THE INJURIES PREVENTION TECHNOLOGY OF STUDENTS – ROCK CLIMBERS, FUTURE SPECIALISTS IN PHYSICAL EDUCATION AND SPORTS

MONOGRAPH

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The monograph presents the author's biomechanical technology of injury prevention in the training of specialists in physical education and sports. The developed technology contains 3 directions: 1 - theoretical and methodical (creation of bases for understanding by students of mechanisms of formation of movements without risk of injury, formation at students of concept of biomechanically rational movements in general); 2 - analytical (providing students with knowledge about modern means of self-analysis of the level of technical skills); 3 - practical (students' mastery of practical means of injury prevention, ie, exercises that will promote the formation of biomechanically rational movements in any sport, and thus prevent injury).

The monograph contains an algorithm for identifying the main kinematic parameters of different models of equipment, typical for students with different levels of mastery of sports techniques. Based on biomechanical analysis, the main aspects of movement technique on the example of climbing, which affect the level of injuries of students. The monograph also presents the principles of application of means for injury prevention. The monograph contains developed and systematized tools to prevent injuries to students - future professionals in physical education and sports. The effectiveness of biomechanical technology in the use of neuromuscular training using exercises in a closed kinematic circuit, exercises in eccentric mode in combination with strength exercises for injury prevention and the formation of effective movement techniques for climbing students majoring in "Physical Culture and Sports".

The application of the developed biomechanical technology of injury prevention in the process of training specialists in physical education and sports has a positive effect on the formation of technical skills of students in the chosen sport and in non-core sports. It is shown that the application of the developed biomechanical technology of injury prevention in the process of training specialists in physical education and sports significantly reduces the risk of injury to students.

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INTRODUCTION

Topicality

At the present stage, the development and implementation of health technologies in the training of specialists in various fields is becoming increasingly important. (Lynall, R. C., et al. 2018; Martinez-de-Quel-Perez, O., et al., 2019; McLoughlin, R. J., et al., 2019; Nonoyama, T., et al., 2016; O'Connor, K. L., et al., 2017; Russell, K., et al., 2019; Sang, M. X., 2019; Slater, L. V., et al., 2019; Sommerfield, L. M., et al., 2020; Stanley, L. E., et al., 2016; Street, E. J. and K. H. Jacobsen, 2017; Wanke, E. M., et al., 2014). The process of training specialists in physical education and sports, which has its own specifics, which is significantly different from the process of training specialists in other specialties, is no exception. (Goossens, L., et al., 2019). This specificity is that the future specialist in physical education and sports must not only improve their skills in the chosen sport, but also learn on a basic basis other sports (athletics, gymnastics, swimming, basketball, volleyball, football, handball, music-rhythmic education, etc.).

The process of training specialists in physical education and sports is built in such a way that students have a large number of practical disciplines in various sports along with the chosen (Goossens, L., et al., 2019). In practical classes, students learn technical skills, develop physical qualities, and learn to conduct classes not only in the chosen sport, but also in others. Therefore, the schedule of students - future specialists in physical education and sports is built in such a way that in one day there can be 2-3 pairs of practical classes in different sports, and in the evening - training in the chosen sport. This puts a heavy burden on the cardiovascular system, which overtraining creates the conditions for injury.

In addition, each sport has its own characteristics (Kozina et. al, 2018). When mastering the basics of a particular sport from childhood, the process of learning motor skills is easier compared to adulthood, when the sensitive periods of natural learning are over. And so the nervous system and musculoskeletal system of students with mastery of skills in various sports receive a heavy load. It should be noted that different movements in their biomechanical structure require the formation of different connections in the nervous system, and this is quite a difficult task. And the constant switching from one movement to another, which occurs when changing the type of activity, chaotic activity of the nervous system, and, accordingly, the musculoskeletal system. This creates the conditions for increased injuries. That is why the question of developing such learning technologies that will provide reliable prevention of injuries to students - future professionals in physical education and sports.

To prevent injuries, it is necessary to form rational movements in the most optimal way (Bahrani, S. M. N., et al., 2015; Chan, D. K. C., et al., 2020; Liang, J. X. and B. Zhang, 2014; Yin, J. X., et al., 2020). That is why the technology of preserving the health of students - future specialists in physical education and sports should contain universal approaches to the process of learning technical skills, which will ensure the prevention of injuries and, consequently, the preservation of health. First, it is necessary to form in students the concept of biomechanically rational movements in general (LaBella et al.,, 2011; Pasanen et al., 2008; Parkkari et al., 2011; Steffen et al., 2013). Secondly, it is necessary to create conditions for students to master modern means of self-analysis of movement techniques (LaBella et al.,, 2011; Pasanen et al., 2008). Third, it is necessary to introduce into the learning process of students practical tools, ie, exercises that will promote the formation of biomechanically rational movements in any sport, and thus prevent injuries (Lynall, R. C., et al. 2018; Martinez-de-Quel-Perez, O., et al., 2019; Wanke, E. M., et al., 2014).

These provisions determine the great importance of research on the prevention of injuries of students - future professionals in physical education and sports, and based on these provisions, we can conclude that this work is timely and relevant.

Connection of work with scientific programs, plans, themes

The study was conducted according to:

- research work funded by the state budget of the Ministry of Education and Science of Ukraine for 2019-2020. "Theoretical and methodological foundations of integrated technologies for self-improvement, harmonious physical, intellectual and spiritual development and the formation of a healthy lifestyle for people of all ages and social groups, including athletes and people with special needs"(№ state registration: 0119U100616);
- research work funded by the state budget of the Ministry of Education and Science of Ukraine for 2019-2020. "Theoretical and methodological foundations of technology development to restore the musculoskeletal system and functional status and injury prevention of different age groups in physical culture and sports" (№ state registration: 0119U100634); on the topic of the Department of Olympic and Professional Sports, Sports Games and Tourism of Kharkiv National Pedagogical University named after GS Frying pans for 2012-2026 "Development and substantiation of technologies for health promotion and harmonious development of people of different ages and social groups (state registration number 0121U110053).

The aim of the study – to develop, substantiate and experimentally test the biomechanical technology of injury prevention of future specialists in physical education and sports in the process of professional training.

Objectives of the study:

1. To determine the current state of the world in terms of injury prevention for students - future professionals in physical education and sports.
2. Identify the main features of movement techniques (on the example of certain sports) that affect the level of student injuries.
3. Develop and substantiate biomechanical technology for injury prevention of future specialists in physical education and sports, which contains three areas: theoretical and methodological (creating a basis for students to understand the mechanisms of movement without risk of injury), analytical (providing students with knowledge of modern means of self-analysis of technical skills), practical (students' mastery of practical means of injury prevention).
4. Experimentally test the effectiveness of biomechanical technology for the formation of rational movement techniques.

5. Experimentally test the effectiveness of the developed biomechanical technology to reduce the risk of injury to students - future professionals in physical education and sports in the training process.

Object of study – professional training of future specialists in physical education and sports.

Subject of study – biomechanical technology of injury prevention of future specialists in physical education and sports in the process of professional training.

Research methods: analysis of literature sources, method of biomechanical analysis of sports equipment, method of expert evaluation of sports equipment, method of injury registration, method of determining the risk of injury, methods of mathematical statistics.

Scientific novelty of the research. In this work *for the first time:*

- developed biomechanical technology for injury prevention in the training of specialists in physical education and sports, which contains 3 areas: 1 - theoretical and methodological (creating a basis for students to understand the mechanisms of movement without risk of injury, students' notion of biomechanically rational movements in general); 2 - analytical (providing students with knowledge about modern means of self-analysis of the level of technical skills); 3 - practical (students' mastery of practical means of injury prevention, ie, exercises that will promote the formation of biomechanically rational movements in any sport, and thus prevent injury);
- the algorithm of revealing of the basic kinematic parameters of various models of technics characteristic of students with various level of possession of technics of sports movements is developed;
- the principles of application of means for prevention of injuries are defined: 1 - strengthening of the muscles participating in performance of the movement; 2 - the formation of functional movement, ie coordinated work of the muscles of the torso, upper and lower extremities;
- developed and systematized tools to prevent injuries to students - future professionals in physical education and sports. All means are conditionally divided into two groups: means from a sport and means specific to physical therapy, namely: Feldenkrais's methods, Redcord-therapy, PNF-therapy. For the first time, physical therapy was used in a non-traditional way: to improve movement technique and to prevent injuries;
- for the first time the effectiveness of biomechanical technology in the use of neuromuscular training using exercises in a closed kinematic circuit, exercises in eccentric mode in combination with strength exercises for injury prevention and the formation of effective movement techniques for climbing students majoring in "Physical Culture and sport";
- it was found that the application of the developed biomechanical technology of injury prevention in the process of training specialists in physical education and sports has a positive effect on the formation of

technical skills of students in the chosen sport and in non-core sports;
- it is shown that the application of the developed biomechanical technology of injury prevention in the process of training specialists in physical education and sports significantly reduces the risk of injury to students;
- for the first time developed and demonstrated the effectiveness of the technology of injury prevention in climbing, in particular - students majoring in "Physical Education and Sports".

The paper **confirms** the data on the need for the formation of biomechanically sound movement techniques for the prevention of injuries in sports, the theory of movement control on the need for the formation of rational techniques for injury prevention.

The paper **expands** and **supplements** the data on the use of neuromuscular training to prevent injuries in various sports, including climbing.

The practical significance of the study. The application of the developed biomechanical technology of injury prevention in the process of training specialists in physical education and sports helped to improve movement techniques and reduce the number and severity of injuries. The results of the research are introduced into the educational process of training specialists in physical education and sports of Kharkiv National Pedagogical University named after GS Frying pans, specialists in physical therapy of Kharkiv Pharmacological University, seminars "Biomechanics of the musculoskeletal system", "Biomechanics of fitness", "Biomechanics of physical therapy" 18-19.07.2020, 10-11.10.2020, 7-8.11.2020.

CHAPTER 1. MODERN CONCEPTS OF INJURY PREVENTION OF FUTURE SPECIALISTS IN PHYSICAL EDUCATION AND SPORT IN THE PROCESS OF PROFESSIONAL TRAINING

1.1. The concept of injury prevention in physical culture and sports

Prevention (from the Greek Πρόφύλακτικός "precautionary" (Prevention. Big medical encyclopedia, 1983) - precautions to prevent something. Prevention - a set of medical, sanitary, hygienic, pedagogical and socio-economic measures aimed at preventing disease and injury and eliminating risk factors.

The word "prevention" is used in various industries. Prevention in the technical field - preventive measures to maintain the technical facility and equipment in good or working order. Prevention in psychology - one of the types (areas) of work of a psychologist. Social prevention - preventive activities carried out to implement the principle of social justice.

Prevention (Greek Πρόφύλακτικός "precautionary" - in medicine, a set of measures aimed at preventing the occurrence of diseases and injuries, eliminating risk factors for their development.

As for the prevention of injuries of future specialists in physical education and sports, it can be determined that in this case the term "prevention" combines medical and psychological prevention.

Preventive measures are the most important component of the health care system, aimed at the formation of medical and social activity and motivation for a healthy lifestyle.

The preventive measures used seek to prolong a full healthy human life by identifying changes in the body of an individual, which can lead to further disease and take targeted measures to prevent disease.

Issues of disease prevention based on the rules of personal hygiene and rational dietetics occupied a significant place in the medicine of the ancient world. However, the development of scientific foundations of prevention began only in the XIX century. due to the development of general biological sciences, medical science in general and the emergence of its numerous disciplines dealing with private issues, especially physiology, hygiene and epidemiology; the spread of social ideas in clinical medicine played an important role. Leading physicians and medical scientists (both in Russia and abroad) saw the future of medicine in the development of social prevention and the connection between curative and preventive medicine.

The outstanding surgeon MI Pirogov defined: "The future belongs to preventive medicine".

The main areas of prevention

There are public, which includes a system of measures for the health of teams and individual prevention, which involves compliance with the rules of personal hygiene at home and at work.

Individual - includes measures to prevent disease, maintain and promote health, carried out by the person himself, and is practically reduced to the observance of a healthy lifestyle, personal hygiene, hygiene of marital and family relations, clothing hygiene, footwear, nutrition and drinking , hygienic education of the younger generation, rational mode of work and rest, active physical culture, etc.

Group - includes preventive measures carried out with groups of people with similar symptoms and risk factors (target groups).

Public - includes a system of social, economic, legislative, educational, sanitary, sanitary, anti-epidemic and medical measures, systematically conducted by state institutions and public organizations to ensure the full development of physical and spiritual strength of citizens, eliminating factors that adversely affect public health. Public prevention measures are aimed at ensuring a high level of public health, eradicating the causes of disease, creating optimal conditions for collective life, including working conditions, recreation, material security, housing, expanding the range of food and consumer goods, and also the development of health, education and culture, physical culture. The effectiveness of public prevention measures largely depends on the conscious attitude of citizens to protect their health and the health of others, on the active participation of the population in the implementation of preventive measures, on how fully each citizen uses the opportunities provided by society to strengthen and maintain health. 'I. The practical implementation of public prevention requires legislative measures, constant and significant material costs, as well as joint action of all parts of the state apparatus, medical institutions, industrial enterprises, construction, transport, agro-industrial complex, etc.

Types of prevention

Depending on the state of health, the presence of risk factors for the disease or severe pathology, three types of prevention can be considered.

Primary prevention - a system of measures to prevent the occurrence and impact of risk factors for disease (disinsection, rodent control, vaccination, rational work and rest, rational nutrition, physical activity, environmental protection, etc.). A number of primary prevention measures can be implemented nationwide. Preventing disease and creating good health prolongs our life. Health promotion measures are not targeted at a specific disease or condition, but contribute to health promotion. On the other hand, special protection is targeted at the type or group of diseases and complements the goals of health promotion [6]. The main principles of primary prevention: 1) continuity of preventive measures (throughout life, starting in the antenatal nature); 2) differentiated nature of preventive measures; 3) mass prevention; 4) scientific prevention; 5) the complexity of preventive measures (participation in the prevention of medical institutions, authorities, NGOs, the population).

Secondary prevention - a set of measures aimed at eliminating the pronounced risk factors that under certain conditions (stress, weakened immunity, excessive stress on any other functional systems of the body) can lead to the emergence, exacerbation and recurrence of the disease. The most effective method of secondary prevention is medical examination as a comprehensive method of early detection of diseases, dynamic monitoring, targeted treatment, rational and consistent recovery.

Some experts (Pletaev, 1986) suggest the term tertiary prevention as a set of measures for the rehabilitation of patients who have lost the opportunity for full life.

Tertiary prevention aims at social (formation of confidence in one's own social suitability), labor (possibility of restoring work skills), psychological (restoration of behavioral activity) and medical (restoration of functions of organs and body systems) rehabilitation.

1.2. Analysis of modern programs for the prevention of student injuries in physical education and sports

Sports injuries of students now, according to databases Endnote, Web of Science, Scopus, PubMed, are devoted to many studies. This indicates the high urgency of this problem in the world. Scientific works on this topic can be divided into 2 groups: 1 - articles on sports injuries of students in general (the largest number of articles); 2 - articles on sports injuries of students studying in the programs "Physical Education and Sports". This program provides training for physical education teachers or coaches in a particular sport. Also, articles on student sports injuries can be divided into groups as follows: 1 - articles on determining the number of injuries received by students over a period of time (maximum number of articles) (Lynall, RC, et al. 2018; Martinez-de-Quel -Perez, O., et al., 2019; McLoughlin, RJ, et al., 2019; Nonoyama, T., et al., 2016; O'Connor, KL, et al. 2017; Russell, K., et al., 2019; Sang, MX, 2019; Slater, LV, et al., 2019; Sommerfield, LM, et al., 2020; Stanley, LE, et al., 2016; Street, EJ and KH Jacobsen 2017 Wanke, EM, et al., 2014 and others); 2 - articles on student injury prevention programs (Emery, CA, et al., 2005; Emery, CA, et al., 2020; Goossens, L., et al., 2019; Hart, L., 2008; Lee, ASY, et al., 2019; Pysny, L., et al., 2015; Richmond, SA, et al., 2020; Richmond, SA, et al., 2016; Richmond, SA, et al., 2016 ; Shen, YQ, et al. 2017), including providing quality information to students about sports injuries (Bahrani, SMN, et al., 2015; Chan, DKC, et al., 2020; Liang, JX and B. Zhang, 2014; Yin, JX, et al., 2020 and others); 3 - articles on rehabilitation after injury (Brewer, B. W., et al. (2002; Lee, Y. S., et al., 2020).

1.2.1. The problem of student injuries in physical education and sports in the modern world

Currently, the role of physical culture and sports as the most powerful means of physical development, prevention of various diseases, recovery from illness. Sports contribute to the increase of motor intelligence, the development of psychological qualities that are necessary for building a career, the manifestation of individuality, success in all spheres of activity. Of particular importance is the importance of sports for students. However, sports are also accompanied by injuries of varying severity. This often leads to a large amount of time spent recovering from injuries, skipping classes, psychological problems (Brown, S. and EE Hall, 2018; Hao, FX, et al., 2011; Heaney, CA, et al. 2017; Narvaez , WCM, et al. 2017).

In this regard, the problem of injuries to students in sports is widely covered in modern literature. The authors mainly pay attention to the registration of injuries of varying severity in different sports under different circumstances (Lynall, RC, et al. 2018; Martinez-de-Quel-Perez, O., et al., 2019; McLoughlin, RJ, et al. ., 2019;

Nonoyama, T., et al., 2016; O'Connor, KL, et al. 2017; Russell, K., et al., 2019; Sang, MX, 2019; Slater, LV, et al. ., 2019; Sommerfield, LM, et al., 2020; Stanley, LE, et al., 2016; Street, EJ and KH Jacobsen 2017; Wanke, EM, et al., 2014 and others).

For example, Asperti, A. M., et al. (2017) found that Brazilian students engaged in amateur sports. traumatic impact was defined as the participation of one amateur student in one workout or game, and was expressed as the impact on the athlete (A-E). Injury rates are significantly higher in games (13.13 injuries per 1,000 student-athletes who participated in training or games (AE), 95% confidence interval = 10.3-15) than in training (4.47 injuries per 1,000 , 95% confidence interval = 3.9-5.1). The mechanisms that accounted for the most injuries in games and training were contact (52.9%) and non-contact (54.5%). Ankle sprains were the most common injury (18.2% of all reported injuries). There was also a relatively high incidence of anterior cruciate ligament injuries (0.16 injuries per 1,000 student-athletes who participated in training or games (A-E)). Asperti, A. M., et al. (2017) concluded that Brazilian amateur students are at high risk for non-contact injuries such as ankle sprains and anterior cruciate ligament injuries. Burchard, R., et al. Also indicate the highest prevalence of injuries of the distal parts of the lower extremities (ankle joint and knee) during sports. (2017), who studied the injuries of schoolchildren in Germany. Their study found that most school-related injuries occur in school sports, especially ball sports. The distal extremities were mainly injured.

In a study by Clifton, D. R., et al. (2018) describes the epidemiology of injuries received in basketball by high school girls in the period from 2005-2006 to 2013-2014 school years and student women's basketball in the period from 2004-2005 to 2013-2014 school years. Injuries were recorded through an online sports surveillance program. The online high school reporting system documented 2,930 injuries with loss of working time over 24 hours during 1,609,733 workouts and games; The National University Sports Association's Injury Monitoring Program recorded 3,887 injuries with a loss of time of more than 24 hours during 783,600 workouts and games. Injury rates were higher in college than in high school (4.96 vs. 1.82 / 1000 training and games; injuries (IRR) = 2.73; 95% confidence interval (CI) = 2.60, 2.86) . The level of injuries was higher in competitions than in training, both for high school students (injury index (IRR) = 3.03; 95% confidence interval (CI) = 2.82, 3.26) and for students (injury index) IRR) = 1.99; 95% confidence interval (CI) = 1.86, 2.12). The most common injuries at both levels were sprains, concussions, and sprains of muscles and tendons. Most of the injuries affected the knees, head and face. These injuries were often caused by contact with another player or a non-contact mechanism. Clifton, D. R., et al. (2018) concluded that the level of injuries was higher in students than in high school students, higher in competitions than in training.

In a study by Fraser, M.A., et al. (2017) described injuries from contact with the ball in 11 sports (men's soccer, women's field hockey, women's volleyball, men's baseball, women's softball, men's and women's basketball, men's and women's lacrosse, men's and women's football) National Student Sports Association (NCAA) for the period 2009-2010 to 2014-2015 academic years. As a result of the study, 1123 injuries from contact with the ball were registered. The highest scores were women's softball, women's field hockey (7.71 / 10,000 student-athletes who participated in training or games (AE)) and men's baseball (7.20 / 10,000 student-athletes who participated in training or games (AE)). The majority of ball-related injuries occurred on the hand / wrist (32.7%) and head / face (27.0%) and were diagnosed as strokes (30.5%), sprains (23.1 %) and concussion (16.1%). Among sexually comparable sports (eg, baseball / softball, basketball, and soccer), women had a higher rate of concussion diagnosed as concussion than men (ratio of injuries = 2.33; 95%). confidence interval (CI) = 1.63, 3.33). More than half (51.0%) of injuries from contact with the ball were associated with loss of time (ie time of restriction of participation, 24 hours), and 6.6% were severe (ie time of restriction of participation> = 21 days). The most frequent severe injuries in contact with the ball were concussions (n = 18) and fractures of the fingers (n = 10). Thus, the percentage of injuries from contact with the ball was highest in women's softball, women's field hockey and men's baseball. Although more than half were injuries without loss of time, serious injuries such as concussions and fractures were reported.

Hurtubise, J. M., et al. (2015) conducted a study of gender differences in severe injuries in different sports. It was found that men received 1155 injuries, of which 13.3% were severe, and women received only 502 injuries, 17.7% of which were severe. The chances of severe injuries in women are 1.4 times higher than in men (OR: 1.40, CI (confidence interval) = 1.05-1.86). Eleven percent of all injuries in women were concussions - significantly more than in men (chi (2) = 11.03, p = 0.001). The probability of concussion in women is 1.9 times higher than in men (OR: 1.85, CI 1.28-2.67). Thus, Hurtubise, J. M., et al. (2015) concluded that women are at increased risk of severe injuries, especially concussions, and this should be taken into account when planning preventive measures.

Jin, J. (2020) found a high number of injuries in college football students. Similar results were obtained by Kahlenberg, C. A., et al. (2016). It was found that every student is an athlete. on average engaged in 1.6 different sports. The average number of hours of sports per year was 504.3 and 371.6 hours, respectively. The average total number of sports injuries received by athletes was 1.7 per participant. 80.8% of respondents reported having suffered at least one sports injury. Thus, the number of injuries in students engaged in sports is high.

Kerr, Z. Y., et al. (2017) data on injuries and impacts collected on 27 sports using the National Network for Sports Treatment, Injuries and Outcomes (NATION). The results provided by certified sports coaches (AT) for the collection of data on injuries of athletes (AE) in training and competitions in 27 sports in the period from 2011/2012 to 2013/2014 were analyzed. It was found that most of the 47,014 injuries were injuries of the ankle and knee joints (82.8%). Among boys in sports, the injury rate was highest in football (3.27 / 1000 AE) and wrestling (2.43 / 1000 AE); The number of ankle and knee injuries was also highest in football (15.29 / 1000 AE) and wrestling (11.62 / 1000 AE). Among women's sports, the injury rate was highest in football (1.97 / 1000AE) and basketball (1.76 / 1000AE); The number of ankle and knee injuries was highest in field and lacrosse field hockey (both 11.32 / 1000 AE).

LeBrun, D. G., et al. (2018) found that more than 23 million African adolescents receive sports injuries each year, which requires certain measures to prevent injuries during sports.

High injuries of sports students are also evidenced by data from other authors (Lynall, RC, et al. 2018; Martinez-de-Quel-Perez, O., et al., 2019; McLoughlin, RJ, et al., 2019; Nonoyama, T., et al., 2016; O'Connor, KL, et al., 2017; Russell, K., et al., 2019; Sang, MX, 2019; Slater, LV, et al., 2019; Sommerfield, LM, et al., 2020; Stanley, LE, et al., 2016; Street, EJ and KH Jacobsen 2017; Wanke, EM, et al., 2014). Thus, the authors note the high prevalence of injuries among students involved in various sports. In most studies, traumatic impact was defined as the participation of one amateur student in one workout or game, and was expressed as the impact on the athlete (A-E). This value ranges from 1.82 to 15.29 per 1,000 student-athletes who participated in training or games (A-E). At the same time, women have a higher chance of injury than men. The most traumatic sports are team sports from the port with the ball and wrestling.

It should be noted that no such sports as climbing have been analyzed, although currently this sport is becoming increasingly popular among young people, including students. Therefore, a promising area, in our opinion, will be the analysis of injuries among students involved in climbing, and the development of injury prevention programs.

A number of studies on the injuries of student-athletes are devoted to injury prevention measures, including informing the possible causes of injuries (Bahrani, SMN, et al., 2015; Chan, DKC, et al., 2020; Liang, JX and B. Zhang, 2014; Yin, JX, et al., 2020).

Thus, Bahrani, S. M. N., et al. (2015) conducted a study of knowledge of male and female students in the field of sports injury prevention. The results of this study show that 94.6 percent of students (332 students) showed poor knowledge of sports injury prevention, 4 percent (14 students) showed satisfactory knowledge, 1.4 percent (5 students) showed good knowledge and none of the students received rating "excellent". These inductive statistics show that there is no significant difference between female and male students in terms of their knowledge. According to the results of this study, insufficient knowledge of students in the field of prevention of sports injuries proves the lack of practical and theoretical courses on sports pathology and first aid in the curricula of schools and universities.

Chan, D. K. C., et al. (2020) reviewed the literature on risky behavior and sports injuries in elite athletes in terms of occupational safety and health. This review found that most elite athletes are unaware that sports injuries are occupational injuries that require occupational safety behavior.

Liang, J. X. and B. Zhang (2014) point to the need to introduce online courses in university student injury prevention programs. Minoughan, C., et al. (2018) indicate the need to review training materials for patients who have received various injuries during sports. The review should be aimed at compliance with the recommended level of eighth grade.

Thus, many authors note the low level of knowledge of students about injuries in sports and suggest different ways to raise awareness of students on injury prevention.

Among such ways - the creation of online courses, the introduction of special programs in the educational process of students, improving the quality of information on injuries in sports.

1.2.2. Modern views on the problem of injury prevention of future specialists in physical education and sports

Among the scientific works devoted to student injuries, a special place is occupied by works devoted to the prevention of injuries of students studying in the programs "Physical Education and Sports".

In a study by Goossens, L., et al. (2019) show that sports injuries received by students enrolled in the programs "Physical Education and Sports" can cause serious damage to the further career of a physical education teacher and coach. Goossens, L., et al. (2019) registered injuries in 128 first-year students of the Physical Education and Sports program during one academic year. The authors also assessed the overall risk factors for sports injuries according to the literature and found that the incidence rate of students enrolled in the programs "Physical Education and Sports" is 1.91, and the risk of injury - 0.85, which is higher than usual among people who are actively involved in sports. Most injuries affected the lower extremities and occurred in non-contact situations. More than half of all injuries result in a period of inactivity of 1 week or more, and more than 80% of all injuries required medical attention. The main part of these injuries occurred during classes in the specialty "Physical Education and Sports". There were few differences between women and men. History of injuries was a significant risk factor ($p = 0.018$) for future injuries. The use of contrast baths was probably associated with a lower incidence of ankle injuries ($p = 0.031$). These data can be used in future sports injury prevention programs for students enrolled in the programs "Physical Education and Sports".

Goossens, L., et al. (2019) also indicate that students enrolled in Physical Education and Sports programs spend approximately 15-19 hours per week on the theory and practice of sports. The content of the programs of students enrolled in the programs "Physical Education and Sports" in different countries may be different. It should be noted that in Ukraine the amount of time devoted to the practice of sports is about 20-26 hours per week. The number of hours allotted for the chosen sport and the number of hours allotted for the development of other sports varies. This is due to the fact that in Ukraine, according to the training programs in the field of physical education and sports at universities, for a career in this field you need to have not only your own sport, but also other sports (gymnastics, athletics , swimming, sports games, skiing and others) at the basic level. Thus the expert in the field of physical culture and sports should not only possess an arsenal of movements, but also be able to teach the basic movements of researched kinds of sports. In Ukraine, depending on the sports qualifications of students and the peculiarities of the curriculum, from 6 to 18 hours per week is spent on classes in the chosen sport and from 6 to 20 hours per week is allocated to classes in other sports. Therefore, you can expect a high risk of injury.

Goossens, L., et al. (2019) indicate that a relatively small number of studies are devoted to the risk of injury in students enrolled in the programs "Physical Education and Sports". However, the data available in the literature confirm that future professionals in the field of physical education and sports have an increased risk of injury. Lysens et al. (1989) found 1.7 injuries per student enrolled in the Physical Education and Sports program during the first year of study in Belgium. In Austria, Ehrendorfer (1998) reported more than three injuries per student enrolled in the Physical Education and Sports program, averaging 2.35 years. Similarly, Flicinski (2008) reported musculoskeletal pain in the previous year in almost half of the group of Polish students enrolled in Physical Education and Sports. In addition, Twellaar et al. (1996) found 525 sports injuries over a four-year period in 136 students who completed the Physical Education and Sports program in the Netherlands. In a prospective follow-up study over one academic year in Belgium, Goossens et al. (2014) registered 109 injuries in 128 undergraduate students of the program "Physical Education and Sports". As shown by Goossens et al. (2014), the content of the programs of students studying in the programs "Physical Education and Sports" differs in the mentioned countries, which leads to a great variety of the mentioned prevalence indicators. The main proportion of injuries are the lower extremities, with the most common injuries to the legs, knees and ankles (Flicinski, 2008; Goossens et al., 2014; Twellaar et al., 1996).

These injuries have different consequences. Injured students miss sports and practice hours (Goossens et al., 2014), which can lead to re-exams or lower grades. Some injuries even cause academic reorientation (Goossens et al., 2014). In school-age children (Sorensen et al., 1998), sports injuries have a significant impact on the functional and socio-economic status of students and their families.

Many students enrolled in the Physical Education and Sports program begin their careers as physical education teachers after graduation. Because a history of injury is an important predictor of future injury (Van Mechelen et al., 1996), physical education teachers may suffer from the detrimental effects of injury throughout their careers. Indeed, Makela and Hirvensalo (2015) found that musculoskeletal disorders are the most common problem at work among physical education teachers. Lemoyne et al. (2007) report that 37.6% of physical education teachers in Canada at three school levels (primary and secondary school, college) suffer from injuries each year. Pihl et al. (2002) showed that this figure increases to 51.2% among physical education teachers aged 51-72. Compared to teachers of other specialties, teachers of physical education and sports have significantly more injuries of the musculoskeletal system. The hindquarters, knees, and ankles are most commonly affected (Goossens et al., 2016b; Lemoyne et al., 2007; Ma¨kela and Hirvensalo, 2015). Such a high level of injuries has far-reaching consequences. Physical education teachers are more often absent from work and have to change jobs more often than the rest of the population. In addition, some may not work as physical education teachers or trainers until retirement mainly due to musculoskeletal dysfunction (Sandmark, 2000). Injuries can also affect the pedagogical practice of physical education teachers. Injuries can prevent physical education teachers from demonstrating methods and skills, which in the case of chronic injury will significantly reduce the effectiveness of the teacher (Kovac et al., 2013).

It should be noted that the above-mentioned high prevalence of injuries and related consequences strongly confirm the need to prevent injuries in training programs for teachers (coaches) in the field of physical education and sports.

Regarding injury prevention in students enrolled in the programs "Physical Education and Sports" Goossens, L., et al. (2019) also note that, according to the multifactor model proposed by Meeuwisse et al. (2007), sports injuries are the result of a combination of internal and external risk factors.

To date, many interventional studies have focused on modifying the factors that are associated with the musculoskeletal load of the athletes themselves. These preventive strategies are aimed at training the athlete, improving his skills. These are the so-called "internal prevention strategies" (Schiff et al., 2010) and their effectiveness has been proven in specific sports contexts. It is logical that internal prevention strategies are suitable for the training of specialists in the field of physical culture and sports, because they are closely related to the physically active aspect of training a specialist in this field. In addition to the benefits for their own health of students enrolled in the programs "Physical Education and Sports", consistently used and structured prevention. which will help prepare future students for a healthy and active lifestyle (Vercruysse et al., 2016). Prevention of sports injuries helps to achieve one of the main goals of training in the field of physical education and sports (Hardman, 2008).

Thus, the need to prevent sports injuries of students enrolled in the programs "Physical Education and Sports" is obvious.

Goossens, L., et al. (2019) analyzed the literature data on the existing effective prevention programs for sports injuries and evaluated their applicability for students enrolled in the courses "Physical Education and Sports". Goossens, L., et al. (2019) according to the analyzed literature identified the following aspects of injury prevention programs that can be used for students enrolled in the courses "Physical Education and Sports": 1 - Functional strength training; 2 - Stretching; Warm-up (WU) or warm-up (CD); 3 - Dynamic stability training for the lower extremities; 4 - Stability of the cortex. For each analyzed program, Goossens, L., et al. (2019) give the ratio of the chances of injury without the use and with the use of injury prevention program (confidence interval - 95%). According to the data presented in the review Goossens, L., et al. (2019), Petersen et al. (2011) in the proposed program of injury prevention suggest the use of eccentric strengthening exercises (Scandinavian exercises for the hamstrings). The effectiveness of these exercises in accordance with the value of the odds ratio is 0.28 (0.15-0.50). Hartig and Henderson (1999) suggest the use of exercises aimed at stretching the hamstrings. The effectiveness of these exercises in accordance with the value of the odds ratio is 0.49 (0.28-0.85).

Emery et al. (2007) developed special exercises on a wobbler to prevent injuries. The effectiveness of these exercises in accordance with the value of the odds ratio is 0.72 (0.55-0.96).

McGuine and Keene (2006) recommend increasing the gradual increase in training load both in terms of coordination aspects and in relation to the development of various physical qualities. The effectiveness of these exercises in accordance with the value of the odds ratio is 0.60 (0.35-1.02). Verhagen et al. (2004), in addition to gradually increasing the load, also recommend the use of variations of each exercise during warm-up. The ratio of the chances of injury without the use and with the use of this program is 0.58 (0.35-0.96).

Coppack et al. (2011) recommend for the prevention of injuries to perform exercises for the kinetic chain of the quadriceps muscle and gluteal eccentric, as well as static stretching of the quadriceps muscle, patella, calf muscle and iliac-tibial ligament. The ratio of the chances of injury without the use and with the use of this program is 0.26 (0.13-0.53).

Emery et al. (2005) propose to apply at home a program of gradual increase in proprioception using a wobbler board in combination with isometric contraction of the abdominal and gluteal muscles. The effectiveness of these exercises, according to the value of the odds ratio is 0.15 (0.03-0.75).

The original injury prevention program proposed by LaBella et al. (2011). These authors investigated the effectiveness of focusing on knee control, as well as on bending the hips and knees during jumping exercises. Concentration is recommended to be combined with strengthening of the specified muscles and plyometricheskie uparzheniya in combination with dynamic exercises, exercises on balance and dexterity. Plyometric exercises can be used as in the initial version, developed by Yu.V. Verkhoshansky (Verkhoshansky, 1974). And in the modern version (Chu, 1998).

Let's dwell on the plyometric method in more detail. Plyometric exercises use explosive, rapid movements to develop muscle strength and speed. These exercises help the muscles to develop the greatest effort in the shortest possible time. The name "plyometrics" was coined in the 1980s by Fred Wilt (Wilt, 1984), a member of the US long-distance team. Observing the warm-up of Soviet athletes, he noted that while the Americans spent time on static stretching, the Soviet team performed intense jumps. Later, Wilt was deeply convinced that these jumps were a key element in the success of Soviet athletes.

After returning to the United States, Wilt learned about the work of Michael Yessis (Yessis, 1984) on the study of the Soviet approach to training, namely the "shock method" developed by Professor Yu.V. Verkhoshansky. Through their joint efforts, the term "plyometrics" has become widespread. However, with the popularization of plyometrics, the meaning of the term has faded, and now they are called any jumping exercises, regardless of intensity. There are even "plyometric" push-ups or pull-ups.

Thus, we can distinguish two meanings of the term "plyometrics": the shock method and modern plyometrics.

The idea of the percussion method is to stimulate the muscles with percussive stretching, which precedes active effort.

The central exercise of the percussion method is a deep jump. A deep jump is a jump down from a certain height (usually 50-70 cm) with an immediate jump up. It is extremely important that the landing and jumping is very fast, in 0.1-0.2 seconds. The mechanics of a deep jump are as follows: when an athlete falls from a height, he gains kinetic energy, and when landing the muscles of the thigh and lower leg perform an eccentric contraction in order to slow down the fall. The eccentric contraction is momentarily replaced by an isometric one (without movement), which is immediately replaced by a concentric contraction when the athlete jumps up.

The shock method was developed by Yu.V. Verkhoshansky (Verkhoshansky, 1974) for training the national team of the Soviet Union in the late 1960's - early 70's. He was tasked with improving the performance of Soviet athletes in athletics. Observing the mechanics of jumping and running, he found that these classes are characterized by adding a very large force to the ground, and for a short period of time (when jumping contact with the ground lasts 0.2 seconds, when running - 0.1 seconds). Based on this, it was concluded that to improve performance you need to develop the ability of the athlete to make a great effort very quickly. The deep jump was chosen by him as the exercise that best reproduces this short-term contact with the ground.

In modern sources (Chu, 1998) plyometrics is called any jumping exercise, regardless of the speed of the jump. Conventional jumping exercises are available to all athletes, regardless of the level of training and the requirements for explosive muscle strength.

The technique of ordinary jumping is no different from the technique of explosive jumping. However, conventional jumps differ from explosives by prolonged contact with the ground. Thus, a common mistake of beginners when jumping into the depths is that the athlete squats too deeply when landing, and the rapid transition from eccentric to concentric muscle contraction does not occur. Then the exercise trains not an explosive force, but simply the ability to jump. The ratio of the chances of injury without the use and with the use of the program proposed by LaBella et al. (2011), is 0.55 (0.38-0.80).

Olsen et al. (2005) recommend enhanced technical preparation for landing after a jump in combination with strength exercises for the lower extremities. In the general warm-up, these authors recommend using exercises on a balancing mat or wobbleboard. The ratio of the chances of injury without the use and with the use of this program is 0.53 (0.37-0.78).

Parkkari et al. (2011) recommend preventive counseling for the purposes of cognitive-behavioral learning. This means concentrating on proper posture exercises. Also Parkkari et al. (2011) recommend the use of eccentric exercises for the popliteal tendon, exercises for the joints of the lower extremities in combination with stretching the flexors of the thighs and popliteal tendons, and the development of mobility of the thoracic spine. In addition, Parkkari et al. (2011) suggest stance exercises on one leg combined with the development of coordination and dexterity and transitional exercises. The ratio of the chances of injury without the use and with the use of this program is 0.85 (0.63-1.14).

Pasanen et al. (2008) propose a program that includes a focus on proper technique, plyometric exercises, the development of eccentric force of the patellar tendon, variations of squats in combination with static stretching of the lower back, patellar tendon and hip flexors. Pasanen et al. (2008) recommend jogging, jogging exercises, board and balancing exercises in combination with conscious control of body position in space. The effectiveness of these exercises, according to the value of the odds ratio is (0.19 -0.60).

Thus, as noted by Goossens, L., et al. (2019), in a study by Parkkari et al. (2011) applied all strategies except warm-up and hitch. Pasanen et al. (2008) also applied all strategies except contrast baths. Three studies used only dynamic stability of the lower extremities (Emery et al., 2007; McGuine and Keene, 2006; Verhagen et al., 2004), one study used only patellar sprain (Hartig and Henderson, 1999) and one study used only functional strengthening of the popliteal tendons (Petersen et al., 2011).

Parkkari et al. (2011) and Pasanen et al. (2008) propose applications consisting of a combination of all or most internal strategies. Their programs require almost no equipment, and the programs consist of tasks that coincide with a wide range of physical exercises used in the training of students - future professionals in the field of physical education and sports. In addition, Parkkari et al. (2011) found the effectiveness of their program among people involved in various sports, as well as in the training of soldiers.

Thus, as summarized by Goossens, L., et al. (2019), these two programs can serve as examples for the development of injury prevention programs among students - future professionals in the field of physical education and sports.

To train the dynamic stability of the lower extremities Goossens, et al. (2019) recommends a program developed by Emery et al. (2007), McGuine and Keene (2006) and Verhagen et al. (2004). Their programs consisted of 3-5 sessions per week with a gradual increase in exercises, starting with basic tasks without the use of any equipment, followed by tasks using simple equipment such as balls and special balance tools. To meet the need for differentiation in the context of training students - future professionals in the field of physical education and sports, it is useful to increase the curriculum very gradually. Moreover, given the limited financial capacity of some educational institutions, it is very important to be able to implement (part of) these programs without any equipment or with simple equipment. The use of only functional strength training three times a week was effective in reducing hamstring injuries in football players (Petersen et al., 2011).

Goossens, et al. (2019) also note that in the process of training students enrolled in the program "Physical Education and Sports" can be useful exercises aimed at preventing not only injuries of the hamstrings, but also other muscle groups.

Significant results of the stretching program in the reduction of injuries among recruits (Hartig and Henderson, 1999) confirm the hypothesis that stretching may work as a preventive measure in the context of training future professionals in the field of physical education and sports. Hartig and Henderson (1999) found a significantly lower number of overload injuries to the lower extremities after knee tendon stretching.

