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Physical culture as a key to post-injury recovery in sports: Methods and future perspectives

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ABSTRACT

Sports injuries are a significant concern affecting both health and athletic performance, especially among adolescents, whose participation in organized sports continues to increase. This study explored the role of physical culture in post-injury recovery within a sports context, with a particular focus on adolescent athletes. Using content analysis and elements of grounded theory, the research examined current best practices and practical rehabilitation techniques. The findings indicated that the high incidence of sports-related injuries among adolescents is closely linked to their physiological development, as their musculoskeletal systems are still maturing. The study presented a classification of the most common injuries in this age group and highlights the growing demand for adolescent physical therapy due to rising injury rates. Based on systematic reviews, meta-analyses, and empirical studies, the results demonstrated that physical culture-based exercises and integrative rehabilitation programmes offer substantial benefits for recovery—particularly from concussions, spinal cord injuries, and knee injuries. As a key contribution, the study proposed a conceptual model outlining the relationship between components of effective integrative rehabilitation training programmes for adolescents, grounded in the principles of physical culture.

KEYWORDS

Rehabilitation after Injuries; Adolescents; Sports; Physical Culture; Young Athletes

1. INTRODUCTION

Adolescents' primary health issue is injury. The nation's most significant cause of lost years of potentially productive life and the leading cause of mortality among adolescents are injuries. Additionally, non-fatal injuries are highly prevalent, leading to expensive medical care expenses, numerous doctor visits, and hospital admissions. Teenagers are particularly at risk on the road, where they frequently experience injuries as bikers, walkers, motorcyclists, and car occupants. These injuries are frequently caused by alcohol and other substances. Numerous long-term impairments are caused by head and spinal cord injuries. Teens typically suffer non-fatal injuries when participating in sports at school. Adolescents are less likely than younger children to sustain injuries at home.

According to Australian researchers, hundreds of children and teenagers in Australia visit emergency departments (EDs) or are admitted to hospitals each year due to injuries or poisonings. Children and adolescents are characterised by more vulnerability to various damage mechanisms as they mature and develop. In Australia, 603,675 emergency department visits and 88,766 hospitalisations for injuries among children and adolescents were recorded in 2020-2021. According to the data presented by AIHW (2024), this accounted for 28% of all ED presentations. Compared to adults, several age groups are more likely to sustain head injuries, drowning injuries, or submersion injuries. In particular, the likelihood of hospitalisation for transport-related injuries was 1.6 times higher for teenagers aged 16-18 and 1.4 times higher for adolescents aged 13-15 (AIHW, 2024). According to estimates, injury hospitalisations cost Australia $212 million a year and rank third in terms of the burden of illness for children and adolescents ages 0 to 19 (AIHW, 2022). Naturally, this predicament is not unique to Australia. About 30 million kids and teenagers play organised sports in the United States, and each year, over 3.5 million injuries occur among players, resulting in some loss of playing time (AIHW, 2024). Sports involving contact and crashes have the most significant injury rates. Recreational activities and individual sports are associated with more serious injuries.

Ukrainian scientists Hrebik et al. (2023) describe a study in which handball students of grades 8-11 of Lutsk (Ukraine) comprehensive school participated. With the consent of the athletes' parents, entries in the medical records of children involved in handball were studied. A total of 42 athletes were included. The study results showed the most significant number of medium and severe injuries

was in the 8th grade. Medium-severity injuries accounted for 50.0%, and severe injuries accounted for 37.0% of all cases of their occurrence. Moreover, the smallest number of injuries was of mild severity, only 13.0%. Researchers suggest that the small number of mild injuries is primarily because they were not given due importance and were not officially registered (Hrebik et al., 2023). When determining the frequency of cases and localisation of traumatic injuries, it was found that dislocations, sprains, deformations and injuries of the ligaments of the joint and adjacent muscles prevail. Sprains are most common in school handball players. A total of 33.3% of such injuries were found. The main number of them falls on ankle injuries. The causes of such injuries are most likely jerks, stops, and changes in direction of movement (Hrebik et al., 2023).

Sport-related injuries hold a special position among injuries sustained by teenagers. Since most sports are not tailored to the motor capabilities of their particular age group, children and adolescents are particularly vulnerable to accidents (Parry et al., 2024). As a result, teenagers play by adult rules and the equipment is not sized enough for them (Rodrigo et al., 2014). For instance, basketball baskets come in just one height, and practically all sports only utilise one size of ball, which is the adult size (Sheehan et al., 2024). However, injuries, especially to teenagers, can hinder their development and have long-term consequences.

Two types of sports injuries are distinguished:

1. Acute traumatic injuries include broken bones, strained muscles, tendons or ligaments, bruises, concussions, and wounds. They usually occur after a blow or collision.

2. Overuse-related injuries imply injuries such as stress fractures and tendonitis (tendon inflammation). These injuries are also considered chronic because they develop over time from repeated stress, which is usually their main cause.

Additionally, this age group frequently exhibits missing injuries or missed opportunities for recovery. Even minor injuries might increase the likelihood of more serious ones. A minor ankle injury, for instance, is not a significant concern. A few days later, it is possible to observe that the youngster can engage in training with little discomfort. The problem with these kinds of injuries is that they might cause ankle stiffness, weakness, and poor balance after the event (Zheng, 2024). They have a greater chance of developing more serious ankle sprains in the future if they are not recognised and treated. A licensed physiotherapist evaluates the injury, determines the underlying causes, and creates individualised treatment regimens to restore function and prevent re-injury. Some

examples of treatment techniques include manual therapy, therapeutic exercises, neuromuscular re-education, and rehabilitative strength necessary to resume sports safely.

