Hindawi
Journal of Nanomaterials
Volume 2022, Article ID 6062005, 9 pages
https://doi.org/10.1155/2022/6062005

Research Article

Application of Nanofiber Material Based on Electrospinning Technology in Sports Rehabilitation of Basketball Player's Wrist Joint

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Received 1 March 2022; Revised 6 April 2022; Accepted 12 May 2022; Published 26 May 2022

Academic Editor: Runwei Mo

Wrist joint plays an indispensable role in our daily life. The injury of wrist joint has a great influence on the fine movement of the hand and upper limb. For example, you cannot do joint movements, you cannot carry things, and life is very inconvenient. It is necessary to distinguish the types of wrist disorders and take effective rehabilitation methods in time. Wrist joint has a great impact on people's life and work, and the rehabilitation of wrist joint has become a research hotspot in rehabilitation medicine and medical engineering. Carpal tunnel syndrome is the most common peripheral nerve entrapment disease in clinical practice, with a very high incidence. According to data, the incidence of carpal tunnel syndrome in the general population abroad is 1%-5%, while that in special populations is as high as 14.5% above. In order to solve the problem of rehabilitation of wrist joint, using electrospinning technology, the polymer solution is prepared into nanofiber materials with strong adsorption and good filterability under the action of high-voltage electric field. And using some small-sized nanofibers that are similar to organs in shape and structure, as well as their excellent degradability and biocompatibility, this material is used in the research of wrist joint movement rehabilitation. In this paper, sports rehabilitation training is carried out on the wrist joint of basketball players, and the nanofiber material is effectively combined with sports rehabilitation training. By comparing the rehabilitation of athletes who did not use nanofiber materials, the role of nanofiber materials in sports rehabilitation was studied. This article analyzes the three parts of the radial joint, the wrist joint, and the ulnar joint before and after the sports rehabilitation training for basketball players with functional impairments and compares the sports rehabilitation of the basketball players without nanofiber materials. This article analyzes the three parts of the radial joint, the wrist joint, and the ulnar joint before and after the sports rehabilitation training for basketball players with functional impairments and compares the sports rehabilitation of the basketball players without nanofiber materials.

1. Introduction

1.1. Background Meaning. Wrist joint is the most flexible joint in human upper limb, which can complete various complex and accurate movements. It is not only used frequently in life but also bears the largest load in the process of supporting, pushing, and pulling. The wrist joint is a complex joint composed of multiple joints, including the radiocarpal joint, the intercarpal joint, and the carpal metacarpal joint. In a narrow sense, the wrist joint refers to the joint between the lower end of the radius and the first row of carpal bones (except the pisiform bone), that is, the radiocarpal joint; but from a functional point of view, the wrist joint should actually include the radiocarpal joint, the intercarpal joint, and the radioulnar joint. The lateral joints, which are unified in motion, the wrist joint is located deep in the carpal tunnel. The wrist joint is the main part to complete the function of the upper limb, and it is easy to cause injury in daily life. It plays an indispensable role in our daily life. Once the wrist joint is damaged, people's life and work will be greatly affected. Especially for basketball players who need to use it frequently, if their wrist joint is injured, and the untreated and unreported injury will continue to reduce their ability and lead to poor team performance [1]. In the rehabilitation of wrist joint injury, early and correct functional exercise is very important for the recovery of wrist joint function. It can promote blood circulation, accelerate metabolism, prevent muscle atrophy, and enhance muscle strength through muscle movement. Rehabilitation medicine of wrist joint involves many aspects, and there are many methods of wrist rehabilitation training, such as electrocardiography signal control method, AR method, thermotherapy, occupational therapy, mechanical movement, and exercise therapy. However, due to the complexity of wrist joint, the rehabilitation treatment of wrist joint has always been one of the difficult problems in rehabilitation medicine and medical engineering, and it is also a hot research topic in medical field. In recent years, with the emergence of electrospinning technology and nanofiber materials, researchers have seen a new research idea of wrist rehabilitation training.

Electrospinning is a special form of electrostatic atomization of polymer fluids. At this time, the atomized and split substances are not tiny droplets, but tiny polymer jets, which can run for a long distance and eventually solidify into fibers. Electrospinning is a special fiber manufacturing process in which a polymer solution or melt is jet-spun in a strong electric field. Under the action of the electric field, the droplet at the needle changes from a spherical shape to a conical shape (that is, a "Taylor cone") and extends from the tip of the cone to obtain fiber filaments. In this way, polymer filaments with nanometer diameters can be produced.

Some nanofiber materials are very useful in biomedicine. They are similar to human organs in morphology and structure and have excellent degradation and biocompatibility. The smaller the size of the nanofiber particles, the larger the surface area. Because the surface particles lack the coordination of adjacent atoms, the surface energy is extremely unstable, and it is easy to combine with other atoms, showing strong activity. Human organs are similar. These nanofibers can replace biological organs for organ transplantation, repair, and treatment. Because of its small grain size, the size of internal pores or defects is greatly reduced, and it is not easy to break through the crystal and has unique super plasticity. It is mainly used in artificial bone and artificial joint. Carbon nanofibers have good biocompatibility and strong adsorption. They play an important role in the strength and toughness of artificial organs and can be used in the blood purification system. The application of nanopolymer materials has been involved in immunology, drug-controlled release carrier, and interventionism diagnosis and treatment. Due to the various characteristics of these nanomaterials, researchers will make great breakthroughs in biomedical research.

