SIN-CHN
SCIENTIFIC PRESS PTE.LTD.

Molecular & Cellular Biomechanics 2024, 21(4), 161.
https://doi.org/10.62617/mcb161

Article

Functional fitness training for the prevention of acute foot and ankle sports injuries

Shu Qiao

Wuhan Qingchuan University, Wuhan 420204, China; 18086667683@163.com

CITATION

Qiao S. Functional fitness training for the prevention of acute foot and ankle sports injuries. Molecular & Cellular Biomechanics. 2024; 21(4): 161. https://doi.org/10.62617/mcb161

ARTICLE INFO

Received: 24 May 2024
Accepted: 16 June 2024
Available online: 23 December 2024

Abstract: The development of competitive sports makes the development of school sports more scientific. However, as the development progresses, the incidence of sports injuries increases each year. In all kinds of sports, the risk of ankle injury is greatest due to the lack of venue and preparation. If the sports injury is not handled properly, it is easy to lead to complications such as traumatic arthritis. This article is a research analysis on the prevention of acute foot and ankle sports injuries, using machine learning algorithms to use functional gait detection to study foot sports injuries. Studies have shown that after 12 weeks of functional physical training, cadence increases by 10% from the initial period and by 2% after 6 weeks of functional physical training. The total of both sides increased by 6% compared with the initial period and increased by 3% compared with that after 6 weeks of functional physical training. Distance traveled per minute increased by 17% compared to the initial period and increased by 6% compared to 6 weeks of functional physical training. Experiments have shown that functional training can identify human body function defects and asymmetric behaviors by observing human movement patterns, and can achieve body tissue remodeling through targeted functional exercise.

Keywords: foot and ankle movement; functional physical fitness; IoMT healthcare; ecological machine learning

1. Introduction

Functional physical training is a training method that focuses on multi joint and compound movements, aiming to improve an individual's overall physical fitness and functional performance by imitating or enhancing movement patterns in daily life and exercise. This training method focuses on improving the stability, flexibility, coordination, and strength of the body in various environments, helping individuals to more effectively complete daily activities and exercise tasks. Physical function training is developed from physical therapy, medical rehabilitation and so on [1,2]. It restores and improves the human body's athletic ability through training, and is of great help to the patient's physical fitness and the recovery of bones, muscles, and joints. Looking back on the development of world civilization for thousands of years, the form of functional physical exercise has a certain history. For example, Chinese martial arts movements are characterized by "strength arises from the ground", "integration of internal and external, physical and spiritual preparation", that is, focusing on the sequence of physical force and the movement pattern in the movements [3,4]. When ancient Indian yoga appeared, the traditional asana was not just the body, but the combination of the body, nerves and thinking, focusing on the coordination of body and mind.

With the rapid development of sports and the improvement of national health,

sports have become an important part of people's daily life. Hunt et al. [5] evaluated injury records across all varsity sports in a single NCAA Division I track and field program, including 1076 athletes competing in 37 events. His research was designed to assess the incidence of ankle injuries among elite athletes participating in 37 NCAA Division 1 sports. Herzog et al. [6] presented a summary of the incidence of acute ankle sprains in the general population, as well as in the sports population, including organized athletes and military personnel, with an emphasis on incidence in the United States. It described the link between previous ankle sprains and future acute ankle sprains, and summarized successful experiences in injury prevention and directions for future research and prevention. Brandolini et al. [7] pointed out that chronic ankle instability is one of the most common syndromes after ankle sprains. Sprains are often associated with repeated sprains, loss of range of motion, and deficits in proprioceptive and postural control. Chen et al. [8] reviewed the current evidence for ankle sprain treatment and rehabilitation. He proposed a method to assess all levels of athletes with high and low ankle sprains. In the research on the influence of the ankle joint at home and abroad, there have been a certain number of studies on the ankle joint at home and abroad, but there are few studies on the prevention of acute ankle sports injuries by functional training.

Functional training emphasizes the basic quality of improving overall exercise ability and maintaining quality of life, and its application and research are also very extensive. Smith et al. [9] were associated with chronic ankle instability by studying deficits in ankle and hip strength and lower extremity postural control. After strength training, muscle groups show increased strength, a change partly due to improved neuromuscular control. McKeon and Donovan [10] have attempted to synthesize best practice evidence for rehabilitation and computer-assisted instruction in patients with acute ankle sprains through an emerging paradigm that integrates perception, the dynamics of skill acquisition, and bio-psychosocial models of function, disability, and health. From the best available evidence, 4 key elements of an effective treatment and rehabilitation strategy are pain relief, extra-ankle support for up to 1 year, gradual return to movement, and coordination training and combine these factors into a meta-theoretical framework. Minoonejad et al. [11] pointed out that neuromuscular control deficits in patients with chronic ankle instability have been reported, and jumping exercise has been recommended as a functional training tool to prevent lower extremity injuries, but its impact on lower extremity neuromuscular control in patients is unclear. The purpose was to explore the effects of single-jump stabilization training on the neuromuscular control and self-report function of college basketball players under the courseware. Bleakley et al. [12] randomized controlled trial investigating the effect of exercise-based rehabilitation programs on reinjury and patient-reported outcomes (perceived instability, function, pain) in patients with acute ankle sprains. It has no restrictions on exercise type, duration, or frequency, and exercise-based programs can be implemented alone or as an adjunct to daily care. Functional training has been widely used in physical exercise, mass fitness, rehabilitation, etc. From the perspectives of historical origin, development background, and theoretical research, this paper discusses the development and innovation of the theory and practice of physical education in China.

This paper adopted a detailed functional rehabilitation physical training program for the first time, and conducted in-depth analysis and discussion on old ankle injuries, habitual ankle sprains and post-injury problems. Through the rehabilitation of the foot and ankle joint function and the correction of other auxiliary parts, the function of the motor system can be improved and the occurrence of injury can be prevented, which has an important guiding role in the research and prevention of existing sports injuries [13].

2. Methods of preventing acute foot and ankle sports injuries

2.1. Concept of functional training

Competitive sports functional training is a comprehensive development of physical function. In order to better adapt to the athletic ability of sports, its action mode is mainly to carry out multi-joint, multi-plane, multi-body training from aspects such as coordination and flexibility, so as to better adapt to the needs of competition [14].

2.2. Features of functional training

1) Functional training emphasizes movement exercises.
2) Functional training emphasizes the characteristics of the kinetic chain.
3) Functional training emphasizes the training of balance ability.
4) Functional training emphasizes the training of multiple dimensions and multiple joints.