Comprehensive diagnostics and rehabilitation of adolescents, including young athletes, after injuries, is one of the most important problems of pediatric and sports medicine. The emergence of modern diagnostic equipment (computer optical topography, stabilometry, magnetic resonance imaging) and new approaches to rehabilitation therapy for disorders of the musculoskeletal system in adolescents create the need to monitor their health and corrective rehabilitation programmes for diseases and injuries of the musculoskeletal system, including in young athletes.

The rehabilitation process, as a rule, implies several conceptual stages (Joyce & Lewindon, 2015):

1. Pain management: Reducing pain and inflammation is frequently the first step in rehabilitation.

2. Range of motion restoration. After managing pain, attention turns to enhancing the range of motion and flexibility in the damaged region.

3. Strengthening. When mobility has returned, the next goal is to strengthen the injured region. By restoring muscular strength, targeted workouts reduce the likelihood that the injury will repeat.

4. Functional training. This stage entails mimicking the precise motions associated with the sport. Preparing the body for physical exercise demands lowers the chance of re-injury.

5. Education and prevention: If athletes are to succeed in the long run, they must be taught correct technique and injury avoidance.

Physical culture and sports rehabilitation currently occupy a special place among all types of rehabilitation. This system of measures uses physical exercises to restore an individual's health and aims to restore and compensate, through physical culture and sports, the body's functional capabilities to improve the physical and psychological state (Ishchenko et al., 2023; Popovych et al., 2022).

Physical education and sports rehabilitation should be considered as a medical and pedagogical process that uses a complex of medical and rehabilitation means, the main of which are physical exercises and elements of sports, and their application is always a pedagogical, educational process (Costa e Silva et al., 2022). Physical exercises have a positive effect on physical education

and sports rehabilitation when, firstly, they are adequate to the patient's capabilities, and secondly, they have a training effect and increase adaptive capabilities, provided that the methodological rules and principles of physical training are taken into account (Joyce & Lewindon, 2015). The essence of training lies in multiple, systematically repeated, and gradually increasing physical activity, which causes positive functional and sometimes structural changes in the human body. On the one hand, new or existing motor skills are formed and strengthened; on the other hand, various physical qualities (strength, endurance, speed, flexibility, agility), which determine the body's physical performance, are developed and improved. Thus, researching the role of physical education in rehabilitation after injuries, practical approaches, best practices, and prospects is relevant to medical and pedagogical/psychological science and is the goal of our scientific exploration.

Some academics say adolescence is a critical time for physical development, characterised by quick growth spurts and increased athletic involvement (Joyce & Lewindon, 2015; Caine & Purcell, 2016). Strains, sprains, fractures, as well as overuse-related injuries such as stress fractures and tendon injuries, are common sports injuries among teenagers (Abrahames, 2013).

Researchers also took into account the gender-specifics of injuries in teenagers. Specifically, Habelt et al. (2011) describe a sample of 4468 injuries among teenage patients in the United States over ten years; 32.88% were females, and 66.97% were boys. Football-related injuries (31.13%) were the most common sports injuries, followed by handball (8.89%) and school sports (8.77%); 68.71% of the cases involved the lower extremities. Among the patients, 1.99% had brain injuries, 2.57% had spine injuries, and 29.79% had knee issues. Most injuries were ligament rips (18.76%) and distortions (35.34%); fractures accounted for 9.00% of all injuries. Male patients had more skin wounds (6:1) and fractures (7:2) than female patients. Skiing was the activity with the highest risk of ligament tears. Knee issues resulted from three out of four ski injuries. The most common reason for spine injury was riding a horse (1:6). Bicycle accidents resulted in head injuries (1:3). Male patients experienced head traumas much more frequently than female patients (21:1). Fractures were observed during school athletics (1:11), football (1:9), skiing (1:9), and inline (2:3). Many teenagers play a variety of sports. It is undeniable that many athletes suffer from musculoskeletal injuries, some of which are severe, notwithstanding the methodological issues with epidemiological data (Alcock et al., 2024).

In the aforementioned study by Habelt et al. (2011), all patients with sports injuries treated in the sports clinic over a ten-year period were recorded in a specifically created computer software. A

table summarising the findings revealed the location of gender-specific sports injuries among 4468 teenagers (up to 19 years old) (Table 1).

Table 1. Gender-specific location within 4468 sports injuries

	Male	**Female**	**Total**
Head	85	4	89
Spine	65	50	115
Chest	16	3	19
Pelvis	38	8	46
Wrist	114	43	158
Shoulder	199	53	254
Upper arm	14	5	19
Elbow	72	55	127
Ankle	756	316	1073
Forearm	51	17	68
Hip	16	2	18
Hand	110	30	140
Finger	224	139	363
Knee	773	557	1331
Thigh	130	58	188
Foot	123	72	196
Lower leg	149	35	185
Toes	57	22	79
Total	**2992**	**1469**	**4468**

Source: Habelt et al. (2011)

The researchers discovered that most injuries happened while participating in one of the most popular European sports: soccer. Soccer accounted for 31.13% of all injuries, followed by handball (8.89%), school-related sports (8.77%), skiing (5.95%), and riding (5.71%) (Habelt et al., 2011). Upper extremities were implicated in 25.27% of injuries, lower extremities in 68.71%, spines in 2.57%, and heads in 1.99%.