1.2. Related Work. The rehabilitation training of wrist joint and the application of electrospinning technology and nanofiber materials have always been the research hot spot in the academic field. Erben prepared nanofibers and microfiber mats through a new combination of alternating current (AC) electrospinning and bubble electrospinning, Nanofiber refers to a wire-like material with a diameter of nanometer scale and a large length with a certain aspect ratio. In addition, the fibers that are modified by filling nanoparticles into ordinary fibers are also called nanofibers. In a narrow sense, the diameter of nanofibers is between 1 nm and 100 nm, but in a broad sense, fibers with a fiber diameter below 1000 nm are called nanofibers. Microfiber mat refers to nonwoven sheet scrap functional fibers with a fiber diameter of less than 5 μm [2]; however, the practicability of this method is not as good as that of this paper. Warzoha et al. studied the effect of randomly oriented grapheme nanofibers on the overall thermal properties of organic paraffin PCM [3], but the amount of data that this method needs to collect is too large. Iida et al. studied the stability of the distal radioulnar joint (DRUJ) at different wrist joint positions and examined the relative contribution of each ligament component of the triangular fibrocartilage complex (TFCC) to the stability of DRUJ [4], but the research object of this method is too one-sided. Wu et al. studied the effects of processing parameters such as rotation speed, working pressure, carbonation, and SPS temperature on the diameter of nanofibers [5], but the data needed to be calculated by this method is too complicated. Yan et al. prepared a beaded nanocomposite Li3V2(PO4)3(LVP) grown on carbon nanofibers (CNF) through electrospinning and heat treatment. The preparation method is more precise and simple [6]; however, the operation steps of this method are too many and the operation is too complicated [7], but the cost of this method is too high. Pujari et al. studied the potential benefits of vibration stimulation as a motor intervention and its application in exercise rehabilitation [8], but this method is not suitable for all patients. Han's research is aimed at investigating the current sports rehabilitation industry and finding out the possibility of improving rehabilitation policies [9]; however, the experimental results of this study are not accurate, and there are some errors. Although the relevant research of the above scholars has achieved some results to some extent, most of them are theoretical exploration, with few practical applications, and there is no conflict for the research content of this paper, so the research of this paper is of great significance.

1.3. Innovation of This Article. This article uses nanofiber materials produced by electrospinning technology to improve the sports rehabilitation training of athletes' wrist joints and combines nanofiber materials with sports rehabilitation to make the effect of sports rehabilitation better. The innovations of this article are mainly reflected in the following: (1) using the method of comparative analysis, according to whether nanofiber materials are used in sports rehabilitation training and observe the rehabilitation of the two athletes within five weeks; (2) this article links nanofiber materials with sports rehabilitation and obtains further innovations in sports rehabilitation programs, while expanding the application fields of nanofibers; and (3) this article conducts a comparative analysis from various aspects of the athlete's wrist joints to ensure the comprehensiveness of the data and the accuracy of the experimental results, including the ruler and wrist angle, the first moon angle, the ship moon angle, and other aspects of the related indicators for analysis.

2. Proposed Method

2.1. Electrospinning Technology. Electrospinning technology is a technology that overcomes surface tension and viscosity force in a non-Newtonian polymer solution under the action of a high-voltage electric field to obtain nano- to submicron fibers by stretching and bending. Fluids that satisfy a linear relationship between shear stress and shear strain rate are called Newtonian fluids, and those that do not satisfy the linear relationship are called non-Newtonian fluids. Electrospinning technology has changed people's understanding of materials and their properties by manufacturing optimized one-dimensional nanostructures, that is, nanofibers [10]. In recent years, electrospinning has become a promising method to obtain long and continuous fibers with nanometer diameter from a variety of polymers [11]. As a perfect combination of high voltage and nanotechnology, it has injected fresh blood into traditional high-voltage technology. The current background of international research has identified the electrospinning process as one of the key technologies for obtaining nanofibers [12]. Electrospun fibers have attracted attention in many fields, such as tissue engineering, coaxial cables, and drug release due to their huge specific surface area and high porosity. The experimental device of electrospinning technology consists of a high-voltage DC power supply, a sample tube with capillary tube, and a collection plate. The positive pole of the power source output by the DC power supply is connected to the metal electrode inserted into the sample tube, and the negative pole is connected to the receiving plate. With the in-depth research on electrospinning technology in recent years, the laboratory has designed a variety of electrospinning devices that can control the behavior of fiber properties, geometry, and arrangement.

