DIAGNOSIS AND TRAINING BY IMAGING TECHNOLOGY IN KNEE INJURIES IN BASKETBALL

DIAGNÓSTICO E TREINAMENTO POR TECNOLOGIA DE IMAGEM EM TRAUMATISMOS DO JOELHO NO BASQUETEBOL

DIAGNÓSTICO Y ENTRENAMIENTO MEDIANTE TECNOLOGÍA DE IMAGEN EN LESIONES DE RODILLA EN BALONCESTO

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ABSTRACT

Introduction: The research and development of new methods of injury diagnosis and rehabilitation training in benefits to the health and training of athletes is a contemporary priority. Among modern techniques, diagnostic imaging technology stands out. Objective: Study the auxiliary effect of imaging technology in the diagnosis and rehabilitation training of functional knee joint injuries in basketball practice. Methods: 50 basketball players diagnosed and treated in the past four years for knee joint function injuries in a special hospital were selected, including 28 male and 22 female athletes, aged 17 to 25 years. PerkinElmer Spotlight-300 FTIR spectral imaging system was used to scan the articular cartilage sections, visible light and total absorption images of the samples were obtained by reflection mode imaging. Results: The peak infrared feature of the articular cartilage measured by the infrared spectrum imaging technology is very consistent with the FTIR spectrum. After rehabilitation training, the Y test score of female patients increased from 96.72 ± 6.05 to 105.40 ± 4.23, and the Y test score of male patients increased from 98.34 ± 5.33 to 105.51 ± 4.89, showing significant differences. Conclusion: Infrared spectrum imaging technology is an effective technique for identifying functional knee joint injury, and is of great use for diagnosis and training update in basketball players with knee trauma. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Knee Injuries; Diagnostic Imaging; Basketball; Athletes.

RESUMO

*Introdução: A pesquisa e o desenvolvimento de novos métodos de diagnóstico de lesões e treinamento de reabilitação em benefícios para a saúde e o treinamento dos atletas é uma prioridade contemporânea. Entre as técnicas modernas, destaca-se o diagnóstico por tecnologia de imagem. Objetivo: Estudar o efeito auxiliar da tecnologia de imagem no diagnóstico e treinamento de reabilitação das lesões funcionais das articulações do joelho na prática do basquetebol. Métodos: Foram selecionados 50 jogadores de basquetebol diagnosticados e tratados nos últimos quatro anos por lesões da função articular do joelho em um hospital especial, incluindo 28 atletas masculinos e 22 atletas femininos, com idade entre 17 e 25 anos. O sistema de imagem espectral PerkinElmer Spotlight-300 FTIR foi usado para escanear as seções de cartilagem articular, a luz visível e as imagens de absorção total das amostras foram obtidas através da imagem em modo de reflexão. Resultados: O pico da característica infravermelha da cartilagem articular medida pela tecnologia de imagem de espectro infravermelho é muito consistente com o espectro FTIR. Após o treinamento de reabilitação, o escore do teste Y de pacientes do sexo feminino aumentou de 96,72 ± 6,05 para 105,40 ± 4,23, e o escore do teste Y de pacientes do sexo masculino aumentou de 98,34 ± 5,33 para 105,51 ± 4,89, mostrando diferenças significativas. Conclusão: A tecnologia de imagem de espectro infravermelho é uma técnica eficaz para identificar a lesão funcional da articulação do joelho, sendo de grande utilidade para o diagnóstico e atualização de treinamento em praticantes de basquetebol com traumatismos no joelho. **Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Traumatismos do Joelho; Diagnóstico por Imagem; Basquetebol; Atletas.*

RESUMEN

Introducción: La investigación y el desarrollo de nuevos métodos de diagnóstico de lesiones y entrenamiento de rehabilitación en beneficios para la salud y el entrenamiento de los deportistas es una prioridad contemporánea. Entre las técnicas modernas destaca el diagnóstico por tecnología de imagen. Objetivo: Estudiar el efecto auxiliar de la tecnología de imagen en el diagnóstico y entrenamiento de rehabilitación de lesiones funcionales de la articulación de la rodilla en la práctica del baloncesto. Métodos: Se seleccionaron 50 jugadores de baloncesto diagnosticados y tratados en los últimos cuatro años por lesiones funcionales de la articulación de la rodilla en un hospital especial, incluidos 28 atletas de sexo masculino y 22 de sexo femenino, con edades comprendidas entre los 17 y los 25 años. Se utilizó el sistema de imágenes espectrales FTIR PerkinElmer Spotlight-300 para escanear las secciones de cartílago articular, y se obtuvieron imágenes de luz visible y de absorción total de las muestras mediante imágenes en modo de reflexión. Resultados: El pico infrarrojo del cartílago articular medido mediante la tecnología de imagen de espectro infrarrojo es muy coherente