Goossens et al. (2019) found no effective studies with a low risk of systematic error, which would use only the awareness of trauma, only the stability of the cortex, or only warm-up and hitch. However, awareness was part of four effective programs that provide an integrated approach. However, bark stabilization and warm-up were included in three effective comprehensive programs.

Several researchers (Amako et al., 2003; Andrish et al., 1974; Brushoj et al., 2008; Childs et al., 2010; Coppack et al., 2011; Goodall et al., 2013; Hartig and Henderson , 1999); Hofstetter et al., 2012; Knapik et al., 2003, 2004, 2006; Parkkari et al., 2011; Pope et al., 1998, 2000) implemented their program among conscripts. Goossens, L., et al. (2019) indicates that in part these programs can be used in the training of future professionals in the field of physical education and sports.

Given the contribution of theoretical training on injury prevention in several effective programs (LaBella et al., 2011; Olsen et al., 2005; Parkkari et al., 2011; Pasanen et al., 2008), Goossens, L., et al. (2019) conclude that the theoretical basis can increase the effectiveness of injury prevention programs for students enrolled in the program "Physical Education and Sports". Therefore, the authors note that for future professionals in the field of physical education and sports more than in other groups, the theoretical aspect of training is important. Their findings Goossens, et al. (2019) is also based on the fact that students of this profile already have some knowledge in the field of biomechanics and physiology of movements.

Consider in more detail some of these programs. Parkkari et al. (2011) proposed a neuromuscular training program with injury prevention counseling to reduce the risk of acute musculoskeletal injury. The authors conducted a randomized controlled trial that included 968 recruits, including 501 recruits in the experimental group and 467 recruits in the control group. The neuromuscular training program was used to improve the motor skills and control of conscripts' bodies, and the injury prevention educational program was used to raise awareness and awareness of acute musculoskeletal injuries. The main criteria for evaluating the effectiveness of the program was the number of acute injuries of the lower and upper extremities. For neuromuscular training, the authors proposed 9 special exercises. The focus of each of the nine exercises was on maintaining proper posture, maintaining the stability of the body or position, thighs, knees and ankles.

The neuromuscular training program included the following exercises.

Exercise 1. Standing on one leg with a stick in straight arms behind his back, raise your arms up, then lower your arms. Perform 20 repetitions of 10 on each leg. This exercise aims to improve posture in the shoulders and neck and increase the mobility of the shoulder joints combined with improved balance and overall coordination.

Exercise 2. From a standing position and holding a stick behind your back with one hand up, the other - down along the spine to perform squats. You can perform squats on 2 legs and on one leg. When performing squats on one leg, the other leg is set back. Performed 16 repetitions on two legs and eight on one leg. This exercise is aimed at increasing control of the lumbar spine, increasing muscle strength of the lower extremities, improving balance.

Exercise 3. Starting position - emphasis in the lateral position on one arm bent at the elbow. Stage 1 - knees bent, hold this position. Perform five repetitions with a 5-second static hold in turn on each side (5 + 5). Stage 2 - from the emphasis in the lateral position on one arm bent at the elbow, the knees straight to make the transition to the emphasis on the two arms bent at the elbows. The exercise is aimed at strengthening the contractility of the muscles of the torso, improving the stability of the lower back and torso, increasing the endurance of the muscles of the torso.

Exercise 4. Starting position - standing. Perform various jumps from side to side. Rhythm: four slow jumps + eight fast jumps. Exercise time: 60 seconds. The exercise is aimed at increasing coordination and agility, increasing control of the lumbar spine, increasing the endurance of the muscles of the lower extremities.

Exercise 5. Push-ups from the floor. Perform as many repetitions as possible in 60 seconds. The exercise is aimed at improving the extensors of the upper extremities, the development of strength, increasing the contractility of the muscles of the torso, improving the stability of the lower back and torso.

Exercise 6. Stretching exercise for muscles - hip flexors. 10-second stretching, five times alternately. The exercise is aimed at increasing the elasticity of the hip flexors, increasing the muscular strength of the lower extremities

Exercise 7. Starting position - kneeling. The partner supports the shins. Lean forward. Performed from 8 to 12 repetitions. The exercise is aimed at increasing the eccentric ability of the patellar tendon, increasing motor control of the torso. The exercise aims to strengthen and increase the elasticity of the hamstrings.

Exercise 8. Stretching exercise with a stick for the muscles of the patellar tendon. Starting position - similar to exercise 2. Put one foot on the heel forward, return to starting position. Performs 3 repetitions of 20-second stretches with alternating legs. The exercise is aimed at increasing the extensibility of the patellar tendon and leg muscles, increasing control of the lumbar spine.

Exercise 9. Rotation of the upper part of the body in a supine position; "Stretching yoga". Duration - 60 seconds for each party. The exercise is aimed at improving the rotational mobility of the thoracic spine, increasing the extensibility of the pectoral muscles.

Educational counseling was used to increase knowledge and understanding of the causes of musculoskeletal injuries during various training situations.

As a result of the application of this program for 6 months significantly reduced the risk of acute ankle injury in the experimental groups compared with the control groups (adjusted risk ratio (HR) = 0.34, 95%, confidence interval (95% CI) = 0.15 - 0.78, P = 0.011). This reduction in risk was observed in recruits with low as well as moderate to high baseline levels of physical fitness. In the last group of conscripts, the risk of injury to the upper extremities also decreased significantly (adjusted HR = 0.37, 95% CI from 0.14 to 0.99, P = 0.047). In addition, intervention groups tended to have less time loss due to injury (adjusted HR = 0.55, 95% CI from 0.29 to 1.04). Based on the results obtained, Parkkari et al. (2011) conclude that the proposed neuromuscular training program in combination with injury prevention counseling has been shown to be effective in preventing acute injuries to the ankle and upper extremities in young male recruits. These authors believe that such a program can be useful to all young people who regularly play sports.

LaBella et al. (2011) suggested that team coaches in women's football and basketball use a special warm-up. The warm-up combined progressive exercises to strengthen the muscles of the lower extremities, plyometric exercises, exercises for balance and agility. Athletes were advised to avoid dynamic knee valgus and land after jumping on bent hips and knees. Trainers have learned to distinguish the correct form of landing from the incorrect one and use verbal signals to encourage the correct form (for example, "softly land" and "do not allow the knees to go inside"). The trainers received a DVD with recorded videos of the exercises, a laminated card indicating the order and frequency of exercises for use on the court or field, and printed training materials on the risk factors for knee injuries with special neuromuscular exercises. As a result of a study by LaBella et al. (2011) found that neuromuscular warm-up under the guidance of a coach reduces the likelihood of non-contact injuries of the lower extremities in schoolgirls and basketball players.

Pasanen et al. (2008) proposed a program that includes the following elements: 1 - focus on the correct technique of movement in football, 2 - plyometric exercises, 3 - the development of eccentric muscle strength - extensors of the thigh and hamstring, 4 - variations of squats in combination with static stretching lower back, popliteal tendon and hip flexors; 5 - platform balancing exercises with specific movements typical of football, as well as performed with stuffed balls. All the proposed exercises Pasanen et al. (2008) recommend combining with conscious control of body position in space. Pasanen et al. (2008) also recommend including jogging in the injury prevention program to warm up the body during the warm-up process in combination with acceleration, change of direction (zigzag running and others). In a study by Pasanen et al. (2008) 457 players took part (average age 24 years); 256 (14 teams) - in the experimental group and 201 (14 teams) - in the control group. The study was conducted during one season of competition (six months). In this study, it was found that during the season there were 72 acute non-contact leg injuries, 20 - in the experimental group and 52 - in the control group. The frequency of injuries per 1000 hours of play and training in the experimental group was 0.65 (95% confidence interval from 0.37 to 1.13), and in the control group - 2.08 (from 1.58 to 2.72). The risk of non-contact leg injury was 66% lower (adjusted incidence rate of 0.34, 95%, confidence interval 0.20-0.57) in the experimental group. Pasanen et al. (2008) conclude that a neuromuscular training program is effective in preventing acute non-contact leg injuries in soccer players, and neuromuscular training may be recommended in weekly athlete training.

Thus, the central component in the most effective comprehensive injury prevention programs are neuromuscular training. Neuromuscular communication is a conscious ability to feel one's muscles and regulate their level of involvement during exercise (Emery, 2020; Silvers-Granelli, et.al., 2018). It is the developed neuromuscular connection that distinguishes a beginner from a professional athlete. The connection of muscles with the brain involves: the ability to consciously tense the muscles and more technical performance of exercises. One of the elements of neuromuscular training is the concentration on the technique of performing the exercise.

The effectiveness of neuromuscular training has also been confirmed in later studies (Dai, et.al., 2012; Emery, 2020; Faude et.al. 2017; Gatt, 2014; Javier Robles-Palazon et.al. 2017; McCann , et.al., 2011; Owoeye, et.al., 2018, 2020; Silvers-Granelli, et.al., 2018; Steffen, et.al., 2013; Sugimoto, et.al., 2015).

Thus, in a review of Faude et.al. (2017) analyzed multimodal (comprehensive) injury prevention programs for young athletes (under 20 years of age) that can reduce injury by approximately 40%. The neuromuscular component was one of the criteria for the effectiveness of the programs used. This indicates the high importance of the neuromuscular component in the prevention of injuries during sports. Multimodal injury prevention programs include, for example, exercises for balance, strength, power and agility. Faude et.al. (2017) analyzed 14 works with the participation of 704 athletes. Selected works were (cluster) randomized controlled trials that studied healthy participants under the age of 20 engaged in organized sports. In selected studies, the intervention group using the multimodal program was compared with the control group after the usual training regimen and evaluated the parameters of neuromuscular activity (eg, balance, power, strength, sprinting) and the quality of sports skills. Seventy-one percent of all studies studied football players, the rest - basketball, field hockey, futsal, Gaelic football and curling. The average age of participants ranged from 10 to 19 years, and the level of play - from entertainment to professional. The duration of the intervention ranged from 4 weeks to 4.5 months, a total of 12 to 57 workouts. As a result, there was a small overall effect in favor of the applied injury prevention programs in terms of balance / stability (Hedges' g = 0.37; 95% CI 0.17, 0.58 ()), strength (g = 0.22; 95% CI 0.07, 0.38)) and isokinetic strength popliteal tendon and quadriceps. and the ratio of popliteal tendons and quadriceps (g = 0.38; 95% CI 0.21, 0.55). A large overall effect was also found for sprint abilities (g = 0.80; 95% CI 0.50, 1.09) and sports skills (g = 0.83; 95% CI 0.34, 1.32). Analysis of subgroups showed a greater effect in high-level athletes ((g = 0.34-1.18)) compared with low-level athletes ((g = 0.22-0.75 ()), boys (g = 0.27-1.02) compared with girls ((g = 0.09-0.38), in older (g = 0.32-1.16) compared with younger athletes (g = 0.18-0.51) and in studies with large (g = 0.35-1.16) compared with low (g = 0.12-0.38) Faude et al. (2017) conclude that multimodal (complex) injury prevention has a beneficial effect on neuromuscular activity.

Another important component of comprehensive injury prevention programs are exercises with a closed kinematic chain. Thus, Coppack et.al. (2011) showed the effectiveness of an injury prevention program for girls serving in the army, one of the components of which were exercises with a closed kinematic chain for the quadriceps muscle. Exercises were also aimed at strengthening the gluteal muscles. There was a 75% reduction in the risk of injury (uncorrected hazard ratio = 0.25; 95% CI, 0.13-0.52; P <0.001) and a conclusion was drawn on the benefits of an injury prevention program that includes closed-loop kinematic exercises for the four-headed muscle in combination with strengthening the gluteal muscles.

Augustsson. et.al. (1998) showed a higher efficiency of closed kinematic chain exercises compared to open kinematic chain exercises for gaining muscle mass and increasing the jump up. Augustsson et.al. (1998) point out that weight training is commonly used in sports for injury prevention and rehabilitation, and decided to compare the effectiveness of strength training in closed and open kinematic circuits for the development of leg muscle strength. Group 1 performed a program that included exercises with an open kinematic chain: squats with a barbell, activation of the quadriceps and thigh muscle. In group 2, exercises with open kinetic chain were performed: extension of the knee on the simulator and exercises for bringing the thigh, activating the quadriceps and the afferent muscle and thigh muscles separately. Augustsson et.al. (1998) found a significant increase in the results of the jump up (by 5 cm) and an increase in muscle mass in the group that performed exercises with a closed kinematic chain.

Witvrouw et.al. (2004) showed that exercises in closed and open kinematic circuits significantly increase the functionality of people who have just begun to engage in physical culture and sports. However, these authors did not study the impact of different programs on injuries.

In this regard, it is logical to conclude that research aimed at injury prevention in physical culture and sports should be continued in the context of developing effective injury prevention programs in various sports. In addition, the prevention of injuries of students - future specialists in physical education and sports - is especially important.

1.2.3. The problem of injuries of students engaged in climbing

Currently, climbing is becoming an increasingly popular sport among young people (Kozin 2019; Kozin et.al, 2020; Lutter et.al. 2017). Therefore, climbing is introduced in many higher education institutions that train specialists in the field of physical culture as one of the main sports.

Climbing is now becoming an Olympic sport (Lutter et.al. 2017). This will increase the volume and intensity of loads and the number of injuries. Hochholzer et.al. (2005), Schoffl (2008), Schoffl et al. (2012) found a tendency to significantly increase injuries of the upper extremity girdle in climbing. The most commonly injured areas are the fingers, shoulder and forearm (Schoffl et.al., 2008; Jones et.al., 2015; Jones et.al., 2016; Woollings, et.al., 2015).

Backe, Ericson, Janson, Timpka (2009) reported 4.2 injuries per 1,000 hours of training in schaloazania, with injuries associated with overload of the upper extremities, accounting for 93% of all injuries. Inflammatory lesions of the tissues of the fingers and wrist were the most common types of injuries. Multivariate analysis has shown that being overweight and bouldering increases the risk of primary injury. The risk of re-injury was higher among male climbers and lower risk among older climbers. The authors concluded that a high percentage of injuries come from excessive training loads. This suggests that the time of climbing and the intensity of the load should be increased gradually and systematically. Climbers should regularly check for signs and symptoms of overexertion. Further study of the relationship between body mass index and injury during climbing is required.

Jones, Asghar, Llewellyn (2016) found that about 50% of climbers received more or less 1 injury in the last 12 months, resulting in 275 different anatomical injuries. 21 climbers (10%) received acute injuries when climbing as a result of a fall, 67 (33%) - chronic injuries caused by excessive overexertion, and 57 (28%) - acute injuries caused by strenuous movements during climbing. Climbers who are involved in various types of climbing are more prone to finger and shoulder injuries.

Durand-Bechu, Chaminade, Belleudy, Gasq (2014) described injuries during climbing in France between 2004 and 2011. 1.49 injuries were detected per 1,000 hours of practice. Women climbers accounted for 0.35% of injuries per year, while among men the percentage was lower (0.27%). Climbers aged 19 to 30 received the highest rate of injuries - 0.37% per year. The most common injuries were fractures and dislocations (39% and 25% for men and 30% and 34% for women, respectively). The authors concluded that prevention should be strengthened to reduce the number of serious accidental injuries.

Jones and Johnson (2015) showed that previous trauma is a significant risk factor for re-trauma. Insufficient technical training in bouldering and sports bathing were largely associated with repeated injuries. As the number of participants in the competition increases, the probability increases that most climbers may be injured in the upper extremity.

Merritt, 2011; Pozzi, 2016; Schoeffl, 2008, who studied injuries in climbing, concluded that the upper limbs are most often injured. Shoulder injuries are common injuries to climbers. Therefore, the development of injury prevention programs in climbing is necessary.

Climbing injury prevention programs are currently just beginning to be developed (Kozin, 2014). Therefore, there is currently insufficient literature on the prevention of injuries in climbing. There are indirect assumptions about the positive effect of strength exercises on the reduction of injuries in climbing, but no special studies have been conducted. Aras et.al. (2020) investigated the effectiveness of the use of electrical stimulation of muscles in combination with training on a special device "fingerboard". The authors concluded that the use of electrical stimulation in combination with exercises on the fingerboard significantly increases the strength of the arm muscles. Based on the results, the authors conclude that the use of this method can not only increase the strength of the hands, but prevent injuries. This is due to the fact that muscle strength is a factor in injury prevention (Parkkari et.al., 2011; Pasanen et.al., 2008; Woollings et.al., 2015).

Currently, there are also some contradictions in the use of various tools to improve the quality of climbing and injury prevention. Cetinkaya, et.al. (2021) found that modern tools used to improve the adhesion of fingers to rocks in rock climbing on natural terrain (magnesia), worsen the condition of rocks. The authors recommend conversations with climbers and motivate them to use other means.

Thus, the literature data indicate a high predisposition to injury of the upper extremities in climbing. This indicates the need to develop injury prevention programs in climbing. However, currently we have not found research on injury prevention programs in climbing. At the same time, there is a large body of research on injury prevention programs in other sports popular with students (Muszkieta, et.al., 2019; Parkkari et.al., 2011; Pasanen et.al., 2008).

(LaBella et.al., 2011; Parkkari et.al., 2011; Pasanen et.al., 2008) show that the most effective injury prevention programs are comprehensive programs that include neuromuscular training. These authors emphasize the need to combine comprehensive programs with various educational programs to inform about the causes of injuries and means of injury prevention

One of the important components of neuromuscular training programs for injury prevention is closed kinematic chain exercises and eccentric exercises (Coppack et.al., 2011; Parkkari et.al., 2011). Thus, Coppack et.al. (2011) showed the effectiveness of an injury prevention program for girls serving in the army, one of the components of which were exercises with a closed kinematic chain for the quadriceps muscle. Exercises were also aimed at strengthening the gluteal muscles. There was a 75% reduction in the risk of injury (uncorrected hazard ratio = 0.25; 95% CI, 0.13-0.52; P <0.001) and a conclusion was drawn on the benefits of an injury prevention program that includes closed-loop kinematic exercises for the four-headed muscles combined with strengthening the gluteal muscles.

Augustsson et.al. (1998) показали більш високу ефективність вправ з закритим кінематичним ланцюгом в порівнянні з вправами з відкритим кінематичним ланцюгом для набору м'язової маси і збільшення стрибка вгору.

Currently, there are also a large number of techniques aimed at improving the coordination skills of athletes in various sports (Al-Ravashdeh, et.al., 2015; Kartal et.al., 2020; Kozina et.al., 2018). Coordination skills are a necessary component of technical training of athletes and injury prevention (Kozin, 2019), and therefore their development will be effective for these purposes. One of the components of coordination is also the development of strength (Aras et.al., 2020, Parkkari et.al., 2011) and the development of conscious self-control over the technique of performing various movements (Kozina et.al., 2018).

Thus, among the programs aimed at injury prevention in various sports, there are often exercises with a closed kinematic chain, exercises that are performed in an eccentric mode and strength exercises. In our opinion, the combination of these exercises for the prevention of shoulder injuries in climbing will be effective.

In this regard, it is logical to assume that: 1. To identify the causes of injuries of students majoring in "Physical Education and Sports", a qualitative analysis of the technique of performing the basic elements of a particular sport; 2. For the prevention of injuries of students majoring in "Physical Education and Sports" will be effective neuromuscular training in combination with educational programs and an analytical approach to the technique of performing the basic elements of a particular sport.

1.3. Theoretical bases of the reasons of occurrence of injuries at occupations by physical culture and sports

One of the most common prerequisites for injuries and diseases of the musculoskeletal system is inadequate technique (biomechanical structure) of movements (Lion, A., van der Zwaard, BC, Remillieux, PP, & Buatois, S., 2015; Robertson, N., 2012 ; Schö ffl, VR, Ho ff mann, G., & Küpper, T., 2013). This applies to both sports and everyday life. The formation of biomechanically effective motor stereotypes is required to prevent injuries and diseases of the musculoskeletal system. With biomechanically rational functioning of the motion control system, the musculoskeletal system can work without injuries and diseases.

Motor stereotype is a set of the whole mosaic of muscular tensions and relaxations encoded in short-term and long-term memory (Stelzle, F. D., Gaulrapp, H., & Pforringer, W., 2000). In the motor stereotype, a "biomechanically suboptimal" ability to improve and automate is possible. Mastering the culture of movement requires consistency and phasing in the improvement of motor stereotypes (Bernstein, N.A., 1967).

The word "biomechanics" means "movement of living things". "We watch with amazement and admiration as seagulls flying behind the stern of the ship fall down with a stone and snatch pieces of bread on the fly, which are thrown to them by passengers. We are delighted by the light and at the same time powerful movement of a galloping horse, by the graceful curves of the body of a creeping snake. But compared to animals, man is a much more perfect unique creature in diversity, complexity and accuracy of movement "(Bernstein, N.A., 1967).

Ancient thinkers tried to reveal the secret of the movement of the living. The first works in this area were written by Aristotle (384-322 BC), who was interested in the patterns of movement of terrestrial animals and humans. Problems of biomechanics were occupied by the Roman physician Galen (131-201 AD), Leonardo da Vinci (1452-1519), Giovanni Borelli (1608-1679), a student of Galileo and the author of the first book on biomechanics "On the movements of animals", which was published in 1679. The nature of movements, the mechanism of their management was occupied by many domestic scientists: IM Sechenov (1829-1905), IP Pavlov (1849-1936), PF Lesgaft (1837-1930), AA Ukhtomsky. 1875-1942) (cited in Bernstein, NA, 1967).

But the real revolution in biomechanics was made by MO Bernstein (Bernstein, N.A., 1967). He not only created a theory of motor activity of animals and humans, but also turned it into a tool for cognition of the brain.

And the human musculoskeletal system is a self-propelled mechanism consisting of approximately 600 muscles, 200 bones and several hundred tendons. This is not a centipede! Bernstein found a rigorous scientific answer to this seemingly humorous but actually very serious question. He created a theory of coordination of movements, the task of which he considered overcoming the excessive degrees of freedom of the driving organ, in other words - to transform it into a controlled system.

The fact is that human bones, say, in the hands, are fastened together by joints having two and shoulder even three axes of rotation (Gareth Jones, MSc and Mark I. Johnson, 2016; Wright, DM, Royle, TJ, & Marshall, T., 2001; Wright, DM, Royle, TJ, & Marshall, T., 2001). Therefore, the brush has the ability to move on many independent trajectories. And this is only one brush, and a person has two of them, and on each of them five fingers, consisting of three phalanges. However, the parts of the human body, given the mobility of the body, have the amount of possible movements realized by a three-digit number. And how complex the movements of the eyeball, which allow you to monitor moving objects and are provided with the work of 24 eye muscles!

Each particular movement a person makes, overcoming excessive degrees of freedom, and does so, according to NA Bernstein (Bernstein, N.A., 1967), through coordinated control of the elements of the musculoskeletal system (Bernstein, N.A., 1967).

Bernstein in his reasoning developed one of the assumptions of IM Sechenov (1913) that the brain does not passively perceive information from the world around it and not only responds to it with action, but itself actively influences the world. He continuously creates a prognostic model of the future based on probability calculation. Bernstein understood that the brain knows in advance the purpose of any action. This goal causes the action to start, and it changes and adjusts in the process of this action on the basis of feedback, ie constantly receiving messages "from the ground" about the achieved result of the action. As in the above example of feeding seagulls when a bird is seen. as a piece flies, it "calculates" its possible trajectory, compares it with the direction and speed of its flight, and then the brain commands the muscles to direct the body to the point where the beak meets the piece of bread. Man differs from the rest of the animal world only in that he has the principle of activity, combat self-organization has become conscious and is formed, among other things, articulate language, writing, and so on. The essence of the theory of activity MO Bernstein expressed very precisely in the title of his article "From Reflex to Model of the Future", written by him in the last year of his life.

Movement coordination is carried out on a hierarchical ladder (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery, CA, 2015; Thompson, RN, Hanratty, B., & Corry, IS , 2011). This is about the same as during military operations. The general does not monitor the actions of each soldier, he sets a common task for unit commanders. They report it in detail to the unit commanders, and the junior commanders lead the soldiers into battle, trying to occupy one or another height, one or another settlement. The brain also has a group of neurons that determine the overall movement strategy. Groups of second-level neurons organize the order and sequence of activation of muscle groups, and groups of even lower levels send impulses to the muscles.

According to MO Bernstein (Bernstein MO, 1967), there are five levels of control of movements by the central nervous system.

Level A is the lowest and phylogenetically oldest (rubrospinal). At this level, signals come from muscle proprioceptors (receptors located in the muscles of the body), which indicate the degree of muscle tension, as well as from the organs of balance.

Level A participates in the organization of any movement together with other levels and is almost never leading a person. There are movements that are regulated by level A independently: involuntary trembling, gnashing of teeth from cold and fear, trembling of the violinist's finger and so on.

Thus, Level A is the level of tone. The lowest and phylogenetically oldest (its roots must be sought in the distant past, when living has only learned to move). In humans, it is responsible for muscle tone. At this level, signals come from the muscle proprioceptors, which thus inform about the degree of muscle tension. A typical independent manifestation of this level is the trembling of the body from cold or fear.

Level B NA Bernstein (Bernstein, N.A., 1967) calls the level of synergies (from the Greek. Together; synergists - muscles that act together to perform one particular movement). By the name of the anatomical substrate it is called thalamo-pallidar. At this level, signals from musculoskeletal receptors are processed, which inform about the mutual position and movements of body parts. Insufficient development of level A leads to a lack of balanced work of muscles that provide dynamic stability, ie stability when performing certain movements, insufficient work of muscles that provide posture support in the dynamics of movements. One of the most important causes of injuries is the lack of functioning of level A.

Level B participates in the organization of movements of higher levels, taking on the task of internal coordination, highly coordinated movements of the whole body. He is responsible for the automation of various motor skills, expressive facial expressions and pantomime movements, clearly colored. The own movements of this level include those that do not require consideration of external space: free gymnastics, pulling, facial expressions, etc.

Thus, level B is the level of synergies. Taking information from level A, as well as "installations" from the upper levels, this level organizes the work of "temporary ensembles" (synergies). That is, the main task of this level is to coordinate the tension of individual muscles. Typical independent manifestation of this level is sipping, involuntary facial expressions, simple reflexes (for example, pulling the hand away from the hot). Level B dysfunction leads to insufficient interaction of the muscles that provide basic movements, and this is one of the most important causes of injuries in sports.

Level C NA Bernstein (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery, CA, 2015; Thompson, RN, Hanratty, B., & Corry, IS, 2011) calls the level spatial field. According to the name of the anatomical substrate - pyramidal-arrow. It receives signals from sight, hearing, touch, ie all the information about outer space. These are all movement movements: walking, climbing, running, jumping, various acrobatic movements, throwing a ball, playing tennis, aiming movements (playing billiards, telescope aiming).

Level C is the level of the spatial field. Level C receives information from level B, "installations" from the higher level, and - very importantly - collects all available information from the senses about outer space. At this level, simple, pointless movements in space are built. Running, waving his arms - typical independent manifestations. Insufficient development of level C leads to insufficient analysis of the spatial field, which will lead to injuries.

Level D - level of objective action (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery, CA, 2015; Thompson, RN, Hanratty, B., & Corry, IS , 2011). This is the cortical level. By the name of the anatomical substrate - parieto-premotor. He is in charge of organizing actions with objects and is specific to humans. It includes all household movements, work, driving. Movements of this level agree with the logic of the subject. This is not so much movement as action. They do not have a fixed rolling stock, but a given end result. For this level indifferent way of performing an action, a set of motor operations. For example, the bottle can be opened with a corkscrew, you can knock out the cork by hitting the bottom, push the cork inside, etc. In all cases, the result is the same.

Its localization is already in the cerebral cortex. He is responsible for organizing the interaction with objects. Including at this level as a result of experience ideas about the basic physical characteristics of surrounding objects are postponed. Of great importance for the functioning of this level is the concept of purpose, ie the desired position of objects as a result of action. Insufficient functioning of level D leads to a lack of effective interaction with objects, which can lead to injuries associated with interaction with objects.

Level E - the level of intellectual motor acts. The highest level. This level includes movements such as language, writing, symbolic or coded language. In a sense, this level could be called "pointless", because in contrast to level D, here the movements are determined not by the subject but by the abstract content. If, for example, a person writes a note to an acquaintance, then physically he has contact only with paper and pencil, but the line formed on paper is determined by a whole galaxy of abstract meanings: the idea of the absence of man, his personal characteristics, goals and objectives regarding this person, about the possibilities to realize these goals and objectives through the letter, as well as other meanings.

Insufficient inclusion of level E leads to insufficient awareness of the technique of movements, and, accordingly, - to the occurrence of injuries.

It is necessary to consider:

Several levels take part in the organization of complex actions. The one on which the action is built is called the leader, and the others are called below.

Formally, one and the same action can be built on different levels. For example, the circular motion of the hands can be obtained at level A or at level B, or at level C, or at level D.

What determines the fact of building a movement at one level or another?

The leading level of traffic construction is determined by the content or task of the movement. That is, physiology is determined by the purpose of human action.

Thus, N.A. Bernstein (Bernstein, N.A., 1967) introduced a targeted determination of body behavior.

Depending on the information carried by the feedback signals, afferent signals come to different sensitive centers of the brain and accordingly switch to motor pathways at different levels.

Each level has specific, unique motor manifestations; each level corresponds to its own class of movements (Gareth Jones, MSc and Mark I. Johnson, 2016; Wright, DM, Royle, TJ, & Marshall, T., 2001; Wright, DM, Royle, TJ, & Marshall, T., 2001;).

His research NA Bernstein (1896-1966) showed and proved that motor activity is carried out not by means of a reflex arc (as Pavlov and his followers believed), but by means of a so-called reflex ring (due to the presence of feedback). This allowed NA Bernstein (Bernstein, N.A., 1967) to build a sound and proven theory of level construction of movements.

Thus, according to the theory of motion control MO According to Bernstein, the lack of functioning of any level of organization of movement management (especially for levels A and B) leads to injury.

Based on the above, we can formulate definitions of "functional movement" and "functional therapy", "functional training":

Functional movement is the most biomechanically rational movement, economical in terms of energy consumption, as well as in terms of organization of movements, with the required level of activation of levels of movement control.

Functional therapy is a method of physical therapy aimed at restoring the lost or improving the pathological process

Functional training is a type of training aimed at increasing the adaptive resource of mainly the musculoskeletal system, using natural for human and specific to the athlete exercises, with increased motor control.

Preventive exercise is a movement that helps to increase a person's adaptive resource and reduce the impact of pathological factors. This is achieved not only by understanding the work of the body, but also by taking into account a large number of individual characteristics.

Conclusion to the first chapter

When analyzing the literature, a search was made for relevant sources in the databases Endnote, Web of Science, Scopus, PubMed. A total of 2456 sources devoted to this problem were identified, among them 235 sources were selected for our study. The search was conducted by keywords (sports, physical education, training of teachers (coaches) in physical education and sports, injuries). Articles were selected as follows: by rating of magazines: preference was given to magazines 1-3 quartile; among the review articles, preference was given to articles in which the analysis of more than 40 sources was presented; among the research articles, preference was given to articles that presented data on injury analysis in more than 1-2 higher education institutions; Among the randomized control studies, preference was given to articles that presented data using methods of statistical data analysis, including comparisons of averages with parametric and nonparametric statistics, regression analysis, determination of injury risks, and others. In addition, the basic concepts of motion control were analyzed, among which - the theory of level organization of movements MO Bernstein (MO Bernstein, 1967).

Based on the analysis of modern scientific literature, it was found that many studies are currently devoted to sports injuries of students. This indicates the high urgency of this problem in the world. Scientific works on this topic can be divided into 2 groups: 1 - articles on sports injuries of students in general (the largest number of articles); 2 - articles on sports injuries of students studying in the program "Physical Education and Sports". This program provides training for physical education teachers or coaches in a particular sport. The most traumatic and researched sports in terms of injuries are team sports with the ball and wrestling.

A separate group consists of research aimed at injury prevention in physical culture and sports. These studies are devoted to the development of effective injury prevention programs in various sports. The prevention of injuries of students - future specialists in physical education and sports - is especially important. At the same time, many authors note the low level of knowledge of students about injuries in sports and suggest different ways to raise awareness of students on injury prevention. Among such ways are the creation of online courses, the introduction of special programs in the educational process of students, improving the quality of information on injuries in sports.

Among the most effective programs for the prevention of injuries of students in sports, as well as students enrolled in the program "Physical Education and Sports", there is a program of neuro-muscular training. This program involves training muscles that are not characteristic of the main movement, but which provide support for the athlete's posture in the dynamics of the main movements. The program of neuro-muscular training also provides conscious concentration on various aspects of movement technique and on specific elements of specially selected exercises for injury prevention.

It should be noted that among the sources we have studied, such sports as climbing have not been analyzed, although currently this sport is becoming increasingly popular among young people, including students. Therefore, a promising area, in our opinion, will be the analysis of injuries among students engaged in climbing, and the development of injury prevention programs. Analysis of the literature has revealed that the main cause of injuries are biomechanically suboptimal movements, and the basis for injury prevention in everyday life, in sports in general and in climbing in particular is the formation of functional movements - the most biomechanically rational movements, economical in terms of energy consumption and view of the organization of movements, with the required level of activation of levels of movement control.

The analysis of literature sources also allowed to formulate the concepts of "functional movement", "functional therapy", "functional training".

Based on the data of the analyzed literature, we formulated the hypothesis:

1. To identify the causes of injuries of students majoring in "Physical Education and Sports", a qualitative analysis of the technique of performing the basic elements of a particular sport;

2. For the prevention of injuries of students majoring in "Physical Education and Sports" will be effective neuromuscular training in combination with educational programs and an analytical approach to the technique of performing the basic elements of a particular sport.

CHAPTER 2. METHODS AND ORGANIZATION OF RESEARCH

2.1. Research methods

The following research methods were used in the work:

1. Analysis of literature sources
2. Method of biomechanical analysis of one-arm hang technique in climbing
3. The method of expert evaluation of the technique of performing height on one arm in climbing
4. Method of registration of injuries of the upper extremities in climbing
5. Statistical analysis

2.1.1. Analysis of literature sources

When analyzing the literature, a search was made for relevant sources in the databases Endnote, Web of Science, Scopus, PubMed. A total of 2456 sources devoted to this problem were identified, among them 235 sources were selected for our study. The search was conducted by keywords (sports, physical education, training of teachers (coaches) of physical education and sports, injuries). Articles were selected as follows: according to the rating of magazines: preference was given to magazines 1-3 quartiles; among the review articles, preference was given to articles in which the analysis of more than 40 sources was presented; among the research articles, preference was given to articles that presented data on injury analysis in more than 1-2 higher education institutions; Among the randomized control studies, preference was given to articles that presented data using methods of statistical data analysis, including comparisons of averages with parametric and nonparametric statistics, regression analysis, determination of injury risks, and others. In addition, the basic concepts of motion control were analyzed, among which - the theory of level organization of movements MO Bernstein (MO Bernstein, 1967).

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Among the most effective programs for the prevention of injuries of students in sports, as well as students enrolled in the program "Physical Education and Sports", there is a program of neuro-muscular training. This program involves training muscles that are not characteristic of the main movement, but those that provide support for the athlete's posture in the dynamics of the basic movements. The program of neuromuscular training also involves a conscious concentration on various aspects of movement techniques and on specific elements of specially selected exercises for injury prevention.

It should be noted that among the sources we have studied, such sports as climbing have not been analyzed, although currently this sport is becoming increasingly popular among young people, including students. Therefore, a promising area, in our opinion, will be the analysis of injuries among students engaged in climbing, and the development of injury prevention programs.

Analysis of literature sources revealed that the main cause of injuries are biomechanically suboptimal movements, and the basis for injury prevention in everyday life, in sports in general and in climbing in particular is the formation of functional movements - the most biomechanically rational movements, economical in terms of energy consumption and view of the organization of movements, with the required level of activation of levels of movement control.

The analysis of literature sources also allowed to formulate the concepts of "functional movement", "functional therapy", "functional training".

Based on the data of the analyzed literature, we formulated the hypothesis: 1. To identify the factors of injuries of students majoring in "physical education and sports", a qualitative analysis of the technique of performing the basic elements of a particular sport; 2. For the prevention of injuries of students majoring in "physical education and sports" will be effective neuromuscular training in combination with educational programs and an analytical approach to the technique of performing the basic elements of a particular sport.

2.1.2. Method of biomechanical analysis of sports movements

Initially, the technique of performing height in climbing of 20 leading climbers of the World and Ukraine and 20 athletes was analyzed. On the basis of the analysis of the technique of performance by athletes of height, the main characteristics of the correct technique of performance of height were made. In the future, the correct and incorrect technique of performing height was demonstrated and recorded with the help of the Sony FDR-X3000 camcorder. The demonstration was conducted by the author - a qualified athlete, candidate for master of sports of Ukraine, winner and prize-winner of all-Ukrainian competitions.

Using the computer program Kinovea 0.8.15, the kinematic characteristics of two models of equipment (model 1 - typical for novice athletes, model 2 - typical for qualified athletes) were analyzed based on determining the angles between the shoulder and clavicle, as well as between the spine from the middle thoracic to the coccyx and the vertical axis. The analysis of angles was performed from the moment of gripping the hook to a stable fixation of the height (t = 30 s, the number of analyzed frames was 10, the frames were selected at equal intervals; the total number of analyzed attempts was 20 for each model). A comparative characterization of the values of the measured angles at the point of stable fixation of the height was performed on the basis of 20 measurements for each model of equipment. At the fourth stage, a biomechanical analysis of two models of technology based on the laws of classical mechanics (the relationship of forces acting on the body during tension; the interaction of forces in closed kinematic circuits). Based on biomechanical analysis, the main biomechanical characteristics of the correct technique of climbing were given.

The method of biomechanical analysis of one-arm hang technique in climbing was also used in the analysis of one-arm hang technique of athletes of control (n = 22) and experimental (n = 20) groups to determine the effectiveness of the developed technology of injury prevention.

2.1.3. Method of expert evaluation of sports movement technique

The technique of performing high jump on one arm was evaluated by four experts - leading climbing coaches in Kharkiv. The evaluation was performed on a 12-point system. The sum of the scores given by all four experts was used as a quantitative characteristic.

2.1.4. Injury registration method

Cases of injuries and diseases of the upper extremities were registered during the year in the control and experimental groups. The following injuries were registered: injuries and diseases of the fingers, injuries and diseases of the elbow joint, injuries and diseases of the shoulder joint. Injuries were also registered by severity: minor, moderate, severe. Minor injuries include those that heal in less than 1 month, moderate injuries that heal in 2-3 months, and complex injuries include those that heal within 6-12 months and can last a lifetime. Cases of injuries and diseases of the upper extremities were registered during the year in the control and experimental groups. The following injuries were registered: injuries and diseases of the fingers, injuries and diseases of the elbow joint, injuries and diseases of the shoulder joint. Injuries were also registered by severity: minor, moderate, severe. Minor injuries include those that heal in less than 1 month, moderate injuries that heal in 2-3 months, and complex injuries include those that heal within 6-12 months, and their effects can last a lifetime.

2.1.5. Method of determining the risk of injury

To determine the impact of the developed technology on the risk of injury, the following indicators were determined: risk (incidence) of injury, chance of injury, relative risk and odds ratio. Injury risk (incidence) was defined as the ratio of the number of injuries to the total number of athletes in the analyzed group. The relative risk was determined by the ratio of risk in the control group to the risk in the experimental group (relative risk (control group / experimental group). The chance of injury was defined as the ratio of the number of injuries to the number of uninjured athletes in the analyzed group. group / control group) The odds ratio was defined as the ratio of the chances of injury in the control group to the chances of injury in the experimental group. (low, medium and severe), injuries and diseases of the shoulder (low, medium and severe).

The influence of the prior art on the number of injuries was determined by the method of Cochran and Mantel-Hansel. The state of the art is below average according to the expert assessment (less than 25 points) in combination with the values of the angle between the shoulder and the clavicle (more than 1200) was conventionally denoted as 1; the state of the art above the expert average (more than 25 points) in combination with the values of the angle between the shoulder and clavicle (less than 1200) was conventionally denoted as 2.

2.1.6. Statistical analysis

The values of the measured angles at the point of stable fixation of the height were compared on the basis of 20 measurements for each model of technology using the Student's method for odd samples.

When comparing the results of the technique of climbing height and the angle between the shoulder and clavicle of the tested control and experimental groups, the Student's method for odd samples was also used in combination with nonparametric statistics (Mann Whitney, Kolmogorov-Smirnov, Wilcoxon, etc.). Data processing was performed using computer programs - "EXCEL 2016" and "SPSS-17".

To determine the impact of the developed technology on the risk of injury, the following indicators were determined: risk (incidence) of injury, chance of injury, relative risk and odds ratio using the computer program SPSS-17, Crosstabs option.

For the entire sample, we used the exact Fisher test and the Pearson χ-square test to compare the injury rate between the intervention groups and the control group. We calculated the number needed for training to prevent 1 injury as the inverse of the difference between the percentages of injured players in the control and experimental groups. We considered bilateral $P < 0.05$ statistically significant.

We presented the Injury rate indicates as the number of injuries per 1000 NPPs, and we defined the AE as the number of athletes multiplied by the number of all training sessions and competitions in which they participated (AE = athlete * exposure (training sessions, competitions)). In our case, the number of trainings and competitions was the same in the control and experimental groups and was 75 before the experiment and 150 during the experiment. The number of students - climbers in our case was 40 for the experimental group and 44 - for the control). The value of the Injury rate was defined as - the number of injuries 1000 AEs.

Significance of differences in the number and risk of injuries between the control and experimental groups was determined by the Fisher exact test and using the Pearson χ-square test.

