COMPUTED TOMOGRAPHY MEDICAL IMAGE ANALYSIS OF BASKETBALL PLAYERS' BONE GEOMETRY

ANÁLISE DE IMAGENS MÉDICAS POR TOMOGRAFIA COMPUTADORIZADA DA GEOMETRIA ÓSSEA DE JOGADORES DE BASQUETE

ANÁLISIS DE IMÁGENES MÉDICAS POR TOMOGRAFÍA COMPUTARIZADA DE LA GEOMETRÍA ÓSEA DE JUGADORES DE BALONCESTO

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ABSTRACT

Introduction: Basketball sports will effect on the morphology and structure of the hand bones and joints. Objective: The article selected nine professional basketball players (basketball group) and 11 non-basketball players (control group) in the provincial youth team. A 64-row spiral computed tomography scan was used to scan the wrist and three-dimensional reconstruction. The volume of each carpal bone and the computed tomography value (bone density) were measured. Methods: To explore the influence of basketball sports on the hand bones and joints' morphological structure, the paper analyzes the structural characteristics of the computed tomography images of young male basketball players' wrist bones. Results: Compared with the carpal bones in the control group, the volume of the right navicular bone and the small polygonal bone, the left-hand navicular bone, the large triangular bone, and the small polygonal bone in the basketball group increased significantly (P<0.05). Conclusions: Basketball can increase the volume of the part of the wrist bones of adolescent male athletes and reduce the bone density; the morphological structure of the non-smashing wrist bones of basketball players has similar changes to that of the spikers. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Sports nutritional physiological phenomena; Bone density; Tomography; Wrist; Basketball.

RESUMO

Introdução: O basquetebol afetará a morfologia e a estrutura dos ossos e articulações da mão. Objetivo: o artigo selecionou nove jogadores profissionais de basquete (grupo de basquete) e 11 não jogadores de basquete (grupo de controle) da equipe juvenil da província. Uma tomografia computadorizada espiral de 64 linhas foi usada para digitalizar o punho e a reconstrução tridimensional. O volume de cada osso do carpo e o valor da tomografia computadorizada (densidade óssea) foram medidos. Métodos: Para explorar a influência dos esportes de basquete sobre os ossos da mão e a estrutura morfológica das articulações, o artigo analisa as características estruturais das imagens de tomografia computadorizada de ossos do punho de jovens jogadores de basquete do sexo masculino. Resultados: Em comparação com os ossos do carpo no grupo de controle, o volume do osso navicular direito e o osso poligonal pequeno, o osso navicular esquerdo, o osso triangular grande e o osso poligonal pequeno no grupo de basquete aumentaram significativamente (P <0,05). Conclusões: O basquete pode aumentar o volume dos ossos do punho de atletas adolescentes do sexo masculino e reduzir a densidade óssea; a estrutura morfológica dos ossos do pulso que não se quebram em jogadores de basquete tem mudanças semelhantes às dos espigões. ***Nível de evidência II; Estudos terapêuticos-investigação dos resultados do tratamento.***

Descritores: *Fenômenos fisiológicos da nutrição esportiva; Densidade óssea; Tomografia; Punho; Basquetebol.*