con el espectro FTIR. Tras el entrenamiento de rehabilitación, la puntuación de la prueba Y de las pacientes femeninas aumentó de 96,72 ± 6,05 a 105,40 ± 4,23, y la puntuación de la prueba Y de los pacientes masculinos aumentó de 98,34 ± 5,33 a 105,51 ± 4,89, mostrando diferencias significativas. Conclusión: La tecnología de imágenes del espectro infrarrojo es una técnica eficaz para identificar lesiones funcionales de la articulación de la rodilla, y es de gran utilidad para el diagnóstico y la actualización del entrenamiento en jugadores de baloncesto con traumatismo de rodilla. ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

***Descriptores*:** *Traumatismos de la Rodilla; Diagnóstico por Imagen; Baloncesto; Atletas.*

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INTRODUCTION

Due to the strong antagonism of basketball, there will be more frequent application of body collision, jumping, and flying techniques in the process of basketball.[1] For athletes, there is a high probability of sports injury during training and competition. At the same time, because the external factors such as the surrounding field or environment, as well as the internal factors such as the technical level and physical quality of basketball players themselves, may affect the state of basketball players when they play basketball, so the sports injury problem of basketball players occurs very frequently.[2] The problem of lower limb injury, including knee joint function injury, is particularly serious. There are many diagnostic methods for sports injury, for example, the pathological changes of the patient's knee joint can be detected through common imaging methods, including obvious bone spurs, joint space reduction, subchondral bone sclerosis and cysts.[3] In addition, through clinical observation, it can be found that the affected knee joint has obvious movement obstruction, the patient's movement ability is reduced, and there is clear bone friction sound during joint movement.[4] In this paper, infrared spectrum imaging technology is introduced into the detection of knee joint injury in basketball to evaluate and analyze the risk of injury and the location and cause of injury. To reveal the therapeutic effect of physical therapy after knee joint injury in basketball.[5] To provide effective technical support for improving the sports state and life of the athletes, as well as effective recovery training after injury. And the infrared spectrum imaging technology used in this paper is applicable to all kinds of athletes and has a good sense of use experience.[6] It can be popularized in a variety of sports scenes to increase the security of athletes.

METHOD

Research object information

Through retrospective collection of 50 basketball players diagnosed and treated for knee joint function injury in a special hospital in the past four years, including 28 male athletes and 22 female athletes, aged 17-25 years old, 27 left knee and 23 right knee injuries. The study and all the participants were reviewed and approved by Ethics Committee of Longyan University (NO.LYUST107). The clinical manifestations of the patient are pain and swelling of the knee joint, limited extension and flexion activities, and a certain degree of weight bearing disorder. Physical examination showed that Lachman test was positive, knee joint effusion, etc. Before the experiment, all patients had a certain understanding of the study and signed the informed consent form.

Experimental equipment and principle

The infrared spectral imaging technology total reflection accessory in the form of probe must introduce the infrared light in the Fourier transform infrared spectrometer into the infrared spectral imaging technology probe crystal, and return the infrared light to the spectrometer's light import and export components after the total reflection occurs on the inner surface of the contact between the crystal and the sample. Optical conduits and optical fibers are common light import and export components. However, due to the limitation of optical conduit, it cannot meet the requirements of this system.

The device adopts mid-infrared hollow optical fiber. The optical fiber is supported by silicon tube and coated with silver and silver iodide from the outside to the inside. The optical bandwidth (800~4000cm-1), optical characteristics and transmission performance are good (the maximum loss of straight line and bending are 2.5dB/m and 3dB respectively), which can minimize optical loss. The acrylate protective layer on the outer layer of the silicon tube has good flexibility and non-toxicity, which can realize in vivo or in vivo detection in the biomedical field.