Other researchers have argued that children and adolescents may be more vulnerable to sports-related injuries due to inappropriate technique, muscular weakness, and poor proprioception, with boys suffering twice as many injuries as girls (Mountjoy, 2015; Brown et al., 2017). However, according to other research, a variety of physiologic and physical changes that afflict all girls during puberty contribute to female adolescents having much greater injury rates than age-matched male athletes (Grinberg et al., 2024). Adolescent female athletes are more susceptible to injury due to pubertal changes, which include reduced neuromuscular surge at puberty (compared to males); female athlete trifecta (osteoporosis, eating disorders, and amenorrhea); broad hip-to-knee relation (Q

angle); leaping with quadriceps and landing forcefully; running upright; loose joints; playing sports without conditioning; growth plate and joint development; ligament and tendon characteristics; neuromuscular fatigue; tendon reaction to activity; exhaustion of the central nervous system (Potash, 2019). According to studies, neuromuscular training (NMT) can assist female athletes deal with these issues. Adolescent athletes who cross-trained or played more than one activity may experience fewer sports injuries (Ling et al., 2022). NMT aims to stabilise the knee and increase the capacity to create a quick and optimum muscle firing pattern by enhancing joint stability during athletic activity. Neuromuscular training is based on physical therapy rehabilitation techniques following an accident or surgery.

According to the Centers for Disease Control and Prevention (CDC), over 30 million kids and teenagers play organised sports in the US, which is growing. Unfortunately, the number of juvenile sports injuries is also rising: 2 million high school teens and 3.5 million children under the age of 14 are anticipated to get medical care each year for sports-related injuries (Ryan et al., 2019). However, according to the CDC, most of these injuries are preventable (Potash, 2019). In this context, NMT is seen by CDC experts as a rehabilitation tool and injury prevention method. Zech et al., back in 2009, attempted to evaluate the effectiveness of proprioceptive and neuromuscular training (PT/NT) for treating ankle, knee, and shoulder joint injuries. The authors' comprehensive evaluation found that PT/NT was valid in conservatively treating anterior cruciate ligament injuries, improving functioning, and reducing the frequency of recurrent injuries and “giving way’ episodes following ankle sprains. However, for lower extremity strength, neuromuscular control, joint laxity, joint position sensing, and static postural control, training was either ineffective or had inconsistent outcomes (Zech et al., 2009). Overall, the authors concluded that proprioceptive and neuromuscular therapies following injuries to the ankle and knee joints can be beneficial for improving joint functioning and preventing further injuries.

Additionally, physiotherapy is essential to treating and recovering teenage sports injuries. Seeking a physiotherapist's advice is crucial; regardless of the severity of the injury - , a mild ankle sprain requires less intervention. In contrast, a more serious injury necessitates more time for rehabilitation (Costa e Silva et al., 2022).

A physiotherapist can use the intervention mapping (IM) methodology to create an after-injury rehabilitation programme. This entails a methodical procedure that outlines six phases for creating hypotheses and evidence-based health promotion initiatives. Physiotherapists may use this

six-step method (Figure 1) to help create a variety of preventative programmes, such as preventing accidents and injuries in teenagers caused by physical activity (Joyce, 2015).

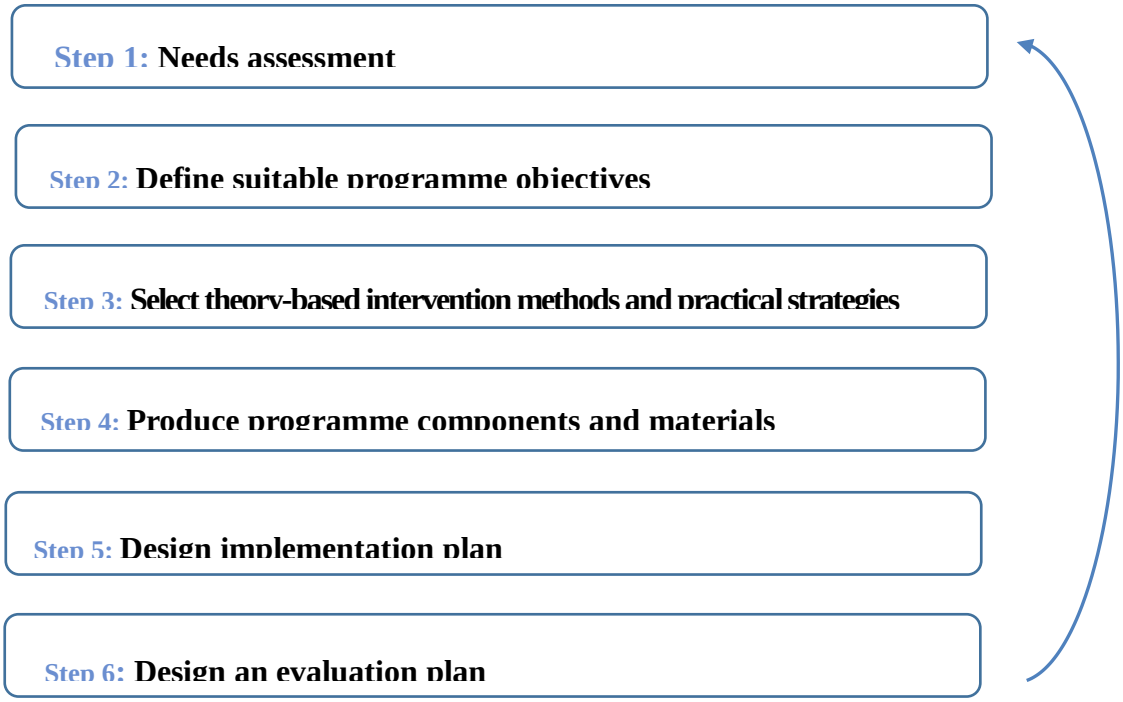

Figure 1. Six-step process of after-injury rehabilitation programme intervention mapping
Source: Joyce (2015)

Although there are many results of empirical studies and systematic reviews devoted to physical therapy interventions within rehabilitation after injuries, this scheme seems to be the standard framework, combining theoretical approaches, individual peculiarities of the case, programme components breakdown, and evaluation of effectiveness.

