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Structural Design of a Device for A Cupping Chair

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Abstract: A mechanical design of a synchronised cupping chair is proposed for the demand of cupping in a seated position. The device consists of an external box, a seat and back and a cupping mechanism. The movements of the cupping mechanisms are independent of each other. The cupping mechanism can be used to effectively apply multiple cupping jars to the human back, either synchronously or asynchronously, to improve efficiency. The cupping mechanism is cushioned to provide a close fit to the back of the body and to improve comfort. The entire cupping process is completed automatically with the cooperation of the various components and the control system, with a high degree of intelligence. The cupping is standardised and unified in the seated position.

Keywords: Cupping; Sitting position; Structural Design.

1. Introduction

With the development of modern science, artificial intelligence and robotics are affecting a wider and wider range of fields. In the current era of "Internet + Medical" and the rapid development of intelligent medical devices, Chinese medicine, as a preserved treasure of national culture, should follow the trend of the times and effectively combine artificial intelligence and robotics to develop artificially intelligent medical treatment in depth. Cupping, as an integral part of TCM physiotherapy, has become increasingly popular among the general public because of its safety and effectiveness and as a "green" physical therapy. This is why it is necessary to combine artificial intelligence and robotics to proactively optimise the structural design of the cupping device and to make cupping therapy more intelligent, visualised and standardised.

Existing studies on cupping devices have focused on scenarios where the subject is lying on his or her back facing downwards, directly underneath the device, which is slightly less comfortable. This position is often inconvenient for cupping therapy on many occasions. Secondly, cupping therapy in this position does not allow for a better implementation of cupping of acupuncture points around the shoulders and neck of the cupper, as in the case of massage therapy in Chinese external medicine, when massage therapy in a seated position is used, a more comprehensive massage therapy can be applied to the back and shoulders and neck of the subject. Thirdly, research has shown that the efficacy of cupping therapy is directly related to the cupping site, i.e. the acupuncture point, the distribution and degree of relaxation of the muscles around the acupuncture point, the location of the acupuncture point, the subject's state of mental health at the time, and the degree of relaxation. These conditions are all affected when the body is in different cupping positions. Therefore, it is not sufficient to study cupping with the person's back facing up and down, i.e. lying on their stomach. Finally, from the point of view of studying the mechanism of cupping, as a primate, the human body spends most of its time in an upright position as opposed to a lying down position, and therefore the physiological information contained in the changes in signs when the back is in an upright position is more abundant and richer.

Most of the existing studies on cupping devices are still based on manual cupping and cupping in a lying position, which is less efficient and more cumbersome, and less standardised. In summary, it is essential to design and propose a cupping device for the seated position.

2. Overall Structural Design

The overall mechanical structure of the synchronous cupping chair is shown in Figure 1. The main components are the external box, the seat and back and the cupping device.

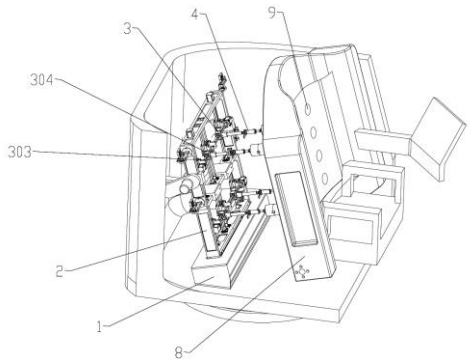


Figure 1. Overall Structural Design

2.1. External Enclosure

The external case of the synchronised cupping chair is shown in the figure. Its function is to encapsulate all parts of the chair that are not in contact with the human body except for the outer sides of the seat and back. The inner wall surface of the case is sealed and equipped with a lighting device for the light of the camera. The purpose of this is to make the light source within the box consistent and to facilitate the identification and positioning of the acupuncture points and the hollowed-out parts of the back by the detection module.