Injury risk (incidence) was defined as the ratio of the number of injuries to the total number of athletes in the analyzed group. Relative risk (control group / experimental group) was determined by the ratio of risk in the control group to the risk in the experimental group and vice versa (chances in the experimental group - to chances in the control group). The chance of injury was defined as the ratio of the number of injuries to the number of uninjured athletes in the analyzed group (Knowles et.al., 2006; Lin et.al., 2016). The relative chance was defined as the ratio of the chances of injury in the control group to the chances of injury in the experimental group. These indicators were determined separately for all analyzed types of injuries: finger injuries (low, medium and severe), injuries and diseases of the elbow (low, medium and severe), injuries and diseases of the shoulder (low, medium and severe).

The Pearson correlation coefficient between the expert assessment of the technique and the value of the angle between the shoulder and the clavicle when performing height in climbing was also determined.

The influence of the prior art on the number of injuries was determined by the method of Cochran and Mantel-Hansel. The state of the art is below average according to the expert assessment (less than 25 points) in combination with the values of the angle between the shoulder and the clavicle (more than 1200) was conventionally denoted as 1; the state of the art above the expert average (more than 25 points) in combination with the values of the angle between the shoulder and clavicle (less than 1200) was conventionally denoted as 2.

2.2. Organization of the study

At the first stage of the study (September 2019 - November 2019) an analysis of literature sources was conducted, the concepts of "Functional movement", "Functional therapy", "Functional training" were formulated, the number of athletes seeking medical help in connection with chronic diseases was analyzed. musculoskeletal system. The study was conducted on the basis of the Aleph Clinic, analyzed 78 cases of athletes seeking help in connection with chronic diseases (35 masters of sports, 11 masters of sports of international class, 32 - candidates for masters of sports).

In the second stage of the study (November 2019 - December 2019) was analyzed the technique of performing height in climbing 20 leading climbers of the World and Ukraine and 20 novice male climbers. Athletes age - 22.4 ± 3.2 years, body length 178.5 ± 12.5 cm, body weight 72.2 ± 8.5 kg. The author - a qualified athlete, candidate for master of sports of Ukraine, winner and prize-winner of all-Ukrainian competitions took part in the demonstration of different models of performance.

In the third stage of the study (January 2020 - July 2020) were selected, systematized (if necessary - modified) and applied means of prevention of injuries of the upper extremities in climbing. The tools were exercises used in climbing and other sports, as well as exercises used in physical therapy to form functional movements.

These tools were used in the experimental group (n = 40). In the control group (n = 44) no special exercises were used to prevent injuries.

Participants and randomization

The participants of this study were 84 male students engaged in amateur climbing in the cities of Ukraine (Kharkiv, Dnipropetrovsk, Lyuvov, Vinnytsia, Kamyanets-Podilsk, Kyiv) from 2 to 4 years aged 18-19 years. All athletes were also students of physical education faculties of Ukrainian universities. All athletes gave written consent to participate in the experiment. The health of the athletes was checked during the first 2 weeks of the study with the help of regular medical examinations conducted by a doctor. Athletes were also observed for 6 months to assess baseline injury rates and baseline techniques of one-arm hang on one arm.

An independent statistician performed a parallel randomization of athletes into a control group and an intervention group using a random distribution method using an online random number generator program. As a result of randomization, 40 athletes were in the experimental group and 44 - in the control.

The groups were compared with indicators of body length, body weight, experience of rock climbing and the number of injuries during the observed period of 6 months before the experiment. For all these indicators, the groups did not differ significantly from each other.

The body length of athletes in the control group was 172.5 ± 8.5 cm, body weight - 65.2 ± 6.5 kg; the body length of the athletes of the experimental group was 173.4 ± 8.7 cm, body weight - 66.1 ± 6.6 kg (p> 0.05). The number of injuries to fingers, elbows and shoulders of varying complexity, recorded during the 6 months before the experiment, is presented in table 2.1. No significant differences in the injury index in the control and experimental groups were found (p = 0.385-0.729).

Table 2.1

Comparison of the number of injuries of the upper extremities of climbers between the control (n = 44) and experimental groups (n = 40) for six months before the experiment

Type of injury		Control group			Intervention group (experimental)			IRR (95% CI)[fa/ b]; OR (95%CI)[c]	P [d]
Localization of the injury	Injuries severity	Injuries, No	AEs, quantity.	Injury Rate[a]	Injuries, No	AEs, No	Injury Rate		
Fingers	Easy	7	3300	2.12	8	3000	2.67	1.051 (0.859; 1.286)[a] 0.795 (0.317; 1.995)[b] 0.757 (0.247; 2.318)[c]	0.418 [d]
	Medium	6	3300	1.82	5	3000	1.67	0.987 (0.836; 1.165) [a] 1.091 (0.361; 3.300) [b]	0.568 [d]

								1.105 (0.310; 3.946) [c]	
	Heavy	4	3300	1.21	2	3000	0.67	0.957 (0.851; 1.076) [a] 1.818 (0.352; 9.396) [b] 1.900 (0.329; 10.983) [c]	0.385 [d]
Elbows	Easy	6	3300	1.82	7	3000	2.33	1.047 (0.870; 1.259) [a] 0.779 (0.286; 2.124) [b] 0.744 (0.227; 2437) [c]	0.425 [d]
	Medium	5	3300	1.52	6	3000	2.00	1.043 (0.882; 1.233) [a] 0.758 (0.250; 2.292) [b] 0.726 (0.203; 2.594) [c]	0.432 [d]
	Heavy	1	3300	0.91	2	3000	1.33	1.029 (0.946; 1.119) [a] 0.455 (0.043; 4.824) [b] 0.442 (0.039; 5.068) [c]	0.464 [d]
Shoulders	Easy	4	3300	1.21	5	3000	1.67	1.039 (0.894; 1.207) [a] 0.727 (0.210; 2.521) [b] 0.700 (0.174; 2.813) [c]	0.439 [d]
	Medium	3	3300	0.91	2	3000	0.67	0.981 (0.881; 1.092) [a] 1.364 (0.240; 7.747) [b] 1.390 (0.220; 8.778) [c]	0.546 [d]
	Heavy	1	3300	0.61	1	3000	1.00	1.002 (0.937; 1.072) [a] 0.909 (0.059; 14.058) [b] 0.907 (0.055;14.997) [c]	0.729 [d]

Notes:
Abbreviation:
AEs - athlete * exposure (training sessions, competitions);
Injury rate indicates the number of injuries per 1000
IRR - incidence rate ratio:
[a]Incidence rate ratio for cohort (injuries=no)
[b]Incidence rate ratio for cohort (injuries=yes)

[c] OR - Odds Ratio for group (control/intervention)
CI - confidence interval (Lower bound; Upper bound);
[d]By Fisher exact test.
.

Both control and experimental groups consisted of novice athletes (amateurs), aged 18-19 years, males; body length of athletes of the control group was 172.5 ± 8.5 cm, body weight - 65.2 ± 6.5 kg; the body length of the athletes of the experimental group was 173.4 ± 8.7 cm, body weight - 66.1 ± 6.6 kg ($p > 0.05$). The groups trained according to the generally accepted plan 3-4 times a week, the number of training hours was the same in both groups. At the beginning and at the end of the pedagogical experiment, an analysis of the technique of performing the height on one arm was performed by experts in both groups. The number of injuries of the upper extremities in both groups was also recorded.

At the fourth stage of the study (August 2020 - December 2020) the analysis of the obtained data was carried out, the work was formalized.

2.3. Characteristics of the directions of biomechanical technology of injury prevention in the process of training specialists in physical education and sports

As a result of analytical and creative work, a biomechanical technology for injury prevention in the training of specialists in physical education and sports was developed. The technology is developed, which contains 3 directions: 1 - theoretical and methodical (creation of bases for understanding by students of mechanisms of formation of movements without risk of injury, formation at students of concept of biomechanically rational movements in general); 2 - analytical (providing students with knowledge about modern means of self-analysis of the level of technical skills); 3 - practical (students' mastery of practical means of injury prevention, ie, exercises that will promote the formation of biomechanically rational movements in any sport, and thus prevent injuries).

Theoretical and methodological direction involved mastering the basic knowledge of dynamic anatomy, which is the basis of biomechanics, the basic laws of motion control, understanding the causes and means of injury prevention in physical culture and sports.

In the analytical direction the algorithm of revealing of the basic kinematic parameters of various models of technics characteristic of students with various level of possession of technics of sports movements is developed.

In the practical direction the principles of application of means for prevention of traumatism are defined:

1 - strengthening of the muscles participating in performance of the movement;

2 - the formation of functional movement, ie coordinated work of the muscles of the torso, upper and lower extremities. In this direction, developed and systematized tools to prevent injuries to students - future professionals in physical education and sports.

All means are conditionally divided into two groups: means from a sport and means specific to physical therapy, namely: Feldenkrais's methods, Redcord-therapy, PNF-therapy. Physical therapy is used in an unconventional way: to improve movement technique and to prevent injuries.

2.3.1. Theoretical and methodological direction of biomechanical technology of injury prevention in the process of training specialists in physical education and sports

It is known that for the development and improvement of motor skills in adulthood requires the most conscious approach, ie only when activating consciousness and forming a detailed idea of the peculiarities of movements in adulthood can learn and improve motor skills. Students are people over the age of 17, ie the age when the sensitive periods of formation of most motor qualities, in particular, coordination abilities, have already been completed. And the formation of technical skills is associated with coordination skills. That is why sports that require maximum coordination, recruit children at a relatively early age, ie 5-7 years and even earlier. But the learning process of students - future specialists in physical education and sports is built in such a way that they have 2 tasks, which are often opposite in content: 1 - improving technical skills in the chosen sport; 2 - mastering motor skills in other sports. That is why the development of a conscious understanding of all the details of the studied motion technique becomes especially important. This requires, first of all, the formation of an idea of the general foundations of the formation of technical skills. The basis of knowledge of the process of formation of technical skills is biomechanics.

First of all, students were explained in an interesting and understandable way that biomechanics studies the movements of living beings. Movement is an opportunity for cognition and an amazing manifestation of life. In order for the movement to take place, it is necessary to have a certain structure of the musculoskeletal system and the corresponding function of this structure. Previously, it was believed that the restoration of the structure (pain relief, treatment of bone, ligaments and other systems) will directly lead to the restoration of function (movement). However, according to current research and clinical observations (both physicians and patients), it has been found that there is no direct consequence between successful treatment of the structure and restoration of movement. Function is a complex, multicomponent process, the difficulties of which can be caused by various problems not directly related to structural pathologies. The versatility of this natural process, and the task of restoring it, have created the need for a specialist in movement.

To master biomechanical technology, students were provided with the following author's theses for further analysis and discussion:

• As one teacher said, "If I have a scalpel, it doesn't mean I'm a surgeon."

• Some movements make us strong and healthy, while others can lead to injury.

• This rather thin limit is determined by how much a person is adaptable to his activity.

• Preventive exercise is a movement that helps to increase a person's adaptive resource and reduce the impact of pathological factors. This is achieved not only by understanding the work of the body, but also by taking into account a large number of individual characteristics.

• When the movement is "operated" by a specialist, he accurately assesses the situation. He takes the movement that is necessary at this time and for a particular

situation. The "angle" of influence, intensity, amplitude is very important, even where the attention is now - everything matters!

• Both the scalpel of the surgeon and the therapeutic movement of the physical therapist are one of the tools to achieve the desired goal.

• To become a true specialist in the field of movement training, you must strive to make your athletes not just winners of competitions, but also healthy. Coaches who work with children should look for tools to help their pets avoid injury.

• The beauty of movements is the interaction with the Universe.

To master the biomechanical technology of injury prevention, the concepts of motor stereotypes, the reasons for the formation of "ineffective" movement, the principles of individual selection of methods of correction were also considered.

Thus, the whole process of training was built from understanding the basics of biomechanics, the principle of sensory corrections and levels of movement organization to model thinking in training.

As a result, students were tasked with learning to understand movement "from within", to train / train according to the principles and laws of biomechanics (which means - both effectively and without injury).

Since the concept of injury prevention closely intersects with physical therapy, students were also explained that physical therapy is not just three rehabilitation periods (immobilization, post-immobilization, rehabilitation). This is a process of restoring movement, in which there are continuous corrections of therapeutic effects. These corrections are based on functional, orthopedic, neurological diagnostic tools and direct feedback from therapist and patient.

The concepts were also explained: "Mobility" - "stability" - "mobility on stability", which means a gradual transition from passive movement of the joint to active movements of the injured limb with elements of instability.

It was also explained to the students that in order to become a real specialist in motor activity, it is necessary to master a higher level of scientifically based competence in biomechanics and dynamic anatomy. And only then sports will be safe and most effective.

In the theoretical and methodological direction of the classes the following tasks were set:

• Knowledge of the laws of biomechanics of the musculoskeletal system and its applied aspects in physical culture and sports.

• Fundamentals of preventive approach and understanding of the principles of effective and injury-safe training.

• Knowledge of the laws of movement in the main synergistic patterns and their practical application in the work of a coach and in independent sports.

• The relationship between functional human anatomy and the dynamics of popular exercises.

• Possession of special sets of summarizing exercises that highlight the target muscle group and form the optimal technique.

As a result of mastering this knowledge, skills and abilities, students were given the opportunity to become a specialist in movement, and to reach a new professional level.

The peculiarity of the theoretical and methodological direction was that classes were held both in classrooms and in special rooms for fitness and physical therapy using popular equipment for maximum application of the transmitted information) (Fig. 2.1).

Fig. 2.1. Illustration of classes on mastering the theoretical and methodological direction of biomechanical technology for injury prevention of students - future professionals in the field of physical culture and sports

2.3.1.1. Characteristics of the author's video manual for the implementation of the theoretical direction of biomechanical technology of injury prevention in the process of training specialists in physical education and sports

In order to form a theoretical foundation for students in the process of formation and improvement of technical skills, an author's video manual on the basics of biomechanics of the musculoskeletal system was developed. The author's video manual is an illustration with an explanation of the biomechanical patterns of proper motor skills and injury prevention.

The author's video manual is entitled: "Biomechanics of the musculoskeletal system" (A.C. №№ 100612-100616 from 17.11.2020) and consists of 5 parts:

Part 1. Biomechanics of the musculoskeletal system. Basic concepts in biomechanics (A.C. № 100612 from 17.11.2020).

Part 2. Biomechanics of the musculoskeletal system. Upper limb (A.C. № 100613 dated 17.11.2020).

Part 3. Biomechanics of the musculoskeletal system. Lower limb (A.C. № 100614 from 17.11.2020).

Part 4. Biomechanics of the musculoskeletal system. Torso and pelvis (A.C. № 100615 from 17.11.2020).

Part 5. Biomechanics of the musculoskeletal system. Head and neck (A.C. № 100616 from 17.11.2020).

Theoretical classes on sports and pedagogical improvement explained to students the main tasks of studying the biomechanical foundations of the process of mastering technical skills.

As a result, students were given the opportunity to get a lot of interesting, relevant information and applied techniques for work and independent training.

The first part of "Biomechanics of the musculoskeletal system. Basic concepts in biomechanics "contains information about the authors, the tasks of the manual, which are as follows:

• Study of basic and clinically significant concepts of biomechanics.

• Study of functional anatomy in motion models.

• Mastering and practicing methods of manual and functional therapy

• Understanding the concept: “It is not optimal movement that is the cause, but optimal therapy.

Next, students are invited to determine their goals in classes on sports and pedagogical improvement. This is a necessary condition and the first step to create a conscious attitude of students to their functional state and injury prevention in both the chosen sport and other physical activities.

The next stage provides a definition of biomechanics as a science of the laws of mechanical motion in living systems, which studies the features of movements in the process of motor activity and exercise. The general task of biomechanics is to find perfect ways of motor actions and to teach / learn to perform them more effectively. The following are partial problems of biomechanics:

• Study and explanation of the human movements in a particular area of his motor activity.

• Study of the results of the motor task.

• Study of the conditions in which they are carried out.

• Based on all this - the development of effective movements, through learning and training.

Pislya ts'go razkrivaєtsya nutrition "How can I know the rational technology of rukhovoy efficiency, with a glance at the specifics of the buildings installed?". In the context of this nutrition, the thesis "The function of controlling the structure and the structure of the controlling function" is opened. For a full understanding of the mechanics of myazovoi iyalnosti, about the "neutral zone" of slopes, about the cinematic pair and cinematic lance, about the closed and open cinematic lancers (Fig. 2.2).

Fig. 2.2. The butt to the slide of the first part of the author's navchany booklet with illustrations of scrutinized and vidcritical lantsyugs

The main understanding of the theory of N.A. Bershteyn and Mechanism of Mechanism of Keruvannya Rukha. To give the value of the steps of freedom of rukhov, factors, to infuse rukiv on the way (reactive force, uninterrupted force, callous force, outward camp of meat), to be able to understand about sensitivity, about the receptor, how to forget It is necessary to explain the principle of sensory corrections and to give an understanding of the rukhovoy stereotype with the prompts of N.A. Bernstein and P.K. Anokhina:

“The ruffian stereotype is the essence of the whole mosaic of meat springs and relaxation, encoded in a short-hour and pre-production memory.

A rooted stereotype is capable of "Biomechanical suboptimality", building up to thorough and automation.

The development of the culture of rukhiv vimag of the last and the stages of the thoroughness of rukh stereotypes ”(Bernshtein N.A., 1954; Ivanichi G.A., 2005; Anokhin P.K., 1935). The basis of the theory of N.A., Bernstein is the basis of the theory of N.A., Bernstein - the roots of the central nervous system, which are ruffled.

• Level "A" - the level of blind execution of movements (pure physiology) provides adjustment of muscle tone (ie the ability of muscles to relax, the relationship of muscle antagonists).

• Level "B" - the level of motor stamps. It provides an innate feature of motility (agility, grace, plasticity), as well as rough technique of repetitive movements (posture, posture, walking, running). Actually at this level the so-called "habitual posture" is formed, ie the posture characteristic of the concrete person. Level "B" is the level of unconscious posture, the level of reflexive posture correction.

• Level "C" level of the spatial field, provides the entry of motor stamps in real space: it is the ability to relax as a team, the ability to tense a single muscle, repetition of movements on the display, grouping the body, maintaining posture. Remote receptors (sight, hearing) are used for this purpose. In relation to posture, this is the level of external correction: for example, correction of body position by a teacher or coach, or correction "on display".

• Level "D" - Level D - level of objective action (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery, CA, 2015; Thompson, RN, Hanratty, B ., & Corry, IS, 2011). This is the cortical level. He is in charge of organizing actions with objects and is specific to humans. It includes all household movements, work, driving. Movements of this level will agree with the logic of the subject. It is no longer so much movement as action. They do not have a fixed rolling stock, but a given end result.

• Level "E" - the level of intellectual and motor acts, especially speech movements, written movements. symbolic language movements (deaf-mute gestures) (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery, CA, 2015; Thompson, RN, Hanratty, B., & Corry, IS, 2011). The level of intellectual motor acts. The highest level. This level includes movements such as language, writing, symbolic or coded language.

In the process of studying the levels of movement control, it is revealed what role each of the levels of movement regulation plays in the prevention of injuries.

• In the following, the concept of the pattern as part of the motor stereotype is given (Fig. 2.3).

Fig. 2.3. Example of a slide of the first part of the author's textbook with an illustration of the pattern as part of the motor stereotype

As a result of the first part of the video tutorial, the following conclusions are identified:

1. Construction of movement is a process in which between a brain and executive bodies there is not only direct, but also continuous feedback (the principle of sensory corrections).

2. The movement is not stored ready in memory, and with the use of instructions (models / patterns) is rebuilt in the process of the action

3. Models / patterns are used not on the basis of nonlinear reproduction, but on the flexible mechanism of expedient adaptation

4. Most chronic orthopedic problems are associated with biomechanically suboptimal motor stereotype.

The second part of the video tutorial is devoted to the structure, functions and prevention of injuries of the upper extremity girdle. First, the degrees of freedom of movement of the upper extremities are considered, the structure of joints and features of movements in them are analyzed. Each muscle that provides movement to the upper extremities is then examined in terms of anatomy and the function it performs. At the end of the characteristics of each muscle, the main pathologies of the upper extremity girdle provided by this muscle are considered. At the next stage, manual and functional methods of physical therapy to prevent injuries and diseases, as well as to restore the functions of the upper extremities are studied. The second part of the manual contains a large number of dynamic illustrations, including the author's, which accompany each explanation of the structure, function, pathologies and means of restoring the girdle of the upper extremities (Fig. 2.4).

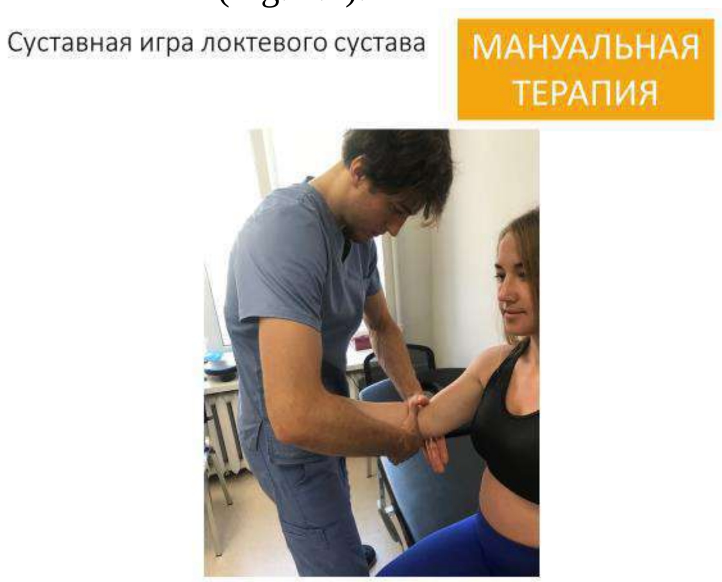

Fig. 2.4. Example of a slide of the second part of the author's textbook with an illustration of manual therapy techniques for injury prevention and recovery from injuries of the upper extremity belt

The third part of the video tutorial is devoted to the structure, functions and prevention of lower extremity girdle injuries. First, the degrees of freedom of movement of the lower extremities are considered, the structure of joints and features of movements in them are analyzed. Each muscle that provides movement to the lower extremities is then examined in terms of anatomy and the function it performs. At the end of the characteristics of each muscle, the main pathologies of the lower extremity girdle provided by this muscle are considered. At the next stage, manual and functional methods of physical therapy to prevent injuries and diseases, as well as to restore the functions of the lower extremities are studied. The third part of the manual contains a large number of dynamic illustrations, including the author's, which accompany each explanation of the structure, function, pathologies and means of restoring the lower extremity girdle (Fig. 2.5).

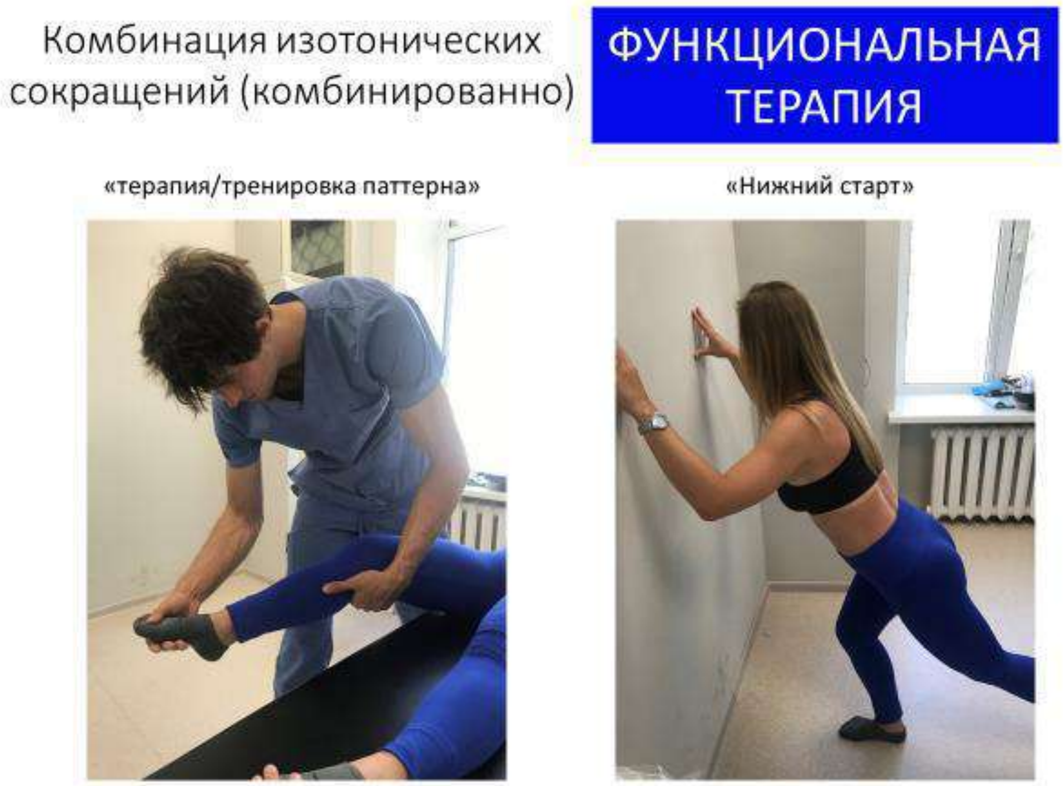

Fig. 2.5. Example of a slide of the third part of the author's textbook with an illustration of functional therapy techniques for injury prevention and recovery from lower extremity girdle injuries

The fourth part of the video tutorial is devoted to the structure, functions and prevention of torso and pelvic injuries. Similarly to the second and third parts, the fourth part also first considers the degrees of freedom of movement of the torso and pelvis, analyzes the structure of joints and features of movements in them. Each muscle that provides torso and pelvic movements is then examined in terms of anatomy and the function it performs. At the end of the characteristics of each muscle, the main pathologies of the torso and pelvis provided by this muscle are considered. At the next stage, manual and functional methods of physical therapy to prevent injuries and diseases, as well as to restore the functions of the torso and pelvis are studied. The fourth part of the manual also contains a large number of dynamic illustrations, including - author's, accompanying each explanation of the structure, function, pathology and means of restoring the movements of the torso and pelvis (Fig. 2.6).

Fig. 2.6. Example of a slide of the fourth part of the author's video tutorial with an illustration of the techniques of manual therapy for injury prevention and recovery after some injuries of the torso and pelvis

The fifth part of the video tutorial is dedicated to the structure, functions and prevention of head and neck injuries. First, the degrees of freedom of movement of the head and neck are considered, the structure of joints and features of movements in them are analyzed. Each muscle that provides head and neck movements is then examined in terms of anatomy and the function it performs. At the end of the characteristics of each muscle, the main pathologies of the head and neck provided by this muscle are considered. At the next stage, manual and functional methods of physical therapy to prevent injuries and diseases, as well as to restore the functions of the head and neck are studied. The fifth part, similar to the previous parts of the manual, contains a large number of dynamic illustrations, including the author's, which accompany each explanation of the structure, function, pathologies and means of restoring head and neck movements (2.7).

Fig. 2.7. Example of a slide of the fifth part of the author's video tutorial with an illustration of the anatomy of the longest neck muscle

2.3.2. Analytical direction of biomechanical technology of injury prevention in the process of training specialists in physical education and sports

The analytical direction of biomechanical technology of injury prevention provided for the introduction of modern means of analysis of the effectiveness of mastering motor skills in the initial process of physical education and sports. In particular, students were asked to learn a modern tool for video analysis of movement techniques - the Kinovea program. The Kinovea sports video analysis program is now an effective, informative, easy-to-learn tool for improving the efficiency of students' acquisition of motor skills and injury prevention.

In the analytical classes, students were explained that for the prevention of injuries it is necessary to have modern tools not only qualitative but also quantitative analysis of movement technique. There are many different computer programs and video tools for this. One of the most common features is the Kinovea program.

In the future, students were invited to master working with this program. To do this, they were given the following instructions.

Instructions for working with the Kinovea program

Kinovea performs video analysis of movements, it is designed for athletes, coaches and health professionals. The software can also be useful for professionals in the field of ergonomics or animation. The main function of Kinovea is to view and analyze sports videos.

The main tools that involve users: "Line", "Chronometer", "Tracking". The "Line" and "Chronometer" functions allow you to measure distance and time, and with the help of the tool "Semi-automatic tracking" you can track both the trajectory and time.

Video upload

When working with Kinovea, you can use video from external sources: camcorders, smartphones, etc. It is enough to save video files on the computer - the program recognizes them independently.

Save video files to your computer

Open Kinovea Click the File button in the upper left corner Select the desired file with the Open Video File command Right-click the video, and then click Open. The selected files are automatically displayed in the application window. To start working with one of the files, right-click on the file and select "Play video". After that, the video file will expand to the entire workspace. Saving a video To select an image area for analysis, use the "[]" tool ("Working Zone") on the bottom panel, which should appear below the video. Use this tool to specify the start and end points for analysis. Save the result with one of the keys on the bottom panel.

How to add in video graphics

To add key data images to the file, use the "Combine video and key images data into the file" option. This option allows you to create videos with original images: later you can play with another player video, which will be superimposed on the time and trajectory. If necessary, it will not be difficult to open the file in Kinovea and make changes to the schedule again.

How to add pictures to a video

To export a movie with pictures, timing or route recording, use the "Permanently paint key images data on the video" option.

How to save only videos You can also save videos without additional data such as routes, times and more. To do this, just use the "Save video only" key. This option will come in handy when you need to cut a long video into small episodes for further analysis.

With Kinovea you can measure time, distance and speed, and the program tracks the movements of a person or individual joints of the body.

Tracking of objects or movements of joints

To track the movement of an object, follow these steps: Right-click on the video and select the "Track Path" option. To select a specific video frame for processing, use the "Play" button. The program allows you to slow down the video playback speed. to make it easier to work with frames Once you have determined the area of the video to be used, right-click and select "End Path Edition".

Creating a trajectory

To track the movements of a specific part of the body or the whole torso, left-click on the desired area of the image. Two rectangles will appear around the object: small and large. The inner small rectangle is the function window A ("feature window [A]"). External Large Rectangle - Feature Window B ("feature window [B" ") When you reach the last frame of the trajectory you want to track, select" End Path Edition "to complete the trajectory creation process. The rectangles will disappear, but checkpoints will be visible when played back. In the process of tracking the trajectory, you can change the objects of analysis. If you find that the tracking area is selected incorrectly while working with the video, move the cursor to the desired area of the image, right-click and click "Restart Path Edition".

Adjust display settings

To make adjustments to the video or highlight specific sections of the path, do the following: Right-click on the motion record, select "Configuration" - and you will be able to change the trajectory. A dialog box with display modes will appear on the screen. The trajectory can be recorded in one of the following modes: [Top photo] - full trajectory that displays all movements for a full period of time. [Middle photo] - the trajectory of a given area of the image. The program will track the movements of only a specific object or body part selected by the user. [Bottom photo] is the minimum trajectory. The program will track only a small point specified by the user.

Measurement

To calculate the distance from the beginning of the path and the end point, use the tool "line drawing" on the panel located directly below the video. It looks like a single line: Specify the physical length of the workspace using the line tool, and then right-click the selected area. In the dialog, select the Calibrate Measure tool. The average on the last leg of the trajectory will be used to calculate the speed. To select one of the measurement options, right-click and select the measurement type. The program will display either distance or speed.

Time measurement

To activate this stopwatch function, click the "Stopwatch" button on the toolbar. Then click on any part of the image - a small icon will appear, which looks like a symbolic image of a watch or sports stopwatch. The countdown will be displayed on top of the main image so you can keep track of time. You can use the dialog box to change the background colors and font size. You can also adjust the size of the stopwatch by stretching its lower right corner

How to measure a certain period of time?

The stopwatch will show zero until you start it from a specific frame. You can select the frames from which the countdown will begin and at which it will end. If you want to remove the stopwatch from the screen, right-click and select the "Delete Stopwatch" button in the dialog box. If you have multiple stopwatches installed to track multiple actions, the application recognizes which stopwatch belongs to which action. Use the Label function to mark the stopwatches in different colors.

Distance measurement

To measure both distance and speed, first draw a line and specify its actual length. Using the tracking function, you can measure the total distance. To do this, right-click on the video in the segment of the path and in the dialog box that appears, select the function "Configuration" ("Settings"). In the "Settings" set the "Distance" function. The display will show the distance from the start of the movement to the selected distance.

Speed measurement

To track the speed of the object, right-click on the frame you are interested in, select "Configuration" in the dialog box, and then "Speed". You will need to specify the units. You can choose meters per second, kilometers per hour, feet per second or miles per hour. The program will determine the speed based on user-defined start and end points.

Source: https://spinet.ru/public/KINOVEA.php Spinet.ru ©

Features of Kinovea program application in the process of training specialists in physical education and sports

Initially, the technique of performing height in rock climbing of 20 leading climbers of the World and Ukraine and 20 student-athletes was analyzed. On the basis of the analysis of the technique of performance by athletes of height, the main characteristics of the correct technique of performance of height were made. In the future, the correct and incorrect technique of performing height was demonstrated and recorded with the Sony FDR-X3000 camcorder. The demonstration was conducted by the author - a qualified athlete, candidate for master of sports of Ukraine, winner and prize-winner of all-Ukrainian competitions.

Using the computer program Kinovea 0.8.15 analyzed the kinematic characteristics of the two models of equipment (model 1 - typical for novice athletes, model 2 - typical for qualified athletes) based on determining the angles between the shoulder and clavicle, and between the spine from the middle thoracic to the coccyx and the vertical axis. The analysis of angles was performed from the moment of gripping the hook to a stable fixation of the height (t = 30 s), the number of analyzed frames was 10, the frames were selected at equal intervals; the total number of analyzed attempts was 20 for each model of equipment). A comparative characterization of the measured angles at the point of stable height fixation was performed on the basis of 20 measurements for each model of equipment. At the fourth stage, a biomechanical analysis of two models of technology was performed on the basis of the laws of classical mechanics (the relationship of forces acting on the body during tension; the interaction of forces in closed kinematic circuits). Based on biomechanical analysis, the main biomechanical characteristics of the correct technique of climbing were given.

2.3.3. Practical direction of injury prevention technology in the process of training specialists in physical education and sports

2.3.3.1. Means of practical exercises for injury prevention in the process of training specialists in physical education and sports on the example of climbing

Biomechanical analysis allowed to determine the tasks for the use of means for the prevention of injuries in climbing: 1 - strengthening the muscles involved in the movement; 2 - formation of functional movement, ie for coordinated work of the muscles of the torso, upper and lower extremities.

On the basis of biomechanical analysis of the technique of hanging in climbing, means were selected and systematized to prevent injuries of the upper extremities. The tools were physical exercises performed independently and with a physical therapist. All means were conditionally divided into two groups: means of sport (climbing) and means specific to physical therapy (Fig. 2.8).

Exercises in sports were presented by the following groups (Fig. 2.8):

1. Exercises aimed at improving the work of the fingers when performing a grip in climbing, taking into account the fact that in climbing there are different types of grips;
2. Exercises for the prevention of injuries and diseases of the elbow, in particular, exercises for the prevention and treatment of epicondylitis;
3. Exercises for the prevention of injuries and diseases of the shoulder, in particular, exercises to strengthen the muscles of the rotating cuff of the shoulder.

Exercises specific to physical therapy were aimed at the formation of functional movements and were represented by the following groups (Fig. 2.8):

1. Feldenkrais method
2. Redcord therapy
3. PNF therapy

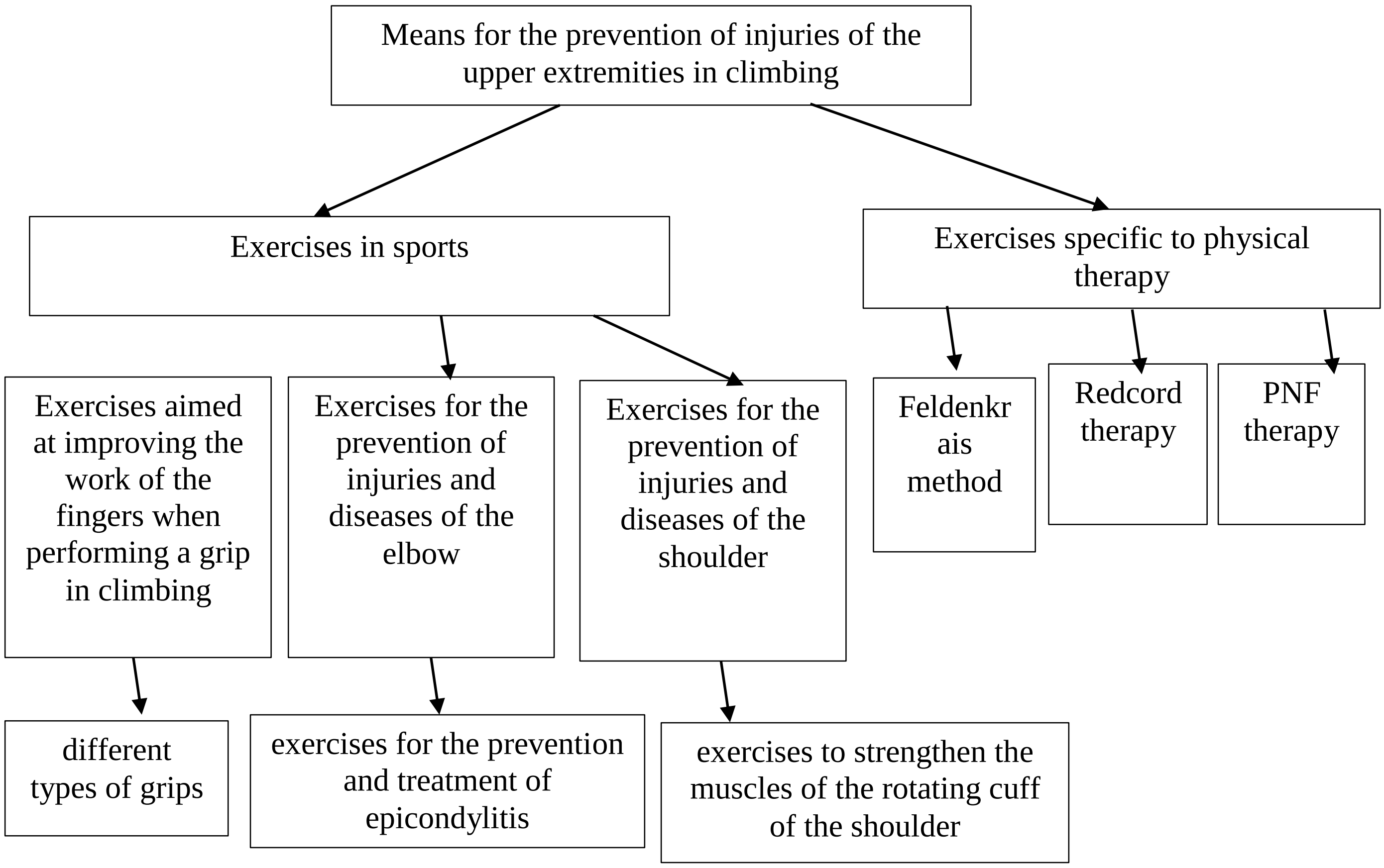

Fig. 2.8. Means of practical exercises for injury prevention in the process of training specialists in physical education and sports

Consider these tools separately.

Exercises in sports

Exercises aimed at improving the work of the fingers when performing a grip in climbing

In the case of injury to the fingers in adults, the annular ligaments that press the tendons of the flexor muscles to the bone are most often damaged.

This injury occurs due to insufficient strength of the ligament in relation to the generated tension of the flexor tendon (Fig. 2.9).

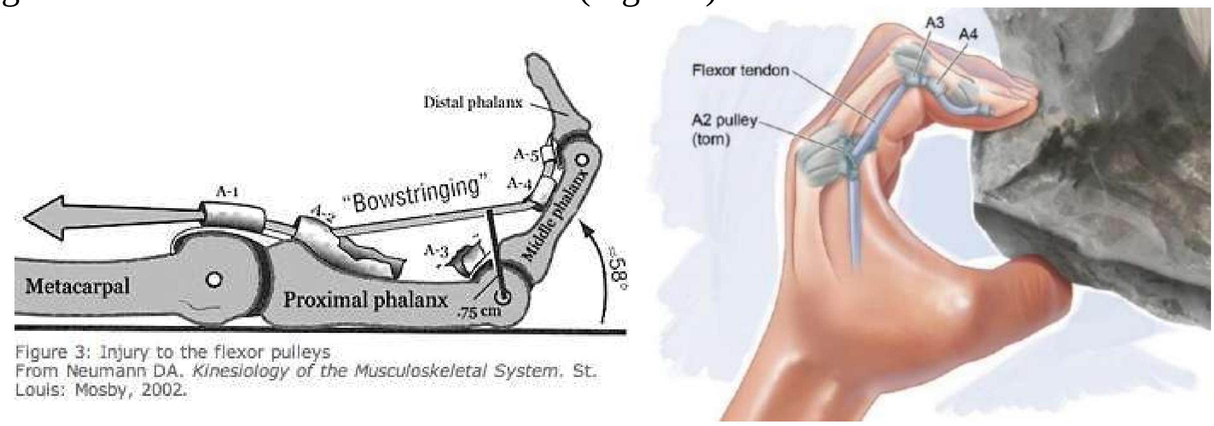

Fig. 2.9. Biomechanical features of the fingers when performing a grip in climbing

In children, due to open areas of growth, more than 50% of finger injuries are fractures of the epiphyseal plate.