2. METHODS

This study employed a qualitative research design based on content analysis and elements of grounded theory. Content analysis was used to systematically examine a wide range of academic literature, including systematic reviews, meta-analyses, and empirical studies related to sports injuries and rehabilitation in adolescents. The approach enabled the identification of recurring patterns, themes, and concepts relevant to physical culture-based recovery practices.

The sample of documents was selected through theoretical sampling, consistent with the grounded theory framework. This allowed for iterative data collection and analysis, where coding and categorization were conducted concurrently. Initial open coding was followed by axial coding to identify key themes, and finally selective coding was used to refine core categories. The analysis focused particularly on the role of physical culture in rehabilitation outcomes and the integration of multidisciplinary practices.

All data were coded manually, and memos were used to support the emergence of conceptual connections. The credibility of the findings was enhanced through peer discussion and triangulation with existing theoretical models in sports rehabilitation.

3. RESULTS AND DISCUSSION

The kind and locations of injury, primarily seen in teenagers, may be summarised from several studies (Del Ciampo et al., 2012; Eapen, 2014; Habelt et al., 2011). One of the classifications is given in Table 2.

Table 2. Classification of type and site of injury, predominantly observed in adolescents (in descending order)

Age	Type of injury	Site of injury
13-15	- Intracranial injury - Dislocation - Soft tissue injury - Fracture - Superficial injury - Other unspecified	- Shoulder and upper limb - Ankle and foot - Hip and lower limb - Wrist and hand - Injuries not described in terms of body location - Head and neck
16-18	- Fracture - Intracranial injury - Dislocation - Soft tissue injury - Superficial injury - Crushing injury - Open wound	- Injuries not described in terms of body location - Ankle and foot - Wrist and hand - Shoulder and upper limb - Head and neck - Other, multiple and incompletely specified body regions

***Source**: Guzzanti (2014)*

Caine & Purcell (2016) present a more generalised classification of adolescents' most common sports injuries (Table 3).

Table 3. Frequent types of injuries in adolescents and their description

Type of injury	Description
Strains and sprains	The most frequent sports-related injuries are sprains and strains. A sprain damages the tissue that joins two bones, whereas a strain is an injury to the tissue or muscle that links the muscle to the bone. Both experience discomfort, swelling, and bruises.
Overuse-related injuries	In addition to the additional physical activity students engage in during gym class or socialising with friends, sports need a significant amount of training and practice. Stress fractures and other overuse ailments might result from these endless hours. When a patient's muscles cannot withstand the strain of physical exercise, the bones are subjected to stress fractures. As a result, the bone becomes stressed, and stress fractures - , tiny breaks, or cracks - may form. Although stress fractures can occur from playing any activity, they are more common in sports that involve a lot of running and leaping, including basketball, track, and gymnastics.
Growth plate fractures	The growth plate is the most vulnerable area of the body to fracture. This is because preteens' and adolescents' bones are still growing. The growth plate is where cartilage tissue is near the end of a bone. As the adolescent becomes an adult, this cartilage solidifies into hard bone in a process called ossification.
Neck and head injuries	Head and/or neck injuries are the most deadly kind of sports injuries. Devastating injuries can result from high-contact sports like football and hockey or from games that need adolescents to be in the air, such as gymnastics or pole vaulting.

Source: *Caine & Purcell (2016)*

These classifications can be depicted schematically (Figure 2).