2.2. Seat and Back

The seat is fixed to the external case. The back of the chair is set on a sliding slot inside the housing. When cupping, the canister needs to be sealed against the human skin. The hollow part of the seat back allows the canister at the front of the cupping device inside the case to be extended through the seat back and pressed against the skin of the human back to

achieve cupping. The back of the chair can be moved from side to side along the slots to adjust the position of the hollow section, and the pitch angle can also be adjusted through the housing to adjust the overall height of the device to suit subjects of different heights and lengths and with different back lengths. The cross-sectional shape of the hollow section in the vertical direction is circular and corresponds to the shape of the bottom surface of the cup. The hollow section is positioned to cover most of the cupping points on the back of the body.

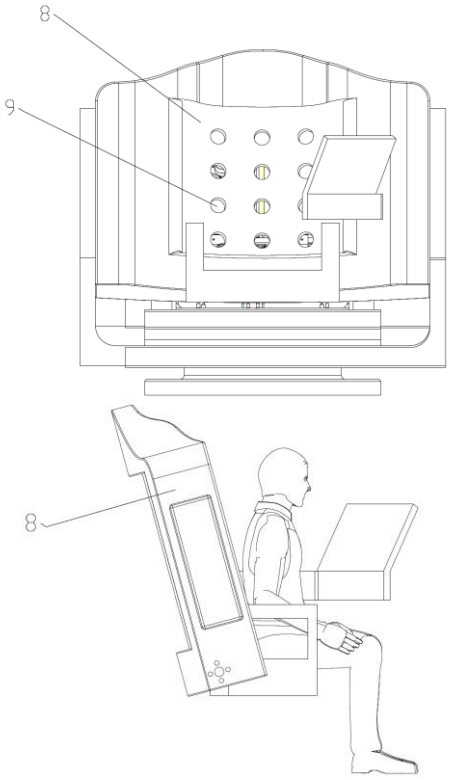


Figure 2. Seat and Back

2.3. Cupping Device

The cupping mechanism of the synchronous cupping chair is shown in the figure. It consists mainly of an external frame and four independently operable cupping mechanisms.

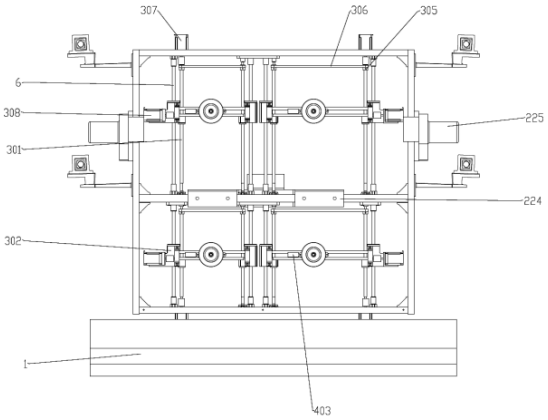


Figure 3. Cupping Device

2.3.1. External Frame

The external frame consists of five aluminium square panels: two side panels, the upper base panel, the middle panel and the lower base panel. The aluminium square panels are fixed to each other by right-angle connectors and are fixed to the cabinet by means of a support base. The side panels are used to hold and mount the control board, power supply, driver and camera mount. The upper and lower base plates are used to fix the stepper motor and the support base. A horizontally positioned intermediate plate is placed in a square hole in the side plate, dividing the case into two parts. The middle plate is further divided into two parts by the vertically positioned guide rails and the plate body, which can be seen in the diagram as a "田" shape.

The external frame includes four drive mechanisms and cupping mechanisms with the same structure and operating principle. The movements are independent of each other and do not interfere with each other, thus satisfying the need for simultaneous cupping at multiple points.

Four camera supports are attached to the side panels of the frame. The camera can be rotated to adjust the focus direction of the camera placed on it according to a certain scale, so that the camera can monitor the whole cupping process without any dead angle or obstruction.

