

The research on the coupling relationship between human skeleton and fascia in Taiji from the perspective of spatial structure

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Abstract—This paper analyzes the spatial structure and movement characteristics of bones in Taiji movement, and puts forward the viewpoint that the human body forms a "rigid and flexible" coupled movement force system with the bones and fascia during Taiji movement, and this relates to the structural forces experiences by the human body in Taiji movement. In Taiji movement, the fascia wraps and connects bones in series. This forms a rigid flexible coupling prestressed force system in the human body. It is believed that to understand the ancient process of Taiji scientifically, it will be required to undertake a combined study of fascia science, fluid mechanics, spatial structure mechanics, modern kinematics, with other research disciplines.

Keywords: Tai Chi; Fascia; space structure

1. Analysis on the spatial structure and movement characteristics of bones in Taiji movement

1.1 Frame -- The spatial structure of the bone system in Taiji movement

The general meaning of frame in Taiji is a frame composed of lines. In traditional Chinese texts, Tai Chi is a movement of "round outside and square inside. The square inside of Tai Chi is reflected by the body, which is the frame, where the trunk of the human skeleton, and the internal frame is the square. However, because flesh and blood, fascia and skin are attached outside this hard frame, the human body presents a soft body, where its shape is flexible.

The body's internal and external performance can be summarized in Fig. 1. In this figure, the inner square is like the white frame in the figure, and the outer circle is composed of black. In this way, bones are local frames, where (1) the bone is the component of the whole structure and the executor of action; (2) The functions of bone are linked to the fulcrum, the force point, and the transmission and transformation of force directions; (3) The rigidity of bone (its tenacity, flexibility and cushioning are all important); and (4) bones do not exert force, but can only receive and transmits force.



Fig. 1 Abstract representation of the internal structure and external form of the human body's "inner square" and "outer circle".







Fig. 1. shows the abstract structure of the "inner square and outer circle" of the human body. However, in terms of structural loads, the human skeleton system is not uniform and it can be divided into two main parts: the central axis (where the spine is the central axis) supporting the skeleton; and the appendages (the limbs), which together form a complex structure with a central axis and cantilever, that creates a three-dimensional frame structure that is able to move left and right, up and down, front and back (Fig. 2).

1.2 Rigidity and flexibility - the difference between the spatial structure of this frame in Taiji movement and ordinary force movements

Integrity, coordination and for most people the building of strength are very similar pursuits in Taiji and many other sports, but one of the major differences between Taiji and other sports lies in the different way the internal structure forms.

In Fig. 2 the movement mode of the internal structure in ordinary (muscle/strength building) exercises is shown, and in Fig. 3 and 4 this is compared to the movement mode of the internal structure in Tai Chi exercise.

Between the two, the major differences can be seen in the distribution in node forms of the internal structure, and the transformation space of flexible nodes is different. **Fig. 2** A three-dimensional frame structure with the combination of real and virtual human body.

In addition, in Tai Chi the Tai Chi nodes are more flexible. Each node can flexibly transform (move) and coordinated in the overall spatial structure, in a larger range of flexible space for accumulating strength (building muscle), emitting this stored strength, and deflecting the strength behind a blow. The internal structure of Tai Chi shows that the movement space range is large and the movement direction is flexible. In other words, the local torque can be large. This links to how the body in Tai Chi can change in close range, can "sacrifice" itself, and respond to the movement of others, and also attack others with the help of the other person's strength, which when combined together create many advantages in close combat.

1.3 The key to flexibility -- the function and characteristics of bone joint in Tai Chi

The key to the flexibility of the whole-body bone system is mainly reflected in the structure of the bone and joint.

In Tai Chi, as in many sports, there is great importance in the process of warming up and relaxing the joint, and in undertaking regular active exercise that strengthens the function of the joint. However, the advantages of Taiji's internal structure and movement are mainly reflected in how the bone and joints are trained, and after clarifying this principle, it is possible to understand many specific principles of Tai Chi that are often difficult to understand from reading classical Chinese texts. A brief summary is as follows:

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1. In the "frame" system of the human body, bony joints not only play a role in connection, but also the role of transformation, Fig. 5.

2. The human body's meridians run through the whole body and connect various bone joints in series. While the bone joints are flexible, the meridians are exercised and elongated.

3. Filament winding force plays a unique role in the process of relaxation of bone joints, and spiral winding movement stretches the joint.

4. Internal Qi takes the meridians as the channel. In the operation of internal Qi, bone joints are also the key nodes. If the bone joints are flexible, Chinese tradition states the internal Qi operates rapidly and in large quantities.