2.3. Training mode of functional training

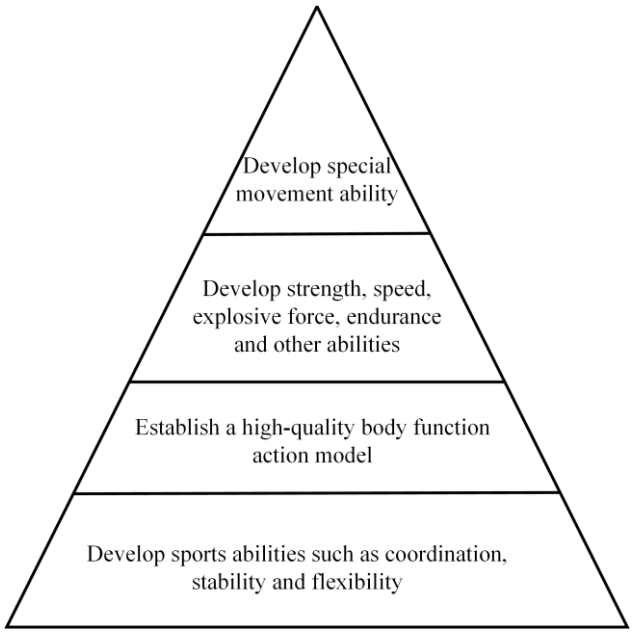

Figure 1. Training mode of functional training.

The current functional training model should employ a 4-layer “pyramid” training model: The first layer is to develop coordination, stability and flexibility,

which are essential elements for establishing movement patterns; the second layer is to build a high-quality athletic ability model. The sports model is a general sports mode that conforms to the characteristics of competitive sports; the third layer is the development of various motor skills required for specific project techniques; the fourth layer is the training of special motor skills. **Figure 1** shows the training model for functional training [15].

2.4. Functional training algorithms based on machine learning

This paper intends to use machine learning algorithms to prevent foot injuries. A machine learning algorithm is an algorithm that learns from data and improves itself from experience without human intervention. In machine learning, the most common is the support vector machine (SVM) algorithm [16]. It has many properties compared to other ways. Its purpose is to construct an optimal classification hyperplane through learning in a high-dimensional feature space, thereby separating two sets with different attributes.

The maximum distance classifier is the simplest support vector machine classification model. In linear classification, where *x* is a vector of sampled data, which may be of high dimensionality, the definition linear function $g(x) = wTx + b$ can be derived. Assuming that the threshold is 0, it can be judged which class the sample *xi* belongs to from the positive or negative aspects of the $g(xi)$ value. Therefore, for a classifiable training sample $Di = (xi, yi)$, $i = 1, ..., n$, were, *xi* is the input sampled data, *yi* is the correct class label, and a positive or negative $g(xi)$ value represents the sampled predicted label. This way the distance between each sample point and the classification plane is $\varepsilon_i = y_i(w^T x_i + b)$ and is always positive. It is further obtained that the geometric distance of the classifier is $y = \frac{|g(x_i)|}{||w||}$. To maximize the geometric spacing of the objects, it can be transformed into solving the following optimization problem:

$$min\frac{1}{2} || w || 2 \tag{1}$$

The optimal problem is subject to:

$$y_i(w^T x_i + b\,) - 1 > 0, i = 1, \ldots, n \tag{2}$$

A maximum geometric spacing of y is achieved, where $w \in R^n$ and $b \in R$ are a parameter controlling the classification surface.

The dual form of the above optimization is derived using the Lagrangian function:

$$\max L = \sum_{i=1}^{n} a_i - \frac{1}{2}(\sum_{i,\ j=1}^{n} a_i\, a_j y_i y_i x_i^T x_j) \tag{3}$$

The optimal problem is subject to:

$$\sum_{i=1}^{n} y_i\, a_i = 0, a_i \geq 0, i = 1, \ldots, n \tag{4}$$

The solution of the optimization problem is the Lagrangian coefficient a_i. The linear classifier is shown in **Figure 2**.

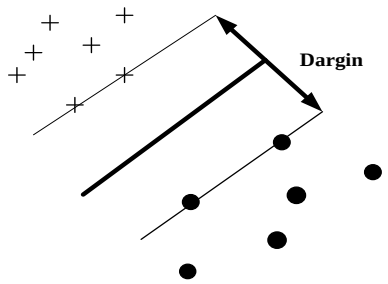

Figure 2. Linear classifier.

Because of the noise in many real-world data, it is often impossible to separate the feature space [17]. To balance the performance and generalization of the model, an introduced slack variable that can tolerate a small amount of errors and outliers is proposed. Finally, the optimization problem is transformed into:

$$\min \frac{1}{2} || w || 2 + C \sum_{i=1}^{n} \varsigma_i \quad (5)$$

The optimal problem is subject to:

$$y_i(w^T x_i + b) \geq 1 - \varsigma, \varsigma_i > 0, i = 1, \ldots, n \quad (6)$$

C is the penalty coefficient. Again, the above optimal problem is transformed into the following dual problem by the Lagrange multiplier method:

$$\max L = \sum_{i=1}^{n} a_i - \frac{1}{2} (\sum_{i,\ j-1}^{n} a_i\, a_j y_i y_i x_i^T x_j) \quad (7)$$

The optimal problem is subject to:

$$\sum_{i=1}^{n} y_i\, a_i = 0, 0 < a_i < C, i = 1, \ldots, n \quad (8)$$

By solving these problems, the coefficient a_i is obtained, and the best classification plane is obtained. The above is the idea of SVM to deal with classification problems [18].

At present, support vector machines have been applied well in many practical problems. In the specific implementation of the algorithm, a doctor from National Taiwan University has developed a general support vector machine program, which can solve problems such as regression problems and classification problems. The program can better solve the cross-validation parameter selection problem in multi-class problems. It is widely used in various fields [19].

2.5. Relationship between functional training and traditional physical training

Functional training is a brand-new physical education system, which is closely related to the characteristics and development trend of physical education in the world today. Compared with the traditional physical exercise system, functional training is more reflected in its optimization and development, rather than completely negating or replacing it. Functional training is a comprehensive stimulation-recovery approach. During exercise, it emphasizes the movement law of human movement and the control of neuromuscular under exercise. It also has a good effect on injury prevention and rehabilitation. The difference is shown in **Table 1**.

Table 1. Differences between traditional physical training and functional training.