Image acquisition control

Before image acquisition, it is necessary to select a suitable environment to avoid the influence of external factors. Due to the measured image information of the knee joint, too high will cause sweating, and too low will make the skeletal muscle tremble. The change of body surface temperature will affect the measurement results, so the measurement environment in this paper is indoor, and the temperature is controlled between 25°C and 27°C. At the same time, it is also necessary to control the ambient humidity and air dust content to reduce the impact of particles and dust on infrared radiation. Therefore, the test environment is relatively dry and the air quality is good. During the shooting process, the distance between the subject and the equipment is 20cm to ensure that the knee joint is fully measured, which can be manually adjusted according to the actual situation of the subject. Before shooting, the equipment parameters need to be adjusted. Since the human body temperature is generally about 37°C, the knee joint surface temperature is slightly higher, and the room temperature is between 25°C and 27°C, the temperature of the infrared thermal imager is set within the range of 27°C - 38°C. The emissivity is set at 0.99 standard.

When measuring, the subjects should ensure that their knees are completely exposed, wear loose and light clothes, keep stable in the measuring environment, and take photos and measurements after 10 minutes of adaptation.

Image processing method

The PerkinElmer Spotlight-300 FTIR spectral imaging system was used to scan the sections of healthy and diseased articular cartilage, and the visible light and total absorption images of the samples were obtained through reflection mode imaging.

The content of proteoglycans in the surface and transition areas of articular cartilage is unstable, and the length of the lower surface of cartilage is 200 μ The infrared spectrum used for SVC is organized within the range of m, every 10 μ M is a group of joint spectra. From cartilage 0 to 640 μ The slices of infrared spectrum used for SVR concentration calculation are obtained within the radial depth range of m, every 10 μ M Take a group of joint spectra. Because the edge effect will affect the quality of the slice, one or two spectra of the edge of the surface area will be ignored in the spectral extraction. Table 1 shows the experimental

Table 1. Vertical section and infrared spectrum information table of articular cartilage.

Grouping	Cartilage sample number	Length x width (um)	Spectral extraction area (um)	Infrared spectrum number
Health samples	AC-1-1sec	985x100	30~210	1-1~1-20
	AC-1-2sec	970x100	20~210	1-21~1-40
	AC-1-3sec	955x100	10~200	1-41-60
	AC-1-4sec	900x100	10~200	1-61~1-80
2-year lesion sample	0A-2Y-1-lsec	970x100	0-200	1-81~1-100
	OA-2Y-1-2sec	955x100	20~220	1-101~1-120
	OA-2Y-1-3sec	1250x100	30~240	1-121~1-140
	OA-2Y-1-4sec	960x100	40~250	1-141~1-160
	OA-2Y-1-5sec	955x100	0-720	1-161~1-192

spectrum number. The SVC and SVR models can be extracted by the Spotlight software of the FTIR spectral imaging system, and constructed and calculated by the Unscrambler X (CAMO Software, Inc., Woodbridge, NJ) multivariate statistical analysis software.

RESULTS

Infrared imaging results of diseased tissue

Figure 1 shows the infrared total absorption image of the cartilage tissue section of the diseased joint in 2 years. Compared with the healthy control, the content of collagen decreased, and the content of proteoglycan in the surface and transition areas also decreased significantly. Because the relative change of the content of the same sample component can be expressed by absorbance. Therefore, with the help of chemometrics algorithms, healthy and diseased articular cartilage tissue can be identified and predicted.

Comparison of FTIRI articular cartilage infrared spectrum effects

Compare the spectrum with the spectrum of articular cartilage obtained by FTIRI. Figure 2 shows the results. The black curve in the figure represents the spectrum obtained using FTIRI, and the vertical coordinate on the right represents its absorbance; The red curve and blue dotted line respectively represent the infrared spectrum at the close position of the articular cartilage measured by the optical fiber ATR measuring device, and the left vertical coordinate is its absorbance.

It can be seen from Figure 2 that the infrared characteristic peaks of articular cartilage measured by infrared spectral imaging technology are in high consistency with FTIRI spectrum. Some characteristic peaks of infrared spectrum imaging technology have shifted slightly, which is because with the change of wavelength, the equivalent penetration depth of attenuation wave is different, resulting in different infrared wavelength absorption of samples. These differences can be ignored. In addition, the difference in spectral absorbance of infrared spectral imaging technology at the adjacent positions shown in the figure is caused by the different contact pressure between the infrared spectral imaging technology crystal probe and articular cartilage tissue. Under different pressure, the contact condition between articular cartilage and the lower cone of infrared spectral imaging technology crystal probe is different, and the spectral absorption intensity will be different. This point can be explored by adding pressure sensing devices.