There are three main types of rock climbing: open, active and closed grips. The latter is the most traumatic due to the very acute angle in the interphalangeal joint, due to which the load is more concentrated on one annular ligament. Its use is not recommended for children and novice athletes. We do not recommend its use on a campus board simulator due to the very high risk of injury. For children, training on campus and weight training should be prohibited until the finger growth zones are closed. Also, to reduce the risk of injury, it is advisable to use tools and devices aimed at strengthening the extensor muscles of the fingers (Fig. 2.10).

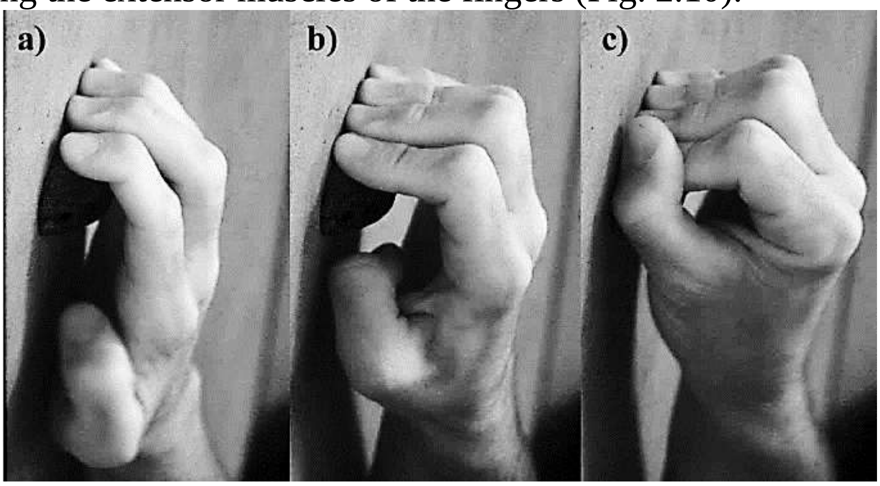

Fig. 2.10. Different grips in climbing

a - open; b - active; c – closed

Exercises for the prevention of injuries and diseases of the elbow

Climbers in the elbow often have a chronic disease such as epicondylitis. This is inflammation of the proximal attachment points of the flexor and extensor muscles of the hand and fingers. Epicondylitis is of two types: lateral and medial. Climbers are prone to both for various reasons.

According to modern authors, one of the most common causes of this disease is muscle imbalance due to the predominance of flexion movements over extension in the elbow joint in the training process of climbers. In this regard, we propose to include in the training process exercises aimed at strengthening the extensor muscles, such as various options for push-ups and training on TRH (Fig. 2.11).

Fig. 2.11. Exercises for the prevention of injuries and diseases of the elbow (source: photo by SV Kozin)

We also recommend the inclusion in the training process of pronation-supination exercises with the exception of the concentric phase (Fig. 2.12).

In addition, a useful tool is stretching the flexors, extensors of the hand and fingers, as well as massage the elbow. These recommendations are suitable for both prevention and the phase of active rehabilitation after injury.

Fig. 2.12. Exercises for the prevention and treatment of epicondylitis (source: photo by SV Kozin)

Exercises for the prevention of injuries and diseases of the shoulder

The most common injuries and diseases of the shoulder in rock climbing include impingement syndrome and tearing of the muscles of the rotating cuff of the shoulder. Fractures of this area are statistically almost non-existent.

Due to the fact that in bathing, especially in competitive bouldering, the shoulder joint is subjected to high dynamic loads in different positions, special attention should be paid to strengthening the muscles of the rotating cuff of the shoulder, namely - supraspinatus, subscapular, subscapular and small round. We offer their strengthening by applying various exercises using gymnastic rubber (Figs. 2.13, 2.14).

Fig. 2.13. Exercises to strengthen the muscles of the rotating cuff of the shoulder (source: photo by the author - SV Kozin)

Thus, to avoid injury it is necessary: to have a scientific approach to the construction of the training process; conducting a proper warm-up; observance of the correct technique; adequate assessment of their capabilities; complete recovery after old injuries and diseases; conducting medical and coaching control. Despite all the above, according to medical statistics, climbing is a much less traumatic sport compared to sports games, martial arts and some cyclic sports.

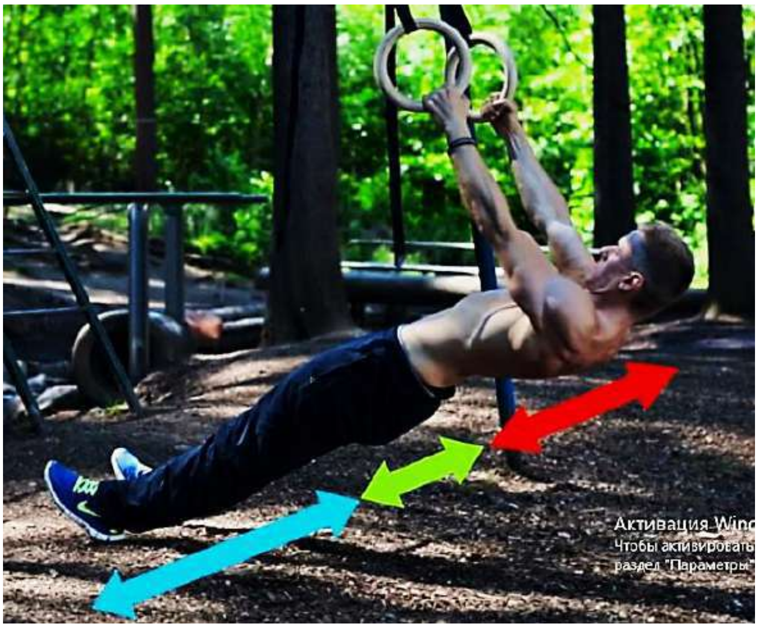

Fig. 2.14. Example of an exercise in a closed kinematic circuit
(source: photo by the author - Serhii Kozin)

Exercises specific to physical therapy

To master the basics of the formation of proper sports equipment, as well as the principles of rehabilitation and physical therapy, it is necessary to deeply understand the basics of the organization of movements of the central nervous system. Based on this understanding, the coach, athlete, physical therapist will be able to select the necessary tools for the formation of biomechanically appropriate movements and recovery of movements in diseases and other disorders of the musculoskeletal system. To do this, consider the basic modern methods of physical therapy and some sports movements.

Feldenkrais method

The Feldenkrais method is a motor practice developed by Moshe Feldenkrais and aims at human development through self-awareness in the process of working on the movement of one's own body. The Feldenkrais method is also called the somatic education method.

The peculiarity of the Feldenkrais method as a motor practice is the emphasis on the awareness of changes that occur in man in the process of working on movement, as opposed to the development and improvement of any specific forms of movement. Classes according to the Feldenkrais method are extremely diverse in terms of forms of movement, dynamics, basic starting position, emphasis on the movement of different parts of the body and the relationships in the body.

There are two forms of practice of the Feldenkrais method:

• Awareness Through Movement (ATM) - group sessions in which the facilitator directs the actions of those involved in verbal instruction without demonstrating movement. You can also practice individually, listening to lesson recordings and independently perform the described movements.

• Functional Integration (FI) - individual non-verbal sessions in which the movement of the practitioner is guided by the movement of the practitioner. Functional integration sessions are usually held on a special couch (massage table option) with the use of special pillows, rollers and other materials that are used to maintain body position and movement, as well as a means of feedback for the practitioner.

The recommended standards of practice of the International Federation of the Feldenkrais Method state that the method is not a medical, massage or any other therapeutic technique, nor a bodywork technique [1]. However, in Russia and some other countries it is sometimes referred to as methods of body-oriented psychotherapy, as well as methods of alternative and complementary medicine.

The main provisions of the Feldenkrais method

□ Smooth, slow, functional movements with increased awareness and attention to the body (Training effect on level B);

□ Classes on mats with activation of different parts of the body and their alternation as a support (Training effect at levels A and C).

Redcord therapy

Redcord therapy is a system of suspension therapy

At the beginning of the work, the instructor tests the patient: the patient performs various movements, leaning on an unstable platform - the suspension, thus involving all the muscles in a particular biomechanical chain. Thus, the therapist sees the combined work of muscle groups and can track disorders in any particular muscle group or link in the biomechanical chain. After testing and evaluation, the therapist forms a diagnosis, on the basis of which a treatment plan is developed. The patient is asked to perform the exercise at his level of difficulty. This triggers the work of deep stabilizing muscles and eliminates disturbances. In the case of a weakened patient after an injury or surgery, the Redcord system suspensions "unload" the body, which allows you to perform complex exercises without pain and with ease. Exercises are performed on a special therapy table or on a rubber mat, depending on the level of difficulty. During repeated classes, the therapist reduces the auxiliary support of the suspensions, thereby seeking to strengthen the stabilizer muscles. The end result of treatment is the ability to perform exercises without the support of suspensions, at this stage the daily load no longer causes any discomfort to the patient, allowing him to return to an active lifestyle without pain.

The main provisions of the Redcord method

□ Additional proprioceptive input due to instability and transmission of vibration to the suspension (Training effect on level A);

□ Exercises in closed kinematic circuits with increased concentration on muscle groups (Training effect on level B) (Fig. 2.15).

Рис. 2.15. Example of an exercise in a closed kinematic circuit for the formation of functional movement using Neurac (Redcord) (source: photo by the author - Serhii Kozin)

PNF therapy

Proprioceptive neuro-muscular facilitation (PNF) is one of the methods of physical therapy based on the principles of functional anatomy and human neurophysiology. The main purpose of the use of PNF is to achieve the highest possible level of functioning of the patient or athlete.

Basically, all movements performed during the PNF procedure follow a certain trajectory called "diagonal". The spiral-diagonal nature of natural movements is due to the structure of the musculoskeletal system. Most muscles are arranged in a spiral around the bones, so when contracted, they usually make a spiral motion. The primary movements of newborns are mainly spiral-diagonal in nature - the reflex of sucking arms and legs, turning, crawling, and others. With the verticalization of man, these movements in appearance become more linear, but at their core remain complex (walking, running, swimming, etc.). The use of "diagonals" of PNF allows in the most physiological mode to involve functional muscle chains and restore the "programs" of primary movements, which contributes to a more effective restoration of motor functions.

This method can be used in the earliest stages of neurorehabilitation, even in patients with severe neurological disorders. In the presence of paresis and plegia PNF can be performed on the healthy side in combination with passive movements diagonally on the side of the lesion.

In peripheral neurological disorders associated with impaired nerve conduction or pain, there are certain areas of diagonal movements that are most effective for restoring the function of a particular peripheral nerve (plexus or spinal cord).

All movements in the diagonals of the PNF is recommended to perform in a certain sequence: before performing the movements involved in the work of muscles. which are fixed and passively brought into position with the maximum stretching thanks to what additional stimulation of muscular receptors that improves process of "reflex reprogramming" is reached. After that the command on execution of diagonal movement is carried out and its trajectory is controlled. To consolidate the correctness of the movements, this sequence is performed a certain number of repetitions.

The basis of the method was the position of the "proprioceptive nervous system". In all muscles, joints, ligaments there are proprioceptors that respond to stretching or compression. Through certain manipulations, we affect these receptors and can stimulate, initiate and facilitate the performance of any movement (the whole body or limb, up to the movements of the eyelids and facial muscles). We can also adjust the correct direction, strength and volume of movement.

This method allows you to perform movements that the patient for any reason can not do on their own (which are not part of his spontaneous motility). Due to stimulation, movement is formed and consolidated at higher levels of the CNS, which means that new, correct static and dynamic stereotypes appear, and motor activity increases.

The concept of PNF (proprioceptive neuromuscular facilitation). So multifaceted, deceptively simple and at the same time infinitely incomprehensible, just like the man himself ...

And in combination with other concepts and of course the correct selection of therapeutic exercises, the target movement becomes painless and feasible, which is the goal of physical therapy.

PNF is a rehabilitation method based on the idea that all people, including children with cerebral palsy, have untapped motor potential. The key task of this technique is to help the patient achieve the highest possible level of functioning for him.

PNF - proprioceptive neuromuscular facilitation. PNF-therapy (P - proprioceptive, N - neuromuscular, F - facilitation) is an effective restoration of motor activity after stroke and injury.

PNF-therapy is one of the methods of treatment of movement, which allows to restore the functional connections between the nervous system, which controls the motor act and the muscles that directly perform the movement.

The whole method is based on "manual work", ie on the direct contact of the doctor's hands with the patient's body.

It should be noted that this technique requires the active participation of the patient in the treatment process: he must be aware of and follow the doctor's instructions (for children it is usually older than 4 years). Due to the close interaction with the patient, the doctor always has the opportunity to adjust the amount of work and the degree of load and choose the tasks that are most relevant at the moment.

The main provisions of the PNF method

| | Increase in pro-receptive input due to manual contact during exercise (training effect on level A);

| | Physical therapy in models / patterns of movements (training effect on level B);

| | Classes on mats, manipulations with visual control, exercises in a unique environment (training effect on level C);

| | Integration of previous experience of specific exercises with subjects (training effect on level D).

To activate the movements of physical therapy to ensure functional movements without injury and recovery of movement, if it is disturbed due to injury, the following therapeutic effects can be applied, which activate certain levels of movement control:

- Stretching of the iliopsoas muscle and training the synergy of the anterior pelvic lift using pnf pattern (level B) (Fig. 5.6);
- Synchronization of synergies of the scapula and pelvis using PNF pattern
- (Level B) (Fig. 2.16);
- Synchronization of scapula and pelvic patterns with torso patterns (with flexion and extension synergy) (level B) (Fig. 5.8);
- Stabilization of the shoulder joint in combination with Redcord and PNF therapy
- (C / D level) (Fig. 2.17-2.19).

Fig. 2.16. Stretching of the iliopsoas muscle and training the synergy of the anterior pelvic lift with PNF pattern (level B) (source: photo by the author – S.V. Kozin)

Fig. 2.17. Synchronization of synergies of the scapula and pelvis using PNF pattern (Level B) (source: photo by S.V. Kozin)

Fig. 2.18. Synchronization of scapula and pelvic patterns with torso patterns (with flexion and extension synergy) (level B) (source: photo by the author – S.V. Kozin)

Fig. 2.19. Stabilization of the shoulder joint in combination with Redcord and PNF therapy (Level C / D) (source: photo by the author - SV Kozin)

Thus, as a biomechanical technology in climbing was used neuromuscular training, which used means to prevent injuries of the upper extremities in climbing. Neuro-muscular training involved the use of exercises specific to climbing. Neuro-muscular training also involved concentration on the correct performance of the basic elements of technology in combination with exercises with a closed kinematic chain and with an educational program. Based on the biomechanical analysis of one-arm hang techniques in climbing (Kozin, 2019, Kozin et.al., 2020), means were selected and systematized to prevent injuries of the upper extremities. The means were physical exercises that are performed independently, as well as with a trainer or physical therapist.

According to modern authors (Jones, Llewellyn, Johnson, 2015), one of the most common causes of injuries and diseases of the upper extremities is muscle imbalance due to the predominance of flexion movements over extension of the elbow joint in the training process of climbers. In this regard, we have included in the training process exercises aimed at strengthening the extensor muscles, such as various push-ups.

In addition, as our research (Kozin, 2019, Kozin et.al., 2020) has shown, the correct technique of one-arm hang in climbing involves the inclusion of muscles not only of the upper extremities, but also the muscles of the torso and legs. Improper one-arm hang technique involves mainly the muscles of the upper limb. Therefore, with the right technique of height, the inclusion of the muscles of the torso and legs creates additional links in the kinematic chain (Kozin, 2019, Kozin et.al., 2020). As a result, the upper limb has less load than with the wrong technique of one-arm hang. This ensures the achievement of sports results and prevents injuries. That is why neuromuscular training involved conscious concentration on the correct technique of performing high jump on one arm in climbing.

Based on our findings and based on the results of research Augustsson et.al. (1998), Coppack et al. (2011), we have included in the injury prevention program exercises performed in a closed kinematic circuit. This is because a closed kinematic chain involves all the muscles that make up this kinematic chain. The biomechanical program of neuromuscular training involved conscious concentration on the inclusion of all the muscles of the closed kinematic chain in the process of performing each movement.

Also included in the training process exercises for pronation-supination with the exception of the concentric phase, which are performed in an eccentric mode. The neuromuscular training program involved conscious concentration on slow pronation-supination and on the smoothest involvement of muscles in the eccentric mode. In addition, stretching of flexors, extensors of the hand and fingers, as well as massage were used.

The educational program of injury prevention included: 1. Knowledge of dynamic anatomy, 2. Knowledge of the laws of movement control, 3. Understanding the causes and means of injury prevention. Theoretical classes revealed the basic and clinically significant concepts of biomechanics, functional anatomy in motion models. The degrees of freedom of movement of the upper and lower extremities, torso, neck, pelvis were also considered, the structure of joints and features of movements in them were analyzed. Each muscle that provides movement to the upper extremities is then examined in terms of anatomy and the function it performs. At the end of the characteristics of each muscle, the main pathologies provided by this muscle are considered. At the next stage, manual and functional methods of physical therapy to prevent injuries and diseases, as well as to restore function were studied.

The basic program, which trained control and experimental groups, was the same for both groups. In the intervention group (experimental) athletes performed additional exercises proposed by us. Exercises were performed at each training session (3-4 times a week). The intervention program was given 15 minutes. at each workout. Athletes and coaches recorded in their diaries the fact of using the intervention program. Based on our biomechanical analysis of climbing techniques in previous studies [13], [14]. exercises were selected and systematized to prevent injuries of the upper extremities.

Biomechanical analysis [13], [14] allowed to determine that for injury prevention it is necessary to form the correct technique of performing the basic elements in climbing and to determine the tasks for the application of injury prevention in climbing: 1 - strengthening the muscles involved in proper movement; 2 - formation of functional movement, ie to develop exercises for coordinated work of the muscles of the torso, upper and lower extremities.

Based on our findings and based on the results of research [5], [24], we included in the program of injury prevention exercises performed in a closed kinematic circuit (Fig. 2). This is because a closed kinematic chain involves all the muscles that make up this kinematic chain. We used exercises in closed kinematic circuits, with an emphasis on shoulder retraction to improve muscle coordination.

Examples of exercises in closed kinematic circuits:

1. Push-ups on the rings. Starting position: support with two straight hands on gymnastic rings, feet rest on toes, spine straight. Flexion and extension of the arms in focus on the rings. Keep the spine straight, do not take your feet off the floor. Number of repetitions - 10-20 times depending on the level of preparedness of students.

2. Pulling up in an emphasis. Starting position: hold the crossbar with your hands straight with your feet on the floor. The spine is straight. Flexion and extension of the arms. Keep the spine straight, do not take your feet off the floor. Number of repetitions - 10-20 times depending on the level of preparedness of students.

3. Climbing on a climbing stand with support on 3 points (2 arms and 1 leg or 2 legs and 1 arm). When climbing, athletes must consciously control the involvement of muscles not only in the arms, but also in the torso and legs.

Exercises in closed kinematic circuits act on the entire kinematic circuit completely, more evenly distribute the load on all links of the chain. The program also involved consciously concentrating on involving all the muscles of the closed kinematic chain in the process of performing each movement. Autogenic training was used to improve the ability to concentrate (Kozina, Iermakov, Bartík, Yermakova, Michal, 2018).

We conducted a seminar "Therapeutic biomechanics in climbing" for athletes, coaches and teachers of climbing in universities 2 weeks before the experiment. Athletes, coaches and climbing teachers of the universities who agreed to participate in the study in the intervention group were participants in the seminar. At the seminar, we provided theoretical information on the causes of injuries in climbing, as well as information on the correct technique of one-arm hang in climbing. We also taught the participants of the intervention program exercises in closed kinematic circuits and exercises that are performed in eccentric mode.

CHAPTER 3. RESULTS OF APPLICATION OF BIOMECHANICAL TECHNOLOGY OF INJURY PREVENTION IN THE PROCESS OF TRAINING SPECIALISTS IN PHYSICAL EDUCATION AND SPORTS

3.1. The state of injuries of students of different sports specializations before the experiment

It is believed that highly qualified athletes have perfect technique, they have movements, especially specific to their sport, effective and rational. But in this case, athletes should not have diseases of the musculoskeletal system. But a statistical analysis of athletes' appeals for musculoskeletal disorders shows the opposite. Thus, in just 5 months, 78 athletes, whose sports qualifications are not lower than the master of sports, applied to the Alefclinic physiotherapy clinic (Table 3.1). All these appeals were not related to direct injuries, but to diseases of the musculoskeletal system. This indicates a lack of effective movement techniques, even for highly qualified athletes in their sport. That is why it is important to consider the issues of biomechanics and physiology of functional movement, to determine its patterns, ways of formation and means of recovery in disorders.

Table 3.1

Statistics of applications of athletes for help in "Alefclinic" for the period 01.06.19 - 01.11.19 (n = 78)

Kind of sport / Traumatic bath area	Tennis	Football	Athletics	Swimming	Volleyball	Boxing	Climbing
Shoulder	7	0	0	4	6	0	4
Knee	4	3	2	0	4	0	3
Back	1	4	4	1	3	2	2
Neck	1	0	0	1	2	1	1
Elbow	4	0	0	0	1	1	4
Fingers	0	0	0	0	1	0	5
Thigh	0	1	1	0	0	0	0

This requires theoretical and experimental research.

That is why we conducted a separate study with the participation of representatives of a particular sport - climbing

The participants of this study were 84 male students engaged in amateur climbing in the cities of Ukraine (Kharkiv, Dnipropetrovsk, Lviv, Vinnytsia, Kamyanets-Podilsky, Kyiv) from 2 to 4 years aged 18-19 years. All athletes were also students of physical education faculties of Ukrainian universities. All athletes gave written consent to participate in the experiment. The health of the athletes was checked during the first 2 weeks of the study with the help of regular medical examinations conducted by a doctor. Athletes were also observed for 6 months to assess baseline injury rates and baseline techniques of one-arm hang.

An independent statistician performed a parallel randomization of athletes into a control group and an intervention group using a random distribution method using an online random number generator program. As a result of randomization, 40 athletes were in the experimental group and 44 - in the control.

The groups were compared in terms of body length, body weight, climbing experience and the number of injuries during the period of 6 months observed before the experiment. For all these indicators, the groups did not differ significantly from each other.

The body length of athletes in the control group was 172.5 ± 8.5 cm, body weight - 65.2 ± 6.5 kg; the body length of the athletes of the experimental group was 173.4 ± 8.7 cm, body weight - 66.1 ± 6.6 kg (p> 0.05).

Both control and experimental groups consisted of novice athletes (amateurs), aged 18-19 years, males; body length of athletes of the control group was 172.5 ± 8.5 cm, body weight - 65.2 ± 6.5 kg; the body length of the athletes of the experimental group was 173.4 ± 8.7 cm, body weight - 66.1 ± 6.6 kg (p> 0.05). The groups trained according to the generally accepted plan 3-4 times a week, the number of training hours was the same in both groups. At the beginning and at the end of the pedagogical experiment, an analysis of the technique of performing the height on one arm was performed by experts in both groups. The number of injuries of the upper extremities in both groups was also recorded.

We found that the baseline level of all finger injuries recorded within 6 months before the start of the experiment was 17 injuries in the control group and 15 in the experimental group. The number of AEs for 6 months before the experiment was 3300 in the control and 3000 in the experimental groups. Injury rate per 1000 AEs in the control group was 5.667 (95% Ci, 0.989; 9.243), in the experimental group – 4.545 (95% Ci, 1.267; 7.236), P> 0.05 (Table 2.1).

We found that the baseline level of all elbow injuries recorded within 6 months before the start of the experiment was 11 injuries in the control group and 15 in the experimental group. The number of AEs for 6 months before the experiment was 3300 in the control and 3000 in the experimental groups. Injury rate per 1000 AEs in the control group was 3.333 (95% Ci, 0.96; 6.578), in the experimental group – 4.545 (95% Ci, 0,589; 10.874), P> 0.05 (Table 2.1).

We found that the baseline level of all shoulder injuries recorded within 6 months before the experiment was 9 injuries in the control group and 10 in the experimental group. The number of AEs for 6 months before the experiment was 3300 in the control and 3000 in the experimental groups. Injury rate per 1000 AEs in the control group was 2.727 (95% Ci, 0.89; 4.564), in the experimental group - 3.333 (95% Ci, 1.567; 5.099), P> 0.05 (Table 2.1).

The number of injuries to fingers, elbows and shoulders of varying complexity, recorded during the 6 months before the experiment, is presented in table 2.1. No significant differences in the injury index in the control and experimental groups were found (p = 0.385-0.729).

3.2. Biomechanical analysis of the technique of performing the basic elements in the chosen sport (on the example of climbing) of students - athletes of different qualifications

Analysis of the technique of one-arm hang in climbing by athletes of different qualifications showed the presence of two models of techniques for performing this movement, which differ significantly in basic parameters. Demonstration of these models of equipment is presented in Fig. 3.1, 3.2. Figure 3.1 shows the first model of the technique of climbing. It is characterized by minimal muscle tension of the shoulder, back, a large angle between the shoulder and clavicle and almost vertical position of the lower spine with curved in the upper part. This type of equipment is typical for unqualified athletes. In fig. 3.2 shows the second model of the technique of one-arm hang in climbing. This model is characterized by muscle tension of the shoulder, back, a large angle between the shoulder and clavicle and a large angle between the spine and the vertical axis. The first model of equipment is typical for beginner amateur athletes, the second model of equipment is typical for qualified athletes.

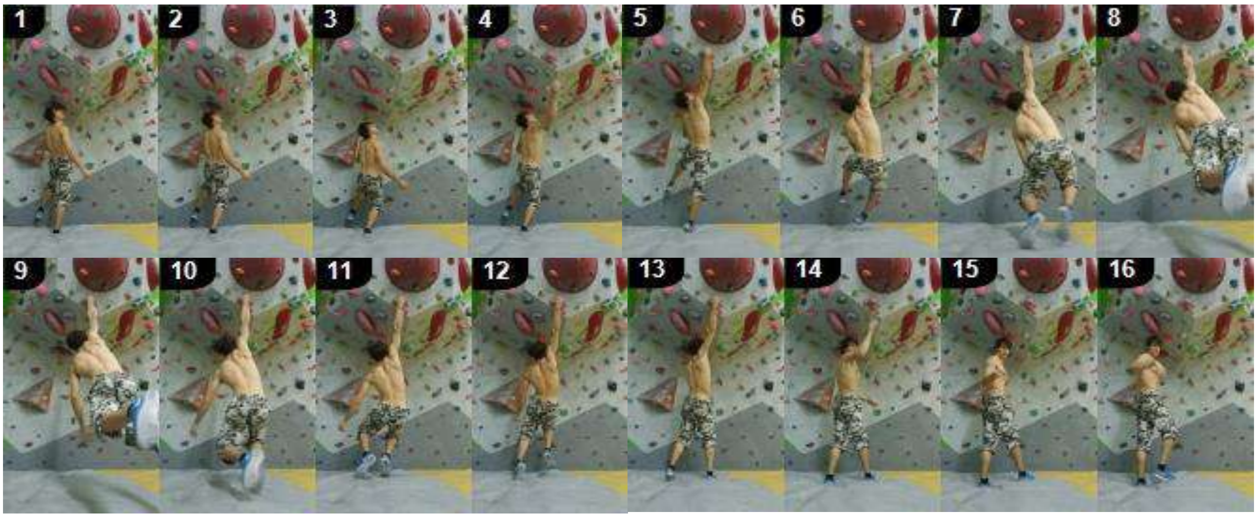

Fig. 3.1. Videogram of one-arm hang in climbing (bouldering), model 1
(source: photo by SV Kozin)

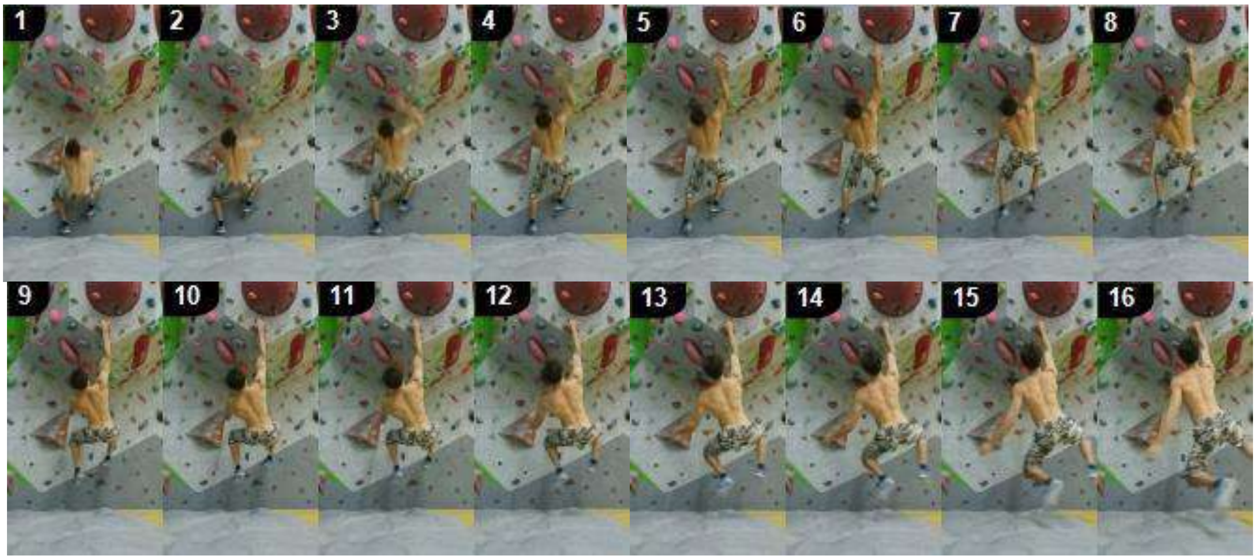

Fig. 3.2. Videogram of climbing, model of equipment 2
(source: photo by SV Kozin)

Kinematic analysis of two models of one-arm hang technique in climbing showed the presence of significant differences (p <0.001) in the magnitude of the angles between the shoulder and clavicle, between the spine and the vertical axis in the phase of fixing the height (Table 3.2, Fig. 3.3). Thus, the angle between the shoulder and clavicle in the first model of technology was 1460 (Fig. 3.3, Table 3.2), in the second model of technology this angle is 970 (Fig. 3.4, 3.5, Table 3.2). The angle between the lower spine and the vertical axis was 110 in the first model (Fig. 3.3, Table 3.1), in the second model this angle was 280 (Fig. 3.4, Table 3.2).

Figure 3.5 shows the dynamics of the change of the angle between the shoulder and the clavicle from the moment of capture of the hook to the phase of fixing the height. At the moment of capture of a hook the size of an angle between a shoulder and a clavicle is almost identical for both models of equipment. However, the main interest is the situation in the phase of fixing the height. In this position there is a significant difference (p <0.001) the value of the angle between the shoulder and clavicle for the first and second models. In the second model of the technique, the angle between the shoulder and the clavicle gradually decreases from the moment of gripping the hook to the phase of fixing the hook, while in the first model this value is kept at the same level (Fig. 3.5). These differences are due to the more pronounced work of the muscles of the torso, legs, shoulder in the second model compared to the first model (Fig. 3.3-3.5). Since the second model (qualified athletes) is characterized by pronounced muscle work not only of the upper limb, but also the torso, legs, we can conclude that the second model requires the development of these muscles, and cannot be used by low-skilled athletes in connection with insufficient development of the muscular apparatus. In the first model, the height is carried out mainly due to the ligament of the joints of the shoulder girdle with minimal muscle involvement, which is dangerous injury to the ligament of the shoulder joint. In the second model, the height also provides the inclusion of muscles, which reduces the load on the ligament and reduces the likelihood of injury to the ligament of the shoulder joint.

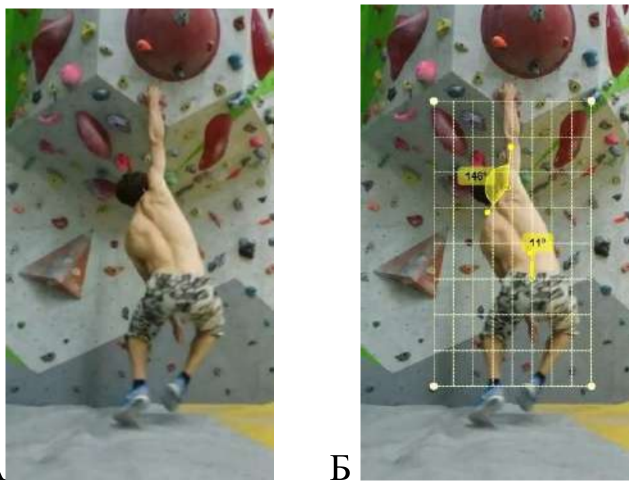

Fig. 3.3. The phase of fixing the height in climbing, model 1
(frame №7 videogram in Fig. 3.1):
A - illustration of the frame fixing height; B - biomechanical analysis of the angles between the shoulder and clavicle, between the lower spine and the vertical axis
(source: photo by the author - SV Kozin)

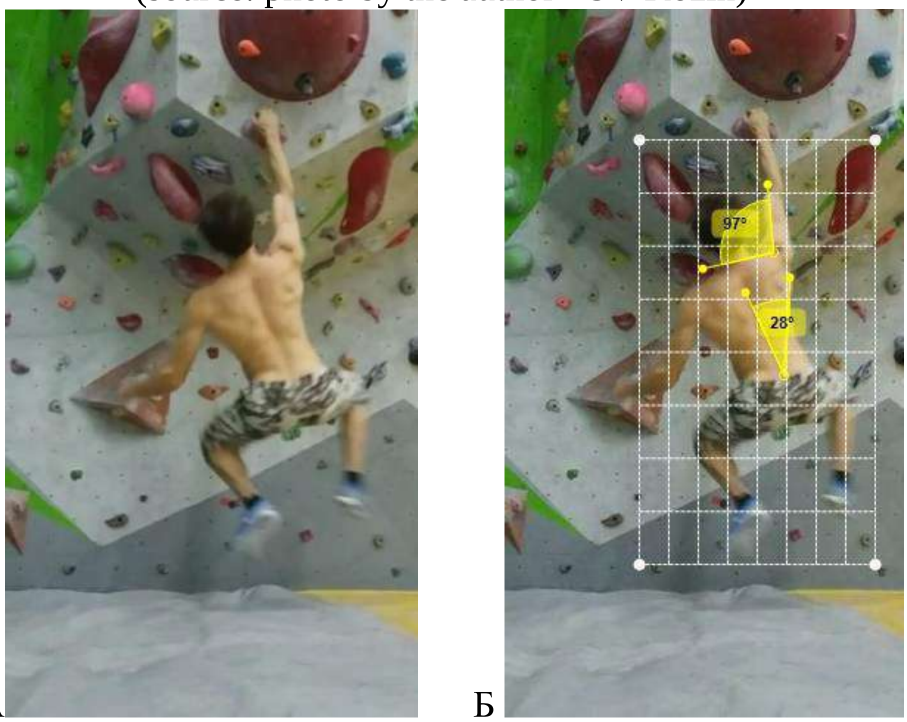

Fig. 3.4. Phase of fixing the height in climbing, model 2
(frame №14 videogram in Fig. 3.2):
A - illustration of the frame fixing height; B - biomechanical analysis of the angles between the shoulder and clavicle, between the lower spine and the vertical axis
(source: photo by the author - SV Kozin)

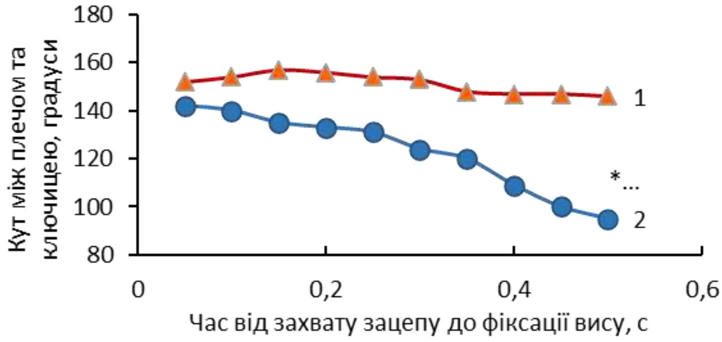

Fig. 3.5. The magnitude of the angles between the shoulder and clavicle when one-arm hang in climbing:

1 - model of equipment 1
2 - model of equipment 2
*** - differences are significant at p <0,001
(source: author's drawing - SV Kozin)

Table 3.2

Comparative characteristics of the values of the angles between the shoulder and clavicle and between the spine and the vertical axis in different models of height in climbing (Model 1, n = 20; Model 2, n = 20)

Indexes	Model of equipment	Statistical indicators				
		$\bar{x}$	S	m	t	p
The angle between the shoulder and the clavicle	Model 1	146	16	3.58	11.94	<0.001
	Model 2	97	9	2.01		
The angle between the vertical axis and the spine	Model 1	11	4	0.89	-11.87	<0.001
	Model 2	28	5	1.12		

We analyzed both models of climbing technique in terms of the laws of physics (Fig. 3.6) and the peculiarities of the interaction of forces in closed kinematic circuits (Fig. 3.7). We have schematically presented the voltage distribution when performing height in the form of interconnected elements. This "structure" is attached by one link to the upper support (d), and is in a state of height (Fig. 3.6). Figure 6 (1) shows a diagram of the first model of the technique of execution of height, Figure 3.6 (2) shows a diagram of the second model of execution of height. The first model of the technique of one-arm hang is characterized by minimal involvement of the muscles of the shoulder girdle, torso, legs, in this regard, the area (b) of the connection links (a, c) is relatively small. The second model of one-arm hang technique in climbing is characterized by a larger area (b) of the connection of the links (a, c) with each other due to the inclusion of more muscles of the shoulder girdle, torso, legs.

In terms of the balance of forces acting on the body (McCarthy, & Soh, 2010; Uicker, Pennock, & Shigley, 2003), these models are the same: in both cases, the weight of the body, which is the product of body mass (m) to accelerate free fall (g), held in the axis by the force of attachment to the support, which is equal to the reaction force of the support Fp:

$$mg + F_p = 0 \qquad (1)$$

where:
m - is body weight,
g - is the acceleration of free fall,
Fp - the force of attachment to the support, equal to the reaction force of the support

However, if we consider the data of the model from the point of view of the laws that determine the preservation of the structure that is subject to stretching, then these models have significant differences. These differences are due to the laws of mechanics, in particular, the resistance of materials to tension or compression (Roylance, 2008).

According to the basic law of the strength condition, when the tensile or compressive deformation in the cross sections of the rod there are normal stresses σ. The longitudinal force N is associated with the normal stress σ by the following dependence (formula 2):

$$\sigma = \frac{N}{A} \qquad (2)$$

where:
σ - is the normal voltage;
N - is the longitudinal force in the cross section of the rod;
A - is the cross-sectional area of the rod.

According to this formula, the stress that occurs when one-arm hang in climbing (σ) depends on the longitudinal force, ie the body weight (N), and the cross-sectional area (A), ie the muscles and ligaments of the shoulder girdle, ensuring the implementation of the height. Body weight (N) is the same in the first and second models, but the cross-sectional area (A) in the second model is larger. Accordingly, the voltage (σ) is higher in the first model compared to the second, because according to formula 2:

$A_1 < A_2$, $N_1 = N_2$, отже $\sigma_1 > \sigma_2$

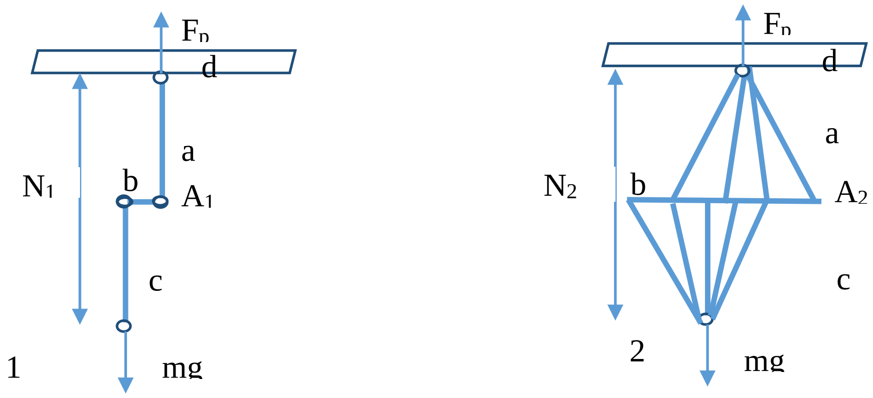

Fig. 3.6. Schemes of models of distribution of tension at performance of height in climbing:

1 - model 1 (incorrect technique);
2 - model 2 (correct technique);
a - the upper part of the chain (arm);
b - connection of the upper and lower parts of the chain;
c is the lower part of the chain (torso);
d - support (climbing stand)
N is the longitudinal force in the cross section of the rod;
A - cross-sectional area of the rod (muscles and ligaments in the connection of the shoulder and torso)
(source: author's drawing - SV Kozin)

The higher efficiency of model 2 can also be explained in terms of the addition of forces in a closed kinematic circuit. Kinematic chain (KL) - a series connection of a series of relatively moving kinematic pairs (arm, leg or whole body of the athlete). Depending on the connections imposed on the body, there are three main types of kinematic chain, important for understanding the technique of sports movement. Open or open kinematic chain (with fixation of one of its ends in positions such as racks on arms, legs, one-arm hang, as well as the movements of the free limb - swing arm, leg, etc.). Closed or closed kinematic circuit (position at fixed both ends of the kinematic circuit, for example - with simultaneous support of arms and legs) (McCarthy, & Soh, 2010; Uicker, Pennock, & Shigley, 2003). In a closed circuit, or a closed circuit, isolated movement is not possible, ie movement in a single joint. So, bending and straightening the legs in the lunge, you can make sure that the movement in any joint inevitably causes movement in others.