Category	Applicable items	Characteristics of movement practice	Training idea
Traditional physical training	Mass fitness competitive sports	1) Single movement 2) Method fixation 3) Most of them are single joint or local muscles 4) Have fixed support	1) Emphasize high strength and large load 2) Emphasize the will quality of athletes 3) Mainly based on local muscle development or single 4) Improvement of item quality
Functional training	Mass fitness competitive sports	1) Diversification of movements 2) Diversification of practice forms disordered change 3) Pay attention to multi-dimensional and multi-joint movement 4) No fixed support	1) Emphasize the improvement of weak chain and symmetry of body movement 2) Emphasize the flexibility and stability of joints 3) Emphasize core strength and transmission effect 4) Emphasize the prevention and sustainable development of sports injuries 5) Mainly based on movements and improving athletic ability

Traditional physical fitness has both advantages and disadvantages. For example, some sports training teams still use complete sets of equipment for training, coupled with fixed training, individual activities, and independent development, especially in high-intensity training, it is more likely to cause injury. Functional training is an innovative training method to develop competitive sports under the new situation. It has achieved remarkable results and has been widely used internationally, but this does not mean that it is universal. Therefore, in the relevant training, it is necessary to strengthen the connection between the two, make up the gap, and promote the formation and improvement of professional ability [20].

3. Experiment of functional physical training on the prevention of acute foot and ankle sports injuries

To verify the effectiveness of functional physical training in preventing acute ankle sports injuries, this study conducted experimental analysis on athletes from 10 university track and field teams, basketball teams, and football teams in a certain city. Based on the analysis of physiological characteristics and injury prevention measures of ankle joints, SVM learning algorithm was used to prevent foot injuries, and a functional training plan was developed.

The sample selection criteria are:

(1) Male athletes aged between 18 and 25.
(2) Train and compete in the track and field teams, basketball teams, and football teams of 10 universities in a certain city.
(3) Participate in at least 3 team training or competitions per week, with a stable record of training and competitions.
(4) Willing and able to continue participating in functional physical training programs for the next 6 weeks.

According to the sample selection criteria, 50 athletes were ultimately selected as the experimental subjects. Before the experiment begins, basic physiological characteristics data of athletes (age, height, weight) and ankle joint condition data (ankle muscle strength, number of injuries) are collected as characteristic variables through physical fitness testing. Clean the collected data. For missing values, interpolation method is used for processing. Identify and remove outliers using the

standard deviation method, and finally check and remove duplicate records. After preprocessing the data, randomly select the top 30 athletes as the training set and the remaining 20 athletes as the test set.

The training parameter settings for the SVM algorithm are shown in **Table 2**.

Table 2. Training parameters of SVM algorithm.

Sequence	Parameter	Specifications
1	Regularization parameter	0.001
2	Control the width of the Gaussian function	0.0001
3	The degree of polynomials	2
4	Constant term	Positive number

According to the parameter settings in **Table 2**, use the collected data to train the algorithm, analyze the preventive effect of functional physical training on ankle joint injuries, and develop a training plan.

3.1. Physiological characteristics of the ankle joint

1) Anatomy of the ankle joint

The ankle joint, also known as the talar calf joint, consists of the cross-joint socket consisting of the inferior articular surface of the tibia at the lower end of the tibia, the medial malleolus articular surface, and the ankle articular surface at the lower end of the fibula. The second bone forms the flexor joint, and the joint capsule is located at the edge of the cartilage of the joint, opposite the anterior and posterior ligaments and the three bundles of ligaments of the lateral malleolus. The three ligaments of the lateral malleolus are the lateral malleolus, the talus, the anterior fibular ligament of the calcaneus, the talofibular ligament, and the calcaneofibular ligament. The lateral malleolus is lower than the medial malleolus [21].

2) Injury mechanism of ankle joint

Ankle sprains are a common trauma. The essence of sprain is a sprain of the lateral fibular ligament, which is more common in sports such as ball games, track and field, and gymnastics. The basic skills of these sports are running and jumping. Many times, it has to make an emergency stop, so such sprains are more common.

3.2. Preventive measures for ankle injuries

1) The professional ethics of athletes and coaches should be strengthened, good competition motivation should be established, and intentional fouls and intentional injuries should be prevented.

2) The technical training is strengthened, and the various techniques are proficient and can be used proficiently. Attention should be paid to the reasonable arrangement of exercise load to prevent fatigue and local overload.

3) The comprehensive development of physique pays special attention to the strength and flexibility of the ankle joint, knee joint, thigh and calf muscle group, and pays attention to and protects the vulnerable parts [22].

4) During competition and training, all regulations must be strictly followed, especially socks and shin guards must be worn.

5) Referees are reinforced, strictly abide by the rules of the game, and punish intentional fouls and intentional injuries. At the same time, attention should be paid to the coordination of venues, equipment, competition, and training.

3.3. Contents of functional rehabilitation physical training

According to the basic principles of ankle function rehabilitation and physical training, it was designed from various aspects, and the plan was formulated in a 6-week period, as shown in **Tables 3–8** [23–25].

Table 3. Contents of physical training for functional rehabilitation in the first week.

Time	Training content	Number of groups	Action essentials and requirements
Monday	Stand on one foot	1 min/3 groups	Barefoot, hands, shoulders, heels slightly raised
	Double foot lift heel	30 times/3 groups	The toes do 10 controlled quick rises and slow falls forward, forward, outward, forward and inner respectively
	Stability training of feet landing in situ	10 times/3 groups	After the body is completely stretched, it will land naturally. Pay attention to fully bending your hips and landing silently
Tuesday	One-legged left-right slow jump hurdle	10 times/4 groups	Make the next jump after each landing
	Footstep plus start training	10 times	Rapid response
	Bi-foot belts resist jumping	20 s/4 direction/4 groups	Keep your feet together quickly and try to keep your torso stable
Thursday	Manual resistance hook foot (inside and outside/hand turning)	10 times/3 groups	The straight knee hip joint does not move. Pay attention to the direction of force. Centrifugal and centripetal should give resistance. Centrifugal resistance is greater
	Fast “cross” jump	40 times/3 groups	Keep your feet together and try to keep driving and landing stably. Immediately take the next jump and hit the bottom. The shorter the time, the better
	Small hurdle footsteps	5–10 min	Multi-directional sensitivity
Saturday	Flexible footwork training of floor ladder	10–15 min	Multi-directional combination is fast and sensitive
	BOSU landed stably on one foot	12:00/group 2	Concentrate on the ankle joint and make the next jump after active force stabilization
	Barbell weight lift heel	12 times/4 groups	Hold your head high, always keep your knees stretched, rise quickly and fall slowly

Table 4. Contents of physical training for functional rehabilitation in the second week.

Time	Training content	Number of groups	Action essentials and requirements
Monday	Stand on one foot	1 min/3 groups	Barefoot, hands, shoulders, heels slightly raised
	Double foot lift heel	30 times/3 groups	The toes do 10 controlled quick rises and slow falls forward, forward, outward, forward and inner respectively
	Stability training of one-foot in-situ landing	10 times/3 groups	After the body is completely stretched, it will land naturally. Pay attention to fully bending your hips and landing silently
Tuesday	One-legged left-right slow jump hurdle	10 times/4 groups	Make the next jump after each landing
	Footstep plus start training	10 times	Rapid response
	Bi-foot belts resist jumping	20 s/4 direction/4 groups	Keep your feet together quickly and try to keep your torso stable

Table 4. (*Continued*).