Electrospinning is a modern and effective method that uses an electric field to produce fine fibers whose diameter can be reduced to nanometers [13]. The experimental process of electrospinning technology is as follows: Firstly, the polymer solution is loaded into the sample tube, and the tilt angle of the spinneret is adjusted to make the droplets hang on the spinneret. Turn on the power, and a gradient electric field is formed between the nozzle and the receiving plate. At this time, the electric field force experienced by the nozzle droplets will counteract the surface tension of the liquid. When the two are equal, a "Taylor cone" is formed at the spinneret. Further increase the voltage and the electric field can overcome the surface tension of the liquid. A Taylor cone is formed by the illusion of a liquid under an electric field (or a gravitational field or a pressure field). The Taylor cone is sharp and unusual, and no weapon in the world can match it. And from the tip of the cone is a jet of liquid as thin as a hair. The cone is named after a generation of fluid mechanics guru Taylor, because he used the theory to calculate the angle of the cone. At this time, the tiny stream of dotted liquid is ejected from the spinneret in the form of fiber bundles and moves toward the negative electrode. In this process, the fiber bundle undergoes a series of bending instability processes and electric field stretching processes. The fiber bundles gradually split, and the diameter continuously decreases. At the same time, the solvent gradually evaporates from the fiber surface, and the dried nanofiber falls on the collecting plate. The positive charge of the fiber is partially neutralized by the negative charge accumulated on the negative electrode, forming multiple layers of positively charged nanofibers. The applied voltage, the flow rate, and the distance from the injector to the collector have a moderate effect on the fiber diameter, while the needle gauge has a small effect on the fiber diameter [14].

Electrospinning technology can be regarded as a special case of electrospray technology. Its principle and related formulas are as follows. The droplet at the top of the spinning tube is convex hemispherical under the action of surface tension. When a voltage of a certain potential is applied in the liquid, the curvature of the droplet surface will gradually change. When the potential reaches the critical value of V_c, the droplet is gradually elongated by a Taylor cone with an angle of 49.3 degrees. The small droplets split by the jet at the tip of the Taylor cone have high monodispersity, and the drug is integrated into the droplets. After the droplets are dried, highly monodisperse nanodrug particles can be obtained, and the obtained nanodrug particles can reach ERP. The effect of targeted drug delivery effectively enhances the efficacy of the drug. The data here comes from actual tests by relevant scientists. The value V_c of the critical potential can be determined by the following formula:

$$V_c = \left(\frac{2H}{L}\right)^2 \left[\ln\left(\frac{2L}{R}\right) - 1.5\right](0.117\pi\gamma R). \tag{1}$$

In the formula, H represents the distance between the capillary and the earth pole, L represents the length of the capillary, radius R represents the radius of the capillary, and γ represents the surface tension of the liquid.

For the hemispherical droplet suspended on the end of the capillary, the solution electrospray/electrospun voltage V is similar to the formula of V_c in formula (1), and its value can be expressed as

$$V = 300(20\pi\gamma r)^{0.5}. \tag{2}$$

The r in the formula represents the radius of the droplet suspended at the end of the capillary. The premise of satisfying formula (2) is that the droplet is surrounded by air. and the fluid in the droplet is a simple molecule. The strength and conductivity of the liquid play a vital role in the dynamics of electrospinning.

2.2. Nanofibers. Nanofibers are linear materials with a nanometer scale diameter and a large length with a certain aspect ratio. Its diameter is between 1 nm and 10 nm. The smaller the diameter of the nanofiber, the higher the tensile strength

[15]. Nanofibers are classified into two categories according to their types: fibers having a nanometer diameter and fibers modified by filling conventional fibers with Na-no particles. So far, there are many methods for preparing nanofibers, such as stretching method, template synthesis method, self-assembly method, electrostatic spinning method, and solution jet spinning method. Pass nanofibers have larger surface area and smaller pore size than other materials and have stronger adsorption, good filterability, and barrier ability and excellent adhesion and heat preservation.

The advantages of nanofibers are as follows: First, due to their small diameter, they have a very large size effect, including excellent electrical, magnetic, optical, and thermal aspects. Secondly, the regular arrangement of molecules allows self-organization, thus exhibiting a unified function. Third, in biomedicine, it can be combined with cells to make nanofibers with specific structures. Due to these advantages of nanomaterials, in recent years, nanofibers have found markets in the fields of healthcare, energy, and defense [16]. At the same time, the improvement of the practical value of nanofibers has also promoted the rapid development of its preparation technology.

Based on the unique characteristics of nanofibers, researchers have conducted corresponding research in the following areas: First, in biomedicine, small-sized nanofibers are similar to organs in morphology and structure. Some fibers have excellent degradability and biocompatibility, so cell scaffolds can be cultured. It can be used for tissue and organ repair, as a carrier for drug-controlled release systems and wound coverings [17]. Secondly, about the environment, due to the fiber membrane, the diameter of the fiber is small, the porosity is high, and the uniformity is good. These characteristics of electrospun nanofibers can be used to prepare adsorption materials and filter materials, which can be effectively combined with submicron filtration, and can be applied in atomic industry, aseptic room, precision industry, finishing and other industries, and greatly improve its filtering effect. When nanofibers are used as barrier materials, they can be used as separators between positive and negative electrodes of batteries, because they can prevent the movement of particles and specific ions. For example, the fiber network made of vinyl chloride acrylonitrile copolymer resin by air injection method has high density and high blocking efficiency. As a special battery separator, it can also work in acid and alkaline medium for a long time. In the field of sensor, nanofiber membrane has high specific surface area and excellent structure controllability, which makes it an ideal material for improving sensor performance and preparing high-performance sensor. Nanofiber mats usually exhibit high particle capture efficiency, but due to their more compact structure, they may also lead to higher air flow resistance than macrofiber materials [18]. Due to its hydrophilicity, nontoxicity, and biocompatibility, electrospun nanofiber mats can be used in tissue scaffolds and wound dressings [19]. In addition, researchers have also used nanofibers in protective clothing, aerospace, energy, and magnetic fields and have made significant progress.