If we consider the set of individual parts of the body when performing height, then this position can be described as an open kinematic chain. However, in modern kinesiology (Shinkle, Nesser, Demchak, McMannus, 2012; Hides, Stanton, 2014; Myer, Ford, Palumbo, Hewett, 2005) under the links of the kinematic chain understand the bones connected by joints, as well as m attachments to the bones. These muscles under tension form a single structure and become another link in the kinematic chain, which makes this chain closed. In fig. 3.7 (1) shows a variant of a closed kinematic circuit formed in the first model of the technique of performing height. In this case, only two links of the kinematic circuit (A1 and A2) take part in the support of the whole structure in the axis. Working muscles determine the forces F1 and F2, form a connected structure, and form another link in the kinematic chain A5. As a result, the total force that ensures the execution of the height is equal to the sum of the forces F1 and F2.

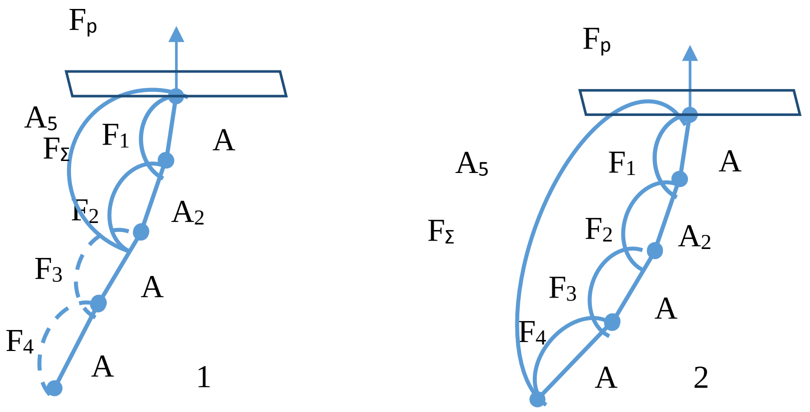

Fig. 3.7. Scheme of a closed kinematic circuit in different models of height in climbing:

1 - model 1 (incorrect technique);

2 - model 2 (correct technique);

Fp - the force of attachment to the support, equal to the reaction force of the support;

FΣ - the force that holds the body on the support in the axis;

F1, F2, F3, F4 - forces arising from the tension of individual muscles;

A1, A2, A3, A4, A5 - links of the closed kinematic chain (A5 - the link arising as a result of tension of mutually transitional muscles, closes a kinematic chain);

Model 1 - closed kinematic chain formed by a small number of links; the force holding the body in the axis (FΣ) is due to the force F1 and F2:

FΣ = F1 + F2

Model 2 - closed kinematic chain formed by a large number of links; the force holding the body in the axis (F5) is due to the force of the links A1, A2 A3, A4:

FΣ = F1 + F2 + F3 + F4

(source: author's drawing - SV Kozin)

Similarly, the addition of forces in the second model of the technique of one-arm hang. However, in this case, the number of involved links in the chain is greater. In this case, in support of the entire structure in the axis involved all the links of the kinematic circuit (A1 and A2). Working muscles cause the action of forces F1, F2, F3, F4 and form a connected structure, as well as form another link in the kinematic chain A5. As a result, the total force that ensures the execution of the height is equal to the sum of the forces F1, F2, F3, F4.

In General, the addition of forces in the presented kinematic circuits can be represented by the formula (formula 3):

$$F\Sigma = \Sigma Fi \qquad (3)$$

where:

FΣ - the force that keeps the body one-arm hang;

Fi - the force caused by inclusion of separate interconnected links of the closed kinematic chain;

In the second model, the total force that provides the position of the height is much greater than this force in the first model. This means that in the second model in maintaining the position of the height involved not only the muscles of the upper limb (as in the first model), but also the muscles of the torso, legs, creating additional links in the kinematic chain. Accordingly, the upper extremity has less load compared to the first model of technology. This determines the effectiveness of the second model of equipment and provides a theoretical basis for the formation of the most effective technique of movement in climbing, which ensures the achievement of sports results and prevents injuries. However, experimental verification of these provisions requires further research.

Thus, in this study, the main kinematic parameters of the height in climbing were identified for different models of equipment, typical for athletes of different qualifications. These provisions were theoretically substantiated in terms of the laws of mechanics and the laws of interaction of forces in a closed kinematic circuit, which are new data. The data of Shinkle, Nesser, Demchak, McMannus, (2012), Hides, Stanton, (2014), Myer, Ford, Palumbo, Hewett, (2005) on the formation of closed kinematic chains when involved in the work of interconnected muscles, forming an additional link in the chain and closing it.

Biomechanical analysis allowed to determine the tasks for the use of means for the prevention of injuries in climbing: 1 - strengthening the muscles involved in the movement; 2 - formation of functional movement, ie for coordinated work of the muscles of the torso, upper and lower extremities.

3.3. The results of expert evaluation and biomechanical analysis of the technique of performing elements in climbing by students as a result of the application of biomechanical technology of injury prevention

Prior to the experiment, the average expert assessment of the technique of performing the technique of climbing in climbing athletes of the control group was 19.05 ± 0.78, in the experimental group this value is equal to 19.5 ± 0.87 ($p > 0.05$), which indicates that that before the experiment, the groups did not differ significantly in terms of one-arm hang technique. After the experiment, the average value of the expert assessment of athletes in the control group was 26.8 ± 0.83, and in the experimental - 32.15 ± 1.18 ($p < 0.05$) (Tables 3.3, 3.4, 3.5), which indicates on the positive effect of the application of means of injury prevention in climbing on the formation of biomechanically functional techniques of height.

Table 3.3

The results of expert evaluation and biomechanical analysis of the technique of climbing in the control group (n = 44) before and after the experiment

№	Name	Total evaluation of 4 experts		The angle between the shoulder and the clavicle		Change of expert assessment	
		Before expertise	After expertise.	Before expertise.	After expertise.	Absolutely	%
1	А-о	17	29	135	98	12	71
2	Г-с	16	25	132	97	9	56
3	Л-в	16	24	147	124	8	50
4	К-к	24	31	140	123	17	71
5	Я-в	18	28	146	125	10	56
6	Д-о	25	32	137	121	7	28
7	В-н	18	24	131	100	6	33
8	Г-ь	14	23	125	96	7	50
9	Д-в	19	28	142	99	9	47
10	З-в	18	27	141	115	9	50
11	К-в	17	26	140	128	9	53
12	М-в	21	32	131	102	11	52
13	Н-о	22	30	138	117	8	36
14	Ш-в	16	22	131	139	6	38
15	З-в	18	21	142	133	3	17
16	Г-в	15	25	148	125	10	67
17	О-о	19	23	131	135	4	21
18	К-о	23	28	135	121	5	22
19	П-н	29	31	126	101	2	7
20	Р-в	21	35	141	99	14	67
21	Л-в	18	21	138	126	3	17
22	Ж-в	15	25	141	135	10	67
$\bar{x}$		19.05	26.8	131.91	127.23	8.14	44.4
S		3.72	3.9	24.71	9.87	3.64	19.4
M		0.79	0.83	5.27	2.10	0.77	4.12

Table 3.4

The results of expert evaluation and biomechanical analysis of climbing techniques in climbing in the experimental group (n = 40) before and after the experiment

№	Name	Total evaluation of 4 experts		The angle between the shoulder and the clavicle		Changing the assessment of experts	
		Before expertise.	After expertise	Before expertise.	After expertise.	Absolutely	%
1	В-й	21	39	135	98	18	86
2	Д-о	22	38	132	97	16	73
3	М-о	16	25	147	124	9	56
4	П-в	18	26	140	123	8	44
5	А-о	15	28	146	125	13	87
6	Б-о	19	26	137	121	7	37
7	В-в	23	31	131	100	8	35

8	Г-в	29	37	125	96	8	28
9	Ж-к	17	31	142	99	14	82
10	З-в	16	28	141	115	12	75
11	Л-в	16	30	146	102	14	88
12	Н-й	24	38	134	99	14	58
13	О-в	18	29	139	114	11	61
14	К-н	25	32	129	99	7	28
15	Я-в	18	28	143	123	10	56
16	Г-о	14	27	148	125	13	93
17	К-в	19	31	131	98	12	63
18	М-в	18	38	132	97	20	111
19	Т-н	26	41	126	92	15	58
20	Л-в	16	40	142	92	24	150
$\bar{x}$		19.5	32.15	137.18	116,32	12.7	68.45
S		3.9	5.31	6.40	14.55	4.5	29.8
M		0.87	1.18	1.43	3.25	1.0	6.6

The results of biomechanical analysis of the technique of performing height in climbing on the indicators of the angle between the shoulder and clavicle confirmed the results of expert evaluation of the technique of height. The correlation coefficient between the value of the analyzed angle and the value of the expert assessment was -0.95 (p <0.001) (Table 4.3), which indicates the coincidence of the subjective assessment of the one-arm hang technique by experts and the objective indicators of the climbing technique in climbing.

There was a significant decrease in the angle between the shoulder and clavicle in athletes of the experimental group (p <0.001), while in the control group these changes are not significant (p> 0.05) (Table 3.5). The groups before the experiment did not differ significantly in the angle between the shoulder and clavicle (p> 0.05). After the experiment, a significant difference was found between the control and experimental groups in terms of the angle between the shoulder and clavicle (Table. 3.5).

Prior to the experiment, the angle between the shoulder and clavicle in athletes of the control group was 131.91 ± 24.71, in the experimental group, this value was equal to 137.18 ± 6.40 (p> 0.05), which indicates that before the experiment, the groups did not differ significantly from each other. After the experiment, the average value of the angle between the shoulder and clavicle in athletes of the control group was 127.23 ± 9.87, and in experimental athletes - 116.32 ± 14.55 (p <0.05) (Tables 3.3, 3.4, 3.5), which indicates the positive effect of the application of injury prevention technology in climbing on the formation of biomechanically functional techniques of height.

There was also a significant improvement in the results of biomechanical analysis of climbing technique in athletes of the experimental group as a result of the experiment: after the experiment in athletes of the experimental group the angle between the shoulder and clavicle decreased significantly (p <0.001), while in the control group not reliable (p> 0.05) (Table 3.5).

Table 3.5

Indicators of the technique of performing the technique of one-arm hang in climbing by athletes of the control (n = 22) and experimental (n = 20) groups before and after the experiment

Performance indicators	Group	$\bar{x} \pm S$ Before the experiment	$\bar{x} \pm S$ After the experiment	t	P
Expert evaluation	Control	19.05±3.72	26.8±3.9	2.01	<0.01
	Experimental	19.5±3.9	32.15±5.31	5.54	<0.001
Statistical indicators of comparison of control and experimental groups	T	0.38	3.69	-	-
	P	>0.05	<0.01	-	-
The magnitude of the angle between the shoulder and clavicle	Control	131.91±24.71	127.23±9,87	0.82	>0.05
	Experimental	137.18±6.40	116.32±14.55	5.87	<0.001
Statistical indicators of comparison of control and experimental groups	T	0.97	2.82	-	-
	P	>0.05	<0.05	-	-
Relationship between technical expertise and the angle between the shoulder and clavicle	R	-0.95		-	<0.001

3.4. The impact of the use of biomechanical technology for injury prevention on the number of injuries and the risk of injury to students – climbers

Recording the number of injuries of the upper extremities received by amateur climbers studying in the specialty "Physical Education and Sports" at the initial stage of training showed that during the year the following number of injuries was observed:

- among finger injuries:

in the control group: 13 - low complexity, 11 - medium complexity, 9 - high complexity;

in the experimental group: 5 - low complexity, 3 - medium complexity, 1 - high complexity;

- among injuries and diseases of the elbow:

in the control group: 12 - low complexity, 10 - medium complexity, 7 - high complexity;

in the experimental group: 3 - low complexity, 2 - medium complexity, 0 - high complexity;

- among injuries and diseases of the shoulder:

in the control group: 8 - low complexity, 7 - medium complexity, 6 - high complexity;

in the experimental group: 2 - low complexity, 1 - medium complexity, 0 - high complexity (Table 4.5-4.7).

The influence of the prior art at the end of the experiment on the number of injuries by the Cochran and Mantel-Hansel method was also determined (Table 3.6). The state of the art is below average according to the expert assessment (less than 25 points) in combination with the values of the angle between the shoulder and the clavicle (more than 1200) was conventionally denoted as 1; the level of equipment above the average according to expert assessment (more than 25 points) in combination with the values of the angle between the shoulder and clavicle (less than 1200) was conventionally denoted as 2. It was found high reliability of the level of ownership of the technique 3.6). Since before the experiment the groups did not differ significantly in the level of mastery of climbing techniques, it can be noted that at the end of the experiment, the level of technique significantly affects the number of injuries.

Таблиця 3.6

The influence of the prior art on the number of injuries

The name of the processing method	χ- Squared	p
Cochran's	65.070	0.000
Mantel-Haenszel	52.990	0.000

Note: according to the conditional assumption of independence, the Cochran statistic is asymptotically distributed as a χ-square 1 df distribution only if the number of layers is fixed, whereas the Mantel-Hansel statistic is always asymptotically distributed as a χ-square 1 df distribution; Continuity correction is removed from the Mantel-Hansel statistics when the sum of the differences between the observed and the expected is 0.

The total number of all registered finger injuries during 1 year of the experiment was 33 in the control group and 9 in the experimental group. The number of AEs during 1 year of the experiment was 6600 in the control and 6000 in the experimental groups. Injury rate per 1000 AEs of all registered finger injuries in the control group during the 1 year of the experiment was 5.5 (95% Ci, 1.061; 9.267), in the experimental group - 1.364 (95% Ci, 0.032; 2.375), P <0.001.

The injury rate of mild finger injuries per 1000 AEs during 1 year of the experiment in the control group was 1.97 (95% Ci, 1.061; 2.303), in the experimental group - 0.83 (95% Ci, 0.068; 0.978). The incidence rate ratio for cohort (injuries = no) for mild shoulder injuries was 0.805 (0.643; 1.00) (Table 3.10). We also found that the Injury rate of moderate finger injuries per 1000 AEs during 1 year of the experiment in the control group was 1.67 (95% Ci, 0.247; 1.783), in the experimental group - 0.50 (95% Ci, 0.088; 1.182). The incidence rate ratio for cohort (injuries = no) for moderate finger injuries was 0.811 (0.669; 0.982; P = 0.030) (Table 3.10). Our study also showed that the Injury rate of severe finger injuries per thousand AEs during 1 year of the experiment in the control group was 1.36 (95% CI, 0.134; 1.685), in the experimental group - 0.17 (95% CI, 0.065; 1.225). The incidence rate ratio for cohort (injuries = no) for severe finger injuries was 0.816 (0.697; 0.955; P = 0.011) (Table 3.10).

The incidence (risk) of finger injuries of low complexity in the control group is 0.23, in the experimental - 0.10; the chances of getting a finger injury of low complexity in the control group is 0.419, in the experimental - 0.143. The relative risk (control group / experimental group) to get a injury of fingers of low complexity in the control group is higher in 2.364 (95% CI = 0.925-6.041, P> 0,05) times in comparison with experimental (tab. 3.7, 3.10). Relative risk - the probability of injury (experimental group / control group) is equal to 0.805 (95% CI = 0.643-1.008, P> 0.05) (Table 3.10). The relative chance of getting a finger injury of low complexity in the control group is 2.935 times higher (95% CI = 0.940-9.170, P> 0.05) compared with the experimental (Table 3.7, 3.10).

The incidence (risk) of finger injuries of medium complexity in the control group is 0.250, in the experimental - 0.075; the chance of getting a finger injury of medium complexity in the control group is 0.333, in the experimental - 0.081. The relative risk (control group / experimental group) to get a finger injury of medium complexity in the control group is higher by 3.333 times (95% CI = 1.001-11.096, P (Fisher) = 0.030) compared to the experimental. Relative risk - the probability of injury (experimental group / control group) is equal to 0.811 (95% CI = 0.669-0.982, P (Fisher) = 0.030) (Table 3.10). The relative chance of getting a finger injury of medium complexity in the control group is 4,111 times higher (95% CI = 1.055-16.020, P ($\chi 2$) = 0.041) compared with the experimental (Table 3.7, 3.10).

The incidence (risk) of finger injuries of high complexity in the control group is 0.205, in the experimental - 0.025; the chances of getting a finger injury of high complexity in the control group is equal to 0.257, in the experimental - 0.026. The relative risk (control group / experimental group) to get a finger injury of high complexity in the control group is 8,182 times higher (95% CI = 1.084-61.749, P (Fisher) = 0.011) compared to the experimental. Relative risk - the probability of injury (experimental group / control group) is 0.816 (95% CI = 0.697-0.955, P (Fisher) = 0.011). The relative chance of getting a finger injury of high complexity in the control group is 10,029 times higher (95% CI = 1.209-83.201, P ($\chi 2$) = 0.016) compared with the experimental (Table 3.7, 3.10).

Table 3.7

Risk indicators of finger injuries in the control (n = 44) and experimental (n = 40) groups during the year

Finger injuries												
Group	Low complexity				Medium difficulty				High complexity			
	Yes*	No *	Incidence (risk) of injuries	Chance of injury	Yes	No	Incidence (risk) of injuries	Chance of injury	Yes	No	Incidence (risk) of injuries	Chance of injury
C	13	31	0.23	0.419	11	33	0.250	0.333	9	35	0.205	0.257
E	5	35	0.10	0.143	3	37	0.075	0.081	1	39	0.025	0.026
IRR(CI) P^a	2.364 (0.925; 6.041)				3.333 (1.001; 11.096) P(Fisher)=0.030				8.182 (1,084; 61.749) P (Fisher)=0.011			
OR(CI) P^a	2.935 (0.940; 9.170)				4.111 (1.055; 16.020) $P(\chi^2)$=0.041				10.029 (1.209; 83.201) p (χ^2)=0.016			

Notes: C-control group; E - experimental group; * - Yes - the number of people injured; No - the number of people who were not injured; IRR (incidence rate ratio) - the ratio of the value of the risk of injury in the control group to the value of risk in the experimental group; OR (Odds Ratio) - the ratio of the chances of injury in the control group to the value in the experimental group; CI -

confidence interval (lower limit. Upper limit); and - only reliable values of P are presented; P (Fisher) - was determined by the exact Fisher test; P (χ2) was determined by the Pearson χ-square test

The total number of all registered injuries of the elbows during 1 year of the experiment was 29 in the control group and 5 - in the experimental. The number of AEs during 1 year of the experiment was 6600 in the control and 6000 in the experimental groups. Injury rate per 1000 AEs of all recorded shoulder injuries in the control group during the 1 year of the experiment was 4.833 (95% Ci, 1.463; 7.984), in the experimental group - 0.758 (95% Ci, 0.079; 1.892), P <0.001.

The injury rate of mild elbow injuries per 1000 AEs during 1 year of the experiment in the control group was 1.82 (95% Ci, 1.071; 2.403), in the experimental group - 0,5 (95% Ci, 0.064; 0.979). The incidence rate ratio for cohort (injuries = no) for mild elbow injuries was 0.786 (0.643; 0.962) (Table 3.10). We also found that the Injury rate of moderate elbow injuries per thousand AEs during 1 year of the experiment in the control group was 1.52 (95% Ci, 0.247; 1.883), in the experimental group - 0.33 (95% Ci, 0.089; 1.272). The incidence rate ratio for cohort (injuries = no) for moderate elbow injuries was 0.813 (0.683; 0.968); P = 0.039) (Table 3.10). Our study also showed that the Injury rate of severe elbow injuries per thousand AEs during 1 year of the experiment in the control group was 1.06 (95% CI, 0.134; 1.795), in the experimental group - 0 (severe injuries in the experimental group did not was found).

The incidence (risk) of injuries and diseases of the elbow of low complexity in the control group is equal to 0.273, in the experimental - 0.075; the chances of injuries and diseases of the elbow of low complexity in the control group is 0.375, in the experimental - 0.081. The relative risk (control group / experimental group) to get injuries and diseases of the elbow of low complexity in the control group is 3.636 times higher (95% CI = 1,106-11,959, P (Fisher) = 0.017) compared with the experimental (Table 3.8, 3.10). Relative risk - the probability of injury (experimental group / control group) is equal to 0.786 (95% CI = 0.643-0.962, P (Fisher) = 0.017) (Table 3.10). The relative chance of injuries and diseases of the elbow of low complexity in the control group is higher by 4.625 times (95% CI = 1.143-27.324, P (χ2) = 0.028) compared with the experimental (Table 4.6).

The incidence (risk) of injuries and diseases of the elbow of medium complexity in the control group is 0.227, in the experimental - 0.050; the chances of getting injuries and diseases of the elbow of medium complexity in the control group is equal to 0.294, in the experimental - 0.053 (Tables 3.8, 3.10). The relative risk (control group / experimental group) to get injuries and diseases of the elbow of medium complexity in the control group is 4.545 times higher (95% CI = 1.059-19.506, P (Fisher) = 0.02) compared with the experimental (Table 3.8, 3.10), Relative risk - the probability of injury (experimental group / control group) is equal to 0.813 (95% CI = 0.683-0.968, P (Fisher) = 0.020) (Table 3.10). The relative chance of getting injuries and diseases of the elbow of moderate complexity in the control group is 5.588 times higher (95% CI = 1.143-27.324, P (χ2) = 0.028) compared with the experimental (Table 3.8, 3.10).

The incidence (risk) of injuries and diseases of the elbow of high complexity in the control group is 0.09, in the experimental - 0.05; the chances of getting injuries and diseases of the elbow of high complexity in the control group is 0.159, in the experimental group - 0.000 (in the experimental group no injuries or diseases of the elbow of severe complexity were found (Tables 3.8, 3.10). control group) is equal to 0.841 (95% CI = 0.739-0.956, P (Fisher) = 0.008) (Table 3.10) The relative risk (control group / experimental group) and the odds ratio were not determined, because in the experimental group no severe elbow injuries.

Table 3.8

Risk indicators of injuries and diseases of the elbow in the control (n = 44) and experimental (n = 40) groups during the year

Injuries and diseases of the elbow												
Group	Low complexity				Medium difficulty				High complexity			
	Yes*	No*	Incidence (risk) of injuries	Chance of injury	Yes	No	Incidence (risk) of injuries	Chance of injury	Yes	No	Incidence (risk) of injuries	Chance of injury
C	12	32	0.273	0.375	10	34	0.227	0.294	7	37	0.159	0.189
E	3	37	0.075	0.081	2	38	0.050	0.053	0	40	0.000	0.000
IRR(CI) P[a]	3.636 (1.106; 11.959) P (Fisher)=0,017				4.545 (1.059; 19.506) P (Fisher)=0.02				-			
OR(CI) P[a]	4.625 (1.198; 17.854) P (χ^2)=0.023				5.588 (1.143; 27.324) P (χ^2)=0.028				-			

Notes: C-control group; E - experimental group; * - Yes - the number of people injured; No - the number of people who were not injured; IRR (incidence rate ratio) - the ratio of the value of the risk of injury in the control group to the value of risk in the experimental group; OR (Odds Ratio) - the ratio of the chances of injury in the control group to the value in the experimental group; CI - confidence interval (lower limit. Upper limit); and - only reliable values of P are presented; P (Fisher) - was determined by the exact Fisher test; P ($\chi2$) was determined by the Pearson χ-square test

The total number of all registered shoulder injuries during 1 year of the experiment was 21 in the control group and 3 in the experimental group. The number of AEs during 1 year of the experiment was 6600 in the control and 6000 in the experimental groups. Injury rate per 1000 AEs of all registered shoulder injuries in the control group during 1 year of the experiment was 3.182 (95% Ci, 1.061; 5.367), in the experimental group – 0.5 (95% Ci, 0.068; 1.375), P <0.001.

The injury rate of mild shoulder injuries per 1000 AEs during 1 year of the experiment in the control group was 1.21 (95% Ci, 1.061; 5.303), in the experimental group - 0.33 (95% Ci, 0.068; 0.968). The incidence rate ratio for cohort (injuries = no) for mild shoulder injuries was 0.862 (0.737; 1.007) (Table 3.10). We also found that the Injury rate of moderate shoulder injuries per thousand AEs during 1 year of the experiment in the control group was 1.06 (95% Ci, 0.347; 1.733), in the experimental group - 0.17 (95% Ci, 0.098; 1.172). The incidence rate ratio for cohort (injuries = no) for moderate shoulder injuries was 0.862 (0.751; 0.990; P = 0.039) (Table 3.9). Our study also showed that the Injury rate of severe shoulder injuries per 1000 AEs during 1 year of the experiment in the control group was 0.91 (95% CI, 0.124; 1.695), in the experimental group - 0, no severe injuries in the experimental group were detected).

The incidence (risk) of injuries and diseases of the shoulder of low complexity in the control group is equal to 0.182, in the experimental - 0.050; the chances of getting injuries and diseases of the shoulder of low complexity in the control group is equal to 0.222, in the experimental - 0.053 (Tables 3.9, 3.10). The relative risk (control group / experimental group) of injuries and diseases of the shoulder of low complexity in the control group is higher by 3,636 times (95% CI = 0.820-16.122, P> 0.05) compared with the experimental. The relative chance of injuries and diseases of the shoulder of low complexity in the control group is 4.222 times higher (95% CI = 0,840-21.232, P> 0.05) compared with the experimental (Table 3.9, 3.10). Relative risk - the probability of injury (experimental group / control group) is equal to 0.861 (95% CI = 0.737-1.007, P> 0.05) (Table 3.10).

The incidence (risk) of injuries and diseases of the shoulder of medium complexity in the control group is equal to 0.159, in the experimental - 0.025; the chances of getting injuries and diseases of the shoulder of medium complexity in the control group is equal to 0.189, in the experimental - 0.026 (Tables 3.9, 3.10). The relative risk (control group / experimental group) of injuries and shoulder diseases of moderate complexity in the control group is 6.364 times higher (95% CI = 1.818-49.487, P (Fisher) = 0.039) compared to the experimental. Relative risk - the probability of injury (experimental group / control group) is equal to 0.862 (95% CI = 0.751-0.990, P (Fisher) = 0.039) (Table 3.10). The relative chance of injuries and diseases of the shoulder of medium complexity in the control group is 7.378 times higher (95% CI = 1.865-62.905, P (χ2)> 0.05) compared with the experimental (Table 3.9, 3.10).

The incidence (risk) of injuries and diseases of the shoulder of high complexity in the control group is 0.09, in the experimental - 0.05; the chances of getting injuries and diseases of the shoulder of high complexity in the control group is equal to 0.136, in the experimental group - 0.000 (in the experimental group no injuries and diseases of the shoulder of severe complexity were recorded) (Tables 3.9, 3.10). Relative risk - the probability of injury (experimental group / control group) is equal to 0.864 (95% CI = 0.768-0.971, P (Fisher) = 0.017) (Table 3.10). The relative risk (control group / experimental group) and the odds ratio were not determined because no severe shoulder injury was detected in the experimental group.

Table 3.9

Risk indicators of injuries and diseases of the shoulder in the control (n = 44) and experimental (n = 40) groups during the year

Group	Injuries and diseases of the shoulder		
	Low complexity	Medium difficulty	High complexity

	Yes *	No*	Incidence (risk) of injuries	Chance of injury	Yes	No	Incidence (risk) of injuries	Chance of injury	Yes	No	Incidence (risk) of injuries	Chance of injury
C	8	36	0.182	0.222	7	37	0,159	0,189	6	38	0.136	0.158
E	2	38	0.050	0.053	1	39	0,025	0,026	0	40	0.000	0.000
IRR(CI) P[a]	3.636 (0.820; 16.122)				6.364 (1.818; 49.487) P(Fisher)=0,039				-			
OR(CI) P[a]	4.222 (0.840; 21.232)				7.378 (0.865; 62.905) $P(\chi^2)=0.060$				-			

Notes: C-control group; E - experimental group; * - Yes - the number of people injured; No - the number of people who were not injured; IRR (incidence rate ratio) - the ratio of the value of the risk of injury in the control group to the value of risk in the experimental group; OR (Odds Ratio) - the ratio of the chances of injury in the control group to the value in the experimental group; CI - confidence interval (lower limit. Upper limit); and - only reliable values of P are presented; P (Fisher) - was determined by the exact Fisher test; P (χ2) was determined by the Pearson χ-square test

Table 3.10

Comparative characteristics of injuries of the upper extremities in the control (n = 44) and experimental (n = 40) groups during the year

Injury Type		Control Group			Intervention Group			IRR (95% CI)	P Value
Injury localization	Injury severity	Injuries, No.	AEs, No.	Injury Rate[a]	Injuries, No.	AEs, No.	Injury Rate[a]		
Fingers	Easy	13	6600	1.97	5	6000	0.83	0.805 (0.643; 1.008) [a] 2.364 (0.925; 6.041)[b] 2.935 (0.940; 9.170) [c]	0.050 [d] 0.067 [e]
	Average	11	6600	1.67	3	6000	0.50	0.811 (0.669; 0.982) [a] 3.333 (1.001; 11.096) [b] 4.111 (1.055; 16.020) [c]	0.030 [d] 0.041 [e]
	Heavy	9	6600	1.36	1	6000	0.17	0.816 (0.697; 0.955) [a] 8.182 (1.084; 61.749) [b] 10.029 (1.209; 83.201) [c]	0.011 [d] 0.016 [e]
Elbows	Easy	12	6600	1.82	3	6000	0.50	0.786 (0.643; 0.962) [a] 3.636 (1.106; 11.959) [b] 4.625 (1.198; 17.854) [c]	0.017 [d] 0.023 [e]
	Average	10	6600	1.52	2	6000	0.33	0.813 (0.683; 0.968) [a] 4.545 (1.059; 19.506) [b] 5.588 (1.143; 27.324) [c]	0.02 [d] 0.028 [e]
	Heavy	7	6600	1.06	0	6000	0.00	0.841 (0.739; 0.956) [a] - -	0.008 [d] 0.013 [e]
Shoulders	Easy	8	6600	1.21	2	6000	0.33	0.861 (0.737; 1.007)[a] 3.636 (0.820; 16.122)[b] 4.222 (0.840; 21.232)[c]	0.061 [d] 0.092 [e]
	Average	7	6600	1.06	1	6000	0.17	0.862 (0.751; 0.990) [a]	0.039 [d]

								6.364 (1.818; 49.487)[b] 7.378 (0.865; 6.905)[c]	0.060 [e]
	Heavy	6	6600	0.91	0	6000	0.00	0.864 (0.768; 0,971)[a] - -	0.017[d] 0.027[e]

Notes:
AEs - athlete * exposure (training sessions, competitions) - number of athletes * number of influences (training sessions, competitions);
Injury rate indicates the number of injuries per 1000 AEs - Injury rate indicates the number of injuries per 1000 AEs;
IRR - incidence rate ratio:
aIncidence rate ratio for cohort (injuries = no) - Coefficient of injuries for cohort (injuries = no)
bIncidence rate ratio for cohort (injuries = yes) - Injury rate for cohort (injuries = yes)
c - OR - Odds Ratio for group (control / intervention) - VS - Odds Ratio for group (control / intervention)
CI - confidence interval (Lower bound; Upper bound) - (CI) - confidence interval (lower limit; upper limit);
d - Determined by Fisher's exact test;
e - Determined by Pearson Chi-Square test

Our study showed that the use of exercises in a closed kinematic circuit and exercises in the eccentric mode reduces the Incidence rate ratio of the shoulders in students - climbers of amateur level. The incidence rate ratio is reduced for mild, moderate and severe shoulder injuries, but a significant reduction was found for moderate and severe injuries. Severe elbow and shoulder injuries in the experimental group were not detected during the experiment.

Thus, it can be noted that the use of the developed technology of injury prevention reduces the risk of finger injuries: low complexity in 2.364 (95% CI = 0.925-6,041, P> 0.05) times; medium complexity – 3.333 times (95% CI = 1.001-11.096, P (Fisher) = 0.030); high complexity – 8.182 times (95% CI = 1.084-61.749, P (Fisher) = 0.011). The use of the developed technology of injury prevention reduces the risk of injuries and diseases of the elbow: low complexity by 3.64 times; medium complexity – 4.545 times (95% CI = 1.059-19.506, P (Fisher) = 0.02); high complexity was not determined, because in the experimental group was not found any injury to the elbow of high complexity. The use of the developed technology of injury prevention reduces the risk of injuries and diseases of the shoulder: low complexity – 3.636 times (95% CI = 1.106-11.959, P (Fisher) = 0.017); medium complexity - 6.364 times (95% CI = 1.818-49.487, P (Fisher) = 0.039); high complexity - was not determined, because in the experimental group was not found any shoulder injury of severe complexity.

A significant effect of the technique of one-arm hang in climbing on the number of injuries of the upper extremities was revealed. Since at the end of the experiment in the experimental group the level of climbing technique was significantly higher than in the control, it can be noted that the applied technology of injury prevention has a significant effect on reducing the number of injuries and the level of technical skill of athletes.

3.5. Analysis and discussion of research results

The hypothesis put forward in this study on the presence of significant differences in the technique of performing high jump by novice athletes and qualified athletes, was fully confirmed. In this study, there are new data on the kinematic parameters of various models of climbing techniques in climbing. Proper technique implies the most efficient execution of the movement, ie movement in which there is an optimal combination of effort and effect (Adrian, & Cooper, 1995; Arend, & Higgins, 1976; Harriett, 1999). Therefore, the question arises as to how justified the muscle tension in the second model of the technique of one-arm hang. On the one hand, athletes come to this model empirically. However, the effectiveness of this model now, although it has shown the effectiveness of the application, is not justified in terms of the laws of biomechanics and kinesiology. To understand the ways to improve the technique of movement in climbing, it is necessary to substantiate the basic principles of movement. One of the most common movements in rock climbing is one-arm hang (White, & Olsen, 2010). Therefore, substantiation of the correctness of this movement is of great importance for the technique of climbing in general, as well as for other sports, in the technique of which there are similar patterns.

As far as we know, this is one of the first randomized studies to prevent shoulder injuries in climbing. The hypothesis about the effectiveness of neuromuscular training, in particular - exercises in a closed kinematic circuit, eccentric and strength exercises for the prevention of injuries in climbing has been confirmed. We obtained a significant reduction in the Injury rate for Incidence rate ratio and Odds Ratio for moderate shoulder injuries and for Incidence rate ratio for severe injuries. It should be noted that no severe shoulder injuries were detected in the intervention group.

Data on the effectiveness of neuromuscular training for the prevention of injuries in exercise and sports (Copack et al., 2011; LaBella et al., 2011; Pasanen et al., 2008; Parkkari et al., 2011) ; Steffen et al., 2013). In addition, these data were supplemented by the spread of the idea of neuromuscular training in the field of sport, in which before our work was not conducted randomized trials on injury prevention programs - climbing.

Provisions for the effectiveness of closed-loop kinematic exercises for injury prevention were based on literature data (Copack et al., 2011) and on the results of our previous studies (Kozin, 2019; Kozina et.al., 2020). A closed kinematic chain involves the inclusion of all the muscles that form this kinematic chain.

Copack et al. (2011) also recommend closed-loop kinematic exercises for the quadriceps muscle and gluteal eccentric, as well as static stretching of the quadriceps muscle, patellar tendon, calf muscle, and iliac-tibial ligament. The ratio of the chances of injury without the use and with the use of this program is 0.26 (0.13-0.53).

Our program is based on the position formulated in our previous work (Kozin et.al., 2020). In skilled climbers, the total force that provides the position of suspension is much greater than this force in unqualified athletes. This is due to the fact that in skilled athletes not only the muscles of the upper limb (as in unskilled athletes), but also the muscles of the torso and legs are involved in maintaining the position of the suspension on one arm when climbing, creating another link in kinematic chain. Accordingly, the upper limb has less load compared to the technique of unqualified athletes. This provided a theoretical basis for the formation of the most effective climbing techniques that ensure the achievement of sports results and prevent injuries. Therefore, to include in the action of not only the muscles of the arms, but also the muscles of the legs and torso, it is advisable to use exercises in a closed kinematic circuit.

Exercises in a closed kinematic chain promote the inclusion of all the muscles that form this kinematic chain. This forms the skill of using not only the muscles of the arms, but also the muscles of the torso and legs when performing one-arm hang in climbing. Exercises performed in an eccentric mode, promote the smooth inclusion of muscles - antagonists. This helps to strengthen them during movements aimed at maintaining body position when performing interceptions during climbing. Therefore, we can conclude that the combination of these exercises with each other and with strength exercises has a theoretical basis, and in our study was confirmed experimentally.

A feature of our climbing injury prevention program is also that the program includes exercises specific to climbing. In the analyzed literature on injury prevention in various sports, all the proposed programs included exercises of a general nature to strengthen the muscles of the cortex, the development of balance, strengthening the muscles of the legs. In our study, we used exercises to prevent injuries specific to climbing. It should be noted that the evidence for the effectiveness of exercises specific to climbing, including - exercises in a closed kinematic circuit, eccentric and strength exercises, are relatively new data.

Our study confirmed the theory of MO Bernshtein (Bernshtein, 1967), from which it follows that the basis of injury prevention is the effective organization of motor control by the central nervous system. The results of research allowed NA Bernstein (Bernstein, 1967) to look at the theory of reflexes from another point of view.

ON. Bernstein (Bernstein, N.A., 1967) introduced the concept of "model of the desired future", considering it as a form of reflection of the living organism of the world. The second form is a reflection of the past and present. Along with this, the brain "reflects" (constructs) the situation of the future, has not yet become a reality, which provided its biological needs motivate to realize. Only awareness of the image of the desired future can serve as a basis for the design of the task and programming its solution. The model of the future is probabilistic. From this point of view, our work confirmed Bernshtein's theory (Bernshtein, 1967) about the probability of a model of the future with respect to the fact that injury has a certain probability and cannot be programmed.

ON. Bernstein (Bernstein, N.A., 1967) proposed a completely new principle of motion control, calling it the principle of sensory correction. This refers to the corrections made to motor impulses based on sensory information about the course of movement. The result of any complex movement depends not only on the actual control signals, but also on a number of additional factors. A common feature of these factors is to make changes in the planned course of movement. The movement, even the most elementary, is always built "here and now", and does not follow automatically (each time the same) following the stimulus that caused it (Thompson, RN, Hanratty, B., & Corry, IS, 2011); Schö ffl, VR, Ho ff mann, G., & Küpper, T., 2013).

From this point of view, our work confirmed Bernshtein's theory (Bernshtein, 1967) with the provisions on the need to use neuromuscular training to prevent injuries to improve the mechanism of sensory correction.

The ultimate goal of the movement can be achieved only if it is constantly amended (corrected). The CNS must know what the real share of the current movement is, ie it must continuously receive afferent signals containing information about the real course of movement, and then process them into correction signals.

Barnshtein (Bernshtein, 1967) identified the main factors influencing the course of movement:

1. Reactive forces - involuntary reactions that occur in the systems of muscles, tendons, bones, etc. (Lion, A., van der Zwaard, BC, Remillieux, PP, & Buatois, S., 2015; Robertson, N., 2012; Schö VR, VR, Ho ff mann, G., & Küpper, T., 2013). If you wave your hand hard, other parts of the body will develop reactive forces that will change their position and tone. For example, if a child climbs on the sofa and starts throwing the ball out of it, then, throwing the ball, she can fly off the couch.

2. Inertial forces - if you raise your hand sharply, it will take off only due to those motor impulses that are sent to the muscle, but at some point will move by inertia (ie longer than necessary) (Stelzle, FD, Gaulrapp , H., & Pforringer, W., 2000).

3. External forces (external resistance) are obstacles that may stand in the way of the running program. If the movement is directed at an object, it necessarily meets its resistance, which is not always predictable (Volker Schöffl, Christoph Lutter, Kaikanani Woollings & Isabelle Schöffl, 2018).

4. The initial state of the muscle - (this is the position of the arm, the degree of muscle contraction, etc.). The state changes along the movement with a change in its length, as well as as a result of its fatigue, etc. Therefore, one and the same control impulse, coming to the muscle, can give a completely different motor effect (Gareth Jones, MSc and Mark I. Johnson, 2016; Wright, DM, Royle, TJ, & Marshall, T., 2001; Wright, DM, Royle, TJ, & Marshall, T., 2001).

From this point of view, our work confirmed Bernshtein's theory (Bernshtein, 1967) with the provisions on the need to use exercises in eccentric mode in combination with exercises to strengthen muscles to prevent injuries to improve the factors influencing movements, namely: the initial state of m muscles, because strengthening the muscles improves their initial condition; to interact with reactive and inertial forces, as the use of exercises in the eccentric mode promotes the sequential activation of the muscles and does not allow the muscles to remain without control of the brain when switching from one movement to another.

The action of all these factors necessitates the continuous accounting of information about the state of the musculoskeletal system and the direct course of movement. This information is called "feedback signals". Motion feedback signals are often parallel, ie come simultaneously through several channels. For example, when a person walks, he feels his steps with the help of muscular feeling and can see and hear them at the same time (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery, CA, 2015; Thompson, RN, Hanratty, B., & Corry, IS, 2011).

Since NA Bernstein - the creator of the theory of levels of construction of movements (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery, CA, 2015; Thompson, RN, Hanratty, B., & Corry, IS, 2011), consider the main points confirmed by our study in the theory of level construction of motion control, separately. They found that depending on what information is carried by feedback signals, afferent signals come to different sensitive centers of the brain and, accordingly, switch to motor pathways at different levels.