Time	Training content	Number of groups	Action essentials and requirements
Thursday	Manual resistance hook foot (inside and outside/hand turning)	10 times/3 groups	The straight knee hip joint does not move. Pay attention to the direction of force. Centrifugal and centripetal should give resistance. Centrifugal resistance is greater
	Fast "cross" jump	40 times/3 groups	Keep your feet together and try to keep driving and landing stably. Immediately take the next jump and hit the bottom. The shorter the time, the better
	Small hurdle footsteps	5–10 min	Multi-directional sensitivity
Saturday	Flexible footwork training of floor ladder	10–15 min	Multi-directional combination is fast and sensitive
	BOSU landed stably on one foot	12:00/group 2	Concentrate on the ankle joint and make the next jump after active force stabilization
	Barbell weight lift heel	12 times/4 groups	Hold your head high, always keep your knees stretched, rise quickly and fall slowly

The two-foot training on Monday of the first week was upgraded to a single-foot training.

Table 5. Contents of physical training for functional rehabilitation in the third week.

Time	Training content	Number of groups	Action essentials and requirements
Monday	Stand on one foot	1 min/3 groups	Barefoot, hands, shoulders, heels slightly raised
	Swiss ball lift heel with two feet	30 times/3 groups	The toes do 10 controlled quick rises and slow falls forward, forward, outward, forward and inner respectively
	Stability training of one-foot in-situ landing	10 times/3 groups	After the body is completely stretched, it will land naturally. Pay attention to fully bending your hips and landing silently
Tuesday	One-legged slow jumping hurdle	10 times/4 groups	Make the next jump after each landing
	Footstep plus start training	10 times	Rapid response
	Bi-foot belts resist jumping	20 s/4 direction/4 groups	Keep your feet together quickly and try to keep your torso stable
Thursday	Manual resistance hook foot (inside and outside/hand turning)	10 times/3 groups	The straight knee hip joint does not move. Pay attention to the direction of force. Centrifugal and centripetal should give resistance. Centrifugal resistance is greater
	Fast "cross" jump	40 times/3 groups	Keep your feet together and try to keep driving and landing stably. Immediately take the next jump and hit the bottom. The shorter the time, the better
	Small hurdle footsteps	5–10 min	Multi-directional sensitivity
Saturday	Flexible footwork training of floor ladder	10–15 min	Multi-directional combination is fast and sensitive
	BOSU landed stably on one foot	12:00/group 2	Concentrate on the ankle joint and make the next jump after active force stabilization
	Barbell weight lift heel	12 times/4 groups	Hold your head high, always keep your knees stretched, rise quickly and fall slowly

From **Tables 4** and **5**, the calf raises on Monday in the second week were upgraded to Swissball calf raises, and the change of support points required more body control. The one-legged left and right lifting on Tuesday became the one-leg front and back. The most difficult part of the human body is the backward jump. This training will greatly improve your control.

Table 6. Contents of physical training for functional rehabilitation in the fourth week.

Time	Training content	Number of groups	Action essentials and requirements
Monday	Stand on one foot	1 min and a half/3 groups	Barefoot, hands, shoulders, heels slightly raised
	Swiss ball lift heel with two feet	30 times/3 groups	The toes do 10 controlled quick rises and slow falls forward, forward, outward, forward and inner respectively
	Landing stability training of bipedal platform	10 times/3 groups	After the body is completely stretched, it will land naturally. Pay attention to fully bending your hips and landing silently
Tuesday	One-legged slow jumping hurdle	10 times/4 groups	Make the next jump after each landing
	Footstep plus start training	10 times	Rapid response
	Bi-foot belts resist jumping	25 s/4 direction/4 groups	Keep your feet together quickly and try to keep your torso stable
Thursday	Manual resistance hook foot (inside and outside/hand turning)	10 times/3 groups	The straight knee hip joint does not move. Pay attention to the direction of force. Centrifugal and centripetal should give resistance. Centrifugal resistance is greater
	Fast hexagonal jump	40 times/3 groups	Keep your feet together and try to keep driving and landing stably. Immediately take the next jump and hit the bottom. The shorter the time, the better
	Small hurdle footsteps	5–10 min	Multi-directional sensitivity
Saturday	Flexible footwork training of floor ladder	10–15 min	Multi-directional combination is fast and sensitive
	BOSU three-point water	15 times/2 groups	Keep your back straight, your spine always in the neutral position, pay attention to the pelvis, straighten your hind legs, and your toes always face the ground
	Quick barbell weight-bearing lift heel	30 times/4 groups	Hold your head high and keep your knees stretched all the time

From **Tables 5** and **6**, the standing on one foot on Monday in the third week increased from one point to one and a half points, and the single-foot landing training was upgraded to double-foot box jumping training. On Tuesday, the time of the belt jump direction will increase by 5 s, from the original 20 s to 25 s. Thursday's fast "ten" was elevated to a fast hex. Saturday's BOSU single-foot landing training was upgraded to BOSU three-point water exercise, and the barbell weight-bearing calf raise was advanced to barbell fast calf raise [26].

Table 7. Contents of physical training for functional rehabilitation in the fifth week.

Time	Training content	Number of groups	Action essentials and requirements
Monday	Standing on one foot to pass and catch the ball	1 min/3 groups	Barefoot, hands, shoulders, heels slightly raised
	Swiss ball one-legged lift heel	30 times/3 groups	The toes do 10 controlled quick rises and slow falls forward, forward, outward, forward and inner respectively
	Landing stability training of bipedal platform	10 times/3 groups	After the body is completely stretched, it will land naturally. Pay attention to fully bending your hips and landing silently
Tuesday	Slow hexagonal jump with one foot	20 times/4 groups	Make the next jump after each landing
	Footstep plus start training	10 times	Rapid response
	Bi-foot belts resist jumping	30 s/4 direction/4 groups	Keep your feet together quickly and try to keep your torso stable

Table 7. (*Continued*).

Time	Training content	Number of groups	Action essentials and requirements
Thursday	Manual resistance hook foot (inside and outside/hand turning)	10 times/3 groups	The straight knee hip joint does not move. Pay attention to the direction of force. Centrifugal and centripetal should give resistance. Centrifugal resistance is greater
	Fast hexagonal jump	40 times/3 groups	Keep your feet together and try to keep driving and landing stably. Immediately take the next jump and hit the bottom. The shorter the time, the better
	Small hurdle footsteps	5–10 min	Multi-directional sensitivity
Saturday	Flexible footwork training of floor ladder	10–15 min	Multi-directional combination is fast and sensitive
	BOSU three-point water	15 times/2 groups	Keep your back straight, your spine always in the neutral position, pay attention to the pelvis, straighten your hind legs, and your toes always face the ground
	Quick barbell weight-bearing lift heel	30 times/4 groups	Hold your head high and keep your knees stretched all the time

From **Tables 6** and **7**, in the fourth week, standing on one foot on Monday was upgraded to standing on one foot to pass and catch the ball; Swissball with two feet was upgraded to Swissball with one foot; on Tuesday, one foot was upgraded to one foot slow hexagonal jump. The resistance time of the belts on both feet will increase by 5 s, from the original 25 s to 30 s [27].

