significantly in terms of pain duration, intensity, and physical state. However, many adolescents tend to confuse acute strains with delayed-onset soreness, thereby delaying appropriate rest and recovery [2].

3. Multidimensional causes of sports injuries in adolescents

3.1. Physiological causes: Immature structure and function

The manifestations of the four major categories of common sports injuries in adolescents indicate that the causes of these injuries are multifaceted. One significant factor is the physical limitations resulting from immature innate development in adolescents. Specifically, their bones are not fully closed, muscle strength is imbalanced, and neural control is immature, leading to lower exercise tolerance and a higher risk of injury [3]. For instance, Osgood-Schlatter disease is prevalent among adolescents with immature skeletal development. This condition arises because the longitudinal growth rate of bones accelerates significantly, while the growth rates of muscles, tendons, and ligaments lag behind. The growth plates at the ends of bones are relatively immature, structurally loose, and have limited toughness. Without adequate support from soft tissues, bones are prone to congestion, edema, or micro-tears when subjected to traction, compression, and impact. Chronic strain accumulated over time can induce organic damage.

3.2. Training load causes: Specialization overload and insufficient recovery

In addition to innate factors, improper exercise arrangements also contribute significantly to sports injuries in adolescents. Firstly, some schools organize specialized sports training for adolescents whose bodies are not yet fully developed. This leads to repeated stress on specific body parts while neglecting balanced exercise for other areas, potentially inducing issues such as ankle ligament strain. For example, some schools arrange for football specialized students to engage in long-term specialized movement drills such as shuttle runs, directional shots, and single-leg pushes. Their knees and ankles are subjected to high-frequency stress, making them highly susceptible to injuries like patellar tendinitis over time. Secondly, some ordinary adolescents emphasize exercise but neglect warm-up and recovery, allowing body damage to accumulate continuously and eventually inducing stress fractures. For instance, some students preparing for the physical education entrance examination insist on long-distance running and long jumps every day but only perform perfunctory warm-ups before exercise. Muscles and ligaments enter the exercise state without being fully

activated, making them highly prone to strains and sprains [4].

3.3. Psychological and behavioral causes: Overestimation of risk and concealment of hazards

Adolescence is characterized not only by physical development but also by psychological dimensions. These characteristics serve as another factor contributing to sports injuries in adolescents. For example, adolescents' strong competitiveness drives them to deliberately perform actions beyond their physical capabilities to outperform others and win confrontations. In basketball games, they may force jumps and rebounds despite insufficient jumping and balance abilities [5]. Landing with an unstable body center of gravity can easily result in ankle sprains and knee contusions. Due to a desire to save face, adolescents generally are reluctant to admit that fatigue or insufficient physical function has caused sports injuries. They persist in training and competing despite muscle soreness, joint pain, and physical fatigue. This only exacerbates sports injuries, with minor muscle soreness potentially developing into stress fractures.

3.4. Environmental management causes: Substandard facilities and lack of supervision

A review of relevant materials reveals that mismatched sports facilities and equipment, along with a lack of supervision, can amplify physical, training, and psychological vulnerabilities, exacerbating sports injuries in adolescents. For example, the cement-hardened playground of a rural school is old and worn, with the plastic completely peeled off, losing its shock-absorbing capacity. Jumping rope or performing interval runs on such a playground causes all the impact forces generated by exercise to rebound to the weak lower limb areas, such as adolescents' ankles and knees. Repeated and sustained mechanical impact continuously wears down bone tissue, irritates joint soft tissues, and may even lead to micro-fractures in the trabecular bone. Without professional supervision and scientific guidance, adolescents cannot accurately judge exercise loads or correct or stop movements based on field conditions. Continuous exercise only leads to persistent walking pain and limited exercise function [6].