The level should be understood as morphological "layers" in the CNS. Thus, the levels of the spinal cord and medulla oblongata, the level of the subcortical centers, the levels of the cortex were identified (Bernstein, N.A., 1967).

Each level has specific, unique motor manifestations, implements its own class of movements.

Basic ideas

1. In the organization of a particular movement usually involves several levels: the one on which the movement is built and all that is below. In a sense, this is similar to a military operation: its overall course and tasks are determined at one level of command, in the implementation of the operation usually involves this level and lower, ending with performers (soldiers) (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery, CA, 2015; Thompson, RN, Hanratty, B., & Corry, IS, 2011).

2. The same movement can be built on different leading levels (initiated by different levels), with different quality of execution, but still the same. Running, for example, can be built at the level of C, D or E. In the first case, the features of running are almost not controlled by consciousness, it reflects a simple "run" or "run there". In the second and third cases, the control of consciousness over the process of running is much higher: specific features of running are controlled, communication with some objects (such as a soccer ball) or even the use of running not to move in space, but for some complex tasks (eg coach can to depict another man running; in the end, you can even run the Morse code if you really want to run (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery , CA, 2015; Thompson, RN, Hanratty, B., & Corry, IS, 2011).

3. Levels of movement construction have a "permanent place of registration" in separate "layers" of the central nervous system in which levels of a spinal cord, oblong, subcortical centers, bark are allocated. Each level is associated with specific, phylogenetically complex motor manifestations, each level corresponds to its class of movements (Fig. 3.8).

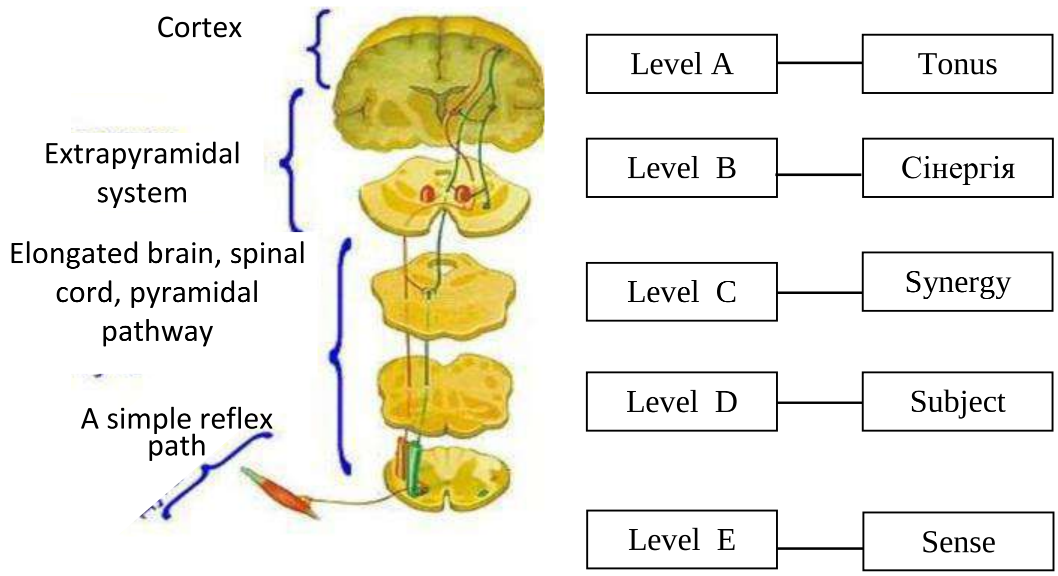

Fig. 3.8. Levels of organization of movements according to NA Bernstein (Bernstein, N.A., 1967)

Level A - level of tone (rubro-spinal level of the CNS)

Level A functions:

| | Controls an important aspect of any movement - muscle tone;

| | Controls reciprocal inhibition (intermuscular coordination);

| | Participates with other levels in the organization of any movement.

Based on the listed provisions of the level A function, it can be noted that this is almost the basic level for ensuring movements without injuries, as muscle tone and intermuscular coordination are one of the main conditions for injury prevention. Neuromuscular training primarily affects the level of A. and this is a confirmation of Bernshtein's theory (Bernshtein, 1967). Властивості рухів на рівні A:

• Posture;

• Spontaneous shaking / knocking of teeth;

• Posture correction in flight.

At this level, mainly receive signals of muscle proprioceptors, which report the degree of muscle tension and signals from the body of balance

In case of violations / reduction of functionality:

o Deteriorating self / limb perception in space;

o Deteriorating agonistic-antagonistic muscle interactions;

o Impossibility to create a good background base for building traffic at higher levels

Based on the above provisions of the level A function, it can be noted that this is almost the basic level for ensuring injury-free movements, as self-perception and limbs in space and agonistic-antagonistic muscle interactions are one of the main conditions for injury prevention. Neuromuscular training primarily affects these aspects of the level of A. and this is a confirmation of Bernshtein's theory (Bernshtein, 1967).

Recovery / training:

o Exercises for balance and on unstable grounds;

o Increased cutaneous and musculoskeletal propricept input.

These exercises were provided by our biomechanical technology of injury prevention.

Level B is the level of synergy

(Thalamo-pallidar level of the CNS)

Functions:

| | Provides great muscle synergies;

| | Ability to move harmoniously and coherently, ensuring optimal alternation of muscle contraction;

| | Creation of models / patterns of movement;

| | Great participation in the organization of movements at higher levels.

Own movements:

Only movements without external space are possible

• Facial expressions;

| | Sip.

At this level, mainly signals from the muscle, joint, ligaments, skin proprioceptors.

In case of violations / reduction of functionality:

o Selection of suboptimal synergies;

o Creation of pathological models / patterns;

o The emergence of excessive or unnecessary synergies, "pre-movements";

o Pathological hypofunction is manifested by parkinsonism.

Recovery / training:

o Physical therapy in models / patterns of movements;

o Exercises in closed kinematic circuits;

o Increased attention and awareness on the body during exercise.

Based on the listed provisions of the level B function, it can be noted that this is also almost the basic level for ensuring movements without injuries, as synergies in the work of muscles are one of the main conditions for injury prevention. Neuromuscular training, in particular exercises in closed kinematic circuits, affects level B in the first place, and this is a confirmation of Bernshtein's theory (Bernshtein, 1967).

Level C is the level of the spatial field

(Pyramidal-striatal level of the CNS)

"Level C corrections monitor how the movement fits into a foreign body space. He is not particularly worried about how the biomechanical side of the movement will take shape" (Bernstein, 1947)

Level C functions:

| | Target accuracy;

| | Beginning and end of movement.

Strength, accuracy and volume of movement:

• Target movements in space;

• Running, walking, jumping, climbing, goalkeeping and many others;

• This level receives signals from the centers of sight, hearing, touch, ie information about outer space.

In case of violations / reduction of functionality:

o Ataxia (loss of the target nature of the movement);

o Decreased functionality associated with problems of information input (vision, hearing), which is manifested, for example, difficulties or inability to perceive several objects.

Recovery / training:

o Biological feedback method (BOF);

o Exercises in a changing environment.

From this point of view, our work confirmed Bernshtein's theory (Bernshtein, 1967) with the provisions on the need to use neuromuscular training, because non-muscular training is aimed at understanding the details of movements in space. Awareness of the details of each movement in space reduces the likelihood of injury.

Level D - the level of objective action

(Cortical level of the CNS)

"The movements will agree with the logic of the subject. In all cases, the specific movements will be different, but the end result is the same "(NA Bernstein, 1947)

Functions:

| | Provides the implementation of chains of successive movements with objects that together solve a particular motor task.

Motion properties:

• Manipulation of objects;

• Ruiu juggler, swordsman, possession of the ball;

• All household movements.

Level E - the level of intellectual and motor acts, primarily speech movements, written movements, movements of symbolic language (gestures of the deaf and dumb) (Bernstein, NA, 1967; Woollings, KY, McKay, CD, Kang, J., Meeuwisse, WH, & Emery, CA, 2015; Thompson, RN, Hanratty, B., & Corry, IS, 2011). The anatomical substrate of movements of this level is not very clear, but MO Bernshtein (Bernshtein, 1967) emphasized the involvement of the frontal lobes of the cerebral cortex.

From this point of view, our work confirmed Bernshtein's theory (Bernshtein, 1967) with the provisions on the need to use information and analytical directions of our developed biomechanical technology to improve the work of consciousness in the assimilation of movement techniques and injury prevention.

Thus, based on the above, we can say that the scientific novelty of our work lies in the following provisions:

The paper confirms the data on the need for the formation of biomechanically sound movement techniques for the prevention of injuries in sports, the theory of movement control on the need for the formation of rational techniques for injury prevention (Bernshtein, 1967).

The paper expands and supplements the data (Copack et al., 2011; LaBella et al., 2011; Pasanen et al., 2008; Parkkari et al., 2011; Steffen et al., 2013) on the use of neuromuscular training for injury prevention in various sports, in particular - in climbing.

Conclusions to the third section

Biomechanical analysis allowed to determine the tasks for the use of means for the prevention of injuries in climbing: 1 - strengthening the muscles involved in the movement; 2 - formation of functional movement, ie for coordinated work of the muscles of the torso, upper and lower extremities.

On the basis of biomechanical analysis of the technique of one-arm hang in climbing, means were selected and systematized to prevent injuries of the upper extremities. The tools were physical exercises performed independently and with a physical therapist. All means were conditionally divided into two groups: means of sport (climbing) and means specific to physical therapy (scheme 4.1).

Exercises in sports were presented by the following groups:

1. Exercises aimed at improving the work of the fingers when performing a grip in climbing, taking into account the fact that in climbing there are different types of grips;
2. Exercises for the prevention of injuries and diseases of the elbow, in particular, exercises for the prevention and treatment of epicondylitis;
3. Exercises for the prevention of injuries and diseases of the shoulder, in particular, exercises to strengthen the muscles of the rotating cuff of the shoulder.

Exercises specific to physical therapy were aimed at the formation of functional movements and were represented by the following groups:

1. Feldenkrais method;
2. Redcord therapy;
3. PNF therapy.

After the experiment, there was a significant increase in the expert assessment of the performance of height on one arm in athletes of the experimental group ($p < 0.05$), which indicates a positive effect of the application of means of injury prevention in climbing on the formation of biomechanically functional technique of height.

Recording the number of injuries of the upper extremities received by amateur climbers studying in the specialty "Physical Education and Sports" at the initial stage of training showed that during the year the following number of injuries was observed: among finger injuries: in the control group: 13 - low complexity, 11 - medium complexity, 9 - high complexity; in the experimental group: 5 - low complexity, 3 - medium complexity, 1 - high complexity; among injuries and diseases of the elbow: in the control group: 12 - low complexity, 10 - medium complexity, 7 - high complexity; in the experimental group: 3 - low complexity, 2 - medium complexity, 0 - high complexity; among injuries and diseases of the shoulder: in the control group: 8 - low complexity, 7 - medium complexity, 6 - high complexity; in the experimental group: 2 - low complexity, 1 - medium complexity, 0 - high complexity.

It is established that the application of the developed technology of injury prevention reduces the risk of finger injuries: low complexity in 2.364 (95% CI =

0.925-6.041, P> 0.05) times; medium complexity – 3.333 times (95% CI = 1.001-11.096, P (Fisher) = 0.030); high complexity – 8.182 times (95% CI = 1.084-61.749, P (Fisher) = .,011). The use of the developed technology of injury prevention reduces the risk of injuries and diseases of the elbow: low complexity by 3.64 times; medium complexity – 4.545 times (95% CI = 1.059-19.506, P (Fisher) = 0.02); high complexity was not determined, because in the experimental group was not found any injury to the elbow of high complexity. The use of the developed technology of injury prevention reduces the risk of injuries and diseases of the shoulder: low complexity – 3.636 times (95% CI = 1.106-11.959, P (Fisher) = 0.017); medium complexity – 6.364 times (95% CI = 1.818-49.487, P (Fisher) = 0.039); high complexity - was not determined, because in the experimental group was not found any shoulder injury of severe complexity.

CONCLUSIONS

1. Scientific works on the topic of student injuries can be divided into 2 groups: 1 - articles on sports injuries of students in general (the largest number of articles); 2 - articles on sports injuries of students studying in the program "Physical Education and Sports". The most traumatic and researched sports in terms of injuries are team sports with the ball and wrestling. Among the most effective programs for the prevention of injuries of students in sports, as well as students enrolled in the program "Physical Education and Sports", there is a program of neuro-muscular training. A promising area will be the analysis of injuries among climbing students and the development of injury prevention programs. The main cause of injuries are biomechanically suboptimal movements, and the basis of injury prevention in everyday life, in sports in general and in climbing in particular is the formation of functional movement - ie the most biomechanically rational movement, economical in terms of energy consumption and in terms of movement, with the necessary activation of traffic control levels.
2. The main features of movement technique (on the example of climbing), which affect the level of injuries of students, are determined. An algorithm for identifying the main kinematic parameters of different models of equipment, typical for students with different levels of mastery of sports movements.
3. The main kinematic parameters of height in climbing for different models of equipment, typical for athletes of different qualifications, are revealed. For unskilled athletes is characterized by a type of technique with minimal muscle tension of the shoulder, back, a large angle between the shoulder and clavicle and almost vertical position of the lower spine. Qualified athletes are characterized by a type of technique with tension in the muscles of the shoulder, back, a small angle between the shoulder and clavicle and a large angle between the spine and the vertical axis.
4. The presence of significant differences ($p < 0.001$) in the magnitude of the angles between the shoulder and clavicle, between the spine and the vertical axis in the phase of fixation of the height. Thus, the angle between the shoulder and clavicle in the first model was 1460, in the second model this angle is 970. The angle between the lower spine and the vertical axis was 110 in the first model, in the second model this angle was 280.
5. The dynamics of change of an angle between a shoulder and a clavicle from the moment of capture of a hook to a phase of fixing of height is shown. At the moment of capture of a hook the size of an angle between a shoulder and a collarbone is practically identical for both models of equipment. In the second model of the technique, the angle between the shoulder and the clavicle is gradually reduced from the moment of capture of the hook to the phase of fixing the hook, while in the first model, this value is kept at the same level.
6. It is shown that in the first model the height is carried out mainly due to the ligament of the shoulder girdle joints with minimal muscle involvement, which is dangerous to injure the ligament of the shoulder joint. In the second model, the height also

provides the inclusion of muscles, which reduces the load on the ligaments and reduces the likelihood of injury to the ligaments of the shoulder joint. Theoretical substantiation of the correct technique of height in climbing from the point of view of the laws of mechanics and laws of interaction of forces in a kinematic chain is given.

7. Developed biomechanical technology for injury prevention in the training of specialists in physical education and sports, which contains 3 areas: 1 - theoretical and methodological (creating a basis for students to understand the mechanisms of movement without risk of injury, students' concept of biomechanically rational movements in general); 2 - analytical (providing students with knowledge about modern means of self-analysis of the level of technical skills); 3 - practical (students' mastery of practical means of injury prevention, ie, exercises that will promote the formation of biomechanically rational movements in any sport, and thus prevent injury).
8. The tasks for the use of means for the prevention of injuries are defined: 1 - strengthening of the muscles involved in the movement; 2 - formation of functional movement, ie for coordinated work of the muscles of the torso, upper and lower extremities.
9. Selected and systematized means for the prevention of injuries of the upper extremities on the basis of biomechanical analysis of the technique of climbing. Means are physical exercises that are performed independently and with a physical therapist. All means were conditionally divided into two groups: means for sports (climbing) and means specific for physical therapy. Exercises in sports are represented by the following groups: exercises aimed at improving the work of the fingers when performing a grip in climbing, taking into account the fact that in climbing there are different types of grips; exercises for the prevention of injuries and diseases of the elbow, in particular, exercises for the prevention and treatment of epicondylitis; exercises for the prevention of injuries and diseases of the shoulder, in particular, exercises to strengthen the muscles of the rotating cuff of the shoulder. Exercises specific to physical therapy were aimed at the formation of functional movements and were represented by the following groups: Feldenkrais method; Redcord therapy; PNF therapy.
10. It is determined that the application of the developed technology of injury prevention has a positive effect on the level of technical skill of athletes in terms of expert assessment of height and biomechanical analysis of the angle between the shoulder and collarbone in athletes of control and experimental groups. If before the experiment the groups did not differ significantly in terms of one-arm hang technique, then after the experiment the average value of the expert assessment of athletes in the control group was 26.8 ± 0.83, and in the experimental - 32.15 ± 1.18 ($p < 0.05$), which indicates the positive effect of the use of means of injury prevention in climbing on the formation of biomechanically functional techniques of height. In the experimental group there was also a significant improvement in the expert assessment of the technique of height ($p <0,001$), in the control group these changes are significant at $p <0,01$ Th results of biomechanical analysis of the

technique of height in rock climbing The correlation coefficient between the value of the analyzed angle and the value of the expert assessment was -0.95 (p <0.001), which indicates the coincidence of the subjective assessment of the one-arm hang technique by experts and the objective indicators of the one-arm hang technique in climbing.

11. There was a significant decrease in the angle between the shoulder and clavicle in athletes of the experimental group (p <0,001), while in the control group these changes are not significant (p> 0,05). The groups before the experiment did not differ significantly in the angle between the shoulder and clavicle (p> 0.05). After the experiment, a significant difference was found between the control and experimental groups in terms of the angle between the shoulder and clavicle (p <0.05). There was also a significant improvement in the results of biomechanical analysis of climbing technique in athletes of the experimental group as a result of the experiment: after the experiment in athletes of the experimental group the angle between the shoulder and clavicle decreased significantly (p <0,001), while in the control group not reliable (p> 0.05).
12. Recording the number of injuries of the upper extremities received by amateur climbers studying in the specialty "Physical Education and Sports" at the initial stage of training showed that during the year the following number of injuries was observed: among finger injuries: in the control group: 13 - low complexity, 11 - medium complexity, 9 - high complexity; in the experimental group: 5 - low complexity, 3 - medium complexity, 1 - high complexity; among injuries and diseases of the elbow: in the control group: 12 - low complexity, 10 - medium complexity, 7 - high complexity; in the experimental group: 3 - low complexity, 2 - medium complexity, 0 - high complexity; among injuries and diseases of the shoulder: in the control group: 8 - low complexity, 7 - medium complexity, 6 - high complexity; in the experimental group: 2 - low complexity, 1 - medium complexity, 0 - high complexity.
13. It is established that the application of the developed technology of injury prevention reduces the risk of finger injuries: low complexity in 2.364 (95% CI = 0.925-6.041, P> 0,05) times; medium complexity – 3.333 times (95% CI = 1.001-11.096, P (Fisher) = 0.030); high complexity – 8.182 times (95% CI = 1.084-61.749, P (Fisher) = 0.011). The use of the developed technology of injury prevention reduces the risk of injuries and diseases of the elbow: low complexity by 3.64 times; medium complexity – 4.545 times (95% CI = 1.059-19.506, P (Fisher) = 0.02); high complexity was not determined, because in the experimental group was not found any injury to the elbow of high complexity. The use of the developed technology of injury prevention reduces the risk of injuries and diseases of the shoulder: low complexity – 3.636 times (95% CI = 1.106-11.959, P (Fisher) = 0.017); medium complexity – 6.364 times (95% CI = 1.818-49.487, P (Fisher) = 0.039); high complexity - was not determined, because in the experimental group was not found any shoulder injury of severe complexity. The applied technology of injury prevention significantly influences both the reduction of the number of injuries and the level of technical skill of athletes.

REFERENCES

1. Adrian, M.J. and Cooper, J.M. (1995). Biomechanics of Human Movement, 2nd edn. Madison, WI: Brown & Benchmark.
2. Aerts I, Cumps E, Verhagen E, et al. (2013) A 3-month jump-landing training program: a feasibility study using the RE-AIM framework. Journal of Athletic Training 48(3): 296–305.
3. Affana, C. K. (2019). Correlation between Involvement in Specific Sports and Lifetime Risk of Developing a Traumatic Brain Injury in Young Students Athletes. *Journal of Neurosurgery, 131*(1).
4. Affana, C. K., Toninato, J., Abdallah, T., Samadani, U., & Bergman, T. (2018). Association between involvement in specific sports and lifetime risk of developing a traumatic brain injury in young student athletes. *Journal of Neurosurgery, 128*(4), 77-77.
5. Al-Ravashdeh A.B., Kozina Z.L., Bazilyuk T.A., Ilnickaya A.S., Influence of skills' training methodic with the application of interdisciplinary connections on motor fitness of senior pupils in light athletic, Pedagog. psychol. med.-biol. probl. phys. train. sports, 2015, 19(9), 3-11, DOI: 10.15561/18189172.2015.0901
6. Amako M, Oda T, Masuoka K, et al. (2003) Effect of static stretching on prevention of injuries for military recruits. Military Medicine 168(6): 442–446.
7. Andrish JT, Bergfeld MD and Walheim J (1974) A prospective study on the management of shin splints. The Journal of Bone and Joint Surgery 56(8): 1697–1700.
8. Aras D., Gül S., Akça F., Gülü M., Güler Özkan, Bıldırcın C., Arslan E., Çetinkaya G., Four-week of local electromyostimulaiton training on fingerboard increases the isokinetic wrist strength and endurance, Phys. educ. stud., 2020, 24(3), 127-34, DOI: 10.15561/20755279.2020.0301.
9. Arend, S. and Higgins, J. (1976). A strategy for the classification, subjective analysis and observation of human movement. Journal of Human Movement Studies, 2, 36-52.
10. Arnason A, Andersen TE, Holme I, et al. (2008) Prevention of hamstring strains in elite soccer: an intervention study. Scandinavian Journal of Medicine and Science in Sports 18: 40–48.
11. Arnason A, Engebretsen L and Bahr R (2005) No effect of a video-based awareness program on the rate of soccer injuries. The American
12. Asperti, A. M., Fernandes, T. L., Marinho, I. M., Pedrinelli, A., & Hernandez, A. J. (2017). Sports injuries among amateur athletes at a brazilian university. *Acta Ortopedica Brasileira, 25*(2), 93-98. doi:10.1590/1413-785220172502165651
13. Augustsson, J., Esko, A., Thomee, R., & Svantesson, U. (1998). Weight training of the thigh muscles using closed vs. open kinetic chain exercises: A comparison of performance enhancement. *Journal of Orthopaedic & Sports Physical Therapy, 27*(1), 3-8. doi:10.2519/jospt.1998.27.1.3

14. Backe S., Ericson L., Janson S., Timpka T., Rock climbing injury rates and associated risk factors in a general climbing population, Scand J Med Sci Sports, 2009, 19(6), 850-6, DOI: 10.1111/j.1600-0838.2008.00851.x.
15. Bahr R, Lian O and Bahr IA (1997) A twofold reduction in the incidence of acute ankle sprains in volleyball after the introduction of an injury prevention program: a prospective cohort study. Scandinavian Journal of Medicine and Science in Sports 7: 172–177.
16. Bahrani, S. M. N., Jahromi, R. A., & Jahromi, M. K. (2015). An Investigation on the Knowledge of Male and Female Students in Management and Prevention of Sport Injuries. *Research Journal of Pharmaceutical Biological and Chemical Sciences*, *6*(3), 1875-1880.
17. Bartholomew L, Parcel G, Kok G, et al. (2006) Planning Health Promotion Programs: An Intervention Mapping Approach. San Francisco, CA: Jossey Bass. Bauer R and Steiner M (2009) Injuries in the European Union: statistics summary 2005–2007. Available at: http://ec.europa.eu/health/healthy_environments/docs/2009-idb-report_screen.pdf (accessed 13 April 2015).
18. Bayer, T., Schöffl, V. R., Lenhart, M., & Herold, T. (2013). Epiphyseal stress fractures of finger phalanges in adolescent climbing athletes: A 3.0-Tesla magnetic resonance imaging evaluation. Skeletal Radiology, 42(11), 1521–1525.
19. Beachy, G., Akau, C. K., Martinson, M., & Olderr, T. F. (1997). High school sports injuries - A longitudinal study at Punahou School: 1988 to 1996. *American Journal of Sports Medicine*, *25*(5), 675-681. doi:10.1177/036354659702500515
20. Bernstein, N.A. (1967). The coordination and regulation of movements. Oxford : Pergamon Press.
21. Bertuzzi, R. C. D., Franchini, E., Kokubun, E., & Kiss, M. (2007). Energy system contributions in indoor rock climbing. *European Journal of Applied Physiology*, *101*(3), 293-300. doi:10.1007/s00421-007-0501-0
22. Bieniek, J. M., & Sumfest, J. M. (2014). Sports-related Testicular Injuries and the Use of Protective Equipment Among Young Male Athletes. *Urology*, *84*(6), 1485-1489. doi:10.1016/j.urology.2014.09.007
23. Bixler BBA and Jones RLD (1992) High-school football injuries: effects of a post-halftime warm-up and stretching routine. The Family Practice Research Journal 12(2): 131–139.
24. Bollen SR. Injury to the A2 pulley in rock climbers. J. Hand Surg. Br. 1990; 15:268Y70.
25. Bowie WS, Hunt TK, Allen HA Jr. Rock-climbing injuries in Yosemite National Park. West. J. Med.1988; 149:172Y7.
26. Brewer, B. W., Avondoglio, J. B., Cornelius, A. E., Van Raalte, J. L., Brickner, J. C., Petitpas, A. J., . . . Hatten, S. J. (2002). Construct validity and interrater agreement of the sport injury rehabilitation adherence scale. *Journal of Sport Rehabilitation*, *11*(3), 170-178. doi:10.1123/jsr.11.3.170

27. British Mountaineering Council Web site [Internet]. Climbing Wall Directory; [cited 2016 January 5]. Available from: https://www.thebmc.co.uk/find-aclimbing-wall.
28. Brown, S., & Hall, E. E. (2018). Evaluating The Effectiveness Of Applying Grief-Response Models To Sport Injury In Collegiate Student-Athletes. *Medicine and Science in Sports and Exercise, 50*(5), 325-325.
29. Brumitt, J., Sikkema, J., Mair, S., Zita, C., Wilson, V., & Petersen, J. (2020). Preseason Y Balance Test Scores are Not Associated With a Lower Quadrant Sports Injury in a Heterogeneous Population of Division III Collegiate Athletes. *International Journal of Athletic Therapy & Training, 25*(2), 68-75. doi:10.1123/ijatt.2018-0071
30. Brushoj C, Larsen K, Albrecht-Beste E, et al. (2008) Prevention of overuse injuries by a concurrent exercise program in subjects exposed to an increase in training load. The American Journal of Sports Medicine 36(4): 663–670.
31. Buda,R.,DiCaprio,F.,Bedetti,L.,Mosca,M.,&Giannini,S.(2013).Footoverusediseasesinrockclimbing: An epidemiologic study. Journal of the American Podiatric Medical Association, 103(2), 113–120.
32. Burchard, R., Stolpp, A., Kratz, T., Efe, T., Soost, C., Forreiter, C., & Lahner, M. (2017). School sport-associated injuries in adolescents: A single center experience. *Technology and Health Care, 25*(6), 1053-1059. doi:10.3233/thc-170931
33. Cahill BR and Griffith EH (1978) Effect of preseason conditioning on the incidence and severity of highschool football knee injuries. The American Journal of Sports Medicine 6(4): 180–184.
34. Caine, D. (2010). Are kids having a rough time of it in sports? British Journal Sports Medica, 44(1), 1–3.
35. Cameli, E., & Wertheim, M. (2001). Handverlertzungen bei jugendlichen und erwachsenen Sportkletterern. Deutsche Zeitschrift Fur Sportmedizin, 52, 285–288.
36. Campbell, A. D., Davis, C., Paterson, R., Cushing, T. A., Ng, P., Peterson, C. S., . . . McIntosh, S. E. (2015). Preparticipation Evaluation for Climbing Sports. *Clinical Journal of Sport Medicine, 25*(5), 412-417. doi:10.1097/jsm.0000000000000247
37. Caraffa A, Cerulli G, Projetti M, et al. (1996) Prevention of anterior cruciate ligament injuries in soccer. A prospective controlled study of proprioceptive training. Knee Surgery, Sports Traumatology, Arthroscopy 4: 19–21.
38. Carmeli, E., Azencot, S., Wertheim, M., & Coleman, R. (2003). Sports injuries in students aged 12-18 during physical education classes in israel. *Biology of Sport, 20*(4), 271-280.
39. Carr, G. (1997). Mechanics of Sport. Champaign, IL: Human Kinetics.
40. Çetinkaya G., Güngör A., Aras D., Impact of the "Chalk" on perceived visual quality and the willingness to climb: a research on sports climbing, Pedagogy phys. cult. Sports, 2021, 25(1), 15-3, DOI: 10.15561/26649837.2021.0103.

41.Chan, D. K. C., Zhang, L., Lee, A. S. Y., & Hagger, M. S. (2020). Reciprocal relations between autonomous motivation from self-determination theory and social cognition constructs from the theory of planned behavior: A cross-lagged panel design in sport injury prevention. *Psychology of Sport and Exercise, 48*. doi:10.1016/j.psychsport.2020.101660

42.Chan, D., Lee, A., Standage, M., Lonsdale, C., & Hagger, M. (2018). STUDENTS' MOTIVATION AND BELIEFS IN SPORT INJURY PREVENTION: A QUALITATIVE INVESTIGATION OF THE TRANS-CONTEXTUAL MODEL. *Annals of Behavioral Medicine, 52*, S181-S181.

43.Chang CY, Torriani M, Huang AJ. Rock climbing injuries: acute and chronic repetitive trauma. Curr. Probl. Diagn. Radiol. [Internet]. 2015 [cited 2015 September 22]. Available from: http://www.cpdrjournal.com/inpress. doi:10.1067/j.cpradiol.2015.07.003.

44.Chell, J., Stevens, K., Preston, B., & Davis, T. R. (1999). Bilateral fractures of the middle phalanx of the middle finger in an adolescent climber. The American Journal of Sports Medicine, 27(6), 817–819.

45.Chen, Y. B., Buggy, C., & Kelly, S. (2019). Winning at all costs: a review of risk-taking behaviour and sporting injury from an occupational safety and health perspective. *Sports Medicine-Open, 5*(1). doi:10.1186/s40798-019-0189-9

46.Chen, Y. Y. (2016). INVESTIGATION ON THE SITUATION AND CAUSES OF SPORTS INJURIES IN COLLEGE STUDENTS' BASKETBALL EXERCISE. *Basic & Clinical Pharmacology & Toxicology, 119*, 20-20.

47.Childs JD, Teyhen DS, Casey PR, et al. (2010) Effects of traditional sit-up training versus core stabilization exercises on short-term musculoskeletal injuries in US army soldiers: a cluster randomized trial. Physical Therapy 90(10): 1404–1412.

48.*Chu, Donald.* Jumping into plyometrics (неопр.). — 2nd. — Champaign, IL: Human Kinetics, 1998. — С. 1—4. — 177 с. — ISBN 978-0880118460.

49.Clifton, D. R., Hertel, J., Onate, J. A., Currie, D. W., Pierpoint, L. A., Wasserman, E. B., . . . Kerr, Z. Y. (2018). The First Decade of Web-Based Sports Injury Surveillance: Descriptive Epidemiology of Injuries in US High School Girls' Basketball (2005-2006 Through 2013-2014) and National Collegiate Athletic Association Women's Basketball (2004-2005 Through 2013-2014). *Journal of Athletic Training, 53*(11), 1037-1048. doi:10.4085/1062-6050-150-17

50.Cole, T. J., & Lobstein, T. (2012). Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatric Obesity, 7, 284–294.

51.Cooper, J.M., & Glassow, R.B. (1916).Kinesiology, 4th edn. St. Louis, MO: Mosby.

52.Coppack, R.J., Etherington, J. & Wills, A.K. (2011) The effects of exercise for the prevention of overuse anterior knee pain. *The American Journal of Sports Medicine, 39*(5), 940–948.

53. Coxe, K., Hamilton, K., Harvey, H. H., Xiang, J., Ramirez, M. R., & Yang, J. Z. (2018). Consistency and Variation in School-Level Youth Sports Traumatic Brain Injury Policy Content. *Journal of Adolescent Health, 62*(3), 255-264. doi:10.1016/j.jadohealth.2017.07.003
54. Cross KM and Worrell TW (1999) Effects of a static stretching program on the incidence of lower extremity musculotendinous strains. Journal of Athletic Training 34(1): 11–14.
55. Cumps E, Verhagen E and Meeusen R (2007) Efficacy of a sports specific balance training programme on the incidence of ankle sprains in basketball. Journal of Sports Science and Medicine 6: 212–219.
56. Cumps E, Verhagen E, Annemans L, et al. (2008a) Injury rate and socioeconomic costs resulting from sports injuries in Flanders: data derived from sports insurance statistics 2003. British Journal of Sports Medicine 42: 767–772.
57. Cumps E, Verhagen EA, Duerinck S, et al. (2008b) Effect of a preventive intervention programme on the prevalence of anterior knee pain in volleyball players. European Journal of Sport Science 8(4): 183–192.
58. Dahab, K., Potter, M. N., Provance, A., Albright, J., & Howell, D. R. (2019). Sport Specialization, Club Sport Participation, Quality of Life, and Injury History Among High School Athletes. *Journal of Athletic Training, 54*(10), 1061-1066. doi:10.4085/1062-6050-361-18
59. Dai, B., Herman, D., Liu, H., Garrett, W. E., & Yu, B. (2012). Prevention of ACL Injury, Part II: Effects of ACL Injury Prevention Programs on Neuromuscular Risk Factors and Injury Rate. *Research in Sports Medicine, 20*(3-4), 198-222. doi:10.1080/15438627.2012.680987
60. Danes-Daetz, C., Toro, F. R., & Mendoza, V. T. (2020). Sports injuries in Chilean university athletes. *Retos-Nuevas Tendencias En Educacion Fisica Deporte Y Recreacion*(38), 490-496.
61. Deci EL and Ryan RM (1985) Intrinsic Motivation and Self-Determination in Human Behavior. New York: Plenum Press.
62. Ding, D. M. (2013a). College Student Sports Injury in Roller Skating Teaching. In J. Lee & P. He (Eds.), *Social Science and Education* (Vol. 10, pp. 315-318).
63. Ding, D. M. (2013b). College Women and Prevention of Sports Injury in Volleyball Teaching. In T. Zhang & Q. Luo (Eds.), *Proceedings of 2013 International Conference on Sports Medicine and Sports Management* (Vol. 1, pp. 354-357).
64. Douwes, M., & DuI, J. (1991). Validity and reliability of estimating body angles by direct and indirect observations. In Designing for Everyone: Proceedings of the International Ergonomics Association (edited by Y. Queinnec and F. Daniellou), pp. 885-887. London: Taylor & Francis.
65. Drapper, N., Gilles, D., Schöffl, V., Fuss, F. K., Watts, P., Wolf, P., … Abreu, E. (2016). Comparative grading scales, statistical analyses, climber descriptors and ability grouping: International rock climbing research association position statement. Sports Technology. doi:10.1080/ 19346182.2015.1107081

66. Durand-Bechu M., Chaminade B., Belleudy P., Gasq D., Rock-climbing injuries in France from 2004 until 2011, SCI SPORT, 2014, 29(3), 125-30, **DOI:** 10.1016/j.scispo.2013.12.005
67. Ehrendorfer, S. (1998). Survey of sports injuries in physical education students participating in 13 sports. *Wiener Klinische Wochenschrift*, *110*(11), 397–400.
68. Eils E, Schro¨ter R, Schro¨der M, et al. (2010) Multistation proprioceptive exercise program prevents ankle injuries in basketball. Medicine and Science in Sports and Exercise 42(11): 2098–2105.
69. Ekerhovd, K. M., Novomesky, F., Komarekova, I., & Straka, L. (2013). Descriptive epidemiological study of fatal incidents and injury mechanisms among civilian sport parachutists in Norway from 1963 to 2008. *Romanian Journal of Legal Medicine, 21*(1), 31-36. doi:10.4323/rjlm.2013.31
70. Emery CA, Cassidy JD, Klassen TP, et al. (2005) Effectiveness of a home-based balance-training program in reducing sports-related injuries among healthy adolescents: a cluster randomized controlled trial. Canadian Medical Association Journal 172(6): 749–754.
71. Emery CA, Rose MS, McAllister JR, et al. (2007) A prevention strategy to reduce the incidence of injury in high school basketball: a cluster randomized controlled trial. Clinical Journal of Sport Medicine 17: 17–24.
72. Emery, C. A., & Tyreman, H. (2009). Sport participation, sport injury, risk factors and sport safety practices in Calgary and area junior high schools. *Paediatrics & Child Health, 14*(7), 439-444. doi:10.1093/pch/14.7.439
73. Emery, C. A., Cassidy, J. D., Klassen, T. P., Rosychuk, R. J., & Rowe, B. H. (2005). Effectiveness of a home-based balance-training program in reducing sports-related injuries among healthy adolescents: a cluster randomized controlled trial. *Canadian Medical Association Journal*, *172*(6), 749-754. doi:10.1503/cmaj.1040805
74. Emery, C. A., Meeuwisse, W. H., & McAllister, J. R. (2006). Survey of sport participation and sport injury in calgary and area high schools. *Clinical Journal of Sport Medicine, 16*(1), 20-26. doi:10.1097/01.jsm.0000184638.72075.b7
75. Emery, C. A., van den Berg, C., Richmond, S. A., Palacios-Derflingher, L., McKay, C. D., Doyle-Baker, P. K., . . . Hagel, B. E. (2020). Implementing a junior high school-based programme to reduce sports injuries through neuromuscular training (iSPRINT): a cluster randomised controlled trial (RCT). *British Journal of Sports Medicine, 54*(15), 913-+. doi:10.1136/bjsports-2019-101117
76. Engebretsen AH, Myklebust G, Holme I, et al. (2008) Prevention of injuries among male soccer players: a prospective, randomized intervention study targeting players with previous injuries or reduced function. The American Journal of Sports Medicine 36(6): 1052–1060.
77. Ettlinger CF, Johnson RJ and Shealy JE (1995) A method to help reduce the risk of serious knee sprains incurred in alpine skiing. The American Journal of Sports Medicine 23(5): 531–537.
78. Faude, O., Rossler, R., Petushek, E. J., Roth, R., Zahner, L., & Donath, L.

(2017). Neuromuscular Adaptations to Multimodal Injury Prevention Programs in Youth Sports: A Systematic Review with Meta-Analysis of Randomized Controlled Trials. *Frontiers in Physiology, 8*. doi:10.3389/fphys.2017.00791

79. Feng, Y. J., Ning, N., & She, M. K. (2016). The Research on the Current Situation and the Preventive Strategies of the Students' Sports Injuries in the Volleyball College of Wuhan Sports Institute. In H. Zhang (Ed.), *2016 6th International Conference on Education and Sports Education* (Vol. 52, pp. 85-90).
80. Finch C (2006) A new framework for research leading to sports injury prevention. Journal of Science and Medicine in Sport 9: 3–9.
81. Finch CF (2011) No longer lost in translation: the art and science of sports injury prevention implementation research. British Journal of Sports Medicine 45(16): 1253–1257.
82. Finch CF and Donaldson A (2010) A sports setting matrix for understanding the implementation context for community sport. British Journal of Sports Medicine 44: 973–978.
83. Flicinski J (2008) Occurrence and risk factors of musculoskeletal pain and sport injuries in students of physical education in University of Szczecin. Annales Academiae Medicae Stetinensis Journal 54(3): 31–47.
84. Flicinski, J., Brzosko, M., Przepiera-Bedzak, H., & Prajs, K. (2006). The impact of sport injuries, intensity of training, concomitant diseases and psychosocial factors upon occurrence of pain in upper extremities in university students of physical education. *Annals of the Rheumatic Diseases, 65*, 239-240.
85. Flicinski, J., Prajs, K., Przepiera-Bedzak, H., & Brzosko, M. (2003). The impact of sport injuries upon occurrence of pain in lower extremities in university students of physical education. *Annals of the Rheumatic Diseases, 62*, 339-340.
86. Flicinskiб J. (2008). Occurrence and risk factors of musculoskeletal pain and sport injuries in students of physical education in University of Szczecin. Annales Academiae *Medicae Stetinensis Journal, 54*(3), 31–47.
87. Folkl, A. K. (2013). Characterizing the consequences of chronic climbing-related injury in sport climbers and boulderers. Wilderness & Environmental Medicine, 24(2), 153–158.
88. Ford, J. A., Pomykacz, C., Veliz, P., McCabe, S. E., & Boyd, C. J. (2018). Sports involvement, injury history, and non-medical use of prescription opioids among college students: An analysis with a national sample. *American Journal on Addictions, 27*(1), 15-22. doi:10.1111/ajad.12657
89. Fraser, M. A., Grooms, D. R., Guskiewicz, K. M., & Kerr, Z. Y. (2017). Ball-Contact Injuries in 11 National Collegiate Athletic Association Sports: The Injury Surveillance Program, 2009-2010 Through 2014-2015. Journal of Athletic Training, 52(7), 698-707. doi:10.4085/1062-6050-52.3.10
90. Furlan AD, Pennick V, Bombardier C, et al. (2009) Updated method guidelines for systematic reviews in the Cochrane Back Review Group. Spine 34(8): 1929–1941.