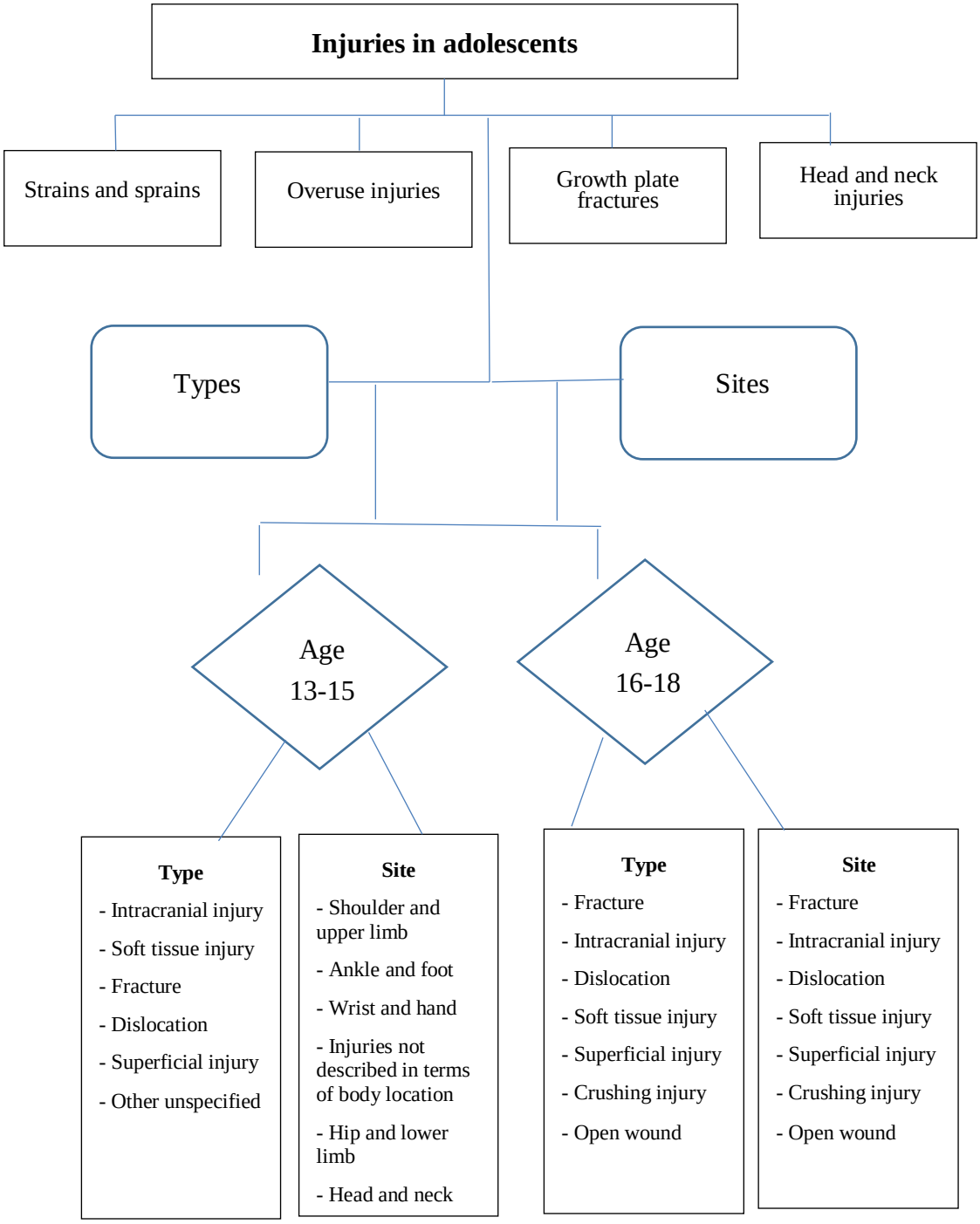

Figure 2. General classification of frequent types of injuries in adolescents

Source: *Developed by the author based on Guzzanti (2014); Caine an Purcell (2016)*

Physical therapy is an essential part of the all-encompassing treatment strategy for these injuries. It entails evaluating, diagnosing, and treating musculoskeletal injuries to regain function,

strength, and mobility, as per the conceptual system shown in Figure 1 above. Many phases in this framework determine the purpose and makeup of a physical culture programme:

- Assessment and diagnosis. A comprehensive examination to determine the degree of the injury and its effect on the adolescent's physical function is the first step in physical therapy. This might entail several examinations, including functional movement analysis, strength testing, and range of motion evaluations. A precise diagnosis is established based on the evaluation results, which directs the creation of a customised treatment strategy (Houglum et al., 2022).

- Pain management. Adolescents who sustain sports injuries frequently experience pain and suffering. To successfully manage pain, physical therapists use a variety of modalities and procedures, including electrical stimulation, manual therapy, cold and heat therapy, and therapeutic exercises. During rehabilitation, physical therapy helps the teenager feel more comfortable and healthier by treating their discomfort (Houglum et al., 2022).

- Restoring strength and range of motion muscle weakening and range of motion loss are frequent outcomes of sports injuries. Physical therapy interventions aim to restore strength and flexibility in the afflicted regions through gradual strengthening exercises, joint mobilisations, and stretching activities. Physical therapy helps teenagers restore function and safely resume their athletic activities by progressively restoring joint stability and muscular strength (Pustovoit, 2023).

The phases of musculoskeletal injury rehabilitation should be understood as the healing phases, the transitions between phases, the preservation of cardiovascular fitness during rehabilitation, and the progression of objectives that need to be fulfilled prior to returning to sports participation.

Physical therapy focuses on functional rehabilitation, which entails teaching the teen how to carry out daily duties and sports-specific motions, in addition to treating particular impairments brought on by injuries. This may involve agility drills, balance and coordination exercises, and sport-specific training to enhance biomechanics and lower the chance of future injuries. Education is another crucial component of physical treatment for teenage sports injuries. Physical therapists teach teens and their parents about the type of injury, how to move their bodies properly, and how to avoid being hurt again. This might entail discussing the value of warm-up and cool-down exercises, appropriate form when playing sports, and the part rest and recuperation play in preventing injuries.

Physical therapy therapies, such as aerobic exercise and multimodal approaches, have been proven to help treat adolescent and young adult athletes after a concussion, according to the

systematic review by Art et al. (2023). Compared to standard physical and cognitive rest therapy, aerobic or multimodal therapies for this population enable a speedier recovery from symptoms and return to sport. For individuals who have experienced a concussion, physical therapy interventions, such as aerobic interventions or multimodal approaches, provide benefits in recovery time and a decrease in symptoms following the injury. In addition to allowing for an earlier return to play and/or shorter healing times, physical exercise and physical therapy as soon as a few days after injury are thought to be safe for treating post-concussion symptoms.

Teenagers with knee injuries treated with arthroscopy can benefit from physical therapy, according to Catan & Negru (2020). Approximately three weeks following the injury, an arthroscopy was conducted. Following chondral fractures, the cartilage or meniscus pieces were removed, and the meniscus tears were treated conservatively. The patients were then directed to the Rehabilitation Department and underwent the physical exercise regimen. Passive knee range of motion, wall slides, passive heel slides, quadriceps and hamstring isometrics, heel lifts, half squats, low-resistance stationary cycling, and gait training comprised the exercise programme (Figure 3). The patients continued their ten sessions with a programme that included supervised exercises, such as mini-squats, closed-chain exercises, balance activities, balance boards, stair-stepping, and treadmills, three times a week for ten weeks. The patients were evaluated at the start of rehabilitation and again after three months for knee ROM (flexion and extension deficiency) and subjective evaluation by the International Knee Documentation Committee (IKDC). At the final examination, all patients significantly improved knee range of motion and functional ability. The best outcomes were observed in teenagers with meniscal lesions (Catan & Negru, 2020).