Measuring effect of glycerol reagent

Glycerin reagent has a single component, standard spectral data is easy to obtain, and can well contact the crystal probe of infrared spectral imaging technology. Therefore, it is very suitable for verifying spectral quality. The device measures glycerol and compares the scanning results with the standard spectrum to verify whether the mid-infrared hollow fiber ATR coupling probe can be used for the infrared spectrum detection of substances. Figure 3 shows the detection results. The black curve represents the measured spectrum of infrared spectral imaging technology, and the gray curve represents the standard spectrum of glycerol (NITS database). It can be seen that the measured results of glycerol reagent are basically consistent with the results of standard spectrum.

Sample monitoring accuracy

The spectrum of articular cartilage obtained by different preprocessing methods and combination processing, the original and pretreated spectral data are dimensionally reduced by PCA, and the influence of preprocessing methods on spectral characteristics is analyzed on the basis of calculating the scatter diagram of each spectral score matrix. Because of the large difference between the spectra of normal samples and 2-year pathological samples, and the change in the surface area of cartilage matrix is the most obvious. The one-dimensional classification vector of normal articular cartilage and 2-year lesion sample spectrum is

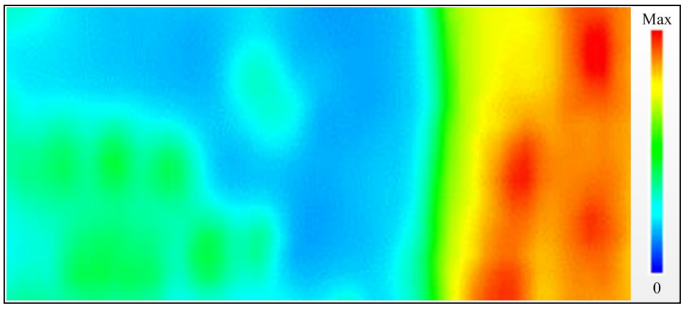

Figure 1. Characteristic absorption image of articular cartilage tissue of the lesion (male, 22 years old, left knee joint injury for 2 years).

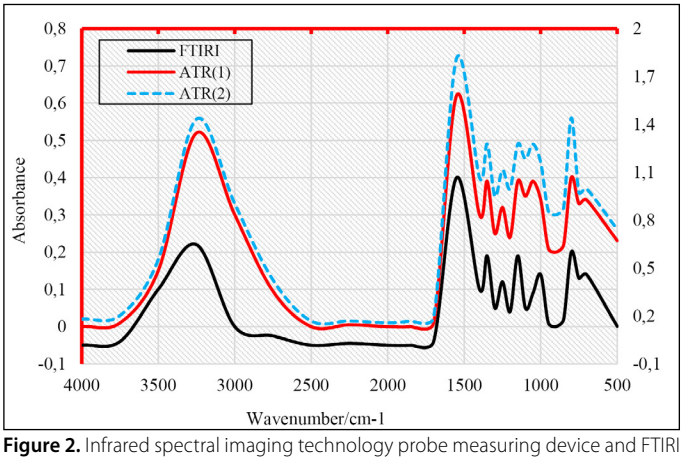

Figure 2. Infrared spectral imaging technology probe measuring device and FTIRI articular cartilage infrared spectral contrast map.

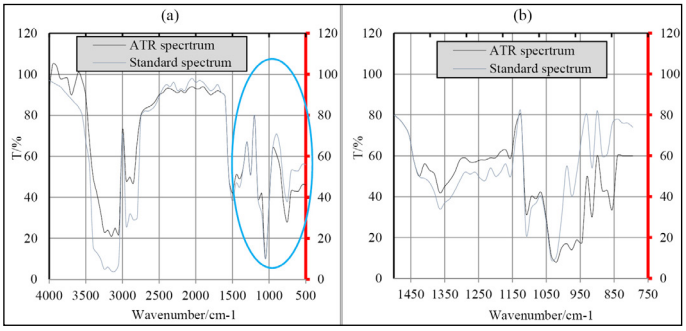

Figure 3. Comparison diagram of glycerol spectrum measured by optical fiber infrared spectrum imaging technology probe measuring device and standard glycerol spectrum. ((a) Comparison diagram of the two spectra at full band (b) Comparison diagram of the spectra in the elliptical region after amplification)