RESUMEN

Introducción: el baloncesto afectará la morfología y la estructura de los huesos y articulaciones de la mano. Objetivo: El artículo seleccionó nueve jugadores de baloncesto profesionales (grupo de baloncesto) y 11 jugadores no baloncesto (grupo de control) en el equipo juvenil provincial. Se utilizó una tomografía computarizada en espiral de 64 filas para escanear la muñeca y la reconstrucción tridimensional. Se midieron el volumen de cada hueso del carpo y el valor de la tomografía computarizada (densidad ósea). Métodos: Para explorar la influencia de los deportes de baloncesto en la estructura morfológica de los huesos de la mano y las articulaciones, el artículo analiza las características estructurales de las imágenes de tomografía computarizada de los huesos de la muñeca de los jóvenes jugadores de baloncesto. Resultados: En comparación con los huesos del carpo en el grupo de control, el volumen del hueso navicular derecho y el hueso poligonal pequeño, el hueso navicular izquierdo, el hueso triangular grande y el hueso poligonal pequeño en el grupo de baloncesto aumentaron significativamente (P <0,05). Conclusiones: El baloncesto puede aumentar el volumen de los huesos de la muñeca de los deportistas varones adolescentes y reducir la densidad ósea; la estructura morfológica de los huesos de las muñecas que no se rompen de los jugadores de baloncesto tiene cambios similares a los de los atacantes. ***Nivel de evidencia II; Estudios terapéuticos- investigación de los resultados del tratamiento.***

Descriptores: *Fenómenos fisiológicos en la nutrición deportiva; Densidad osea; Tomografía; Muñeca; Baloncesto.*

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INTRODUCTION

To explore the impact of basketball sports on the morphology and structure of the hand bones and joints, this study selected provincial professional young male basketball players as the research object, using computed tomography (CT) and digital image processing technology to quantitatively observe the adaptability of the wrist bone volume and density change.[1] This research not only provides a basis for the anatomical analysis of basketball players' wrist skeletal movement but also provides a theoretical basis for young athletes' bone development, selection, scientific training, and biomechanical research.

METHODS

Research object

The thesis selects nine professional young male basketball players as the experimental group, all of which are right-handed smashers. Simultaneously, the thesis selects 11 non-professional athletes from other events as the control group, all of which are right-handed.

Image scanning

The thesis uses GE LightSpeed 64-slice spiral CT. The subject was placed in a prone position, palms down on top of the head. The scanning range is the palms of both wrists. Scanning field of view: 30cm×30cm; tube voltage 120kV, tube current 250mA. Detector: 64mm×0.625mm, pitch: 0.984:1. Bed speed: 9.84mm/s; scanning layer thickness 0.6mm, scanning distance 0.3mm.

Data collection and measurement

We obtain two sets of raw wrist data and use the 3D reconstruction tool in Analyze AW 4.3 to perform image post-processing. Bone density (BMD) is the amount of bone mineral contained in a unit area of bone, and it is an important indicator reflecting the metabolism of human bones.so we choose the CT value to represent the bone density.[2] The CT value is converted from the X-ray absorption coefficient of the tissue in Hu.

Motion estimation algorithm of the basketball motion model

The paper first defines the image sequence $I(x,y,t)$ as the projection of a three-dimensional scene on a two-dimensional image plane, so the projection of the same scene at different times naturally establishes a corresponding relationship between pixels in different frames. This relationship generally uses a two-dimensional vector field. (U_x, U_y) means that there is a correspondence between all x, y, t_1 and t_2 pixels $I(x+U_x(x,y,t_2), y+U_y(x,y,t_2), t_1)$ and $I(x,y,t_2)$. Generally, (U_x, U_y) is called the basketball playground of the image and $E(x,y,t_2) = I(x,y,t_2) - I(x+U_x(x,y,t_2), y+U_y(,x,y,t_2)t_1)$ is defined as the inter-frame prediction error image. In theory, if the lighting conditions remain unchanged, the more accurate the basketball stadium (U_x, U_y) is estimated, the smaller the inter-frame prediction error.[3] Figure 1 shows the motion estimation algorithm flow of the basketball motion model. Here are several basketball motions models:

Second-order geometric transformation

It can model complex basketball motion situations such as translation, rotation, enlargement or reduction, curling, miscutting, and irregular stretching.[4-5] The formula is as follows:

$$\begin{pmatrix} U_x \\ U_y \end{pmatrix} = \begin{pmatrix} a_1x^2+b_1xy+c_1y^2+d_1x+e_1y+f_1 \\ a_2x^2+b_2xy+c_2y^2+d_2x+e_2y+f_2 \end{pmatrix} \quad (1)$$