4. Targeted preventive and intervention measures for sports injuries in adolescents

4.1. Strengthening physiological weaknesses: Developmental adaptation and neuromuscular training

The causes of sports injuries in adolescents are multidimensional; therefore, preventive and intervention measures should also be diverse. Firstly, scientific training should be organized in alignment with adolescents' physical developmental rhythms to offset injury risks arising from physiological limitations. Considering that adolescents aged 10–16 have not fully closed bones, high-risk movements such as single-leg pushes, continuous vertical jumps, extreme flexion and extension, and high-intensity sudden stops and directional changes should be actively reduced. For example, high-load knee training contents such as 100-meter full sprints and multiple consecutive standing long jumps should be compressed to 40%–50% of the overall training. Alternatively, they can be replaced with low-impact, low-traction training subjects focusing on posture repair. This way, adolescents can improve the flexibility of their knees and ankles through exercises like steady jogging and pelvic neutral position correction, as well as prevent high-frequency traction of the knee patellar tendon on the tibial tuberosity growth plate.

Simultaneously, synchronized strengthening training focusing on muscle strength balance and neural

control should be conducted. This not only addresses weaknesses in adolescents' weak muscle groups but also enhances their limb control abilities, reducing the risk of sudden sprains and other sports injuries. For example, adolescents generally have stronger anterior muscle groups and weaker posterior muscle groups, particularly weak hamstring and gluteal muscle strength. To address this issue, standardized "prone leg curl training + static glute bridge + posterior chain dynamic stretching" can be organized. The first part of the training consists of three sets of 15 repetitions each; the second part consists of three sets of 40 seconds each; and the final stretching should be controlled within 3–5 minutes. This comprehensive training can gradually correct knee flexion and extension muscle strength imbalances, allowing lower limb joints to bear forces evenly and work together stably. With increased muscle strength, the occurrence probability of acute muscle strains and chronic joint compensatory injuries decreases [7].

4.2. Correcting training load biases: Periodic regulation and forced recovery integration

To avoid sports injuries caused by improper training loads, specialized training should strictly adhere to adolescents' metabolic and tissue repair patterns. For example, a complete training cycle can be defined as 3–4 weeks, with a dedicated deload week at the end of each cycle. During the deload week, an individual's training intensity, volume, and number of sets should be reduced by approximately 30%, but all training content should not be stopped. This approach retains basic exercise states while reducing the compressive load on bone growth plates from extreme sprints and continuous weight-bearing, allowing soft tissues and trabecular bones sufficient time for repair. Within a training cycle, there should be at least one mandatory recovery day per week [8]. On recovery days, high-intensity specialized training, intense ball games, and extreme physical fitness tests should not be conducted. Instead, activities such as fascial relaxation and static stretching, posture correction, core stability training, and low-intensity aerobic relaxation should be performed. This approach can interrupt the accumulation chain of exercise fatigue among adolescents in campus track and field teams, basketball teams, and rope skipping intensive training teams, controlling the occurrence of sports injuries from the root.

For ordinary adolescents not participating in specialized sports training, the starting point for adjusting training loads should be upgrading warm-up modes. Specifically, a 10–15 minute dynamic warm-up that is "gradual, in-depth, and fully activates the body" should be organized based on the characteristics of different sports. Basic warm-up items include, but are not limited to, the first stage of in-place slow running and full-body joint rotations, the second stage of high knee lifts, small strides, and lateral shuffles, and the third stage of dynamic lunge stretches. Through these three stages of warm-up, an individual's basal body temperature increases, muscle viscosity decreases, limb muscle groups and body motor nerves are fully activated, and the activity ranges of core joints such as shoulders, knees, ankles, waist, and hips are opened up. In addition to organizing basic warm-ups, targeted warm-up movements should be added based on the characteristics of sports such as basketball, football, long-distance running, and rope skipping. For example, before basketball games, dynamic warm-ups such as ankle plantarflexion and dorsiflexion activation and knee joint circumduction and flexion and extension should be performed to preheat the core force-generating muscle groups required for basketball movements, helping individuals maintain body stability when performing sudden stops, directional changes, jumps, and landings, thereby avoiding sports injuries. Before long-distance running, it is essential to focus on activating the deep muscle groups of the calves and the plantar fascia, allowing muscles, ligaments, and joints to adapt to high-intensity exercise states in advance [9].