2.3. Wrist Joints. The wrist joint is an important joint of the human arm. It can make up for the lack of freedom of the shoulder and elbow joint. It is a typical elliptical joint. The wrist joint connects the hand and the forearm, is an important part of the upper limb support and thrust, and can withstand heavy loads. Wrist joints, including radiowrist joint, interwrist joint, and ulnar joint, are the most complex joints in the human body. This complex mechanism is conducive to the functioning of the hand. The radiowrist joint is an elliptical deformed ball-and-socket joint, which is a hinge-like motion system with the wrist bone. The radiocarpal joint transfers the load from the forearm to the hand and promotes the fine work of the hands and fingers by providing a considerable degree of stability [20]. Due to different hand movements, the carpal bone is divided into three kinematic chains according to the articular surface of the distal radial carpal. The central chain contains the moon bone, skull, and radius. The side chain is mainly boat-shaped, which can stabilize the wrist bone. The internal measurement chain controls the rotation of the hand, including the triangular fibrocartilage disc, the triangular bone, and the hook bone. Damage to any of the anatomical structures, or even fractures, will affect the function of the entire wrist joint.

In a narrow sense, the wrist joint refers to the joint formed between the lower end of the radius and the proximal row of the wrist bone (not including the pea bone). However, from a functional point of view, wrist joints include the following: (1) the proximal articular surface of the scaphoid, lunate and triangle bones are used as the joint head, and the wrist joint surface of the articular disk below the radius and ulna is used as the joint; (2) distal radioulnar joint; and (3) wrist joints: construct adjacent carpal bones in stages. The bones are intertwined and in contact with each other, connected to each other by complex ligaments and tendons, and have varying degrees of mobility. Due to the complex structure, many joints, and ligaments, the wrist joint is highly flexible. The anatomical properties of the wrist joint allow the wrist joint to move in two planes, frontal uplift offset (abduction and adduction) and surface flexion/extension (palm flexion and extension). The stability of the wrist joint is mainly caused by the wrapping of the joint capsule and the traction of the intercarpal ligaments.

Most of the wrist joint movement is done by the radiowrist joint. In biomechanics, the ulna may be regarded as the pillar of radius activity [21]. It has three degrees of freedom for flexion, extension, contraction, and a certain limit of circular motion. Among them, turning the palm toward the center of the hand is called wrist flexion, also called palm bending; turning to the back of the hand is called wrist extension, also called palm extension; movement in the direction of the thumb is called radial bending. Movement in the direction of the little finger is called ulnar flexion; movement to the outside of the body is called outward rotation; movement to the inside of the body is called internal rotation. There are many kinds of wrist motion theory: the traditional two-row theory, Taleisnik wrist column theory, Gilford's hinge theory, etc.

2.4. Sports Rehabilitation. Sports rehabilitation is a noninvasive and effective treatment method for sports injuries [22]. In recent years, due to social leisure behaviors, sports rehabilitation after joint or other parts of the body has been injured and has become more and more important [23]. The purpose of sports rehabilitation training is to improve the patient's physical function and athletic ability. Patients can be assisted by rehabilitation therapists or train their own muscle strength. Sports rehabilitation originated in the sports world and is used for rehabilitation exercises for athletes injured. Sports rehabilitation is a new "trinity" cross-discipline where sports and health medicine overlap, and it is an important part of modern rehabilitation [24]. With the development of medicine, exercise rehabilitation is also suitable for certain diseases, such as stroke, Parkinson's disease, high blood pressure, heart disease, diabetes, and lung diseases.

For sports players, it is important to determine strategies to prevent injuries, optimize rehabilitation, and improve performance [25]. In a sense, the key to the success or failure of sports rehabilitation also depends on the implementation of personal prescriptions and exercise prescriptions. Its content mainly includes form, intensity, time, frequency, and matters. The most important forms of exercise are appropriate resistance exercises and conditioning exercises, as well as aerobic exercises. They can also perform some powerful physical tasks, such as housework and indoor fitness exercises. Exercise intensity is mainly divided into low intensity, medium intensity, and high intensity. It is necessary to comprehensively evaluate the patient's general condition and medical condition according to the patient's risk category and select and exercise the appropriate exercise intensity. It should be noted that the exercise intensity, duration, and exercise frequency of different patients are not exactly the same. Exercise intensity setting methods mainly include age prediction method, heart rate reserve method, resting heart rate+20 method, peak oxygen uptake method, and anaerobic threshold method. When planning an exercise, the main requirement is to ensure patient safety first. Based on this, the intensity and time will gradually increase, and the time of each exercise depends on the situation, ranging from 30 minutes to 1 hour.