sufficient to meet the requirements. Set the classification matrix in the model as a one-dimensional classification vector, 1 and 0 are the spectra of normal articular cartilage and pathological samples respectively. Set 0.5 as the threshold value. According to the above parameters, the PLS-DA algorithm is used to build a classification model based on the training group spectral data, and classify and recognize the prediction group spectra. Table 2 shows the PLS-DA classification results of the original and pretreated spectra. The spectra of both training groups were correctly identified. The spectral pretreatment method has a good optimization effect on the prediction ability of PLS-DA model, and the overall accuracy can reach 96.92%.

Effect analysis of rehabilitation training

The Y-balance test can effectively balance the knee joint of basketball players. The specific data of the external balance scores of all patients after the evaluation of rehabilitation training are shown in Table 3. All patients showed significant differences in external balance scores after rehabilitation training intervention. The data analysis results can prove that rehabilitation training can effectively improve the balance stability of knee joint patients.

DISCUSSION

With the rapid development of imaging, the application of various computer imaging techniques in sports injury is gradually popularized. Computer imaging technology has the characteristics of non-invasive, radiation-free, multi-directional, high-resolution and so on. Compared with traditional diagnosis methods, computer imaging technology is more specific and perfect, which is of great significance for the subsequent injury identification and rehabilitation treatment of athletes. The research results of this paper prove the effectiveness of infrared imaging technology in the examination of knee joint injury of basketball players. It can combine multiple sequences to improve the accuracy of the diagnosis of knee joint cartilage and ligament. Especially when the athlete's knee joint cartilage is injured, but it is not certain whether the injury extends to other parts, the infrared imaging technology can further enhance the examination results, which can judge the injury level and movement ability of the pain part to a certain extent, and is of great significance for the selection of clinical treatment plan. It can reduce the missed diagnosis during film reading due to poor display of primary lesions or the existence of certain blind areas. By accurately judging the location of knee joint lesions, the degree of injury and the basic situation of the surrounding parts, it can provide valuable information for the treatment plan in the follow-up rehabilitation treatment process and conduct a more comprehensive evaluation of the treatment effect. This is of great significance to the rapid recovery of basketball players and the subsequent training and competition.

Table 2. Identification accuracy.

	Accuracy of training group	Prediction group accuracy	Number of misjudgments of normal samples	Number of misdiagnoses of pathological samples
Original spectrum	100%	91.57%	0	11
Pretreatment spectrum	100%	98.82%	0	3

Table 3. Comparison of Y balance (%) scores of knee joint patients before and after rehabilitation training.

Group	Before intervention	After intervention
Female patients	96.7295±6.0525	105.4061±4.2327*
Male patients	98.3482±5.3386	105.5167±4.8962*

Note: * represents that the result is compared with that before intervention, P<0.05.

CONCLUSION

Sports injury refers to all kinds of injuries occurring in the process of sports, which are related to the intensity of the movement of the sportsman, the external environment in which he is exercising, whether he has the corresponding sports conditions and the training intensity of the exercise. With the popularity of basketball in the world, the performance and technical requirements of basketball are gradually improved. Therefore, in order to achieve the best results, the probability of basketball players' sports injuries has also increased significantly. The sports injury of basketball players will seriously affect the current competition and training schedule, and even have a lasting impact on subsequent competitions. And for athletes, sports injuries are usually not only once. Previous studies have found that the body parts that are more prone to sports injury are often the parts that have been injured before. Based on the better diagnosis of basketball athletes' sports injuries, taking knee joint injuries as an example, this paper integrates infrared spectral imaging technology into the diagnosis of injuries, providing a reference for improving measures to avoid sports risks and promote rehabilitation treatment, providing direction for Feng to create a safe sports environment, and further promoting the optimization of basketball training.

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AUTHORS' CONTRIBUTIONS: The author has completed the writing of the article or the critical review of its knowledge content. This paper can be used as the final draft of the manuscript. Every author has made an important contribution to this manuscript. Dan Luo and Yuze Liu: writing and execution.

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