2.3.2. Drive Mechanism

The external frame is divided into four subframes by an aluminium plate. The drive mechanism of the cupping mechanism is placed in each of the subframes and consists mainly of structures in the X-axis and Y-axis directions. The function is to achieve a planar movement of the cupping mechanism so that the jar corresponds precisely to the target point. The movement of the subframes is synchronous or asynchronous to achieve the cupping requirements. The cupping mechanisms within the subframes do not affect each other during movement and can be controlled individually according to the needs of the subject. The transmission mechanism is composed as follows:

In the X-axis direction, two synchronous pulleys are connected to the shaft end of the vertical screw with a timing belt. The stepper motor is connected to the vertical screw through a coupling, and the vertical screw is fitted with a brass nut inside the moving slider to form a screw-nut pair. When the stepper motor drives the screw, the moving slider changes the rotation of the screw into axial movement by means of the screw-nut pair. The upper shaft section of the vertical screw is partially mated to a thrust ball bearing that is subjected to axial force and is fixed in a sleeve in the base. The outer side of the vertical screw is supported by a guide rail through the flanged linear bearing inside the moving slide, effectively reducing the friction of the moving slide during sliding and restricting the slide to axial movement only, ultimately enabling the moving slide on the vertical screw to achieve up and down movement, thereby enabling the Y-axis fixed to the X-axis moving slide to achieve movement in the X-axis direction.

In the Y-axis direction, a similar motion structure is used as in the X-axis direction: the stepper motor is fixed to the moving slider in the X-axis direction through the motor base, and is connected to the horizontal screw through a coupling, driving the screw to rotate, thus achieving the left and right motion of the moving slider in the Y-axis direction, thus enabling the cupping mechanism fixed to the moving slider in the Y-axis to achieve the left and right motion in the Y-axis direction.

Thus, each set of drive mechanisms in the subframe can individually achieve the plane movement of the cupping mechanism.

2.3.3. Cupping Mechanism

The cupping mechanism consists of an outstretched arm, a

cupping section and a connecting section. The cupping section is fixed to the top of the arm by the connecting section. The arm is an electric actuator driven by a DC motor and is fixed to the Y-axis moving slide. Its function is to realize the movement of the cupping mechanism in the Z-axis direction and to control the canister away from or close to the body.

The connecting part consists of a sleeve, a connecting rod and a fish-eye type joint bearing. The sleeve has a built-in pressure sensor and spring. The pressure sensor is placed in the sensor holder. One end of the connecting rod is placed in the sleeve and connected to the spring, while the other end is connected to the cupping part of the housing by means of a fisheye joint bearing. The fisheye joint bearing allows the front end of the cupping section to be cushioned and rotated when the cupping point is pressed against the back in order to allow the cupping body to fit the body better. The sleeve has a built-in spring connected to the rod that moves backwards along the inner wall of the sleeve against the pressure sensor in the sleeve and returns the signal when the force is returned from the back.

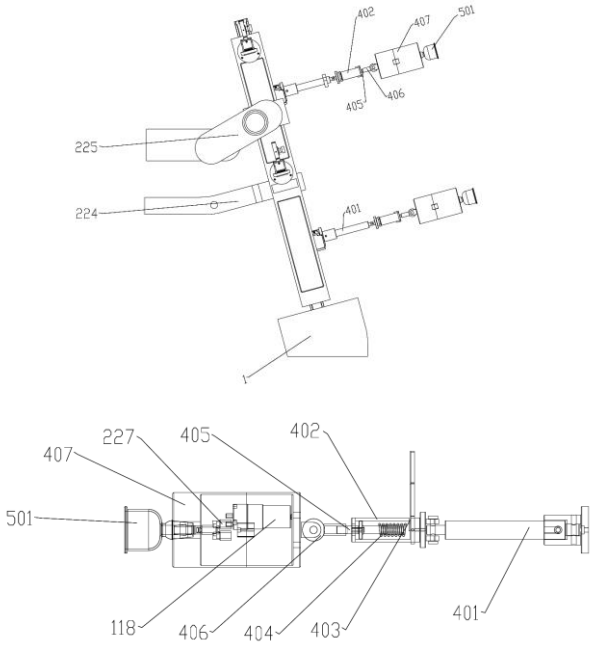


Figure 4. Cupping Mechanism

The cupping part includes a cup, a gas line, a miniature air pump and an outer casing. The cup is connected to the micro air pump via the gas line and is fixed to the front of the outer casing with a sealing joint. The gas line and the micro air pump are enclosed in the housing.