Sports rehabilitation training mainly focuses on joint mobility, muscle strength, and functional sports exercises. Rehabilitation treatment requires the participation of the therapist and his family. The therapist will teach the patient's family how to recover and what to pay attention to during the training process. This allows the family to perform simple rehabilitation after returning home to maintain the patient's athletic performance. Family rehabilitation can not only improve the rehabilitation effect but also reduce the economic pressure of the family and form a joint rehabilitation model of hospital and family. During the exercise, the principles of science, applicability, long term, and regularity must be followed, and the frequency should be at least three times a week. Therefore, in order to consider the exercise rehabilitation process to better perform rehabilitation exercises, according to the consensus of the medical profession, exercise rehabilitation is divided into three stages, the first stage is the hospitalization period, and the second stage is the initial discharge period and outpatient rehabilitation. The third stage is the maintenance stage of outpatient rehabilitation. Standardized exercise rehabilitation can not only alleviate the pain and discomfort of patients but also improve exercise endurance, improve mental state, improve overall quality of life, and reduce patients' medical expenses.

3. Experiments

3.1. Test Subject. This article selects two basketball players' sports rehabilitation data before and after wrist joint damage in different periods for experiments. The athlete who uses nanomaterials in wrist exercise rehabilitation is called Athlete A, and the other is called Athlete B. Rehabilitation training was carried out for two athletes, and the specific conditions of the radial joints, wrist joints and ulnar joints, were observed before and after the training, so as to analyze the role of nanomaterials in wrist joint sports rehabilitation.

3.2. Experimental Data. For the statistics on the degree of wrist joint damage of two basketball players before rehabilitation, the collected wrist-related data include the flexion and extension angles of the radius palm inclination angle, radius ulnar deflection angle, ulna carpal angle, radial moon angle, head moon angle, boat moon angle, carpal angle, radial head angle, and radial boat angle. Table 1 shows the degree of damage to the wrist of the two athletes.

The wrist joint damage data of the two athletes in Table 1 were collected in different periods. In the existing medical data, we can know that the normal angle of each carpal joint is shown in the rightmost column of Table 1. In addition, the medical data shows that the angle change of the palmar inclination angle of the radius indicates the fracture of the distal radius; the change of the ulnar deflection angle of the radius indicates the dislocation of the wrist joint or the fracture of the distal radius; the change of the ulnar angle indicates the fracture of the wrist or the dislocation of the wrist joint; radial-lunar flexion $> 15^\circ$ indicates unstable palm flexion, and dorsal extension $> 10^\circ$ indicates unstable back extension; head-lunar angle $> 20^\circ$ indicates wrist instability; boat moon angle $> 70^\circ$ indicates unstable wrist dorsal extension, and $<30^\circ$ indicates instability of wrist flexion; radial head angle $> 26^\circ$ indicates instability of the wrist joint; radial boat angle $> 75^\circ$ indicates instability of the wrist joint.

4. Discussion

4.1. Rehabilitation of the Radial Joint. We analyze the rehabilitation of the wrist joints of two basketball players and compare the rehabilitation of the radial joints of the two athletes with and without nanomaterials for sports rehabilitation training. In order to analyze the effect of nanomaterials on the exercise rehabilitation of the radial joint. With 7 days as a check cycle, we check the extension and flexion angles of the athlete's radius and ulnar angle, radial moon angle, radial head angle, and radial boat angle within 35 days. The final result is shown in Figure 1.

The broken line in Figure 1 represents the recovery of the radial ulnar angle and the radial moon angle of the radial joint within five weeks of athlete A and athlete B. The bar graph shows the recovery of the radial head angle and radial boat angle of the radial joints for athlete A and athlete B in five weeks. The data of radius ulnar angle and radial moon angle are subject to the data of the left main axis, and the data of radial head angle and radial boat angle are subject

Table 1: Wrist damage data table.

	Athlete A	Athlete B	Normal
Radial pal-mar angle	Normal	Normal	10-15°
Radius and ulnar deflection angle	15°	15°	21-25°
Ulnar angle	18°	18°	21-51°
Radial moon angle	Buckling15° Back stretch10°	Buckling13° Back stretch10°	0°
Head moon angle	25°	25°	0-15°
Boat moon angle	Buckling20° Back stretch75°	Buckling20° Back stretch75°	30-60°
Carpal angle	Normal	Normal	130°
Radial head angle	30°	30°	6-26°
Radial boat angle	80°	80°	55-75°

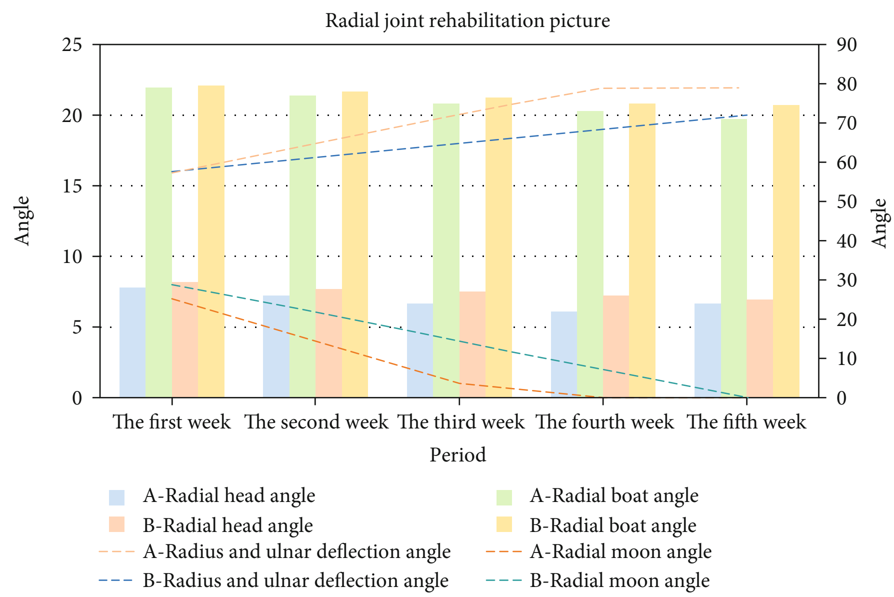

Figure 1: Comparison of the rehabilitation of the radius joint.