91. Gabbe BJ, Branson R and Bennell KL (2006) A pilot randomized controlled trial of eccentric exercise to prevent hamstring injuries in community-level Australian football. Journal of Science and Medicine in Sport 9: 103–109.
92. Gareth Jones, MSc and Mark I. Johnson (2016). A Critical Review of the Incidence and Risk Factors for Finger Injuries in Rock Climbing. Current Sports Medicine Reports, November 2016. DOI: 10.1249/JSR.0000000000000304
93. Gatt, C. J., Jr. (2014). Neuromuscular training for the prevention of ACL injuries: commentary on the article by Eric Swart, MD, et al.: "prevention and screening programs for anterior cruciate ligament injuries in young athletes: a cost-effectiveness analysis". *The Journal of bone and joint surgery. American volume, 96*(9), e77-e77. doi:10.2106/jbjs.n.00172
94. Gatterer H, Ruedl G, Faulhaber M, et al. (2012) Effects of the performance level and the FIFA "11" injury prevention program on the injury rate in Italian male amateur soccer players. Journal of Sports Medicine and Physical Fitness 52: 80–84.
95. Gerdes EM, Hafner JW, Aldag JC. Injury patterns and safety practices of rock climbers. J. Trauma. 2006; 61:1517Y25.
96. Gilchrist J, Mandelbaum BR, Melancon H, et al. (2008) A randomized controlled trial to prevent noncontact anterior cruciate ligament injury in female collegiate soccer players. The American Journal of Sports Medicine 36(8): 1476–1483.
97. Glasgow R, Vogt T and Boles S (2001) Evaluating the public health impact of health promotion interventions: the RE-AIM framework. American Journal of Public Health 89: 1322–1327.
98. Goodall RL, Pope RP, Coyle JA, et al. (2013) Balance and agility training does not always decrease lower limb injury risks: a cluster randomized controlled trial. International Journal of Injury Control and Safety Promotion 20(3): 271–281.
99. Goossens L (2015) Primary prevention of musculoskeletal sports injuries in physical education teacher education students. PhD Thesis, Ghent University, Belgium.
100. Goossens L, Cardon G, Witvrouw E, et al. (2016a) A multifactorial injury prevention intervention reduces injury incidence in physical education teacher education students. European Journal of Sports Science 16(3): 365–373.
101. Goossens L, Vercruysse S, Cardon G, et al. (2016b) Musculoskeletal injuries in physical education versus non-physical education teachers: a prospective study. Journal of Sports Sciences 34(12): 1107–1115.
102. Goossens, L., De Ridder, R., Cardon, G., Witvrouw, E., Verrelst, R., & De Clercq, D. (2019). Injury prevention in physical education teacher education students: Lessons from sports. A systematic review. *European Physical Education Review, 25*(1), 156-173. doi:10.1177/1356336x17711675
103. Goossens, L., Verrelst, R., Cardon, G., & De Clercq, D. (2014). Sports injuries in physical education teacher education students. *Scandinavian Journal of Medicine & Science in Sports, 24*(4), 683-691. doi:10.1111/sms.12054

104. Grinsell, M. M., Butz, K., Gurka, M. J., Gurka, K. K., & Norwood, V. (2012). Sport-Related Kidney Injury Among High School Athletes. *Pediatrics, 130*(1), E40-E45. doi:10.1542/peds.2011-2082

105. Grooms DR, Palmer T, Onate JA, et al. (2013) Soccer-specific warm-up and lower extremity injury rates in collegiate male soccer players. Journal of Athletic Training 48(6): 782–789.

106. Guan, L. Y., & Zhou, X. D. (2010). *A Study on the Application of Fair Responsibility Rule in School Sports Injuries*.

107. Hammes D, Aus Der Fu¨nten K, Kaiser S, et al. (2014) Injury prevention in male veteran football players – a randomised controlled trial using "FIFA 11þ". Journal of Sports Sciences 33(9): 873–881.

108. Han, L. (2016). Research on the Sports Injury in Physical Education. In Z. Jiang & Y. Xue (Eds.), *Proceedings of the 2016 International Conference on Economy, Management and Education Technology* (Vol. 62, pp. 883-886).

109. Hao, F. X., Tang, C. J., Huang, D. Y., & Cheng, B. S. (2011). Pre-test into Legal Issues on the School Sports Injury Accidents. In T. B. Zhang (Ed.), *Future Computer, Communication, Control and Automation* (Vol. 119, pp. 235-239).

110. Hardman K (2008) The situation of physical education in schools: a European perspective. Human Movement 9(1): 5–18.

111. Hardman K and Marshall J (2000) The state and status of physical education in schools in international context. European Physical Education Review 6(3): 203–229.

112. Harriett, R. (1999). Sports Biomechanics: Reducing Injury and Improving Performance. London: E & FN Spon.

113. Hart, L. (2008). Which interventions prevent sport injuries? A review. *Clinical Journal of Sport Medicine, 18*(5), 471-472. doi:10.1097/JSM.0b013e318187c353

114. Hartig DE and Henderson JM (1999) Increasing hamstring flexibility decreases lower extremity overuse injuries in military basic trainees. The American Journal of Sports Medicine 27(2): 173–176.

115. Heaney, C. A., Rostron, C. L., Walker, N. C., & Green, A. J. K. (2017). Is there a link between previous exposure to sport injury psychology education and UK sport injury rehabilitation professionals' attitudes and behaviour towards sport psychology? *Physical Therapy in Sport, 23*, 99-104. doi:10.1016/j.ptsp.2016.08.006

116. Heid, A., Popp, D., & Schöffl, V. (2013). Traumatic peroneal tendon dislocations in rock climbers "the climbers pulley lesion of the foot". Medica Sport, 17(4), 188–192.

117. Hewett TE, Lindenfeld TN, Riccobene JV, et al. (1999) The effect of neuromuscular training on the incidence of knee injury in female athletes. The American Journal of Sports Medicine 27(6): 699–706.

118. Hides, J., Stanton, W. (2014). Can motor control training lower the risk of injury for professional football players? Med Sci Sports Exerc., 46(4), 762-8. doi: 10.1249/MSS.0000000000000169. PubMed PMID: 24056268.

119. Ho¨lmich P, Larsen K, Kogsgaard K, et al. (2010) Exercise program for prevention of groin pain in football players: a cluster-randomized trial. Scandinavian Journal of Medicine and Science in Sports 20: 814–821.

120. Hochholzer T., Schoffl V. R., Epiphyseal fractures of the finger middle joints in young sport climbers, *Wilderness* Environ Med, 2005, 16(3), 139-142, DOI: 10.1580/pr15-04.1.

121. Hochholzer, T., & Schöffl, V. (2012). Overuse syndroms in young sport climbers - cause and preventive measures (Überlastungsbeschwerden bei jugendlichen Sportkletterern). Flug Trop Reisemedizin, 19(3), 109–112.

122. Hochholzer, T., & Schöffl, V. (2013). Overuse bone marrow edema of the hands in sport climbers. Sport Orthopedic Traumatology, 29(3), 219–224.

123. Hochholzer, T., & Schoffl, V. R. (2005). Epiphyseal fractures of the finger middle joints in young sport climbers. *Wilderness & Environmental Medicine, 16*(3), 139-142. doi:10.1580/pr15-04.1

124. Hochholzer, T., Schöffl, V., & Bischof, B. (2002). Epiphyseal fractures of the middle phalanx in sportclimbers. Sport Ortho Trauma, 18, 87 –92.

125. Hochholzer, T., Schöffl, V., & Krause, R. (1997). Finger-Epiphysenverletzungen jugendlicher Sportkletterer. Sport Ortho Trauma, 13(2), 100–103.

126. Hochholzer, T., Straub, G., Schöffl, V., & Bayer, T. (2013). Knöcherne Stressreaktionen der Hand bei jugendlichen Sportkletterern. Alp Medica Rundbrief, 48, 20 –25.

127. Hofstetter M-C, Ma¨der U and Wyss T (2012) Effects of a 7-week outdoor circuit training program on Swiss army recruits. Journal of Strength and Conditioning Research 26(12): 3418–3425.

128. Hohlrieder, M., Lutz, M., Schubert, H., Eschertzhuber, S., & Mair, P. (2007). Pattern of injury after rock-climbing falls is not determined by harness type. Wilderness & Environmental Medicine, 18 (1), 30–35.

129. Hoog, P., Warren, M., Smith, C. A., & Chimera, N. J. (2016). FUNCTIONAL HOP TESTS AND TUCK JUMP ASSESSMENT SCORES BETWEEN FEMALE DIVISION I COLLEGIATE ATHLETES PARTICIPATING IN HIGH VERSUS LOW ACL INJURY PRONE SPORTS: A CROSS SECTIONAL ANALYSIS. *International Journal of Sports Physical Therapy, 11*(6), 945-953.

130. Hosaini, S. A., Atri, A. E., & Kavosi, A. (2013). Injuries at the Iranian championship in indoor rock climbing. Wilderness & Environmental Medicine, 24(2), 167–168.

131. Hrysomallis C (2007) Relationship between balance ability, training and sports injury risk. Sports Medicine 37(6): 547–556.

132. Hu, W. L., & Liu, D. (2011). *An Investigation and Analysis of Athletic Injury of Tennis Sports in Jiangxi Universities*.

133. Hurtubise, J. M., Beech, C., & Macpherson, A. (2015). Comparing Severe Injuries by Sex and Sport in Collegiate-Level Athletes: A Descriptive

Epidemiologic Study. *International Journal of Athletic Therapy & Training, 20*(4), 44-50. doi:10.1123/ijatt.2014-0090

134. FSC, M. C. (2014). International federation of sport climbing. Retrieved from http://www.ifsc-climb ing.org/

135. Ilie, G., Boak, A., Mann, R. E., Adlaf, E. M., Hamilton, H., Asbridge, M., . . . Cusimano, M. D. (2015). Energy Drinks, Alcohol, Sports and Traumatic Brain Injuries among Adolescents. *Plos One, 10*(9). doi:10.1371/journal.pone.0135860

136. Ince, D. C., Swearingen, C. J., & Yazici, Y. (2014). HALF OF HIGH SCHOOL STUDENTS PLAYING SPORTS EXPERIENCE INJURIES, EVEN MORE WITH CONTACT SPORTS: TIME FOR NEW REGULATIONS? *Annals of the Rheumatic Diseases, 73*, 306-306. doi:10.1136/annrheumdis-2014-eular.5543

137. Jamvedt G, Herbert RD, Flottorp S, et al. (2010) A pragmatic randomized trial of stretching before and after physical activity to prevent injury and soreness. British Journal of Sports Medicine 44: 1002–1009.

138. Javier Robles-Palazon, F., & Sainz de Baranda, P. (2017). Neuromuscular training programs for the injury prevention in young athletes. A literature review. *Sport Tk-Revista Euroamericana De Ciencias Del Deporte, 6*(2), 115-125.

139. Jin, J. (2020). Analysis of sports injuries and the causes in football teaching of college students. *Basic & Clinical Pharmacology & Toxicology, 126*, 41-42.

140. Jones D, Louw Q and Grimmer K (2000) Recreational and sporting injury to the adolescent knee and ankle: prevalence and causes. Australian Journal of Physiotherapy 46: 179–188.

141. Jones G., Llewellyn D., Johnson M.I., Previous injury as a risk factor for reinjury in rock climbing: A secondary analysis of data from a retrospective cross sectional cohort survey of active rock climbers, BMJ Open SEM, 2015, 1(1), 1-5, DOI: 10.1136/bmjsem-2015-000031.

142. Jones, G., & Johnson, M. I. (2016). A Critical Review of the Incidence and Risk Factors for Finger Injuries in Rock Climbing. *Current Sports Medicine Reports, 15*(6), 400-409. doi:10.1249/jsr.0000000000000304

143. Jones, G., Asghar, A., & Llewellyn, D. J. (2007). The epidemiology of rock climbing injuries. British Journal of Sports Medicine, 15(6), 773–778.

144. Jorgensen U, Fredensborg T, Haraszuk JP, et al. (1998) Reduction of injuries in downhill skiing by use of an instructional ski-video: a prospective randomised intervention study. Knee Surgery, Sports Traumatology, Arthroscopy 6: 194–200.

145. Josephsen, G., Shinneman, S., Tamayo-Sarver, J., Josephsen, K., Boulware, D., Hunt, M., & Pham, H. (2007). Injuries in bouldering: A prospective study. Wilderness & Environmental Medicine, 18(4), 271–280.

146. Junge A, Lamprecht M, Stamm H, et al. (2011) Countrywide campaign to prevent soccer injuries in Swiss amateur players. The American Journal of Sports Medicine 39(1): 57–63.

147. Kahlenberg, C. A., Nair, R., Monroe, E., Terry, M. A., & Edwards, S. L. (2016). Incidence of injury based on sports participation in high school athletes. *Physician and Sportsmedicine, 44*(3), 269-273. doi:10.1080/00913847.2016.1180269

148. Kartal A., The relationships between dynamic balance and sprint, flexibility, strength, jump in junior soccer players, Pedagogy phys. cult. Sports, 2020, 24(6), 285-289, DOI: 10.15561/26649837.2020.0602.

149. Keats MR, Emery CA and Finch CF (2012) Are we having fun yet? Fostering adherence to injury preventive exercise recommendations in young athletes. Sports Medicine 42(3): 175–184.

150. Kerr, Z. Y., Collins, C. L., Pommering, T. L., Fields, S. K., & Comstock, R. D. (2011). Dislocation/Separation Injuries Among US High School Athletes in 9 Selected Sports: 2005-2009. *Clinical Journal of Sport Medicine, 21*(2), 101-108. doi:10.1097/JSM.0b013e31820bd1b6

151. Kerr, Z. Y., Putukian, M., Chang, C. J., DiStefano, L. J., Currie, D. W., Pierpoint, L. A., . . . Marshall, S. W. (2018). The First Decade of Web-Based Sports Injury Surveillance: Descriptive Epidemiology of Injuries in US High School Boys' Soccer (2005-2006 Through 2013-2014) and National Collegiate Athletic Association Men's Soccer (2004-2005 Through 2013-2014). *Journal of Athletic Training, 53*(9), 893-905. doi:10.4085/1062-6050-166-17

152. Kerr, Z. Y., Roos, K. G., Djoko, A., Dompier, T. P., & Marshall, S. W. (2017). Rankings of High School Sports Injury Rates Differ Based on Time Loss Assessments. *Clinical Journal of Sport Medicine, 27*(6), 548-551.

153. Killian, R. B., Nishimoto, G. S., & Page, J. C. (1998). Foot and ankle injuries related to rock climbing. The role of footwear. Journal of the American Podiatric Medical Association, 88(8), 365–374.

154. Klauser A, Frauscher F, Bodner G, et al. Finger pulley injuries in extreme rock climbers: Depiction with dynamic US. Radiology. 2002; 222:755Y61.

155. Knapik JJ, Bullock SH, Canada S, et al. (2004) Influence of an injury reduction program on injury and fitness outcomes among soldiers. Injury Prevention 10: 37–42.

156. Knapik JJ, Darakjy S, Hauret KG, et al. (2006) Increasing the physical fitness of low-fit recruits before basic combat training: an evaluation of fitness, injuries, and training outcomes. Military Medicine 171(1): 45–54.

157. Knowles S., Marshall S.W., Guskiewicz K.M., Estimating rates and risks in sports injury research, J Athl Train, 2006, 41(2):207–215.

158. Kolt, G. S., Brewer, B. W., Pizzari, T., Schoo, A. M. M., & Garrett, N. (2007). The Sport Injury Rehabilitation Adherence Scale: a reliable scale for use in clinical physiotherapy. *Physiotherapy, 93*(1), 17-22. doi:10.1016/j.physio.2006.07.002

159. Kondo, A., Ishioka, C., & Hongu, N. (2019). Sports Injury Management Program in Pima Community College Offers Study Abroad Opportunities for International Students. *Medicine and Science in Sports and Exercise, 51*(6), 990-990. doi:10.1249/01.mss.0000563468.27920.a8

160. Korobejnikov, G., Korobejnikova, L., Kozina, Z. (2012). *Evaluation and correction of physiological states in sports*, Kharkiv, KNPU.

161. Kozin S.V., Biomechanical substantiation of the technique of hanging in rock climbing, Health, sport, rehabilitation, 2019, 5(1), 25-35, DOI: 10.34142/HSR.2019.05.01.03.

162. Kozin S.V., Safronov D.V., Kozina Z.L., Kniaz H.O., Proskurnia O., Prontenko K., Lahno O., Goncharenko V., Kholodniy A., Comparative biomechanical characteristics of one-arm hang in climbing for beginners and qualified athletes, Acta Bioeng Biomech, 2020, 22(1), 57-67, DOI: 10.37190/ABB-01440-2019-03.

163. Kozina Z.L, Goloborodko Y.A, Boichuk Y.D., Sobko I.M., Repko O.O., Bazilyuk T.A., et.al., The influence of a special technique for developing coordination abilities on the level of technical preparedness and development of psycho-physiological functions of young volleyball players 14-16 years of age, J. Phys. Educ. Sport, 2018, 18(3), 1445–1454, DOI: 10.7752/jpes.2018.03214.

164. Kozina Z.L., Iermakov S.S., Bartík P., Yermakova T.S., Michal J., Influence of self–regulation psychological and physical means on aged people´s functional state, J. hum. sport., 2018, 13(1), 99-115, DOI: 10.1016/*j*.jshs.2016.07.002.

165. Kozina, Z., Repko, O., Kozin, S., Kostyrko, A., Yermakova, T., Goncharenko, V. (2016). Motor skills formation technique in 6 to 7-year-old children based on their psychological and physical features (rock climbing as an example). *Journal of Physical Education and Sport, 16*(3), 866-874. doi:10.7752/jpes.2016.0313

166.Kozina, Z., Repko, O., Safronov, D., Kozin, S., Evarnickii, I., & Grebniova, I. (2018). System of development of coordination abilities of young climbers 6-7 years. *Health, Sport, Rehabilitation, 4*(4), 62-71. In Russian doi:http://dx.doi.org/10.5281/zenodo.2536470

167. Kozina, Z., Uvarova, N., Cieslicka, M., et. al. (2020a). Experimental substantiation of the program of the annual cycle preparation of climbers 16-17 year to the discipline “Climbing Combined”. *Journal of Physical Education and Sport, 20* (4), 1250- 1256. DOI:10.7752/jpes.2020.s2174.

168. Kozina, Z., Uvarova, N., Kniaz, H., et. al. (2020b). The influence of results in various types of climbing on the result in the Olympic Climbing Combined at the 2018 World Cup (men). *Journal of Physical Education and Sport, 20* (1), 255 - 261. DOI:10.7752/jpes.2020.01034.

169. Kozina, Zh.L., Koval, V.A. Kovtun, E.V., Temchenko, V.A. (2015). The use of information and communication technologies in the physical

education of university students. *Physical education and sport, 2* (11), 69-73, 2015. http://sportsscience.org/index.php/vuz/article/view/58

170. Kozina, Z.L. (2005). Basic scientific and methodological approaches t o the process of individualizing the training of athletes (by the example of bask etball). *Fizicheskoe vospitanie studentov tvorcheskikh spetsialnostey, 5*, 8-20.

171. Kozina, Zh. L., Grin, L.V. & Yefimov, A.A. (2010). The application o f the system of aims, meansand methods of individualization of training athlete s in team sports in the structural elements of the annual training cycle. Fiziches koe vospitanie studentov, 4, 45–52 (in Russ)

172. Kraemer R and Knobloch K (2009) A soccer-specific balance training program for hamstring muscle and patellar and Achilles tendon injuries. The American Journal of Sports Medicine 37(7): 1384–1393.

173. Kubiak EN, Klugman JA, Bosco JA. Hand injuries in rock climbers. Bull. NYU Hosp. Jt. Dis. 2006; 64:172Y7.

174. Kurock, W., & Sennerich, T. (1986). Epiphysenverletzungen beim jugendlichen Sportler. Deutsche Zeitschrift Für Sportmedizin, 37, 122–128.

175. LaBella, C.R., Huxford, M.R., Grissom, J, et al. (2011). Effect of neuromuscular warm-up on injuries in female soccer and basketball athletes in urban public high schools. *Archives of Pediatrics and Adolescent Medicine, 165(*11), 1033–1040. DOI: 10.1001/archpediatrics.2011.168.

176. Lan, Q., & Li, X. J. (2019). Liability Determination of School Sports Injury Accidents: An Analysis Framework Based on Evolutionary Game. *International Journal of Environmental Research and Public Health, 16*(18). doi:10.3390/ijerph16183403

177. Law RYW and Herbert RD (2007) Warm-up reduces delayed-onset muscle soreness but cool-down does not: a randomised controlled trial. Australian Journal of Physiotherapy 53: 91–95.

178. LeBrun, D. G., del Rosario, J., Kelly, J. D., Wren, S. M., Spiegel, D. A., Mkandawire, N., . . . Kushner, A. L. (2018). An Estimation of the Burden of Sports Injuries among African Adolescents. *Journal of Epidemiology and Global Health, 8*(3-4), 171-175. doi:10.2991/j.jegh.2017.10.010

179. Lee, A. S. Y., Standage, M., Hagger, M. S., & Chan, D. K. C. (2019). Sport injury prevention in-school and out-of-school? A qualitative investigation of the trans-contextual model. *Plos One, 14*(9). doi:10.1371/journal.pone.0222015

180. Lee, Y. S., Park, D. S., Oh, J. K., & Kim, S. Y. (2020). Prediction model for utilization of complementary and alternative medicine for sports injuries among Korean elite collegiate athletes. *Integrative Medicine Research, 9*(2). doi:10.1016/j.imr.2020.02.009

181. Lehnhard R, Lehnhard HR, Young R, et al. (1996) Monitoring injuries on a college soccer team: the effect of strength training. Journal of Strength and Conditioning Research 10(2): 115–119.

182. Lei, Z. (2011). *Study about Tennis Elective Students of Zhengzhou University to Participate in Sport Injury Investigation andAnalysis*.

183. Lemoyne J, Laurencelle L, Lirette M, et al. (2007) Occupational health problems and injuries among Quebec's physical educators. Applied Ergonomics 38: 625–634.
184. Li, L. W., & Liu, C. Y. (2010). *Enlightenment of Legal Liability of America School Sports Injuries on China*.
185. Liang, J. X., & Zhang, B. (2014). Design and Practice Research of Sports Injury Network Consulting System. In Y. H. Kim & P. Yarlagadda (Eds.), *Materials, Mechanical and Manufacturing Engineering* (Vol. 842, pp. 678-681).
186. Limb, D. (1995). Injuries on British climbing walls. British Journal of Sports Medicine, 29(3), 168–170.
187. Lin, D. Y., Dai, L., Cheng, G., & Sailer, M. O. (2016). On confidence intervals for the hazard ratio in randomized clinical trials. *Biometrics*, *72*(4), 1098–1102. https://doi.org/10.1111/biom.12528
188. Lion, A., van der Zwaard, B. C., Remillieux, P. P., & Buatois, S. (2015). Risk factors of hand climbingrelated injuries. Scandinavian Journal of Medicine & Science in Sports. doi:10.1111/sms.12505
189. Logan AJ, Makwana N, Mason G, et al. Acute hand and wrist injuries in experienced rock climbers. Br. J. Sports Med. 2004; 38:545Y8.
190. Lutter, C., El-Sheikh, Y., Schoffl, I., & Schoffl, V. (2017). Sport climbing: medical considerations for this new Olympic discipline. *British Journal of Sports Medicine*, *51*(1), 2-U5. doi:10.1136/bjsports-2016-096871
191. Lutter, C., Hochholzer, T., Bayer, T., & Schöffl, V. (2017). Rock climbing-related bone marrow edema of the hand: A follow-up study. Clinical Journal of Sport Medicine. doi:10.1097/ JSM.0000000000000463
192. Lutter, C., Schweizer, A., Hochholzer, T., Bayer, T., & Schoffl, V. (2016). Pulling Harder than the Hamate Tolerates: Evaluation of Hamate Injuries in Rock Climbing and Bouldering. *Wilderness & Environmental Medicine*, *27*(4), 492-499. doi:10.1016/j.wem.2016.09.003
193. Lynall, R. C., Gardner, E. C., Paolucci, J., Currie, D. W., Knowles, S. B., Pierpoint, L. A., . . . Kerr, Z. Y. (2018). The First Decade of Web-Based Sports Injury Surveillance: Descriptive Epidemiology of Injuries in US High School Girls' Field Hockey (2008-2009 Through 2013-2014) and National Collegiate Athletic Association Women's Field Hockey (2004-2005 Through 2013-2014). *Journal of Athletic Training*, *53*(10), 938-949. doi:10.4085/1062-6050-173-17
194. Lysens, R.J., Michel, S., Ostyn, M.D., et al. (1989). The accident-prone and overuse-prone profiles of the young athlete. The American Journal of Sports Medicine 17(5): 612–619.
195. Ma¨kela, K., Hirvensalo, M. (2015) Work ability of Finnish physical education teachers. *The Physical Educator*, 72, 379–393.
196. Malliou P, Rokka S, Beneka A, et al. (2007) Reducing risk of injury due to warm up and cool down in dance aerobic instructors. Journal of Back and Musculoskeletal Rehabilitation 20: 29–35.
197. Mandelbaum BR, Silvers HJ, Watanabe DS, et al. (2005) Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior

cruciate ligament injuries in female athletes. The American Journal of Sports Medicine 33(7): 1003–1010.

198. Martinez-de-Quel-Perez, O., Sanchez-Moreno, A., Zamorano-Feijoo, C., & Ayan-Perez, C. (2019). SPORT INJURIES IN SCHOOL AND EXTRACURRICULAR ACTIVITIES IN THE COMMUNITY OF MADRID (SPAIN). *Revista Internacional De Medicina Y Ciencias De La Actividad Fisica Y Del Deporte, 19*(73), 151-166. doi:10.15366/rimcafd2019.73.011

199. McCann, R., Cortes, N., Van Lunen, B., Greska, E., Ringleb, S., & Onate, J. (2011). Neuromuscular Changes Following an Injury Prevention Program for ACL Injuries. *International Journal of Athletic Therapy & Training, 16*(4), 16-20. doi:10.1123/ijatt.16.4.16

200. McCarthy, J. & Soh G. (2010). *Geometric Design of Linkages,* Springer, New York.

201. McGuine TA and Keene JS (2006) The effect of a balance training program on the risk of ankle sprains in high school athletes. The American Journal of Sports Medicine 34(7): 1103–1111.

202. McLoughlin, R. J., Green, J., Nazarey, P. P., Hirsh, M. P., Cleary, M., & Aidlen, J. T. (2019). The risk of snow sport injury in pediatric patients. *American Journal of Emergency Medicine, 37*(3), 439-443. doi:10.1016/j.ajem.2018.06.006

203. McLoughlin, R. J., Green, J., Nazarey, P. P., Hirsh, M. P., Cleary, M., & Aidlen, J. T. (2019). The risk of snow sport injury in pediatric patients. *American Journal of Emergency Medicine, 37*(3), 439-443. doi:10.1016/j.ajem.2018.06.006

204. Meeuwisse WH, Tyreman H, Hagel B, et al. (2007) A dynamic model of aetiology in sport injury: the recursive nature of risk and causation. Clinical Journal of Sport Medicine 17(3): 215–219.

205. Merritt A.L., Huang J.I., Hand Injuries in Rock Climbing, J. Hand Surg. (Am. Vol.), 2011, 36A(11), 1859-61, DOI: 10.1016/j.jhsa.2011.08.020.

206. Milewski, M. D., Skaggs, D. L., Bishop, G. A., Pace, J. L., Ibrahim, D. A., Wren, T. A. L., & Barzdukas, A. (2014). Chronic Lack of Sleep is Associated With Increased Sports Injuries in Adolescent Athletes. *Journal of Pediatric Orthopaedics, 34*(2), 129-133. doi:10.1097/bpo.0000000000000151

207. Ming, H. (2017). Mechanism and Precautions of Common Knee Joint Sport Injuries. *Agro Food Industry Hi-Tech, 28*(3), 2412-2415.

208. Minoughan, C., Schumaier, A., Kakazu, R., & Grawe, B. (2018). Readability of Sports Injury and Prevention Patient Education Materials From the American Academy of Orthopaedic Surgeons Website. *Journal of the American Academy of Orthopaedic Surgeons Global Research and Reviews, 2*(3). doi:10.5435/JAAOSGlobal-D-18-00002

209. Mo, S. Y. (2014). The Analysis of the Courses of the Injury Management and Rescues in Outdoor Sports for the Social Sports Special. In F. Zheng (Ed.),

Proceedings of the 2nd International Conference on Education, Management and Social Science (Vol. 6, pp. 429-432).

210. Moher D, Shamseer L, Clarke M, et al. (2015) Preferred reporting items for systematic review and metaanalysis protocols (PRISMA-P) 2015 statement. Systematic Review 4(1): 1.

211. Moon, S., Ryoo, H. W., Ahn, J. Y., Park, J. B., Seo, K. S., Shin, S. D., . . . Hong, S. O. (2016). Analysis on sports and recreation activity-related eye injuries presenting to the Emergency Department. *International Journal of Ophthalmology, 9*(10), 1499-1505. doi:10.18240/ijo.2016.10.22

212. Morrison, A. B., & Schöffl,V. R. (2007). Review of the physiological responses to rock climbing in young climbers. British Journal of Sports Medicine, 41, 852–861.

213. Morrison, A., & Schöffl, V. (2009). Climbing shoes - is pain insane?. BMC Medical,1 –4.

214. Mosimann, U. (2006). Notfälle beim Eisklettern. Bergundsteigen, 4(4), 70–73.

215. Mukherjee, S. (2014). Sports Injuries Amongst University Physical Education Students. *Medicine and Science in Sports and Exercise, 46*(5), 766-766. doi:10.1249/01.mss.0000495797.71549.24

216. Muszkieta R., Napierała M., Cieślicka M., Zukow W., Kozina Z.L., Iermakov S.S., Górny M., The professional attitudes of teachers of physical education, J. Phys. Educ. Sport, 2019, 19(Supplement issue 1), 92–99, DOI:10.7752/jpes.2019.s1014.

217. Myer, G., Ford, K., Palumbo, J., Hewett, T.(2005). Neuromuscular training improves performance and lower-extremity biomechanics in female athletes. J Strength Cond Res. 2005 Feb;19(1):51-60.

218. Myklebust G, Engebretsen L, Braekken IH, et al. (2003) Prevention of anterior cruciate ligament injuries in female team handball players: a prospective intervention study over three seasons. Clinical Journal of Sport Medicine 13(2): 71–78.

219. Narvaez, W. C. M., Maldonado, G. E. P., Gomez, D. I. O., & Cando, E. O. C. (2017). Perception of students on the possible impact of sports injuries on academic performance. *Revista Publicando, 4*(12), 857-864.

220. Nelson, N. G., & McKenzie, L. B. (2009). Rock climbing injuries treated in emergency departments in the U.S., 1990-2007. American Journal of Preventive Medicine, 37(3), 195–200.

221. Neuhof, A., Hennig, F. F., Schöffl, I., & Schöffl, V. (2011). Injury risk evaluation in sport climbing. International Journal of Sports Medicine, 32(10), 794–800.

222. Newell, K.M. (1986). Constraints on the development of coordination. In M.G. Wade & H.T.A. Whiting (Eds.), Motor development in children: Aspects of coordination and control (pp. 341–361). Amsterdam: Nijhoff

223. Nixon, H. L. (1994). COACHES VIEWS OF RISK, PAIN, AND INJURY IN SPORT, WITH SPECIAL REFERENCE TO GENDER DIFFERENCES. *Sociology of Sport Journal, 11*(1), 79-87. doi:10.1123/ssj.11.1.79

224. Nonoyama, T., Shimazaki, Y., Nakagaki, H., & Tsuge, S. (2016). Descriptive study of dental injury incurred by junior high school and high school students during participation in school sports clubs. *International Dental Journal, 66*(6), 356-365. doi:10.1111/idj.12250

225. O'Connor, K. L., Baker, M. M., Dalton, S. L., Dompier, T. P., Broglio, S. P., & Kerr, Z. Y. (2017). Epidemiology of Sport-Related Concussions in High School Athletes: National Athletic Treatment, Injury and Outcomes Network (NATION), 2011-2012 Through 2013-2014. *Journal of Athletic Training, 52*(3), 175-185. doi:10.4085/1062-6050-52.1.15

226. Olsen O-E, Myklebust G, Engebretsen L, et al. (2005) Exercises to prevent lower limb injuries in youth sports: cluster randomised controlled trial. BMJ 330(7489): 449.

227. Orchard, J. (1995). Orchard sports injury classification system (OSICS). Sport Health, 11, 39 –41.

228. Owen AL, Wong DP, Dellal A, et al. (2013) Effect of an injury prevention program on muscle injuries in elite professional soccer. Journal of Strength and Conditioning Research 27(12): 3275–3285.

229. Owoeye, O. B. A., Emery, C. A., Befus, K., Palacios-Derflingher, L., & Pasanen, K. (2020). How much, how often, how well? Adherence to a neuromuscular training warm-up injury prevention program in youth basketball. *Journal of Sports Sciences, 38*(20), 2329-2337. doi:10.1080/02640414.2020.1782578

230. Owoeye, O. B. A., Palacios-Derflingher, L. M., & Emery, C. A. (2018). Prevention of Ankle Sprain Injuries in Youth Soccer and Basketball: Effectiveness of a Neuromuscular Training Program and Examining Risk Factors. *Clinical Journal of Sport Medicine, 28*(4), 325-331. doi:10.1097/jsm.0000000000000462

231. Owoeye, O. B. A., Palacios-Derflingher, L. M., & Emery, C. A. (2018). Prevention of Ankle Sprain Injuries in Youth Soccer and Basketball: Effectiveness of a Neuromuscular Training Program and Examining Risk Factors. *Clinical Journal of Sport Medicine, 28*(4), 325-331. doi:10.1097/jsm.0000000000000462

232. Paige TE, Fiore DC, Houston JD. Injury in traditional and sport rock climbing. Wilderness Environ. Med. 1998; 9:2Y7.

233. Paquet, Y. (2008). Validation of a sport injury locus of control scale. *Encephale-Revue De Psychiatrie Clinique Biologique Et Therapeutique, 34*(2), 146-152. doi:10.1016/j.encep.2006.08.004

234. Pardhan, S., Shacklock, P., & Weatherill, J. (1995). Sport-related eye trauma: A survey of the presentation of eye injuries to a casualty clinic and the use of protective eye-wear. *Eye, 9*, 50-53.

235. Parkkari, J., Taanila, H., Suni, J, et al. (2011). Neuromuscular training with injury prevention counseling to decrease the risk of acute musculoskeletal injury in young men during military service: a populationbased, randomized study. *BMC Medicine, 9*(1), 35.
236. Pasanen, K., Parkkari, J., Pasanen, M., et al. (2008). Neuromuscular training and the risk of leg injuries in female floorball players: cluster randomised controlled study. *British Journal of Sports Medicine,* 42, 802–805.
237. Peters, P. (2001). Orthopedic problems in sport climbing. Wilderness & Environmental Medicine, 12 (2), 100–110.
238. Petersen J, Thorborg K, Nielsen MB, et al. (2011) Preventive effect of eccentric training on acute hamstring injuries in men's soccer: a randomized controlled trial. The American Journal of Sports Medicine 39(11): 2296–2303.
239. Petersen W, Braun C, Bock W, et al. (2005) A controlled prospective case control study of a prevention training program in female handball players: the German experience. Archives of Orthopaedic and Trauma Surgery 125: 614–621.
240. Petrie, T. A., & Falkstein, D. L. (1998). Methodological, measurement, and statistical issues in research on sport injury prediction. *Journal of Applied Sport Psychology, 10*(1), 26-45. doi:10.1080/10413209808406376
241. Pfeiffer RP, Shea KG, Roberts D, et al. (2006) Lack of effect of a knee ligament injury prevention program on the incidence of noncontact anterior cruciate ligament injury. The Journal of Bone and Joint Surgery 88(8): 1769–1774.
242. Pieber K, Angelmaier L, Csapo R, et al. Acute injuries and overuse syndromes in sport climbing and bouldering in Austria: a descriptive epidemiological study. Wien. Klin. Wochenschr. 2012; 124:357Y62.
243. Pihl E, Matsin T and Jurimae T (2002) Physical activity, musculoskeletal disorders and cardiovascular risk factors in male physical education teachers. The Journal of Sports Medicine and Physical Fitness 42(2): 466–471.
244. Pope R, Herbert R and Kirwan J (1998) Effects of ankle dorsiflexion range and pre-exercise calf muscle stretching on injury risk in army recruits. Australian Journal of Physiotherapy 44(3): 165–172.
245. Pope RP, Herbert RD, Kirwan JD, et al. (2000) A randomized trial of pre-exercise stretching for prevention of lower-limb injury. Medicine and Science in Sports and Exercise 32(2): 271–277.
246. Pozzi, A., Pivato, G., & Pegoli, L. (2016). Hand injury in rock climbing: Literature review. The Journal of Hand Surgery (Asian-Pacific Volume), 21(1), 13–17. doi:10.1142/S2424835516400038
247. Pysny, L., Pysna, J., & Petru, D. (2015). Kinesio Taping Use in Prevention of Sports Injuries During Teaching of Physical Education and Sport. In C. Hursen (Ed.), *Proceedings of 5th World Conference on Learning, Teaching and Educational Leadership* (Vol. 186, pp. 618-623).
248. Rahlf Augustsson, J., Esko, A., Thomee, R., & Svantesson, U. (1998). Weight training of the thigh muscles using closed vs. open kinetic chain

exercises: A comparison of performance enhancement. *Journal of Orthopaedic & Sports Physical Therapy, 27*(1), 3-8. doi:10.2519/jospt.1998.27.1.3

249. Rahlf, A. L., John, C., Hamacher, D., & Zech, A. (2020). Effects of a 10 vs. 20-Min Injury Prevention Program on Neuromuscular and Functional Performance in Adolescent Football Players. *Frontiers in Physiology, 11*. doi:10.3389/fphys.2020.578866
250. Rahlf, A. L., John, C., Hamacher, D., & Zech, A. (2020). Effects of a 10 vs. 20-Min Injury Prevention Program on Neuromuscular and Functional Performance in Adolescent Football Players. *Frontiers in Physiology, 11*. doi:10.3389/fphys.2020.578866
251. Rahlf, A. L., John, C., Hamacher, D., & Zech, A. (2020). Effects of a 10 vs. 20-Min Injury Prevention Program on Neuromuscular and Functional Performance in Adolescent Football Players. *Frontiers in Physiology, 11*. doi:10.3389/fphys.2020.578866
252. Ray, M. K. J., & Kohandel, M. (2010). EPIDEMIOLOGY OF SOME SPORT INJURIES AMONG PHYSICAL EDUCATION COLLEGE STUDENTS. *Injury Prevention, 16,* A128-A129. doi:10.1136/ip.2010.029215.461
253. Rechel, J. A., Yard, E. E., & Comstock, R. D. (2008). An epidemiologic comparison of high school sports injuries sustained in practice and competition. *Journal of Athletic Training, 43*(2), 197-204. doi:10.4085/1062-6050-43.2.197
254. Rettig, A. C., Stube, K. S., & Shelbourne, K. D. (1997). Effects of finger and wrist taping on grip strength. The American Journal of Sports Medicine, 25(1), 96–98.
255. Richmond, S. A., Donaldson, A., Macpherson, A., Bridel, W., van den Berg, C., Finch, C. F., . . . Emery, C. A. (2020). Facilitators and Barriers to the Implementation of iSPRINT: A Sport Injury Prevention Program in Junior High Schools. *Clinical Journal of Sport Medicine, 30*(3), 231-238. doi:10.1097/jsm.0000000000000579
256. Richmond, S. A., et al. (2016). "A School-Based Injury Prevention Program to Reduce Sport Injury Risk and Improve Healthy Outcomes in Youth: A Pilot Cluster-Randomized Controlled Trial." Clinical Journal of Sport Medicine **26**(4): 291-298.
257. Richmond, S. A., et al. (2020). "Facilitators and Barriers to the Implementation of iSPRINT: A Sport Injury Prevention Program in Junior High Schools." Clinical Journal of Sport Medicine **30**(3): 231-238.
258. Richmond, S. A., Kang, J., & Emery, C. A. (2013). Is body mass index a risk factor for sport injury in adolescents? *Journal of Science and Medicine in Sport, 16*(5), 401-405. doi:10.1016/j.jsams.2012.11.898
259. Richmond, S. A., Kang, J., Doyle-Baker, P. K., Nettel-Aguirre, A., & Emery, C. A. (2016). A School-Based Injury Prevention Program to Reduce Sport Injury Risk and Improve Healthy Outcomes in Youth: A Pilot Cluster-Randomized Controlled Trial. *Clinical Journal of Sport Medicine, 26*(4), 291-298. doi:10.1097/jsm.0000000000000261