Equation (1) uses 12 parameters to represent a model. If the four parameters of b_1, c_1, a_2 and b_2 are always 0, then (1) degenerates into an 8-parameter model:

$$\begin{pmatrix} U_x \\ U_y \end{pmatrix} = \begin{pmatrix} a_1x^2+d_1x+e_1y+f_1 \\ a_2y^2+d_2x+e_2y+f_2 \end{pmatrix} \quad (2)$$

Furthermore, if a_1 and c_2 are always 0, then (2) will become an affine transformation. Figure 2 shows the second-order geometric transformation process.

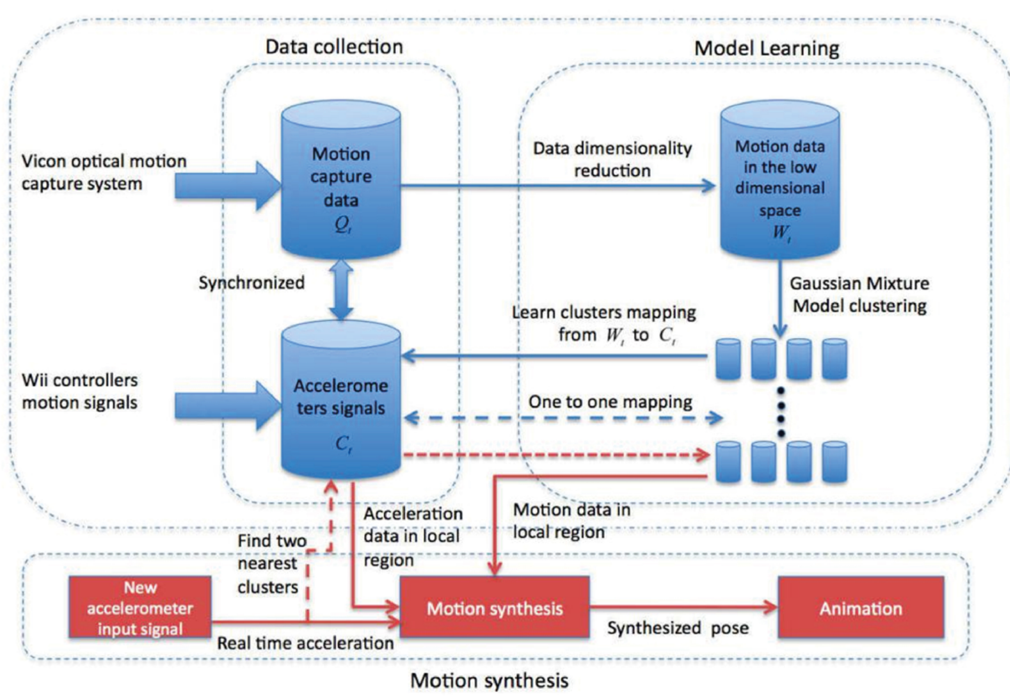

Figure 1. Motion estimation algorithm of the basketball motion model.

Affine transformation

It can model basketball movements such as translation, rotation, zoom in or zoom out, and the formula is as follows:

$$\begin{pmatrix} U_x \\ U_y \end{pmatrix} = \begin{pmatrix} a_1x+e_1y+f_1 \\ a_2x+e_2y+f_2 \end{pmatrix} = \begin{pmatrix} s_x & q \\ q & s_y \end{pmatrix} \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} f_1 \\ f_2 \end{pmatrix} \quad (3)$$

(3) The formula is determined by six parameters. If let $q = 0, s = s_x = s_y$, then formula (3) degenerates into a 4-parameter model, namely:

$$\begin{pmatrix} U_x \\ U_y \end{pmatrix} = s \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} f_1 \\ f_2 \end{pmatrix} \quad (4)$$

If you further simplify, let $s = 1, \theta = 0$, then the affine transformation will become a pure translation model. Figure 3 shows the affine transformation.