to the data of the right secondary axis. According to the data in Figure 1, it can be seen that athlete A's radial joint recovered faster than athlete B's in the same cycle. Therefore, the rehabilitation effect of sports rehabilitation training using nanofibers is better than that of sports rehabilitation training without nanofibers, and the recovery ability is stronger.

4.2. Rehabilitation of Other Parts of the Wrist. With 7 days as an inspection cycle, we check the recovery of the ulnar wrist angle, head moon angle, and boat moon angle of the two athletes within 35 days after sports rehabilitation training. The final result is shown in Figure 2.

According to Figure 2, the wrist joint recovery of the two athletes in five weeks can be seen, athlete A who uses nanofibers for sports rehabilitation has a faster recovery speed, and the time required for rehabilitation training is shorter. Athlete B who does not use nanofibers requires a longer period of time for sports rehabilitation and a slower recovery speed.

4.3. Comparison of Rehabilitation Effects between the Two. After five weeks of sports rehabilitation training for two athletes and observation, we can understand that nanofiber materials have a certain influence on the rehabilitation effect of wrist joint sports rehabilitation training. By comparing the degree of wrist joint recovery of the two athletes in five weeks, the final result is shown in Figure 3.

According to the data in Figure 3, it can be seen that the rehabilitation effect of athlete A who uses nanofiber materials for sports rehabilitation training is better than that without nanofiber materials. And before the end of the rehabilitation, the average degree of rehabilitation per week was 0.3 faster than that of athletes who did not use nanofiber materials. Ordinary sports rehabilitation training is about 2 times faster than wrist joints without rehabilitation training, and sports rehabilitation training using nanofiber materials is about 3 times faster than wrist joints without rehabilitation training.

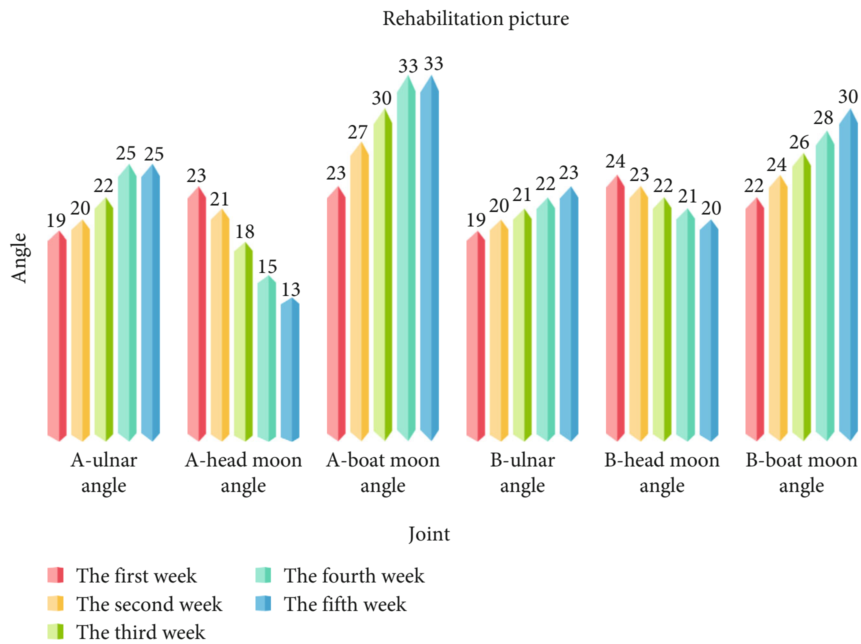

Figure 2: Rehabilitation of other parts of the wrist joint.