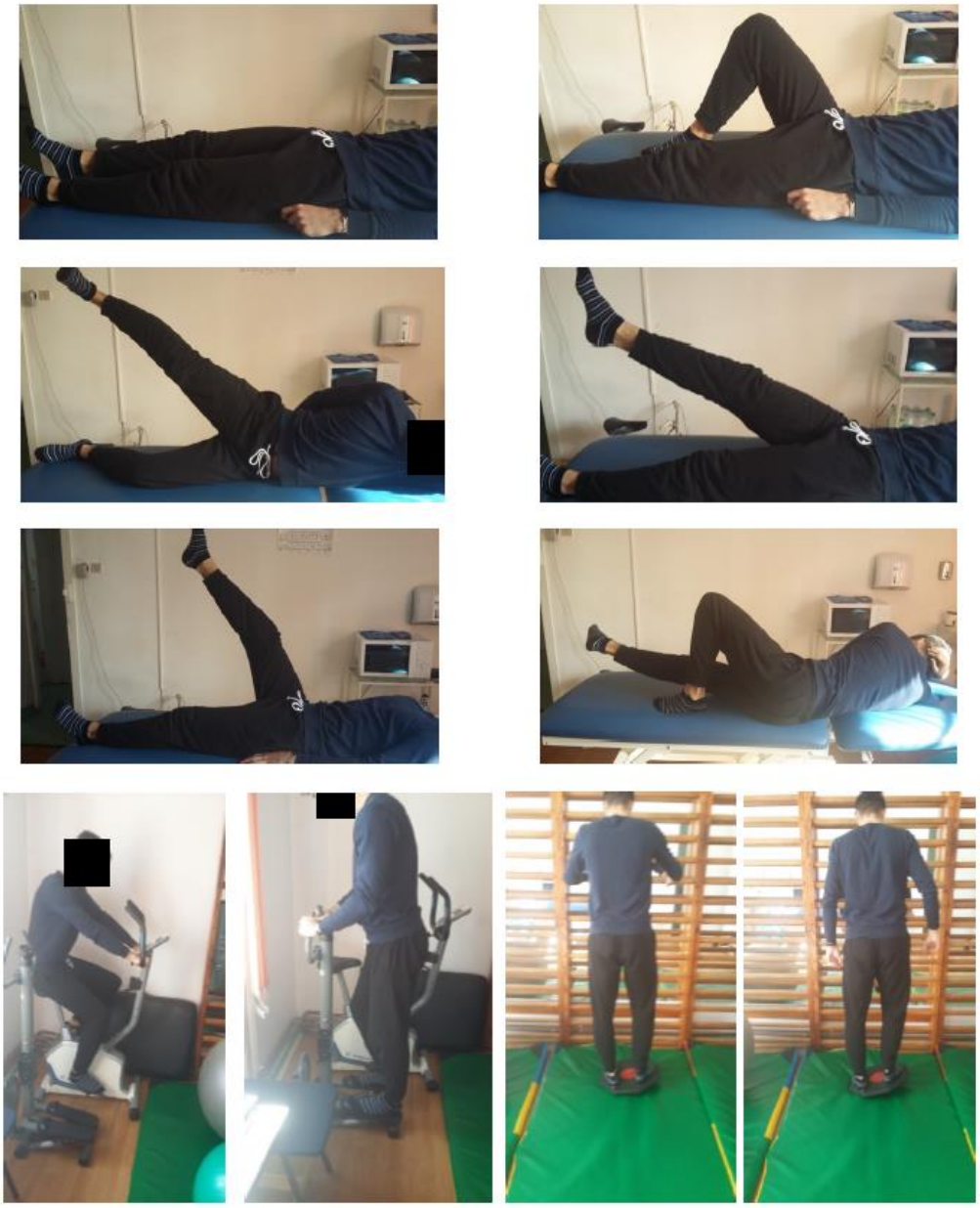

Figure 3. Options of rehabilitation exercises within physical therapy in adolescents with knee injuries treated with arthroscopy

Source: *Catan & Negru (2020)*

Understanding frequent knee injuries in young athletes, including anterior cruciate ligament (ACL) injuries, patellar tendinitis, meniscal tears, and Osgood-Schlatter disease, allows for appropriate treatment and the development of an effective physical culture rehabilitation programme. The rehabilitation period after therapy is critical for the complete healing of young patients with knee injuries. Exercises, manual treatments, and functional training are commonly used in rehabilitation

programmes to improve strength, mobility, and range of motion. At the same time, more serious knee injuries may imply the necessity of surgical treatment. Orthopaedic doctors perform ACL reconstruction, meniscus repair, and patellar realignment surgery to treat particular injuries or disorders. Following surgery, a comprehensive rehabilitation programme is essential to promote healing, restore function, and avoid future issues. The alignment of rehabilitation tools with common knee injuries in adolescents and their treatment is presented in Table 4.