4.3. Rectifying psychological shortcomings: Risk education and self-reporting mechanisms

To address psychological and behavioral issues in adolescents, such as adventurous mindsets and a tendency to conceal fatigue, risk education should be actively conducted, and their self-monitoring abilities should be cultivated. On the one hand, sports training evaluation standards should be actively reformed to reshape a positive sports culture. Specifically, traditional assessment items such as bonus points for training despite illness and full attendance throughout should be eliminated. Evaluation contents such as self-examination of body state, proactive risk avoidance, and scientific and standardized training should be added. Moreover, the proportion of these newly added parts in the physical education literacy assessment index system should not be lower than 15%. When introducing new assessment standards, clear guidance should be provided with case studies: attractive sports behaviors involve adjusting exercise strategies based on one's exercise state and competitive level to avoid sports injuries. This can also prevent individuals from taking collective actions due to fatigue. It enables individuals to intuitively recognize the potential risks of concealing injuries and forcing participation in training [10].

On the other hand, systematic pain grading education should be conducted to help adolescents accurately identify physical feedback after exercise. Specifically, if an individual experiences overall muscle soreness, body stiffness, and slight force generation lag within 24–72 hours after high-intensity exercise, it is likely physiological delayed-onset muscle soreness. This usually represents a normal metabolic repair reaction of muscle fibers and can be alleviated through rest, stretching, and relaxation without excessive concern. However, if there is localized pressure pain in bones, stabbing pain during joint flexion and extension, sharp pain during ligament traction, or local swelling and fever, it is basically determined that micro-tears or inflammatory damage have occurred in the growth plate, tendons, or ligaments. If training continues, the damage will continuously accumulate. For such pathological injuries, adolescents should immediately report to teachers or coaches and actively cooperate with body repair to prevent reversible micro-injuries from developing into complete stress fractures. Teachers, coaches, etc., should publicly praise individuals who actively report sports injuries, stop subsequent training, and organize scientific repair activities. Through positive demonstrations, all students can be guided to transform their psychological perceptions of sports injuries and sports risks.

4.4. Filling environmental gaps: Standardized facilities and equipment, and a medical supervision grid

In addition to the aforementioned three measures, addressing deficiencies in facilities, equipment, and supervision is also a necessary step to ensure the safety of adolescents in sports. In terms of facility renovation and construction, buffer coefficients, ground friction, and flatness should be used as indicators to eliminate extensive management issues, such as using facilities despite defects and repairing them only after damage occurs. Specifically, the buffer coefficient of standard plastic sports fields should be controlled within 35%–50%, with a dry-state friction coefficient of the ground ≥ 0.5 and an overall flatness error $\leq$ 3mm/2m. Such sports fields meet the construction specifications for primary and secondary school sports fields and can protect adolescents' immature bones and lower limb joints during running and jumping. In terms of equipment adaptation, the fact that adolescents' foot bones are not yet fully formed and their arches are not fully developed should be fully considered, and footwear and protective gear should be selected based on the actual exercise needs of the sports. For example, adolescents participating in endurance sports

such as long-distance running and rope skipping should be equipped with professional shock-absorbing running shoes with higher shock absorption levels, more solid arch support, and flexible and durable soles. Adolescents participating in sports requiring sudden stops, directional changes, and lateral confrontations, such as basketball and football, should wear specialized ball shoes with stronger wrapping and anti-torsion soles. Meanwhile, schools and sports training institutions should also establish a comprehensive supervision network. Specifically, full-time sports protection personnel and medical teams should inspect physical education curricula, sports activities, and sports training to promptly correct non-standard movements, control training loads, and halt dangerous sports behaviors. Through multi-faceted interventions, the risks of various sports can be minimized.

5. Closing remarks

Exercise is a crucial pathway for enhancing the physical fitness of young people, improving their sports skills, and cultivating their mental resilience. Avoiding sports injuries to the greatest extent possible is the key to ensuring the sustainability of exercise. To this end, relevant entities should fully consider the physical and mental development of young people, optimize relevant measures based on existing training and sports support conditions. By implementing reasonable training content, scientific training methods, a positive sports culture, and robust management support, the contradiction between high enthusiasm for sports among young people and the high incidence of sports injuries can be resolved.

Disclosure statement

The author declares no conflict of interest.

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