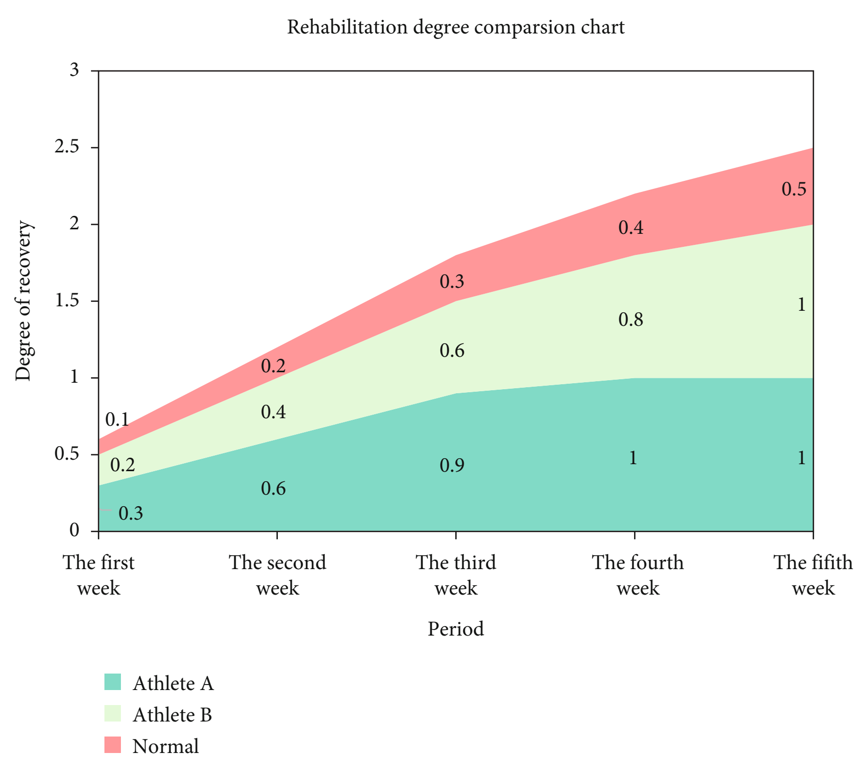

Figure 3: Comparison chart of rehabilitation degree.

4.4. The Application of Nanofibers in Sports Rehabilitation. By collecting data on sports rehabilitation in the past 5 years, we can understand the use of nanofiber materials in sports rehabilitation in recent years and analyze the proportion of nanofiber materials used in sports rehabilitation. The final result is shown in Figure 4.

It can be known from the data in Figure 4 that in the early years, the application of nanofiber materials in sports rehabilitation was relatively small, and it was in a state of research and development. Later, with the progress of science and technology and the mass production of nanofiber materials, as well as scholars' research on nanofiber materials. Nanofiber materials

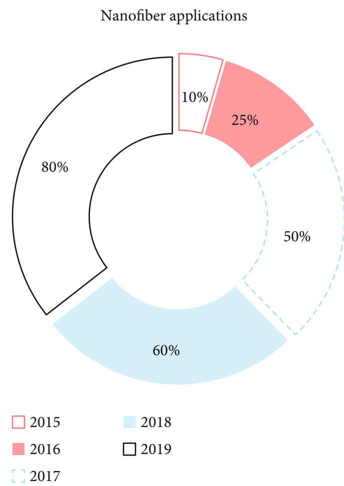

FIGURE 4: The use of nanofibers in sports rehabilitation.

have become more and more widely used in various fields. As many experiments have proved that nanofiber materials have good rehabilitation effects in sports rehabilitation, the application of nanofiber materials in sports rehabilitation is also increasing year by year.

This article has made corresponding research results on the application of nanofiber materials based on electrospinning technology in the rehabilitation of basketball athletes' wrist joints. However, due to the limited time, the experiment still has many areas to be improved and perfected. This experiment is based on the wrist joint as the research object. In the follow-up experiments, other parts can be combined with nanofiber materials for sports rehabilitation training, so as to understand the role of nanofibers in sports rehabilitation more comprehensively and concretely. Since this study only studied the inclination angle of each part of the wrist joint and did not consider other causes of damage to the wrist joint, the different degrees of damage to the wrist joint can be studied in future studies to ensure the integrity of the experiment.

5. Conclusions

The wrist joint is one of the more important joints on the human body. It connects the two parts of the arm and the palm and plays a vital role in the movement of the human hand. If the wrist joint is damaged; then, people's daily life will also be greatly affected, causing great inconvenience to people. Since the internal structure of the wrist joint in the human body is relatively complex, effective and rapid exercise rehabilitation is the focus of medical researchers.

This article conducts sports rehabilitation training on the wrist joints of basketball players and effectively combines nanofiber materials with sports rehabilitation training. By comparing the rehabilitation of athletes who did not use nanofiber materials, the role of nanofiber materials in sports rehabilitation was studied. Finally, the five-week experimental data of two athletes proved that the combination of nanofiber materials and sports rehabilitation can make the athlete's wrist joint rehabilitation faster and has a better rehabilitation effect than ordinary sports rehabilitation training.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no competing interests.

References

[1] R. A. Karasch, F. A. Brown, E. A. Smith, and W. C. Paske, "Objective screening parameters for training-rehabilitation of sports teams," *Journal of Clinical Engineering*, vol. 40, no. 4, pp. 210–219, 2015.

[2] J. Erben, T. Kalous, and J. Chvojka, "Ac bubble electrospinning technology for preparation of nanofibrous mats," *ACS Omega*, vol. 5, no. 14, pp. 8268–8271, 2020.

[3] R. J. Warzoha, R. M. Weigand, and A. S. Fleischer, "Temperature-dependent thermal properties of a paraffin phase change material embedded with herringbone style graphite nanofibers," *Applied Energy*, vol. 137, pp. 716–725, 2015.

[4] A. Iida, S. Omokawa, H. Moritomo et al., "Effect of wrist position on distal radioulnar joint stability: a biomechanical study," *Journal of Orthopaedic Research*, vol. 32, no. 10, pp. 1247–1251, 2014.

[5] X. Wu, S. Mahalingam, A. Amir et al., "Novel preparation, microstructure, and properties of polyacrylonitrile-based carbon nanofiber–graphene nanoplatelet materials," *ACS Omega*, vol. 1, no. 2, pp. 202–211, 2016.