2. Coupling Relationship and Stress Analysis of Skeleton and Fascia in Taiji Exercise

2.1 Human Motion Structure System from the Perspective of Spatial Structure

The human body consists of nerve, muscle, bone, fascia, tissue fluid and many other elements, which can show characteristics of "multiphase flow" (multi-component flow) and "fluid-solid coupling".

From the perspective of solid phase spatial structure, the structure of its motion system is mainly embodied in three motion stress systems that are linked to the muscle system, the skeleton system and the fascia system, see Fig. 6 which shows a schematic diagram of three motion force systems on a human body.







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Fig. 6 Schematic diagram of three motion force systems of human body.



Fig. 7 Schematic diagram of human motion spatial structure.





In general, western kinesiology attaches great importance to strengthening and developing the muscular and skeletal systems, while Taiji, which represents the characteristics of Chinese martial arts, attaches the importance to the skeletal and fascia systems of the human body. The fascia system is the generalized meridian system, including the fascia tissue and skin of the whole body. The skeleton system is an integral hinged rod motion system consisting of a relatively rigid skeleton and a relatively flexible universal joint, and the muscle system and the fascia system, to form an integral space structure stress system which combines ri gidity and flexibility and has the characteristics of a tension hinge, see Fig. 7.

2.2 Rigid-flexible coupling prestress system of human body in Taiji movement

As mentioned above, the human body is composed of a muscle system, a skeletal system and a fascia system, which are rigid-flexible coupling and have the characteristics of a tension hinge. In this system, research, in both the East and the West, pay attention to the exercise of the skeletal system.

However, the difference between the two views of exercise is western fitness exercises emphasize muscle exercise, whereas Taiji exercise, under oriental wisdom, emphasizes the relaxation of muscle groups.

After the relaxation of muscle groups, the function of resisting gravity is transferred to the fascia system. Taiji exercise involves the skillful use of gravity to relax large muscle groups and to place the weight of the whole body on the fascia system.

As shown in Fig. 8, the fascia system connects the human skeleton in series to form a whole stress system, just like the prestressed reinforcement connecting each cantilever component in series in the prestressed cantilever bridge structure. When the human body is standing and in general motion, the body weight is converted into gravity. This is mainly resisted and borne by skeletal and muscular tissues. In the state of Taiji, the muscle tissue of the human body is relaxed, and the weight of the human body falls on the rigid-flexible coupling system formed by the

"fascia" wrapped in series with the skeleton to form the overall prestress, which is traditionally called "strength". This is the main feature of the overall force in the state of Taiji movement.

3. Health preserving principle of fascia

3.1 Health preservation principle of fascia

According to modern fasciology, meridians and collaterals are also part of the fascia, which relates to the connective tissue within the human body. Fascia includes meridians and collaterals and is larger than meridians. As for the health preserving principle of the fascia, modern fascia science is completely consistent with the traditional meridian theory, and it is believed that the health preserving principle is embodied in two aspects: one is that by exercising and "dredging" the meridians (fascia), diseases can be prevented; The second is to strengthen the meridians (fascia) is beneficial to prolonging the life span of people. The function of preventing diseases is mainly achieved by activating and strengthening the function of meridians (fascia) to conduct "Qi". The principle of prolonging life is that the meridian (fascia) system can provide metabolic supplement cells for other functional systems of the human body.

In traditional Chinese medicine, it is said that Qi moves through the meridians. In other words, Qi moves through the whole body, and its running line moves between the meridians (fascia) of the human body, where its running nodes are found in acupoints and joints. In the case of lack of exercise and amongst people of older age, the fascia tissue tends to become rigid, showing that the fascia tissue becomes disorderly, its tissue fibers become rough and its elasticity decreases. At this stage the ability to conduct "Qi" is gradually weakened, and a person's ability to prevent diseases is also weakened.

In the state of Taiji exercise, the meridian (fascia) tissue is often stretched and relaxed, the fascia tissue is exercised and the fascia fibers become smooth and elastic, the ability to conduct Qi is then strengthened, and it is said that the human body's Qi circuit is gradually made smooth and vigorous, and the sense **DOI**: 10.57612/2022.JTS.01.06







Fig. 8 Schematic diagram of prestressed stress of fascia and bone system under Taiji state.



Fig. 9 A Schematic diagram of the overall trend of tissue fluid loosening and sinking in human elastic skin under Taiji state.

of Qi is gradually enriched and steadfast. The movement of internal Qi is continuous in the process of movement, forming a whole within the body, which becomes a "defensive qi", that aids the ability of human body to prevent diseases.