Translation Transformation

It can model the translational basketball movement of rigid objects with the following formula:

$$\begin{pmatrix} U_x \\ U_y \end{pmatrix} = \begin{pmatrix} f_1 \\ f_2 \end{pmatrix} \quad (5)$$

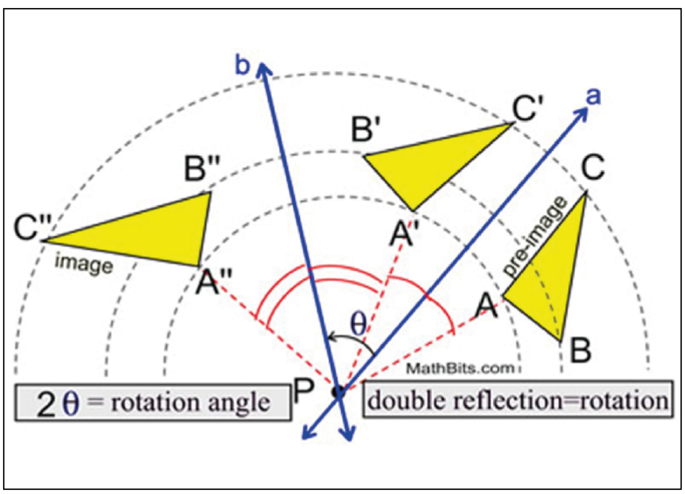

Figure 2. The second-order geometric transformation process.

Figure 4 shows the algorithm flow of translation transformation. Therefore, there must be a reasonable criterion to decide which model to use. The criterion should at least consider the following requirements.

The first is that the number of bits for coding the model parameters is less: because the increase of the model parameters will bring a lot of coding information, which is not conducive to compression; reasonable computational complexity. If each model parameter is described with 8-bit precision when the full search algorithm is used, the 2-parameter model requires $(2^8)^2$ searches, and the 12-parameter model requires $(2^8)^{12}$ searches. The latter is an astronomical number, even if the optimization algorithm is used to find the model parameters. The increase of parameters will also bring massive complexity to the optimization algorithm, and it is almost impossible to find the optimal global solution.

Statistical processing

The paper calculates each wrist bone volume, the mean and standard deviation of CT values in the basketball and control groups. It calculates the difference between the two groups with an independent sample t-test, and the significance level is 0.05.

RESULTS

.arpal volume

After three-dimensional reconstruction, each carpal bone is shown in Figure 5, and the measurement results are shown in Table 1 and Table 2. Table 1 shows that the volume of the navicular bone of the right hand in the basketball group was (3.77±0.67) cm3, and the volume of the small polygonal bone was (1.96±0.35) cm3, which were more extensive than the corresponding wrist bone volume of the right hand of the control group (P<0.05). The volume of the left navicular bone in the basketball group was (3.65±0.7) cm3, the large horn bone was (2.83±0.49) cm3, and the small polygonal bone was (1.91±0.3) cm3, which were more extensive than the corresponding carpal bone volume of the left hand in the control group (P>0.05).

Carpal CT value

It can be seen from Table 2 that the CT value of the right triangle one of the basketball group is 454.56±61.95, the pea bone is 363.44±37.02, the large-angle bone is 393±45.66, and the hook bone is 408.78±51.25, which are respectively smaller than the corresponding CT values of the right wrist-bone of the control group (P<0.05). The left hook bone's CT value in the basketball group was 402.44±52.02, and the control group was 456.64±52.91. The difference between the two groups was significant (P<0.05). CT values of other carpal bones were not statistically significant.[6-7] There was no significant difference in the left and right wrists (P>0.05).