Table 8. Contents of physical training for functional rehabilitation in the sixth week.

Time	Training content	Number of groups	Action essentials and requirements
Monday	Standing on one foot to pass and catch the ball	1 min and a half/3 groups	Barefoot, hands, shoulders, heels slightly raised
	Swiss ball one-legged lift heel	30 times/3 groups	The toes do 10 controlled quick rises and slow falls forward, forward, outward, forward and inner respectively
	Landing stability training of bipedal platform	10 times/3 groups	After the body is completely stretched, pay attention to the natural landing, fully bend the hip, land silently, start the reflection quickly and quickly
Tuesday	Slow hexagonal jump with one foot	20 times/4 groups	Make the next jump after each landing
	Footstep plus start training	10 times	Rapid response
	Bi-foot belts resist jumping	30 s/4 direction/4 groups	Keep your feet together quickly and try to keep your torso stable
Thursday	Manual resistance hook foot (inside and outside/hand turning)	10 times/3 groups	The straight knee hip joint does not move. Pay attention to the direction of force. Centrifugal and centripetal should give resistance. Centrifugal resistance is greater
	Fast hexagonal jump	40 times/3 groups	Keep your feet together and try to keep driving and landing stably. Immediately take the next jump and hit the bottom. The shorter the time, the better
	Small hurdle footsteps	5–10 min	Multi-directional sensitivity
Saturday	Flexible footwork training of floor ladder	10–15 min	Multi-directional combination is fast and sensitive
	BOSU three-point water	15 times/2 groups	Keep your back straight, your spine always in the neutral position, pay attention to the pelvis, straighten your hind legs, and your toes always face the ground
	Quick barbell weight-bearing lift heel	30 times/4 groups	Hold your head high and keep your knees stretched all the time

From **Tables 7** and **8**, the one-legged passing and receiving time on Monday in

the fifth week has been increased from one minute to one and a half minutes; on the basis of the original, a new starting method has been added to the stability training of the feet on the platform [28].

3.4. Gait test

This article uses the gait test among the three most common tests in functional rehabilitation training. Filter motion data through machine learning, the gait test was chosen as the evaluation index. Walking is a human-specific behavior. Walking control includes central command, body balance, coordination and control. In this experiment, a set of gait detection system with unpowered treadmill was used. Competitors walked on this platform to observe, record, and analyze cadence, stride length, and comparison of left and right data [29].

(1) Purpose of gait test

Gait is a movement achieved by a series of activities such as hips, knees, ankles, and toes. The normal gait of gait is body balance, reasonable step length, minimum energy consumption, and maximum stability with minimum energy consumption.

(2) The main process of gait test

The tester stood on the unassisted treadmill and started to start by relying on his own recoil. Stride length refers to the vertical distance between two heels on the same side of the heel, which is equal to the sum of the two steps, generally 100–160 cm. Cadence refers to how many steps you can walk in one minute, usually 95–125 steps per minute. Asian men's cadence is 112.2/min and women's is 123.4/min.

(3) Gait test evaluation index

This test did not set a specific numerical interval for the evaluation index of gait detector. Because the subjects have great differences in height, step length, etc., the healthy side and the injured side, and three experiments before and after are used for longitudinal comparison.

(4) Gait test valid data

As can be seen from **Figure 3**, the average stride frequency in the initial stage is 95.05/min, generally 95–125 steps per minute. The stats stuck at the bottom line, averaging 17% lower than Eastern men's 112.2 steps per minute and 28% lower than women's 123.4 steps per minute. The average stride length on the injured side was 58 cm, and on the healthy side was 62 cm. The total average stride on both sides is 120 cm, which is normally 100–160 cm, belonging to the normal middle to lower level. The average walking distance per minute is 58 cm.

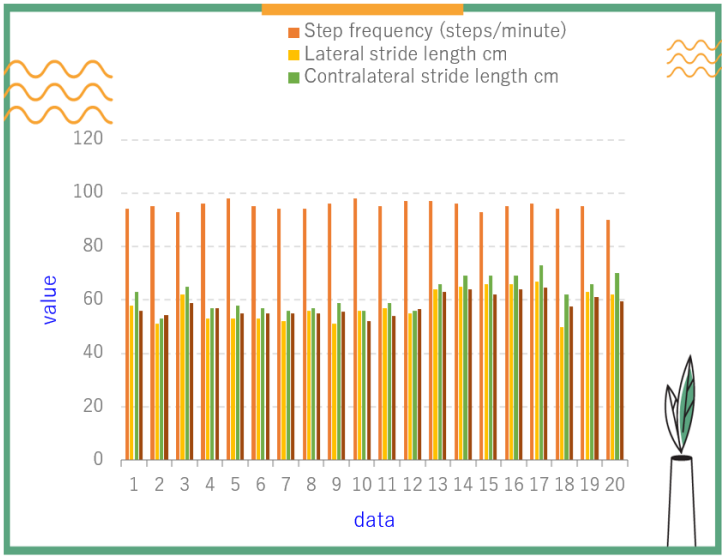

Figure 3. Gait test-initial phase.

It can be seen from **Figure 4** that after 6 weeks of functional physical training, the average stride frequency is 103.2 steps/min, an increase of 8% compared with the initial stage, an average of 9% lower than the 112.2 steps per minute of Oriental males, and an increase of 8% compared with the initial stage, 20% lower than the female average of 123.4 steps per minute, and an 8% increase from the initial stage. The average step length on the injured side was 61.9 cm, an increase of 3.9% compared with the initial stage. The average step length on the unaffected side was still 62 cm, with no change in value. The total average step length on both sides was 124.1 cm, an increase of 4% from the initial stage, and this value was still at the normal lower-middle level. The average travel distance per minute is 64.05 m, a 10% increase from the initial stage.