Table 4. Alignment of rehabilitation tools with common knee injuries in adolescents and their treatment

Common Knee Injuries in Children and Adolescents	Treatment	Rehabilitation
ACL tear	Surgical repair (ACL reconstruction)	Physical treatment to recover strength and flexibility.
Meniscal tear	Arthroscopic surgery aimed at repairing or removing the damaged meniscus	Rehabilitation activities aimed at increasing joint stability and function.
Osgood-Schlatter disease	Conservative type of management (rest, physical therapy)	Strengthening the quadriceps and hamstrings

Source: *developed by the author based on Molony et al. (2022)*

Duran et al. (2001) investigated the impact of an exercise programme on the rehabilitation of individuals with spinal cord injuries. Patients completed a 16-week fitness regimen consisting of three weekly 120-minute sessions. They did mobility, strength, coordination, aerobic resistance, and relaxation exercises. Mobility exercises, aerobic resistance, strength, coordination, enjoyment, and relaxation were all integrated. Some sessions featured water-based exercises. The aerobic programme lasted 11 weeks, with a 4-week adaptation and a 1-week augmentation period. The programme considered the distance travelled and the time spent doing activities such as progressive movements, circuit training with light weights, repetition, and activities that raised the heart rate to the target level. Initially, sessions lasted 15 minutes; however, depending on individual tolerance, the sessions were gradually raised to 40 minutes of aerobic exercise, with the goal heart rate gradually increasing from 40% to 80% of the maximum heart rate. Duran et al.'s study included patients with an average age standard deviation (SD) of 29 ± 13.3 years, including one male participant (17 years old) and one female person (15 years old). Comparison of the values at the beginning and end of the programme showed that patients demonstrated a significant increase in the following parameters: average Functional Independence Measure (FIM) score; weight lifted in the bench press exercise (46%), military press (14%), and butterfly press exercise (23%); number of repetitions for biceps (10%),

triceps (18%), shoulder abductors (61%), abdominals (33%), and curl back neck exercise (19%). The authors found that the guided exercise programme had a beneficial influence on the majority of the variables in the research (Duran et al., 2001). A description of the strength exercise programme is presented in Table 5.

Table 5. Description of the strength exercise programme on the rehabilitation of patients with spinal cord injury

Element of the programme	**Description**	
	Objective	**Position**
Bench press	To make the pectoral muscles stronger	Supine decubitus: passive flexion of knees and hips performed by the instructor. Shoulders abducted 90 degrees, elbows flexed 80 degrees. The bar is held with the corresponding weights and raised until the elbows are fully extended.
Military press	To strengthen the intermediate sections of the deltoid muscles and the superior parts of the trapezius	Sitting position, straight back. Shoulders abducted 45° and externally rotated 90°, elbows flexed 110°, and forearms pronated. The bar is held with the corresponding weights and raised until the elbows are fully extended.
Dumbbell (biceps)	Biceps strengthening	The upper extremity (UE) is in anatomical posture, sitting with a straight back. A specific weight holds the dumbbell, which is then raised until the elbow is fully flexed.
Dumbbell (triceps)	Triceps strengthening	Sitting position, with the back straight and the elbow and shoulder fully flexed. The dumbbell is raised until the elbow is fully extended while being held at a specific weight.
Dumbbell (shoulder abductors)	Strengthening of the shoulder abductors	Sitting with the back upright and the upper limbs in their proper positions. Holding the dumbbell with a specified weight, the UE is abducted until the elbow is extended at a 90° angle.
Butterfly press	Strengthening of the pectorals	Sitting in a multipurpose machine with a straight back, shoulders abducted and externally rotated 90°, and elbows flexed 90°. Arms are displaced (pushed) toward the machine despite resistance until the shoulders are entirely horizontally abducted.
Curl back neck	Strengthening of the inferior trapezius, the latissimus dorsi, the subscapularis, and the teres major muscles	Sitting with a straight back, elbows fully extended, shoulders flexed. Keeping the hands shoulder-width apart, a bar attached to a pulley is grasped and then pushed down until it reaches the back of the neck.

Source: *Duran et al. (2001)*

A systematic evaluation of targeted therapies and their impact on recovery in children, adolescents, and adults who have had a concussion connected to sports was carried out by Schneider et al. in 2023 (6533 papers were evaluated). Individualised cervicovestibular rehabilitation was found to reduce the time it takes for adolescents and adults with headaches, neck pain, and/or dizziness more than 10 days after a concussion to return to sports when compared to rest followed by gradual exertion (HR 3.91 (95% CI 1.34 to 11.34)) and when compared to a subtherapeutic intervention (HR 2.91 (95% CI 1.01 to 8.43)). Vestibular rehabilitation may shorten the duration of medical clearance for adolescents with vestibular symptoms or impairments (vestibular rehab group 50.2 days, 95% CI 39.9 to 60.4), as opposed to control group 58.4 (95% CI 41.7 to 75.3) days. Active rehabilitation combined with collaborative treatment may help reduce symptoms in adolescents whose symptoms have persisted for more than 30 days.

Kurowski et al. (2017) investigated aerobic exercise for teenagers with persistent symptoms following mild traumatic brain injury. Thirty teenagers, aged 12 to 17, who suffered mild traumatic brain injury (mTBI) and experienced persistent symptoms for 4–16 weeks participated in the exploratory randomised clinical study. According to the results of this exploratory RCT, teenagers who experience ongoing symptoms following an mTBI may benefit from sub-symptom exacerbation aerobic exercise.

When used alone or in combination with other impairment-specific active rehabilitation therapies, aerobic exercise training has been linked to enhanced neurologic recovery, a quicker rate of symptom resolution, and a quicker return to sport (Quatman-Yates et al., 2020).

De Wandel et al. (2019) conducted a comprehensive review and meta-analysis on aerobic activity, such as cycling or walking, as an intervention and treatment for children and young adults with concussions. The goal was to see if adding aerobic exercise to an individual's concussion treatment made a significant difference when compared to treatments that included flexibility as a form of physical activity or traditional treatment methods based on the 2016 Berlin Consensus Statement on Concussion in Sport. The search for papers yielded 472 studies. The findings revealed that aerobic exercise significantly reduced the absolute risk difference for the development of protracted post-concussion symptoms in children and adolescents with concussions compared to those who reported no physical activity.