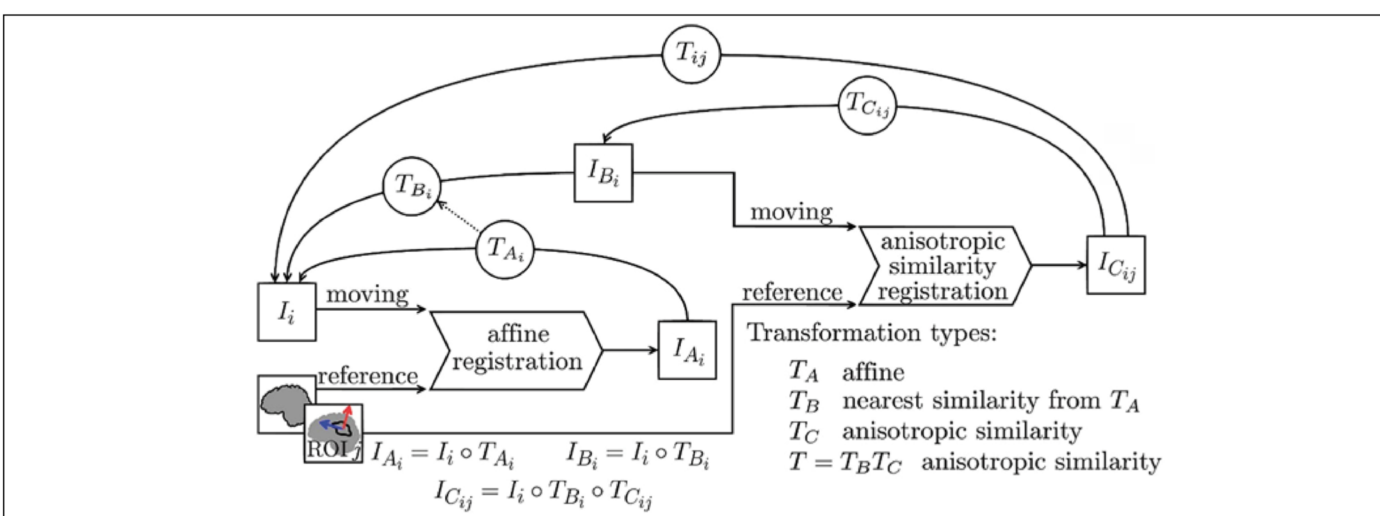

Figure 3. Affine transformation process

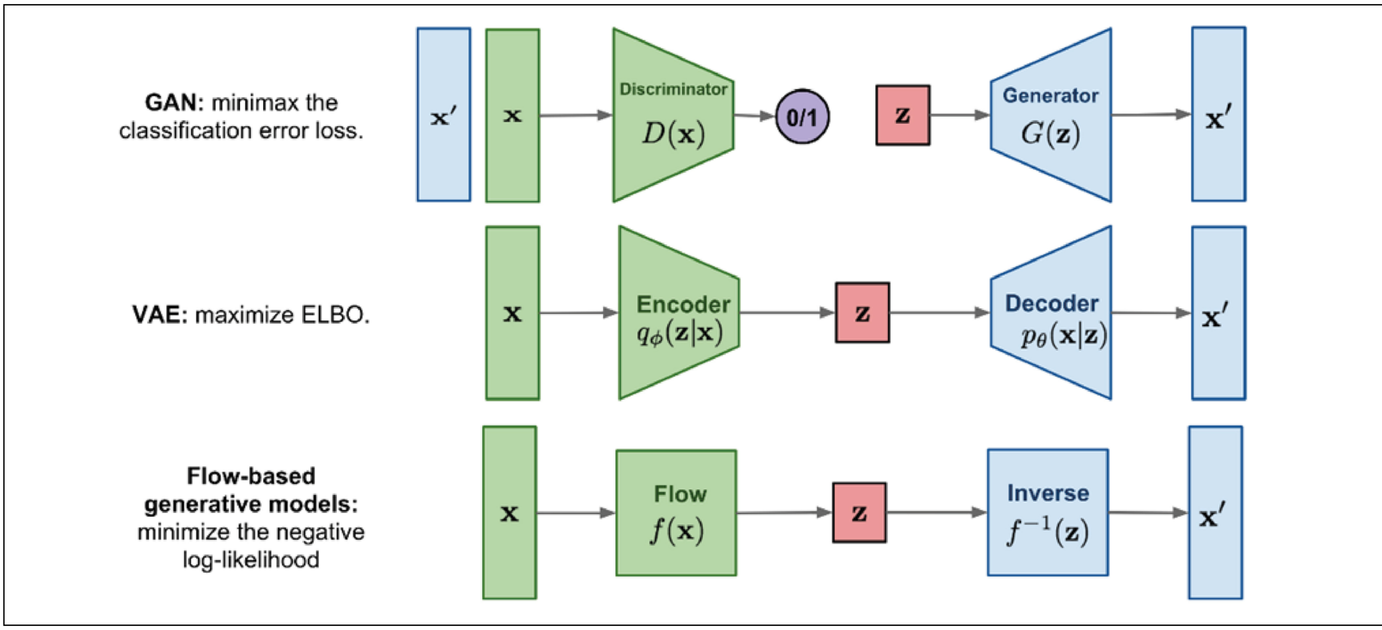

Figure 4. Translation transformation algorithm flow.

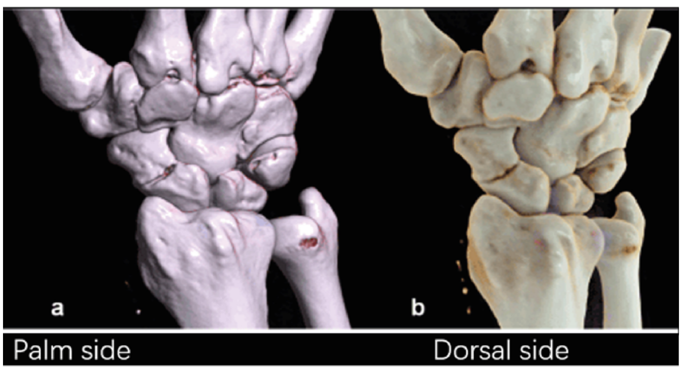

Figure 5. CT image of the right wrist bone after three-dimensional reconstruction of the basketball group.

Table 1. Measurement results of left and right wrist bone volume.

Group	n/person	Navicular bone		Moon's bone	
		Right hand	Left hand	Right hand	Left hand
Control group	11	3.09±0.49	3.08±0.44	2.3±40.32	2.35±0.30
Basketball team	9	3.77±0.67a	3.65±0.67b	2.62±0.81	2.62±0.80
Group	**n/person**	**Large horn**		**Small polygon**	
		Right hand	**Left hand**	**Right hand**	**Left hand**
Control group	11	2.57±0.26	2.43±0.22	1.67±0.22	1.66±0.22
Basketball team	9	2.93±0.52	2.83±0.49a	1.96±0.35a	1.91±0.35b
Group	**n/person**	**Triangle**		**Pea's bone**	
		Right hand	**Left hand**	**Right hand**	**Left hand**
Control group	11	1.82±0.22	1.80±0.24	0.88±0.20	0.94±0.22
Basketball team	9	2.02±0.45	2.00±0.46	1.11±0.33	1.12±0.30
Group	**n/person**	**Head bone**		**Hook bone**	
		Right hand	**Left hand**	**Right hand**	**Left hand**
Control group	11	4.23±0.45	4.03±0.36	3.56±0.50	3.39±0.41
Basketball team	9	4.84±0.82	4.57±0.68	3.81±0.75	3.56±0.60

Remarks: a: Compared with the right hand of the control group, P<0.05; b: Compared with the left hand of the control group, P<0.05.

Table 2. CT value detection results of each carpal bone.