260. Robertson, N. (2012). Improving patient safety: Lessons from rock climbing. The Clinical Teacher, 9 (1), 41–44. Rooks, M. D. (1997).
261. Rock climbing injuries. Sports Medicine, 23(4), 261–270.
262. Rodio, A., Quattrini, F. M., Fattorini, L., Egidi, F., & Marchetti, M. (2006). Physiological significance of efficiency in rock climbing. *Medicina Dello Sport, 59*(3), 313-317.
263. Rogers EM (2003) The Diffusion of Innovations. 5th ed. New York: The Free Press. Sandmark H (2000) Musculoskeletal dysfunction in physical education teachers. Occupational Environmental Medicine 57: 673–677.
264. Rohrbough JT, Mudge MK, Schilling RC. Overuse injuries in the elite rock climber. Med. Sci. Sports Exerc. 2000; 32:1369Y72.
265. Rooks, M. D., Johnston, R. B., 3rd, Ensor, C. D., McIntosh, B., & James, S. (1995). Injury patterns in recreational rock climbers. The American Journal of Sports Medicine, 23(6), 683–685.
266. Rose, M. S., Emery, C. A., & Meeuwisse, W. H. (2008). Sociodemographic predictors of sport injury in adolescents. *Medicine and Science in Sports and Exercise, 40*(3), 444-450. doi:10.1249/mss.0b013e31815ce61a
267. Roylance, D. (2008). Mechanical properties of materials, pp. 6-7
268. Russell, K., Selci, E., Black, B., Cochrane, K., & Ellis, M. (2019). Academic outcomes following adolescent sport-related concussion or fracture injury: A prospective cohort study. *Plos One, 14*(4). doi:10.1371/journal.pone.0215900
269. Sang, M. X. (2019). *Analysis on the Causes of Sports Injury in College Physical Education and Its Prevention Strategies*.
270. Sang, M. X. (2019). Analysis on the Causes of Sports Injury in College Physical Education and Its Prevention Strategies.
271. Slater, L. V., Wasserman, E. B., & Hart, J. M. (2019). Trends in Recurrent Anterior Cruciate Ligament Injuries Differ From New Anterior Cruciate Ligament Injuries in College and High School Sports: 2009-2010 Through 2016-2017. Orthopaedic Journal of Sports Medicine, 7(11). doi:10.1177/2325967119883867
272. Scase E, Cook J, Makdissi M, et al. (2006) Teaching landing skills in elite junior Australian football: evaluation of an injury prevention strategy. British Journal of Sports Medicine 40: 834–838. Schiff MA, Caine DJ and O'Halloran R (2010) Injury prevention in sports. American Journal of Lifestyle Medicine 4(1): 42–64.
273. Schlegel, C., Büchler, U., & Kriemler, S. (2002). Finger injuries of young elite rock climbers. Schweizerische Zeitschrift für Sportmedizin und Sporttraumatologie, 50(1), 7–10.
274. Schlegel, C., Buechler, U., & Kriemler, S. (2012). Finger injuries of young elite rock climbers. Schweizerische Zeitschrift Für Sportmedizin Und Sporttraumatologie, 50(1), 7–10.
275. Scho ̈ffl V, Burtscher E, Coscia F. Injuries and medical incidences during

the IFSC 2012 climbing world cup series. Medicina Sportiva. 2013; 17:168Y70.
276. Scho ¨ffl V, Hochholzer T, Winkelmann HP, Strecker W. Pulley injuries in rock climbers. Wilderness Environ. Med. 2003; 14:94Y100.
277. Scho ¨ffl V, Kuepper T. Injuries at the 2005 World Championships in rock climbing. Wilderness Environ. Med. 2006; 17:187Y90.
278. Scho ¨ffl V, Morrison A, Hefti U, et al. Official standards of the UIAA Medical Commission vol: 17 the UIAA Medical Commission injury classification for mountaineering and climbing sports. Wilderness Environ. Med. 2010; 41:1Y8.
279. Scho ¨ffl V, Morrison A, Schwarz U, et al. Evaluation of injury and fatality risk in rock and ice climbing. Sports Med. 2010; 40:657Y79.
280. Scho ¨ffl V, Popp D, Ku ¨pper T, Scho ¨ffl I. Injury trends in rock climbers: evaluation of a case series of 911 injuries between 2009 and 2012. Wilderness Environ. Med. 2015; 26:62Y7.
281.Scho ¨ffl V, Winkelmann HP. Accident statistics at indoor climbing walls [in German]. Sportverletz Sportschaden. 1999; 13(1):14Y6.
282.Scho ¨ffl VR, Hoffmann G, Kupper T. Acute injury risk and severity in indoor climbing-a prospective analysis of 515,337 indoor climbing wall visits in 5 years.Wilderness Environ. Med. 2013; 24:187Y94.
283. Schoeffl V. Hand injuries in rock climbing, Dtsch Z Sportmed, 2008, 59(4):85-90.
284. Schoffl G., Asghar A., Llewellyn D.J., The epidemiology of rock-climbing injuries, Br J Sports Med., 2008, 42(9), 773-8, DOI: 10.1136/bjsm.2007.037978.
285. Schoffl V., Popp D., Kupper T., Schoffl I., Injury Trends in Rock Climbers: Evaluation of a Case Series of 911 Injuries Between 2009 and 2012, *Wilderness* Environ Med, 2015, 26(1), 62-67, DOI:10.1016/j.wem.2014.08.013.
286.Schöffl, I., & Schöffl, V. (2018). Epiphyseal stress fractures in the fingers of adolescents: Biomechanics, pathomechanism, and risk factors. European Journal of Sports Medicine. in press.
287.Schöffl, I., Einwag, F., Strecker, W., Hennig, F., & Schöffl, V. (2007). Impact of taping after finger flexor tendon pulley ruptures in rock climbers. Journal of Applied Biomechanics, 23, 52 –62.
288.Schöffl, I., Oppelt, K., Jungert, J., Schweizer, A., Bayer, T., Neuhuber, W., & Schöffl, V. (2009). The influence of concentric and eccentric loading on the finger pulley system. Journal of Biomechanics, 42(13), 2183–2187.
289.Schöffl, I., Oppelt, K., Jungert, J., Schweizer, A., Neuhuber, W., & Schöffl, V. (2009). The influence of the crimp and slope grip position on the finger pulley system. Journal of Biomechanics, 42(13), 2124–2128.
290.Schöffl, I., Schöffl, V., Dötsch, J., Dörr, H. G., & Jüngert, J. (2011). Correlations between high level sport-climbing and the development of adolescents. Pediatric Exercise Science, 23(4), 477–486.
291.Schöffl, V. R., & Schöffl, I. (2007). Finger pain in rock climbers: Reaching the right differential diagnosis and therapy. The Journal of Sports Medicine and

Physical Fitness, 47(1), 70–78.
292.Schöffl, V. R., Hochholzer, T., Imhoff, A. B., & Schoffl, I. (2007). Radiographic adaptations to the stress of high-level rock climbing in junior athletes: A 5-year longitudinal study of the German junior national team and a group of recreational climbers. The American Journal of Sports Medicine, 35(1), 86–92.
293.Schöffl, V. R., Hoffmann, G., & Küpper, T. (2013). Acute injury risk and severity in indoor climbing-a prospective analysis of 515,337 indoor climbing wall visits in 5 years. Wilderness & Environmental Medicine, 24(3), 187–194.
294. Schoffl, V. R., Hoffmann, P. M., Imhoff, A., Kupper, T., Schoffl, I., Hochholzer, T., & Hinterwimmer, S. (2018a). Long-Term Radiographic Adaptations to Stress of High-Level and Recreational Rock Climbing in Former Adolescent Athletes: An 11-Year Prospective Longitudinal Study. *Orthopaedic Journal of Sports Medicine, 6*(9). doi:10.1177/2325967118792847
295.Schöffl, V., & Küpper, T. (2006). Injuries at the 2005 world championships in rock climbing. Wilderness & Environmental Medicine, 17, 187–190.
296.Schöffl, V., & Küpper, T. (2008). Rope tangling injuries–How should a climber fall? Wilderness & Environmental Medicine, 19(2), 146–149.
297.Schöffl, V., & Küpper, T. (2013). Feet injuries in rock climbers. World Journal of Orthopedics, 4(4), 218–228.
298.Schöffl, V., & Möckel, F. (2004). Body fat in high level climbers [Körperfettwerte bei Leistungskletterern]. Sport Ortho Trauma, 20(2), 118–119.
299.Schöffl, V., & Schlegel, C. (2004). Statement international boulder competitions in youths. Retrieved from www.uiaa.ch
300.Schöffl, V., & Winkelmann, H. P. (1999a). [Accident statistics at "indoor climbing walls"] Unfallstatistik an "Indoor-Kletteranlagen". Sportverletz Sportschaden, 13(1), 14–16.
301.Schöffl, V., & Winkelmann, H. P. (1999b). Footdeformations in sportclimbers. Journal of Sports Medicine, 13(3), 58.
302.Schöffl, V., & Winkelmann, H. P. (1999c). [Footdeformations in sportclimbers] Fußdeformitäten bei Sportkletterern. Deutsche Zeitschrift Für Sportmedizin, 50, 73 –76.
303.Schöffl, V., Burtscher, E., & Coscia, F. (2013). Injuries and medical incidences during the IFSC 2012 climbing world cup series. Medica Sport, 17(4), 168–170.
304.Schöffl, V., Hochholzer, T., & Imhoff, A. (2004). Radiographic changes in the hands and fingers of young, high-level climbers. The American Journal of Sports Medicine, 32(7), 1688–1694.
305.Schöffl, V., Hochholzer, T., & Lightner, S. (2016). One move too many. Boulder CO, USA: Sharp End Publishing.
306.Schöffl, V., Hochholzer, T., Karrer, A., Imhoff, A., & Winter, S. (2004). Fingerschäden jugendlicher Leistungssportler - Vergleichende Analyse der deutschen Jugendnationalmannschaft sowie einer gleichaltrigen Vergleichsgruppe von Freizeitkletterern. Sport Ortho Trauma, 20(2), 104– 105.
307.Schöffl, V., Hochholzer, T., Karrer, A., Winter, S., & Imhoff, A. (2003). [Finger problems in adolescent top level climbers - a comparison of the German junior

national team with recreational climbers] Fingerschäden jugendlicher Leistungskletterer - Vergleichende Analyse der deutschen Jugendnationalmannschaft sowie einer gleichaltrigen Vergleichsgruppe von Freizeitkletterern. Deutsche Zeitschrift Für Sportmedizin, 54, 317–322.

308.Schöffl, V., Hochholzer, T., Winkelmann, H. P., & Strecker, W. (2003a). [Differential diagnosis of finger pain in sport climbers] Differentialdiagnose von Fingerschmerzen bei Sportkletterern. Deutsche Zeitschrift Für Sportmedizin, 54, 38 –43.

309.Schöffl, V., Hochholzer, T., Winkelmann, H. P., & Strecker, W. (2003b). Pulley injuries in rock climbers. Wilderness & Environmental Medicine, 14(2), 94–100.

310. Schoffl, V., Lutter, C., & Popp, D. (2016). The "Heel Hook"-A Climbing-Specific Technique to Injure the Leg. *Wilderness & Environmental Medicine, 27*(2), 294-301. doi:10.1016/j.wem.2015.12.007

311.Schöffl, V., Lutter, C., & Popp, D. (2016). The „heel hook“-a climbing-specific technique to injure the leg. Wilderness & Environmental Medicine. doi:10.1016/j.wem.2015.12.007

312. Schoffl, V., Lutter, C., Woollings, K., & Schoffl, I. (2018). Pediatric and adolescent injury in rock climbing. *Research in Sports Medicine, 26,* 91-113. doi:10.1080/15438627.2018.1438278

313.Schöffl, V., Morrison, A. B., Hefti, U., Schwarz, U., & Küpper, T. (2011). The UIAA medical commission injury classification for mountaineering and climbing sports. Wilderness & Environmental Medicine, 22(1), 46–51.

314.Schöffl, V., Morrison, A. B., Schwarz, U., Schöffl, I., & Küpper, T. (2010). Evaluation of injury and fatality risk in rock and ice climbing. Sports Medicine, 40(8), 657–679.

315.Schöffl, V., Morrison, A., Schöffl, I., & Küpper, T. (2012). Epidemiology of injury in mountainering, rock and iceclimbing. In D. Caine & T. Heggie (Eds.), Medicine and sport science - epidemiology of injury in adventure and extreme sports (Vol. 58, pp. 17–43). Basel: Karger.

316.Schöffl, V., Popp, D., Küpper, T., & Schöffl, I. (2015). Injury distribution in rock climbers – A prospective evaluation of 911 injuries between 2009-2012. Wilderness & Environmental Medicine, 26, 62 –67.

317. Schoffl, V., Popp, D., Kupper, T., & Schoffl, I. (2015a). Injury Trends in Rock Climbers: Evaluation of a Case Series of 911 Injuries Between 2009 and 2012. *Wilderness & Environmental Medicine, 26*(1), 62-67. doi:10.1016/j.wem.2014.08.013

318.Schöffl, V., Schöffl, I., Schwarz, U., Hennig, F., & Küpper, T. (2009). Injury-risk evaluation in water ice climbing. Medica Sport, 2(1–2), 32–38.

319. Schulz K.F., Grimes D.A., Allocation concealment in randomised trials: defending against deciphering, Lancet, 2002, 359(9306), 614—618, DOI: 10.1016/S0140-6736(02)07750-4.

320.Schussmann LC, Lutz LJ, Shaw RR, et al. The epidemiology of mountaineering and rock climbing accidents. Wilderness Environ. Med. 1990; 1:235Y48.

321.Schweizer A, Hudek R. Kinetics of crimp and slope grip in rock climbing. J.

Appl. Biomech. 2011; 27:116Y21.
322.Schweizer A. Biomechanical properties of the crimp grip position in rock climbers. J. Biomech. 2001; 34:217Y33.
323.Schweizer A. Lumbrical tears in rock climbers. J Hand Surg Br. 2003; 28:187Y9.
324.Schweizer, A. (2000). Biomechanical effectiveness of taping the A2 pulley in rock climbers. Journal of Hand Surgery, 25(1), 102–107.
325.Schweizer, A., Bircher, H. P., Kaelin, X., & Ochsner, P. E. (2005). Functional ankle control of rock climbers. British Journal of Sports Medicine, 39(7), 429–431.
326. Shen, Y. Q., et al. (2017). "Comparison of Online and Onsite Health Education Intervention in Preventing Sports Injury among College Students." Medicine and Science in Sports and Exercise **49**(5): 426-426.
327. Shen, Y. Q., et al. (2017). "Comparison of Online and Onsite Health Education Intervention in Preventing Sports Injury among College Students." Medicine and Science in Sports and Exercise **49**(5): 426-426.
328. Shen, Y. Q., Xia, C. C., & Shen, H. D. (2017). Comparison of Online and Onsite Health Education Intervention in Preventing Sports Injury among College Students. *Medicine and Science in Sports and Exercise, 49*(5), 426-426. doi:10.1249/01.mss.0000518048.97489.e5
329. Shinkle, J., Nesser, T., Demchak, T., McMannus, D. (2012). Effect of core strength on the measure of power in the extremities. J Strength Cond Res. 26(2), 373-80. doi: 10.1519/JSC.0b013e31822600e5.
330. Silvers-Granelli, H. J., Bizzini, M., Arundale, A., Mandelbaum, B. R., & Snyder-Mackler, L. (2018). Higher compliance to a neuromuscular injury prevention program improves overall injury rate in male football players. *Knee Surgery Sports Traumatology Arthroscopy, 26*(7), 1975-1983. doi:10.1007/s00167-018-4895-5
331. Silvers-Granelli, H. J., Bizzini, M., Arundale, A., Mandelbaum, B. R., & Snyder-Mackler, L. (2018). Higher compliance to a neuromuscular injury prevention program improves overall injury rate in male football players. *Knee Surgery Sports Traumatology Arthroscopy, 26*(7), 1975-1983. doi:10.1007/s00167-018-4895-5
332. Silvers-Granelli, H. J., Bizzini, M., Arundale, A., Mandelbaum, B. R., & Snyder-Mackler, L. (2018). Higher compliance to a neuromuscular injury prevention program improves overall injury rate in male football players. *Knee Surgery Sports Traumatology Arthroscopy, 26*(7), 1975-1983. doi:10.1007/s00167-018-4895-5
333. Siupsinskas, L., Garbenyte-Apolinskiene, T., Salatkaite, S., Gudas, R., & Trumpickas, V. (2019). Association of pre-season musculoskeletal screening and functional testing with sports injuries in elite female basketball players. *Scientific Reports, 9*. doi:10.1038/s41598-019-45773-0
334. Slater, L. V., et al. (2019). "Trends in Recurrent Anterior Cruciate Ligament Injuries Differ From New Anterior Cruciate Ligament Injuries in

College and High School Sports: 2009-2010 Through 2016-2017." Orthopaedic Journal of Sports Medicine **7**(11).

335. Slater, L. V., Wasserman, E. B., & Hart, J. M. (2019). Trends in Recurrent Anterior Cruciate Ligament Injuries Differ From New Anterior Cruciate Ligament Injuries in College and High School Sports: 2009-2010 Through 2016-2017. *Orthopaedic Journal of Sports Medicine, 7*(11). doi:10.1177/2325967119883867

336. Smith BE, Littlewood C and May S (2014) An update of stabilisation exercises for low back pain: a systematic review with meta-analysis. BMC Musculoskeletal Disorders 15: 416.

337. So¨derman K, Werner S, Pietila¨, et al. (2000) Balance board training: prevention of traumatic injuries of the lower extremities in female soccer players? A prospective randomized intervention study. Knee Surgery, Sports Traumatology, Arthroscopy 8: 356–363.

338. Sommerfield, L. M., et al. (2020). "A prospective study of sport injuries in youth females." Physical Therapy in Sport **44**: 24-32.

339. Sommerfield, L. M., Harrison, C. B., Whatman, C. S., & Maulder, P. S. (2020). A prospective study of sport injuries in youth females. *Physical Therapy in Sport, 44*, 24-32. doi:10.1016/j.ptsp.2020.04.005

340. Sommerfield, L. M., Harrison, C. B., Whatman, C. S., & Maulder, P. S. (2020). A prospective study of sport injuries in youth females. Physical Therapy in Sport, 44, 24-32. doi:10.1016/j.ptsp.2020.04.005

341. Sorensen L, Larsen SE and Ro¨ck ND (1998) Sports injuries in school-aged children. A study of traumatologic and socioeconomic outcome. Scandinavian Journal of Medicine and Science in Sports 8: 52–56. Steiner H, McQuivey RW, Pavelski R, et al. (2000) Adolescents and sports: risk or benefit? Clinical Pediatrics 39: 161–166.

342. Stanitski, C. L. (1997). Pediatric and adolescent sports injuries. *Clinics in Sports Medicine, 16*(4), 613-&. doi:10.1016/s0278-5919(05)70045-4

343. Stanley, L. E., et al. (2016). "Sex Differences in the Incidence of Anterior Cruciate Ligament, Medial Collateral Ligament, and Meniscal Injuries in Collegiate and High School Sports: 2009-2010 Through 2013-2014." American Journal of Sports Medicine **44**(6): 1565-1572.

344. Stanley, L. E., Kerr, Z. Y., Dompier, T. P., & Padua, D. A. (2016). Sex Differences in the Incidence of Anterior Cruciate Ligament, Medial Collateral Ligament, and Meniscal Injuries in Collegiate and High School Sports: 2009-2010 Through 2013-2014. *American Journal of Sports Medicine, 44*(6), 1565-1572. doi:10.1177/0363546516630927

345. Steffen, K., Emery, C. A., Romiti, M., Kang, J., Bizzini, M., Dvorak, J., . . . Meeuwisse, W. H. (2013). High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: a cluster randomised trial. *British Journal of Sports Medicine, 47*(12), 794-+. doi:10.1136/bjsports-2012-091886

346. Steffen, K., Emery, C. A., Romiti, M., Kang, J., Bizzini, M., Dvorak, J., . . . Meeuwisse, W. H. (2013). High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: a cluster randomised trial. *British Journal of Sports Medicine, 47*(12), 794-+. doi:10.1136/bjsports-2012-091886

347. Steffen, K., Emery, C. A., Romiti, M., Kang, J., Bizzini, M., Dvorak, J., . . . Meeuwisse, W. H. (2013). High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: a cluster randomised trial. *British Journal of Sports Medicine, 47*(12), 794-+. doi:10.1136/bjsports-2012-091886

348. Steinberg, N., Adams, R., Ayalon, M., Dotan, N., Bretter, S., & Waddington, G. (2019). Recent Ankle Injury, Sport Participation Level, and Tests of Proprioception. *Journal of Sport Rehabilitation, 28*(8), 824-830. doi:10.1123/jsr.2018-0164

349.Stelzle, F. D., Gaulrapp, H., & Pforringer, W. (2000). [Injuries and overuse syndromes due to rock climbing on artificial walls]. Sportverletz Sportschaden, 14(4), 128–133.

350. Street, E. J. and K. H. Jacobsen (2017). "Prevalence of Sports Injuries Among 13-to 15-Year-Old Students in 25 Low- and Middle-Income Countries." Journal of Community Health **42**(2): 295-302.

351. Street, E. J., & Jacobsen, K. H. (2017). Prevalence of Sports Injuries Among 13-to 15-Year-Old Students in 25 Low- and Middle-Income Countries. *Journal of Community Health, 42*(2), 295-302. doi:10.1007/s10900-016-0255-x

352. Sugimoto, D., Alentorn-Geli, E., Mendiguchia, J., Samuelsson, K., Karlsson, J., & Myer, G. D. (2015). Biomechanical and Neuromuscular Characteristics of Male Athletes: Implications for the Development of Anterior Cruciate Ligament Injury Prevention Programs. *Sports Medicine, 45*(6), 809-822. doi:10.1007/s40279-015-0311-1

353. Sugimoto, D., Alentorn-Geli, E., Mendiguchia, J., Samuelsson, K., Karlsson, J., & Myer, G. D. (2015). Biomechanical and Neuromuscular Characteristics of Male Athletes: Implications for the Development of Anterior Cruciate Ligament Injury Prevention Programs. *Sports Medicine, 45(*6), 809-822. doi:10.1007/s40279-015-0311-1

354. Sugimoto, D., Alentorn-Geli, E., Mendiguchia, J., Samuelsson, K., Karlsson, J., & Myer, G. D. (2015). Biomechanical and Neuromuscular Characteristics of Male Athletes: Implications for the Development of Anterior Cruciate Ligament Injury Prevention Programs. *Sports Medicine, 45*(6), 809-822. doi:10.1007/s40279-015-0311-1

355. Swanik KA, Swanik CB, Lephart SM, et al. (2002) The effect of functional training on the incidence of shoulder pain and strength in intercollegiate swimmers. Journal of Sport Rehabilitation 11: 140–154.

356.Thompson, R. N., Hanratty, B., & Corry, I. S. (2011). “Heel hook” rock-climbing maneuver: A specific pattern of knee injury. Clinical Journal of Sport Medicine, 21(4), 365–368.

357. Tiirikainen, K., Lounamaa, A., Paavola, M., Kumpula, H., & Parkkari, J. (2008). Trend in sports injuries among young people in Finland. *International Journal of Sports Medicine, 29*(6), 529-536. doi:10.1055/s-2007-965332

358. Tingaz, E. O., Ekiz, M. A., & Cakmak, S. Examination of mindfulness and impulsiveness in university student-athletes in terms of sports injury development history. *Current Psychology*. doi:10.1007/s12144-020-01024-4

359.Tomczak RL, Wilshire WM, Lane JW, et al. Injury patterns in rock climbers. J. Osteopath. Sport Med. 1989; 3:11Y6.

360.Tropet Y, Menez D, Balmat P, et al. Closed traumatic rupture of the ring finger flexor tendon pulley. J. Hand Surg. [Am]. 1990; 15:745Y7.

361. Tsuang, H. C. A., Guo, Y. L., Lin, Y. C., & Su, H. J. (2001). School type, stress and sport-related injuries in middle school students in central Taiwan. *Safety Science, 39*(3), 137-144. doi:10.1016/s0925-7535(00)00057-6

362. Twellaar M, Verstappen FTJ and Huson A (1996) Is prevention of sports injuries a realistic goal? A four-year prospective investigation of sports injuries among physical education students. The American Journal of Sports Medicine 24(4): 528–534.

363. Twellaar, M., Verstappen, F. T. J., & Huson, A. (1996). Is prevention of sports injuries a realistic goal? A four-year prospective investigation of sports injuries among physical education students. *American Journal of Sports Medicine, 24*(4), 528-534. doi:10.1177/036354659602400419

364. Twellaar, M., Verstappen, F. T. J., Huson, A., & vanMechelen, W. (1997). Physical characteristics as risk factors for sports injuries: A four year prospective study. *International Journal of Sports Medicine, 18*(1), 66-71. doi:10.1055/s-2007-972597

365. Uicker, J Pennock, G. & Shigley, J. (2003). Theory of Machines and Mechanisms**,** Oxford University Press, New York.

366. Underwood, J. (2016). Schools should heed concerns over sports' brain injuries. *Phi Delta Kappan, 97*(6), 74-75. doi:10.1177/0031721716636880

367. Van Beijsterveldt AMC, van de Port IGL, Krist MR, et al. (2012) Effectiveness of an injury prevention programme for adult male amateur soccer players: a cluster randomized controlled trial. British Journal of Sports Medicine 46: 1114–1118.

368.van der Putten, E. P., & Snijder, C. J. (2001). Shoe design for prevention of injuries in sport climbing. Applied Ergonomics, 32(4), 379–387.

369. Van Mechelen W, Hlobil H, Kemper HCG, et al. (1993) Prevention of running injuries by warm-up, cooldown, and stretching exercises. The American Journal of Sports Medicine 21(5): 711–719. 172 European Physical Education Review 25(1)

370. Van Mechelen W, Twisk J, Molendijk A, et al. (1996) Subject-related risk factors for sports injuries: a 1-yr prospective study in young adults. Medicine and Science in Sports and Exercise 28(9): 1171–1179.

371. van Middelkoop M, Bruens ML, Coert JH, et al. Incidence and risk factors for upper extremity climbing injuries in indoor climbers. Int. J. Sports Med. 2015; 36:837Y42.

372. van Middelkoop, M., Bruens, M. L., Coert, J. H., Selles, R. W., Verhagen, E., Bierma-Zeinstra, S. A., & Koes, B. W. (2015). Incidence and Risk Factors for Upper Extremity Climbing Injuries in Indoor Climbers. *International Journal of Sports Medicine, 36*(10), 837-842. doi:10.1055/s-0035-1547224

373. Van Middelkoop, M., Rakhshandehroo, S., Bruens, M. L., Koes, B. W., & Bierma-Zeinstra, S. M. A. (2011). Injuries of the upper body extremities in recreational climbers: Incidence and risk factors. British Journal of Sports Medicine, 45, 380–381.

374. Vercruysse S (2016) Primary prevention of sports-related injuries in and through physical education teachers: feasibility, effectiveness and transferability to the adolescents. PhD Thesis, Ghent University, Belgium.

375. Verhagen E, van der Beek A, Twisk J, et al. (2004) The effect of a proprioceptive balance board training program for the prevention of ankle sprains. The American Journal of Sports Medicine 32(6): 1385–1393.

376. Verhagen EALM, Hupperets MDW, Finch CF, et al. (2011) The impact of adherence on sports injury prevention effect estimates in randomised controlled trials: looking beyond the CONSORT statement. Journal of Science and Medicine in Sport 14: 287–292.

377. Verhagen EALM, van Stralen MM and van Mechelen W (2010) Behaviour, the key factor for sports injury prevention. Sports Medicine 40(11): 899–906.

378. Verrall GM, Slavotinek JP and Barnes PG (2005) The effect of sports specific training on reducing the incidence of hamstring injuries in professional Australian Rules football players. British Journal of Sports Medicine 39: 363–368.

379. Verstappen, F. T. J., Twellaar, M., Hartgens, F., & van Mechelen, W. (1998). Physical fitness and sports skills in relation to sports injuries. A four-year prospective investigation of sports injuries among physical education students. *International Journal of Sports Medicine*, *19*(8), 586-591. doi:10.1055/s-2007-971964

380. Volker Schöffl, Christoph Lutter, Kaikanani Woollings & Isabelle Schöffl (2018). Pediatric and adolescent injury in rock climbing, Research in Sports Medicine, 26:sup1, 91-113, DOI: 10.1080/15438627.2018.1438278

381. Wang, J., & Mao, X. (2014). *On the Status Quo and Countermeasures of Students' Sports Injuries in Beijing Sports Schools*.

382. Wang, K. F., & Wang, H. P. (2010). *The Development and Running of the Sports Injuries Network Consultation Service System*.

383. Wanke, E. M., et al. (2014). "Dance Sport: Injury Profile in Latin American Formation Dancing." Sportverletzung-Sportschaden **28**(3): 132-138.

384. Wanke, E. M., Fischer, T., Pieper, H. G., & Groneberg, D. A. (2014). Dance Sport: Injury Profile in Latin American Formation Dancing. *Sportverletzung-Sportschaden, 28*(3), 132-138. doi:10.1055/s-0034-1384851

385. Warme, W. J., & Brooks, D. (2000). The effect of circumferential taping on flexor tendon pulley failure in rock climbers. The American Journal of Sports Medicine, 28(5), 674–678.

386. Watts, P. B., Joubert, L. M., Lish, A. K., Mast, J. D., & Wilkins, B. (2003). Anthropometry of young competitive sport rock climbers. British Journal of Sports Medicine, 37(5), 420–424.

387. Watts, P. B., Martin, D. T., & Durtschi, S. (1993). Anthropometric profiles of elite male and female competitive sport rock climbers. Journal of Sports Sciences, 11(2), 113–117.

388. Wedderkopp N, Kaltoft M, Lundgaard B, et al. (1999) Prevention of injuries in young female players in European team handball. A prospective intervention study. Scandinavian Journal of Medicine and Science in Sports 9: 41–47. Witvrouw E, Mahieu N, Danneels L, et al. (2004) Stretching and injury prevention: an obscure relationship. Sports Medicine 34(7): 443–449.

389. White, D. J., & Olsen, P. D. (2010). A time motion analysis of bouldering style competitive rock climbing. *Journal of Strength and Conditioning Research, 24*(5), 1356-1360. doi:10.1519/JSC.0b013e3181cf75bd

390. Widstrom C, Doyle J, Johnson G, et al. A mechanical study of six digital pulley reconstruction techniques: part II. Strength of individual reconstructions. J. Hand Surg. [Am]. 1989; 14:826Y9.

391. Wilt, Fred & Yessis, Michael. *Soviet Theory, Technique and Training for Running and Hurdling.* Vol 1. Championship Books, 1984.

392. Witvrouw E, Danneels L, Van Tiggelen D, Willems TM, Cambier D. Open versus closed kinetic chain exercises in patellofemoral pain: a 5-year prospective randomized study. Am J Sports Med. 2004;32(5):1122-1130.

393. Woods K, Bishop P and Jones E (2007) Warm-up and stretching in the prevention of muscular injury. Sports Medicine 37(12): 1089–1099.

394. Woollings K.Y., McKay C.D., Kang J., Meeuwisse W.H., Emery C.A., Incidence, mechanism and risk factors for injury in youth rock climbers, Br. J. Sports Med., 2015, 49(1), 44-50, DOI: 10.1136/bjsports.

395. Woollings, K. Y., McKay, C. D., & Emery, C. A. (2015). Risk factors for injury in sport climbing and bouldering: A systematic review of the literature. British Journal of Sports Medicine, 49(17), 1094– 1099. doi:10.1136/bjsports-2014-094372

396. Woollings, K. Y., McKay, C. D., Kang, J., Meeuwisse, W. H., & Emery, C. A. (2015). Incidence, mechanism and risk factors for injury in youth rock climbers. British Journal of Sports Medicine, 49(1), 44–50. doi:10.1136/bjsports-2014-094067

397. Woollings, K. Y., McKay, C. D., Kang, J., Meeuwisse, W. H., & Emery, C. A. (2015). Incidence, mechanism and risk factors for injury in youth rock climbers. *British Journal of Sports Medicine, 49*(1), 44-50. doi:10.1136/bjsports

398.Wright, D. M., Royle, T. J., & Marshall, T. (2001). Indoor rock climbing: Who gets injured? British Journal of Sports Medicine, 35(3), 181–185.

399. Xie, Z. H., Yao, T. F., Zhou, Q., Tian, K., & Li, J. H. (2016). Sport Injuries of the Students Majoring in Tennis in Physical Education School of Jiangxi Normal University. In X. Xiao & F. Bunning (Eds.), *Proceedings of the 2016 International Seminar on Education Innovation and Economic Management* (Vol. 75, pp. 214-217).

400. Xu, B. C., & Destech Publicat, I. (2015). *On Situation and Prevention of College Basketball Sports Injury*.

401. Xu, C., Sun, Y. S., & Yang, J. (2017). Research on Current Situation and Countermeasures of Sports Injury Accidents in Colleges and Universities. In H. Zhang (Ed.), *2017 5th International Conference on Physical Education and Society Management* (Vol. 70, pp. 451-457).

402. Yang, J. W., Zheng, H. F., Chen, Y. S., & Shi, S. Y. (2014). Investingation and Analysis on College Students' Volleyball Sports Injury in Lanzhou City. In X. Zhu (Ed.), *Proceedings of 2014 3rd International Conference on Physical Education and Society Management* (Vol. 23, pp. 107-112).

403. Yang, X. L. (2017). *Exploring the Teaching System of College Basketball from the Perspective of Sports Injury*.

404. Yin, J. X., et al. (2020). "Significance of Injury Protection and Data Mining Policy Coordination in Promoting Students' Sports Consciousness." Basic & Clinical Pharmacology & Toxicology **127**: 214-214.

405. Yin, J. X., Gao, Y., & Lei, L. (2020). Significance of Injury Protection and Data Mining Policy Coordination in Promoting Students' Sports Consciousness. *Basic & Clinical Pharmacology & Toxicology*, *127*, 214-214.

406. Yu, F. Q., Hao, H. X., & Atlantis, P. (2016). Research on the Liability of School Sports Injury Accident under the Comparative. In *Proceedings of the 2016 6th International Conference on Management, Education, Information and Control* (Vol. 135, pp. 280-284).

407. Yuan, X. X. (2014). Discussion on the Subject of School Sports Injuries Compensation. In X. Zhu (Ed.), *Proceedings of 2014 3rd International Conference on Physical Education and Society Management* (Vol. 23, pp. 199-202).

408. Yue, J. P. (2013). Analysis and Prevention on Sports Injury of College Students - A Case Study of Jiaxing University. In W. Chang & T. Zhang (Eds.), *2013 Fourth International Conference on Education and Sports Education* (Vol. 14, pp. 270-273).

409. Zazulak BT, Hewett TE, Reeves NP, et al. (2007) Deficits in neuromuscular control of the trunk predict knee injury risk. The American Journal of Sports Medicine 35(7): 1123–1130.

410. Zhang, X. D., Zhou, X. L., & Huang, L. Z. (2010). *The Analysis of The Law And Reasons of Sports Injuries of Volleyball Players in Colleges and Universities*.

411. Zhang, X. H. (2012). *On Liability Principles for College Sports Injury Accidents and their Preventive Countermeasures*.

412. Zhao, G. Y., & Destech Publicat, I. (2015). *Investigation and Analysis of the Common Sports Injury of Basketball and Preventive Measures*.

413. Zhou, X. D. (2012). *Research of Precautionary Countermeasures Against Injury Accidents in College Sports Classes-Taking the Wuhan Area Partial Universities as the Example*.

414.Kozina Z., Danil Safronov, Sergii Kozin, Nataliya Bugayets, Lyudmila Peretyaha**,** Tatiana Shepelenko**,** Igor Grinchenko. Use of non-traditional recovery means to improve performance of 11-12-year-old athletes specializing in rowing and canoeing. Journal of Physical Education and Sport, Vol 19, issue 1, March 2019

415.Kozina Z., Olena Chaika, Danil Safronov, Ivan Prokopenko, Sergii Kozin, Yurii Shkrebtii, Mykola Trubchaninov, Olena Falyova, Valentina Shishenko, Nataliia Ponomarova, Nadia Olefirenko. Biomechanical Running Indicators and Neurodynamic Functions of an Elite Athlete with Visual Impairment in a Track and Field Sprint. International Journal of Applied Exercise Physiology. 2019;8(3.1):10-25

416. Kozina Z,, T V Shepelenko, I M Sobko, O O Ryepko, O V Seryi, S B Polishchuk, O I Chupryna, V A Korobeinik, Wang Xiaofei, S V Kozin, T M Kravchk, N M Sanzharova, Yu V Golenkova, S Yavorova, R Yavorova, and I Grin. Formation Of Teams In Gaming And Aesthetic Sports Based On Neurodynamic Features Of Athletes Using Multidimensional Analysis Method. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 2018; 9(5): 1889-1905.https://rjpbcs.com/pdf/2018_9(5)/[238].pdf

417.Kozina Z, Chebanu O, Repko O, Kozin S, Osiptsov A. Influence of typological features of the nervous system on individual performance in running for short distances in athletes with visual impairment on the example of an elite athlete. Physical Activity Review 2018; 6: 266-278 doi: 10.16926/par.2018.06.31http://www.physactiv.eu/index.php/volume-6-2018/

418.Kozina Z, Chebanu O, Repko O, Kozin S. The implementation of the concept of individualization in training elite Female athletes with visual impairment in the sprint. *Journal of Physical Education and Sport, 18*(1), 282-292

419. Kozina Z.,Prokopenko I., Lahno iO., Kozin S., Razumenko T., Osiptsov A. Integral method for the development of motor abilities and psycho-physiological functions in children from 2 to 4 years old. *Journal of Physical Education and Sport, 18*(1), 3-16

420.Kozina, Z., Sobko, I., Kozin, S., & Garmash, I. Influence of the use of non-traditional means of restoration of work capacity on the functional condition of young rowers 11-12 years old. *Health, Sport, Rehabilitation*, (2018). *4*(2), 52-63.
doi:http://dx.doi.org/10.5281/zenodo.1342465http://sportsscience.org/index.php/health/article/view/764

421.Abrosimov, E., Kozina, Z., & Kozin, S. Combination of games of Go and physical exercises as a factor of the development of cognitive and neurodynamic functions of children 6 years. *Health, Sport, Rehabilitation*, (2018). *4*(3), 7-22. doi:http://dx.doi.org/10.5281/zenodo.1467962http://sportsscience.org/index.php/health/article/view/774

422. Safronov D., Olena Chaika, Igor Belozerov, SV Kozin, Zhanneta Kozina. Neurodynamic compensatory mechanisms of visual impairment and biomechanical indicators of running in an elite athlete in the Paralympic sprint.Kharkiv National University, series" Medicine", 2019; 37: 62-82

423. Safronov DV, Kozin SV, Author's certificate № 100612 from 17.11.2020 on the literary-written work "Textbook for trainers and physical therapists" BIOMECHANICS OF THE SUPPORT-MOTOR DEVICE. PART 1. BASIC CONCEPTS IN BIOMECHANICS »Application № 102147 dated 23.10.2020.

424. 423. Safronov DV, Kozin SV, Author's certificate № 100613 from 17.11.2020 on the literary-written work "Textbook for trainers and physical therapists" BIOMECHANICS OF THE SUPPORT-MOTOR DEVICE. PART 2. UPPER LIMB »Statement № 102148 dated 23.10.2020

425. Safronov DV, Kozin SV, Author's certificate № 100614 from 17.11.2020 on the literary-written work Textbook for trainers and physical therapists "BIOMECHANICS OF THE SUPPORT-MOTOR DEVICE. PART 3. LOWER LIMBS »Statement № 102149 dated 23.10.2020

426. Safronov DV, Kozin SV, Author's certificate № 100615 from 17.11.2020 on the literary-written work Textbook for trainers and physical therapists "BIOMECHANICS OF THE SUPPORT-MOTOR DEVICE. PART 4. Torso and pelvis »Statement № 102150 dated 23.10.2020

427. Safronov DV, Kozin SV, Author's certificate № 100616 from 17.11.2020 on the literary-written work Textbook for trainers and physical therapists "BIOMECHANICS OF THE SUPPORT-MOTOR DEVICE. PART 5. Head and neck »Statement № 102151 dated 23.10.2020

428. Kozina JL, Antonov OV, Repko OO, Tkachenko KV, Kozin SV Author's certificate № 51092 for the audiovisual work "Textbook on the technique of tying tourist knots with animated illustrations (slide film)" at the request № 51321 from 03.07.2013. Published in the official bulletin of the State Department of Intellectual Property of the Ministry of Education and Science of Ukraine "Copyright and Related Rights". - 2013.

429. Safronov DV, Kozin SV Therapeutic biomechanics. Lower quadrant. Methodical manual. Kharkiv: KhNPU. 2021. 36 p.

430. Safronov DV, Kozin SV Therapeutic biomechanics. The upper quadrant. Methodical manual. Kharkiv: KhNPU. 2021. 35 p.

431. Poletaev, A.B. (1986). Preventive medicine: an introduction to the problem. All-Russian Interdisciplinary Medical Journal, 4 (5), 135-147.

432. Verkhoshansky Yu. V. Fundamentals of special strength training in sports / 2nd ed. reworked. and ext. - M .: Fizkultura i sport, 1977. - 215 s. - (Science of sport).

433. Materials for training and qualification certification in the specialty "Public Health and Public Health" (textbook) ./ Ed. VS Luchkevich and IV Polyakov.— St. Petersburg, 2005
434. Scientific electronic library. monographies.ru. The application date is September 1, 2020.
435. Prevention // Big medical encyclopedia: in 30 volumes / ch. ed. B.V. Petrovsky. - 3rd ed. - Moscow: Soviet Encyclopedia, 1983. - Vol. 21. Prednisone - Solubility. - 560 s. - 150,800 copies.
436. Soviet encyclopedic dictionary / Ch. ed. A.M. Prokhorov. - 4th ed. - M .: Soviet encyclopedia, 1988. - 1600 p.

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Topic: "**Brain structures and connections. Practical applications in medicine, rehabilitation, physical therapy, sports, pedagogy.**"

from 19 June to 12 September 2019
number of hours: 186

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Utrecht, 2019

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М19 № 110884	M19 № 110884
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ступінь вищої освіти **магістр**	**Master** Degree
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освітня програма *Фізична культура і спорт*	Educational program *Physical Education and Sport*
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Proprioceptive Neuromuscular Facilitation
(M/ Knott Concept)

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