Based on the research, we can suggest a diagram of the relationship between components and successful integrative rehabilitation training programmes (Figure 4).

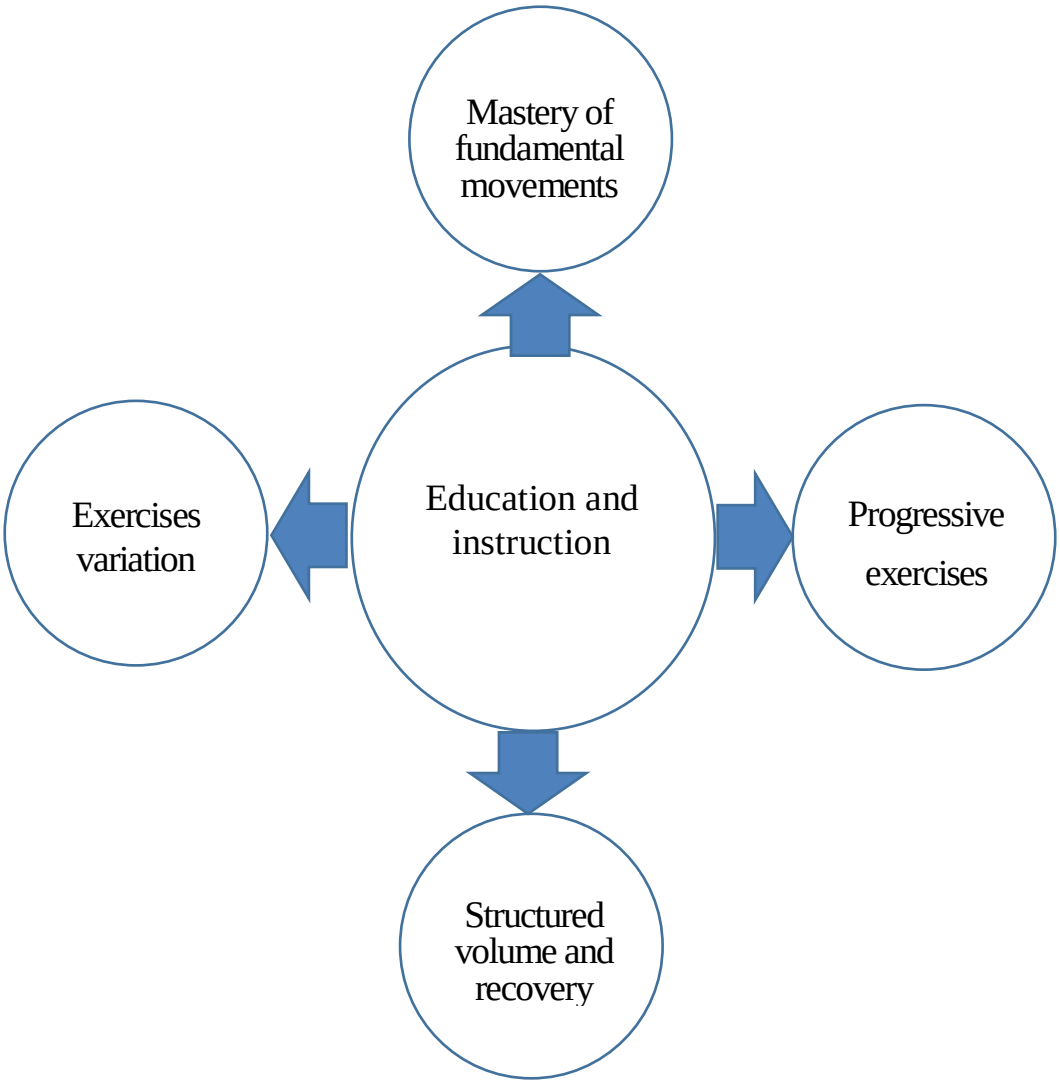

Figure 4. Diagram of the relationship between components to successful integrative rehabilitation training programmes for adolescents after injuries, based on physical culture

Source: *Developed by the author*

As a final remark, it should be mentioned that the timely beginning of physical therapy following a sports injury is critical to avoiding complications and enabling optimal recovery. Early management helps correct underlying biomechanical abnormalities or muscle imbalances, which reduces the probability of future injuries.

Furthermore, to prevent the frequency of non-accidental injuries, appropriate fundamental movement skills and progressive advancement of training programmes should be prioritised. If a young athlete does not master fundamental movement skills at lower intensity levels, impairments shown during the activity are likely to be accentuated as training intensity increases. Instructors

should provide continual feedback to all participants throughout and after each workout. This increases the athlete's awareness of optimal movement mechanics and reduces the possibility of unwanted or potentially harmful body postures.

4. CONCLUSIONS

In conclusion, physical therapy plays a vital role in the treatment and recovery of common sports injuries among adolescents. Its comprehensive and multidisciplinary approach aims not only to reduce pain and restore physical function, but also to implement preventive strategies that enable young athletes to return to sports safely and with confidence. While injuries are an inherent risk in youth sports, they should not discourage adolescents from engaging in physical activity. With appropriate guidance and individualized care—such as that provided by specialized clinics like Revitalize Physical Therapy—young athletes can recover effectively and build resilience. Moreover, by working closely with physical therapists, adolescents can reduce the risk of future injuries while continuing to enjoy the physical, social, and psychological benefits of sports participation.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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