Group	n/person	Navicular bone		Moon's bone	
		Right hand	Left hand	Right hand	Left hand
Control group	11	545.45±56.70	513.45±42.47	546.36±47.26	511.73±49.65
Basketball team	9	488.67±67.48	492.89±67.70	486.89±84.86	470.56±72.01
Group	**n/person**	**Pea's bone**		**Large horn**	
		Right hand	**Left hand**	**Right hand**	**Left hand**
Control group	11	402.55±43.37	388.00±42.47	458.09±50.364	40.82±42.32
Basketball team	9	363.44±37.02a	368.22±34.40	393.00±45.66b	396.89±56.31
Group	**n/person**	**Head bone**		**Hook bone**	
		Right hand	**Left hand**	**Right hand**	**Left hand**
Control group	11	477.82±53.99	450.27±40.10	508.18±69.73	456.64±52.91
Basketball team	9	432.78±54.62	432.33±50.59	408.78±51.25b	402.44±52.02c
Group	**n/person**	**Triangle**		**Small polygon**	
		Right hand	**Left hand**	**Right hand**	**Left hand**
Control group	11	523.27±68.90	489.00±56.44	458.73±57.35	433.73±53.16
Basketball team	9	454.56±61.95a	540.89±55.98	419.11±43.22	416.67±45.56

a: Compared with the right hand of the control group, P<0.05; b: Compared with the right hand of the control group, P<0.01; c: Compared with the left hand of the control group, P<0.05.

DISCUSSION

The impact of basketball on the volume of each wrist bone

This study found that basketball has no significant effect on the wrist bone volume's internal proportion[8-9]. Long-term training can cause the volume of the wrist bone to increase gradually. This study shows that the changes in the volume of the left and right wrist bones of basketball players only occur in the navicular bone and the large and small polygonal bones, indicating that basketball may be related to STT to a certain extent. In this study, it can be observed from CT images that basketball players have large palms and thick cortical bones, which are consistent with the results of the above research.[10] Since the wrist bone volume is related to the individual's age, height, gender, heredity, and other factors, this study selected other male non-professional athletes as the control. It excluded the interference of age and gender factors.

The impact of basketball on the bone mineral density of each wrist

some scholars have studied 5-week-old male rats' use to establish an 11-week high-intensity treadmill exercise model. Through histometric studies, it has been found that bone loss has occurred in the femur and lumbar spine, indicating that overtraining can lead to a decrease in bone density in rats. Some scholars have shown that long-term tennis exercise can cause a significant increase the bone density of the distal radius of the force arm, indicating that the effect of mechanical load on the bone is site-specific. However, some scholars have found that long-term cycling can induce a decrease in bone density of the spine and hips, indicating that high-intensity exercisers are prone to osteoporosis.[11-12] The above research shows that exercise training of appropriate intensity can increase bone density.

The difference between left and right wrist bone volume and bone density

According to retrieval, few reports about the influence of exercise on the morphological structure of left and right hands. Some scholars have found that the bone density of tennis players' holding hands is higher than that of non-holding hands.[13] Some scholars have found that the arm's bone density with a relatively heavy exercise load of basketball players is significantly higher than that of the other arm. In contrast, the left and right legs' bone density has no significant difference, indicating that exercise is specific. The bones in the irritated area have local effects.

CONCLUSION

This study found that there was no significant difference in the bone mineral density and volume of the wrist bones of the basketball player's spiker (right hand) and the non-smasher (left hand), indicating that the morphological structure of the basketball player's non-smashing wrist had similar changes to that of the spiker. Significant difference.

All authors declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Each author made a significant personal contribution to the manuscript. Bi-chuan Liu analyzed and explained data about professional basketball players (basketball group) and 11 non-basketball players (control group). Nai Liu scanned the wrist with K-helical computed tomography technology and performed three-dimensional reconstruction, and was the main contributor to the manuscript. Final manuscript read and approved by all authors.

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