As for the statement that "one inch of muscle prolongs life for ten years", it has also been explained more scientifically in the theory of fascia. The fascia is the support and reserve system of the human body and is linked to fat cells, fibroblasts, and stem cells. The human fascia has the important functions of repairing damaged cells and tissues, regulating life renewal and it is linked to the functional metabolism of specialized cells. The specialized cells of the nine major functional systems of the human body have only a short life cycle, ranging from a few days (such as epidermis) to a few months (for bone cells), but through continuous proliferation and differentiation, the fascia is continuously transformed into functional cells to repair and renew the functional system, thus ensuring the growth of each system. In this way it not only maintains the stability of the life process, but it also prolongs the survival time (the life span) of the human body.





3.2 The Specific Mechanism of Taiji Exercise on Strengthening Fascia

3.2.1 Strength is the basic force to strengthen the fascia

As mentioned above, in the state of Taiji, the weight of the human body falls on the rigid-flexible coupling system formed by the fascia wrapped around the skeleton, forming the overall prestress, which is traditionally called "strength" in a more general sense.

In the process of Taiji movement, traditional instructions state we should pay attention to "not losing the top", which can be translated to mean that we should always keep our strength and never lose it. That is to say, the prestress that is acting on the fascia system should not be allowed to dissipate, and this basic prestress is the basic force to relax the fascia of the human body.

In the Taiji state, when the large muscle groups of the body are relaxed, under the action of gravity, the tissue fluid held within the tough skin that makes up the human body shows an overall trend to loosen. At the same time, it acts on the fascia system to relax the human fascia and lengthen the limbs, so as to achieve the effect of loosening joints and strengthening tendons. Therefore, long-term correct practice of Tai Chi is bound to have the effect of strengthening tendons, (Fig. 9).

3.2.2 Action mechanism of stake standing stretching fascia

Another example is the use of stake standing exercise, which has a positive effect on the fascia tissue at the intersection of the bones between the human spine, crotch and thigh. As shown in Fig. 10, when the human body is upright, the traction force between the spine, crotch and lower limbs is in the same vertical plane, and the force in the three directions is mainly pressure. The fascia tissue between the bones does not bear shear force.

When the human body is in the position of standing pile, the forces in the three directions of spine, crotch and lower limb are not in the same vertical plane, the supporting effect of lower limb bones on the spine is weakened, and the shear force at the force point is enhanced, and combined with the state of relaxing leg and crotch muscles, in addition the gravity felt on the upper body spine produces strong traction on the ligament and fascia between the crotch and thigh. This can effectively stretch the



Fig. 10 Stress analysis diagram of crotch fascia under stake standing.





fascia tissue with this part of the body. Therefore, the standing pile exercise is an effective form of exercise that skillfully uses gravity to stretch and exercise the fascia between the hips, see Fig. 10.

3.2.3 The use of spiral winding wire in fascia stretching

As shown in the Fig. 11, the force of winding wire is a winding movement distributed throughout the body, which acts in the same way as twisting a towel. The force of winding wire twists and lengthens the body motion curve, lengthens the extension distance of muscles and fascia of the whole body, and skillfully uses the tension and pressure generated by torque to stretch and massage the fascia. While stretching and massaging the fascia with the spatial motion curve of the force of "winding silk". In traditional theory this forces stability and order in the movement of body fluid and Qi and blood in the human body, making Qi and blood more unobstructed. Therefore, it not only has the effect of exercising the fascia, but it also plays a role in maintaining the elasticity and health of blood vessels

Conclusions

Based on ten-year experience of Tai Chi, this study draws lessons from the theories of modern fascia, space and structural mechanics and kinematics, and it examines the traditional meridian theory from a new perspective. It is proposed that in Tai Chi, the human body forms a rigid yet flexible coupling motion force system that employs bones and fascia; A new viewpoint on the problems of relaxation of force and "liveliness" in Taiji is presented. In Taiji, the fascia wraps the skeleton in series to form a rigid flexible coupling prestressed stress system. In Taiji, the relaxation of force in the human body is linked to the muscle tissue of the body, and the "liveliness" activates the fascia tissue of the human body. Future multidisciplinary collaborative research will be useful in aiding the understanding of the scientific fitness and health preservation mechanism of Taiji. On the basis of explaining the health preservation mechanism of Tai Chi by fasciology, we can explore more concise and effective ways of Tai Chi practice, and health preservation that are easy to be accepted by the public.



Fig. 11 Schematic diagram of stress route of human spiral winding wire.

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References

1. Chen zheng lei. Chen's Complete Book of Taijiquan [M]. People's Sports Publishing House, first edition, 2009

2. Yuan lin wang jun. Fascia Science [M]. People's Health Publishing House, first edition, 2018

3. Xu zili. Arousing the local -- the internal spatial structure and movement mechanism of Taiji movement Chinese martial arts 2018 (03)