[6] B. Yan, L. Chen, T. Wang, J. Xu, H. Wang, and G. Yang, "Preparation and characterization of $Li_3V_2(PO_4)_3$ grown on carbon nanofiber as cathode material for lithium-ion batteries," *Electrochimica Acta*, vol. 176, pp. 1358–1363, 2015.

[7] H. Ba, "Medical sports rehabilitation deep learning system of sports injury based on MRI image analysis," *Journal of Medical Imaging and Health Informatics*, vol. 10, no. 5, pp. 1091–1097, 2020.

[8] A. N. Pujari, R. D. Neilson, S. S. Aphale, and M. Cardinale, "Upper limb vibration prototype with sports and rehabilitation applications: development, evaluation and preliminary study," *Healthcare Technology Letters*, vol. 4, no. 1, pp. 44–49, 2017.

[9] S.-Y. Han, "Status and improvement direction of sports rehabilitation," *Korean Journal of Sports Science*, vol. 26, no. 1, pp. 197–208, 2017.

[10] S. Chavan and S. M. Shendokar, "Analysis of variance—electrospinning of nylon 6 nanofibers with optimum diameter," *Advanced ence Letters*, vol. 22, no. 4, pp. 808–814, 2016.

[11] L. R. Manea, R. Scarlet, N. Amariei, E. Nechita, and I. G. Sandu, "Study on behaviour of polymer solutions in electrospinning technology," *Revista de Chimie -Bucharest- Original Edition-*, vol. 66, no. 4, pp. 542–546, 2015.

[12] L. R. Manea, B. Cramariuc, V. Caunii, and I. Sandu, "Equipment for obtaining polimeric na-no fibers by electrospinning technology I. constructive and functional elements of the computerized electrospinning equipment," *Materiale Plastice*, vol. 52, no. 1, pp. 82–86, 2015.

[13] M. Mirjalili and S. Zohoori, "Review for application of electrospinning and electrospun na-no fibers technology in textile industry," *Journal of Nanostructure in Chemistry*, vol. 6, no. 3, pp. 1–7, 2016.

[14] F. C. Chang, K. K. Chan, and C. Y. Chang, “The effect of processing parameters on formation of lignosulfonate fibers produced using electrospinning technology,” *BioResources*, vol. 11, no. 2, pp. 4705–4717, 2016.

[15] E. Fallahiarezoudar, M. Ahmadipourroudposht, N. M. Yusof, and A. Idris, “Influence of process factors on diameter of core (γ-Fe2O3)/shell (polyvinyl alcohol) structure magnetic nanofibers during co-axial electrospinning,” *International Journal of Polymeric Materials*, vol. 64, no. 1, pp. 15–24, 2015.

[16] R. Ramakrishnan, J. Gimbun, F. Samsuri et al., “Needleless electrospinning technology – an entrepreneurial perspective,” *Indian Journal of ence & Technology*, vol. 9, no. 15, pp. 1–11, 2016.

[17] Y. Liu, A. Nguyen, A. Allen, J. Zoldan, Y. Huang, and J. Y. Chen, “Regenerated cellulose micro-nano fiber matrices for transdermal drug release,” *Materials ence and Engineering C*, vol. 74, pp. 485–492, 2017.

[18] R. Al-Attabi, Y. Morsi, J. A. Schutz, and L. F. Dumée, “One-pot synthesis of catalytic molybdenum based nanocomposite nano-fiber membranes for aerosol air remediation,” *Environment*, vol. 647, pp. 725–733, 2019.

[19] D. Lei, L. Zhu, and L. O. Papermaking, “Cellulose na-no fibers reinforced electrospun nano-fiber mats containing poly(vinyl alcohol) and waterborne polyurethane,” *Journal of Functional Materials*, vol. 46, no. 3, pp. 03110–03114, 2015.

[20] K. Kobayashi, K. Kazama, and M. Sakamoto, “In vivo assessment of articular contact at radiocarpal joint during dorsal/palmar flexion and ulnar/radial deviation,” *Experimental Mechanics*, vol. 3, no. 1, pp. 215–220, 2018.

[21] A. H. Törnvall, F. A. Ekenstam, C. G. Hagert, and L. Irstam, “Radiologic examination and measurement of the wrist and distal radio-ulnar joint: new aspects,” *Acta Radiologica Diagnosis*, vol. 27, no. 5, pp. 581–588, 1986.

[22] Q. Huasheng, P. Weimin, L. Ran, and L. Xintong, “Sports rehabilitation of chronic ankle instability: research status and characteristics,” *Chinese Journal of Tissue Engineering Research*, vol. 36, no. 1, pp. 7-8, 2018.

[23] M. Schmitt-Sody and C. Valle, “Rehabilitation after sports injuries : current concepts and data,” *Der Unfallchirurg*, vol. 118, no. 2, pp. 122–129, 2015.

[24] W. Daan, “Dilemma and countermeasure on talent training and teaching of "trinity" sports rehabilitation,” *Contemporary Sports Technology*, vol. 18, no. 7, pp. 7–10, 2017.

[25] T. Dn, “Hybridized hierarchical deep convolutional neural network for sports rehabilitation exercises,” *IEEE Access*, vol. 8, no. 1, pp. 118969–118977, 2020.