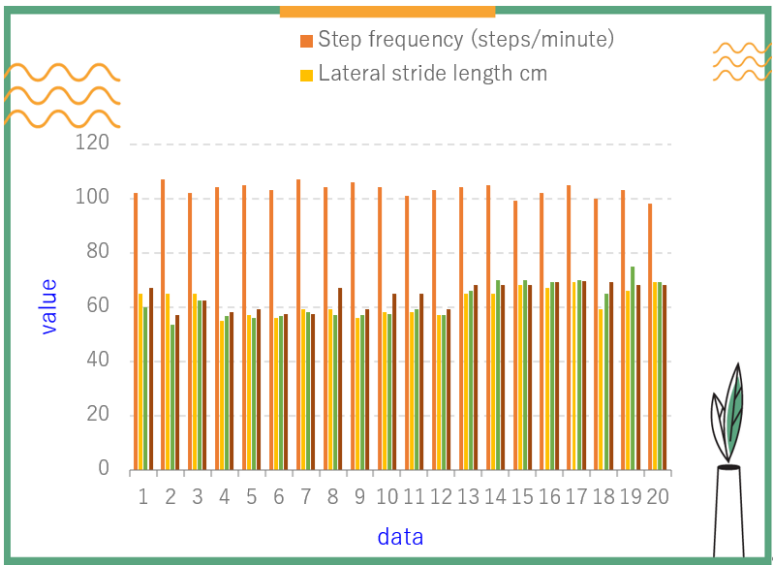

Figure 4. Gait test-functional rehabilitation after 6 weeks of physical training.

It can be seen from **Figure 5** that after 12 weeks of functional physical training, the average stride frequency was 105 steps/min, an increase of 10% compared with

the initial stage, and an increase of 2% compared with 6 weeks of functional physical training. It was 7% lower than the average oriental male's 112.2 steps per minute, an 8% increase from the initial phase, and 18% lower than the female average of 123.4 steps per minute, a 10% increase from the initial phase. The average step length on the injured side was 64.4 cm, an increase of 11% compared with the initial stage, and an increase of 4% compared with that after 6 weeks of functional rehabilitation training. The average step length on the unaffected side was 63 cm, an increase of 1% from the initial stage. The total average step length on both sides was 127.4 cm, an increase of 6% compared with the initial stage, and an increase of 3% compared with that after 6 weeks of functional physical training, and this value has tended to a moderate level. The average distance traveled per minute was 68 m, an increase of 17% from the initial stage and a 6% increase from the 6 weeks of functional physical training.

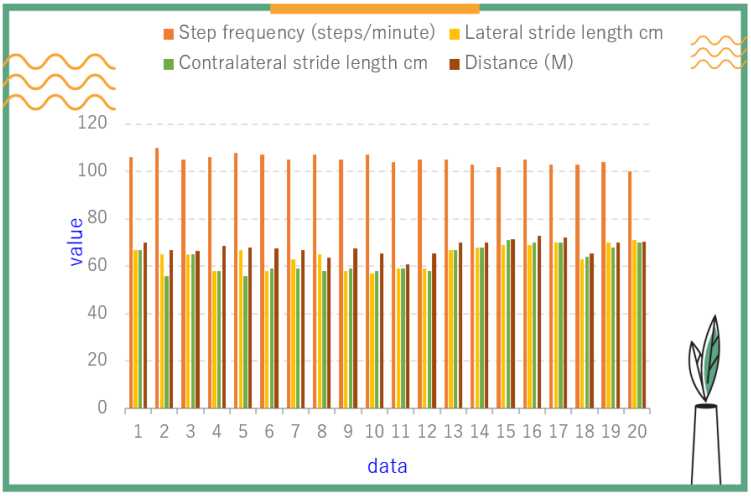

Figure 5. Gait test-functional rehabilitation after 12 weeks of physical training.

In the initial gait test, uneven gait, uncoordinated backward force, and obvious upper body swing were all improved after training. However, no matter it is the injured side or the healthy side, the improvement of gait is not obvious, only the mobility of the upper body has improved, and the gap between the two sides has also narrowed. Since this gait test uses unpowered running, the testers must control their own body and running posture.

3.5. Ankle joint muscle strength test

To verify the effectiveness of functional physical training in preventing acute ankle sports injuries, this study tested the ankle joint muscle strength of athletes. To highlight the experimental results, traditional rehabilitation training methods were used as a control, and athletes were divided into two groups (A and B), with 10 people in each group. Group A athletes received training using the method described in this study, while group B athletes received rehabilitation training for mobilization.

Before the test, two groups of athletes performed slight dynamic stretching and warm-up exercises. In the test, the athlete maintains a stable sitting position, maintains a good body posture, puts their feet flat on the ground, bends their knees about 90 degrees, and performs a maximum force push motion. They use their ankle

area to push down as quickly as possible until the maximum push force is reached, and then hold the motion for 1 s. Measure the maximum contraction force of muscles around the ankle joint using a strength testing device, in kilograms. Conduct 3 repeated tests and record the results of each test. Take the average of the maximum driving force from three tests as the final result. The test results of two groups of athletes are shown in **Table 9**.

Table 9. Ankle joint muscle strength comparison test.

Group A athletes	Test result (kg)	Group B athletes	Test result (kg)
1	63	1	45
2	45	2	58
3	54	3	53
4	42	4	42
5	50	5	52
6	64	6	48
7	47	7	40
8	51	8	53
9	65	9	57
10	53	10	50

From the results of the ankle joint muscle strength comparison test in **Table 9**, compared to the B group athletes who used rehabilitation training methods, the A group athletes generally showed higher results in the ankle joint muscle strength comparison test, with a minimum test muscle strength of 42 kg and a maximum value of 65 kg; However, the results of ankle muscle strength comparison tests for athletes in group B are generally higher, with a minimum test muscle strength of 40 kg and a maximum value of 58 kg. From this result, it can be seen that athletes who receive functional physical training in this article have a more ideal ankle muscle strength state.

3.6. Agility testing

To compare the agility of different groups of athletes in different sports states, this article uses a *T*-test to compare the total time it takes for two groups of athletes to complete the *T*-line in indoor and outdoor sports. During the testing process, athletes run along a *T*-shaped route. Starting from the bottom of the *T*-shaped object, then run forward to the midpoint of the *T*-shaped object, laterally to the left endpoint, then laterally to the right endpoint, finally laterally to the midpoint, and then backwards to the starting point. Record the total time taken to complete the *T*-shaped route. The final test results of the two groups of athletes are shown in **Tables 10** and **11**.

Table 10. Indoor agility testing.

Group A athletes	Test result (s)	Group B athletes	Test result (s)
1	9.3	1	10.1
2	9.5	2	10.4
3	9.3	3	9.6
4	9.6	4	10.3
5	9.8	5	10
6	9.9	6	9.7
7	9.8	7	9.9
8	9.3	8	9.5
9	9.2	9	10.0
10	9.4	10	10.1
Mean value	9.51	Mean value	9.96

Table 11. Outdoor agility testing.

Group A athletes	Test result (s)	Group B athletes	Test result (s)
1	9.6	1	10.1
2	9.4	2	10
3	9.3	3	9.5
4	8.9	4	9.5
5	9.5	5	9.7
6	9.4	6	9.6
7	9.2	7	10.1
8	9.1	8	10.1
9	9.6	9	9.6
10	9.1	10	9.7
Mean value	9.31	Mean value	9.79

From **Table 10**, it can be seen that the average indoor agility test results of group A athletes based on functional physical fitness training in this article reached 9.51 s, while the average indoor agility test results of group B athletes based on traditional rehabilitation training only reached 9.96 s. From this specific result, it can be seen that under indoor sports, athletes using the training method in this article showed more ideal agility performance.

From **Table 11**, it can be seen that compared to indoor sports, athletes exhibit stronger agility in outdoor sports. From the specific comparison results, it can be seen that the average outdoor agility test result of group A athletes reached 9.31 s, while the average outdoor agility test result of group B athletes based on traditional rehabilitation training only reached 9.79 s. This indicates that athletes under functional physical training have a more significant agility advantage.

3.7. Oswestry dysfunction index (ODI)

ODI provides an objective assessment of the extent to which athletes are restricted in their daily activities. Verify the impact of different training methods on

the overall athletic ability and quality of life recovery of athletes by evaluating their degree of functional impairment. This article evaluates the ODI of different groups of athletes after treatment, comparing the effects of functional physical training and traditional rehabilitation training methods on restoring ankle joint function in athletes. This article mainly evaluates ODI from five aspects: pain level, personal care, walking, sitting, and standing. The scoring criteria are shown in **Table 12**.

Table 12. Scoring criteria.

Range	Score	Meaning
ODI assessment	0	No functional impairment
	1	Mild functional impairment
	2	Moderate functional impairment
	3	Severe functional impairment
	4	Very serious functional impairment
	5	Complete functional impairment

According to the scoring criteria in **Table 12**, the scores for each section are accumulated to obtain the total score, as shown in **Table 13**.

From **Table 13**, it can be seen that after functional physical training, the ODI scores of athletes in group A are generally lower than those of athletes in group B. This indicates that functional physical training is more effective in improving athlete function and reducing functional impairments compared to traditional rehabilitation training.

Table 13. Athlete ODI score.

Group A athletes	Score (points)	Group B athletes	Score (points)
1	6	1	9
2	5	2	9
3	2	3	6
4	4	4	8
5	2	5	9
6	5	6	5
7	3	7	6
8	6	8	10
9	7	9	9
10	3	10	7
Mean value	4.3	Mean value	7.8

4. Results and discussion

Using machine learning algorithm to use functional gait detection index to reflect and diagnose the basic ability of athletes in ankle [30–32].

(1) For athletes with habitual ankle sprains, systematic ankle function rehabilitation training can not only enhance the sensation, strength, flexibility and stability of the ankle, but also prevent injuries.

(2) Through regular inspection of athletes' ankle injuries, the existing problems can be truly and effectively reflected, and corresponding intervention measures can be taken to ensure that athletes can carry out professional training. The research results of functional rehabilitation physical training show that it is scientific and reasonable to perform functional rehabilitation exercises on the ankles of athletes.

5. Conclusion

With the advent of the era of big data, machine learning has become a hot issue and has been widely used in real life. In this paper, a machine learning related algorithm is designed on the research problem of functional physical training on the prevention of acute foot and ankle sports injuries. Therefore, it is believed that sports injury prevention is something that coaches should seriously consider, which is not only the guarantee of daily training, but also the symbol of scientific training. Sports injuries should be minimized as much as possible while actively training and preparing for excellent results in competition. Compared with traditional physical training, physical training is more scientific and comprehensive, and can be targeted for each athlete who may be injured, and the effect is also more significant. The selective combination of physical function training and sports training has certain practical significance for the prevention of athletes' injuries. Although functional physical training has many advantages in preventing acute ankle sports injuries, there are also some potential risks, side effects, and limitations. The actual training plan needs to consider individual differences. If the athlete's physical foundation, physical condition, and exercise history are not taken into account during training, it may lead to some athletes having difficulty adapting to the training intensity and increasing the risk of injury. Moreover, due to the different physical conditions and needs of each athlete, designing a functional fitness training program suitable for everyone is challenging. Personalized training programs require more time and resources. In order to minimize the risk of functional physical training, a comprehensive physical assessment and functional testing should be conducted before designing a training plan to ensure guidance from professional coaches or therapists, thereby achieving effective prevention of acute ankle sports injuries while ensuring the safety and health of athletes.

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

References

1. Lindberg K, Lohne-Seiler H, Fosstveit SH, et al. Effectiveness of individualized training based on force-velocity profiling on physical function in older men. Scandinavian Journal of Medicine & Science in Sports. 2022; 32(6): 1013-1025. doi: 10.1111/sms.14157
2. Jackman M, Sakzewski L, Morgan C, et al. Interventions to improve physical function for children and young people with cerebral palsy: international clinical practice guideline. Developmental Medicine & Child Neurology. 2021; 64(5): 536-549. doi: 10.1111/dmcn.15055
3. Pepera G, Mpea C, Krinta K, et al. Effects of multicomponent exercise training intervention on hemodynamic and physical

function in older residents of long-term care facilities: A multicenter randomized clinical controlled trial. Journal of Bodywork and Movement Therapies. 2021; 28: 231-237. doi: 10.1016/j.jbmt.2021.07.009
4. Long DE, Peck BD, Tuggle SC, et al. Associations of muscle lipid content with physical function and resistance training outcomes in older adults: altered responses with metformin. GeroScience. 2021; 43(2): 629-644. doi: 10.1007/s11357-020-00315-9
5. Hunt KJ, Hurwit D, Robell K, et al. Incidence and Epidemiology of Foot and Ankle Injuries in Elite Collegiate Athletes. The American Journal of Sports Medicine. 2016; 45(2): 426-433. doi: 10.1177/0363546516666815
6. Herzog MM, Kerr ZY, Marshall SW, et al. Epidemiology of Ankle Sprains and Chronic Ankle Instability. Journal of Athletic Training. 2019; 54(6): 603-610. doi: 10.4085/1062-6050-447-17
7. Brandolini S, Lugaresi G, Santagata A, et al. Sport injury prevention in individuals with chronic ankle instability: Fascial Manipulation® versus control group: A randomized controlled trial. Journal of Bodywork and Movement Therapies. 2019; 23(2): 316-323. doi: 10.1016/j.jbmt.2019.01.001
8. Chen ET, McInnis KC, Borg-Stein J. Ankle Sprains: Evaluation, Rehabilitation, and Prevention. Current Sports Medicine Reports. 2019; 18(6): 217-223. doi: 10.1249/jsr.0000000000000603
9. Smith BI, Curtis D, Docherty CL. Effects of Hip Strengthening on Neuromuscular Control, Hip Strength, and Self-Reported Functional Deficits in Individuals with Chronic Ankle Instability. Journal of Sport Rehabilitation. 2018; 27(4): 364-370. doi: 10.1123/jsr.2016-0143
10. McKeon PO, Donovan L. A Perceptual Framework for Conservative Treatment and Rehabilitation of Ankle Sprains: An Evidence-Based Paradigm Shift. Journal of Athletic Training. 2019; 54(6): 628-638. doi: 10.4085/1062-6050-474-17
11. Minoonejad H, Karimizadeh Ardakani M, Rajabi R, et al. Hop Stabilization Training Improves Neuromuscular Control in College Basketball Players with Chronic Ankle Instability: A Randomized Controlled Trial. Journal of Sport Rehabilitation. 2019; 28(6): 576-583. doi: 10.1123/jsr.2018-0103
12. Bleakley CM, Taylor JB, Dischiavi SL, et al. Rehabilitation Exercises Reduce Reinjury Post Ankle Sprain, But the Content and Parameters of an Optimal Exercise Program Have Yet to Be Established: A Systematic Review and Meta-analysis. Archives of Physical Medicine and Rehabilitation. 2019; 100(7): 1367-1375. doi: 10.1016/j.apmr.2018.10.005
13. Otzel DM, Hass CJ, Wikstrom EA, et al. Motoneuron Function Does not Change Following Whole-Body Vibration in Individuals With Chronic Ankle Instability. Journal of Sport Rehabilitation. 2019; 28(6): 614-622. doi: 10.1123/jsr.2017-0364
14. Kunugi S, Masunari A, Yoshida N, et al. Postural stability and lower leg muscle activity during a diagonal single-leg landing differs in male collegiate soccer players with and without functional ankle instability. The Journal of Physical Fitness and Sports Medicine. 2017; 6(4): 257-265. doi: 10.7600/jpfsm.6.257
15. Nuzzo JL. The Case for Retiring Flexibility as a Major Component of Physical Fitness. Sports Medicine. 2019; 50(5): 853-870. doi: 10.1007/s40279-019-01248-w
16. Young JL, Rhon DI, de Zoete RMJ, et al. The influence of dosing on effect size of exercise therapy for musculoskeletal foot and ankle disorders: a systematic review. Brazilian Journal of Physical Therapy. 2018; 22(1): 20-32. doi: 10.1016/j.bjpt.2017.10.001
17. Wright CJ, Linens SW, Cain MS. A Randomized Controlled Trial Comparing Rehabilitation Efficacy in Chronic Ankle Instability. Journal of Sport Rehabilitation. 2017; 26(4): 238-249. doi: 10.1123/jsr.2015-0189
18. Smith MD, Vicenzino B, Bahr R, et al. Return to sport decisions after an acute lateral ankle sprain injury: introducing the PAASS framework—an international multidisciplinary consensus. British Journal of Sports Medicine. 2021; 55(22): 1270-1276. doi: 10.1136/bjsports-2021-104087
19. Hubbard-Turner T. Lack of Medical Treatment from a Medical Professional After an Ankle Sprain. Journal of Athletic Training. 2019; 54(6): 671-675. doi: 10.4085/1062-6050-428-17
20. Delahunt E, Bleakley CM, Bossard DS, et al. Clinical assessment of acute lateral ankle sprain injuries (ROAST): 2019 consensus statement and recommendations of the International Ankle Consortium. British Journal of Sports Medicine. 2018; 52(20): 1304-1310. doi: 10.1136/bjsports-2017-098885
21. Feger MA, Glaviano NR, Donovan L, et al. Current Trends in the Management of Lateral Ankle Sprain in the United States. Clinical Journal of Sport Medicine. 2017; 27(2): 145-152. doi: 10.1097/jsm.0000000000000321
22. Barelds I, van den Broek AG, Huisstede BMA. Ankle Bracing is Effective for Primary and Secondary Prevention of Acute Ankle Injuries in Athletes: A Systematic Review and Meta-Analyses. Sports Medicine. 2018; 48(12): 2775-2784. doi:

10.1007/s40279-018-0993-2

23. da Silva Vieira AG, Pinto ACPN, Garcia BMSP, et al. Telerehabilitation improves physical function and reduces dyspnoea in people with COVID-19 and post-COVID-19 conditions: a systematic review. Journal of Physiotherapy. 2022; 68(2): 90-98. doi: 10.1016/j.jphys.2022.03.011
24. Gavelin HM, Dong C, Minkov R, et al. Combined physical and cognitive training for older adults with and without cognitive impairment: A systematic review and network meta-analysis of randomized controlled trials. Ageing Research Reviews. 2021; 66: 101232. doi: 10.1016/j.arr.2020.101232
25. Lysogorskaia E, Ivanov T, Mendalieva A, et al. Yoga vs Physical Therapy in Multiple Sclerosis: Results of Randomized Controlled Trial and the Training Protocol. Annals of Neurosciences. 2023; 30(4): 242-250. doi: 10.1177/09727531231161994
26. Doherty C, Bleakley C, Delahunt E, et al. Treatment and prevention of acute and recurrent ankle sprain: an overview of systematic reviews with meta-analysis. British Journal of Sports Medicine. 2016; 51(2): 113-125. doi: 10.1136/bjsports-2016-096178
27. Bejarano-Pineda L, Amendola A. Foot and Ankle Surgery. Clinics in Sports Medicine. 2018; 37(2): 331-350. doi: 10.1016/j.csm.2017.12.009
28. Prakash AA. Epidemiology of High Ankle Sprains: A Systematic Review. Foot & Ankle Specialist. 2020; 13(5): 420-430. doi: 10.1177/1938640020916266
29. Lin C, Houtenbos S, Lu Y, et al. The epidemiology of chronic ankle instability with perceived ankle instability- a systematic review. Journal of Foot and Ankle Research. 2021; 14(1). doi: 10.1186/s13047-021-00480-w
30. Xia W, Jiang Y, Chen X, et al. Application of machine learning algorithms in municipal solid waste management: A mini review. Waste Management & Research: The Journal for a Sustainable Circular Economy. 2021; 40(6): 609-624. doi: 10.1177/0734242x211033716
31. Moulaei K, Shanbehzadeh M, Mohammadi-Taghiabad Z, et al. Comparing machine learning algorithms for predicting COVID-19 mortality. BMC Medical Informatics and Decision Making. 2022; 22(1). doi: 10.1186/s12911-021-01742-0
32. Gupta S, Saluja K, Goyal A, et al. Comparing the performance of machine learning algorithms using estimated accuracy. Measurement: Sensors. 2022; 24: 100432. doi: 10.1016/j.measen.2022.100432