The air circuit is equipped with a filter and a differential pressure gauge. The purpose of the filter is to prevent solid impurities adhering to the skin surface from being drawn into the air pump. The differential pressure gauge is used to monitor the air pressure in the cup in real time.

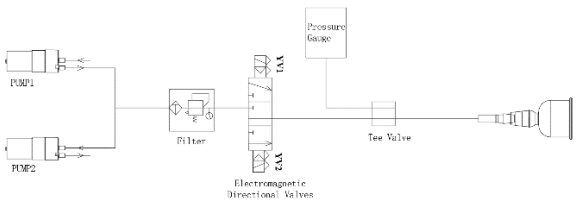


Figure 5. Pneumatic Schematic Diagram

In the process of cupping, the working principle of the gas path is as follows: the head of the miniature air pump is connected with two gas pipe interfaces, one interface is the air extraction interface, the other is the exhaust port for extracting gas. When the three-way solenoid valve YV2 is connected, the air extraction interface of the miniature air pump 2 is connected to the cup interface, and the exhaust port is suspended. At this time, the air pump is energized and begins to work, and the air in the cup is extracted and discharged from the exhaust port to achieve negative pressure in the cup and achieve cupping effect. When the three-way solenoid valve YV1 is connected, the air extraction interface of the miniature air pump 1 is suspended, and the exhaust port is connected to the cup body interface. At this time, the air pump will press the gas in the air along the pipeline into the cup to achieve positive pressure in the cup, so as to realize the automatic fall off and removal of the cup.

3. Work Steps

The working steps of synchronous cupping chair are as follows:

Before cupping, subjects should sit on the seat, as shown in FIG. 5 and FIG. 7, and bare back. At the same time, the focusing position of the camera should be adjusted to ensure that all areas of the back of the human body can be monitored without dead corners during the whole process of cupping without being blocked.

After completion of the preparatory work, according to the image data transmitted back by the camera, firstly confirm the posture of the subject's back and the general flatness of the back. After a general comparison between the back image and the back-acupoint location map, the approximate position of the acupoint for cupping was determined, and the corresponding position coordinate system was established by the upper computer.

In the position coordinate system, the positions of some executing canisters and the positions of target cupping acupoints are compared. According to the field structure shown in the figure, the four areas are divided, corresponding to the four areas shown in the figure. In each area, the image of the back and the map of the location of acupoints on the back are compared to determine the location of acupoints for cupping, complete the corresponding path planning, calculate the distance that the cup should move in the spatial coordinate system, and the corresponding Angle that the lead screw needs to rotate. The distance the push rod needs to travel, and the corresponding Angle the motor should turn.

When the motor drives the actuator to the position of the acupuncture point, the electric push rod will push forward. When the cup hits the back, it will be buffered by the rotation of the fisheye bearing, and the contact between the cup and the back will be properly adjusted to make the contact surface more fit. The electric push rod then continues to move forward, pressing the cup against the back. This causes the connecting rod to receive the opposite thrust, sliding backward along the inner wall of the sleeve and squeezing the spring inside. When the spring is squeezed, it exerts reverse thrust on the pressure sensor mounted at the bottom of the sleeve. When the reverse thrust returned by the pressure sensor reaches the set value, the forward motion of the electric push rod is ended, and the cup body is considered to have been closely fitted with the back.

The next step is to drive a miniature air pump inside the housing. According to the set power operation for a certain time, reduce the air pressure in the cup, preliminarily achieve

the effect of cupping. When the pressure in the cup reaches the target pressure, the miniature air pump stops. After cupping is finished, the miniature air pump is inflated, the cup body is separated from the human body, and the electric push rod is reset, the cupping is finished.

4. Conclusion

Aiming at the shortcomings of existing cupping technology and the requirements of cupping in sitting position, a mechanical structure design of synchronous cupping chair was proposed. The advantages of the cupping chair are as follows:

1) The hollowed-out part of the back of the chair perfectly solves the cupping condition in which the back of the human body needs to be supported and the cup body needs to be closely fitted to the back of the human body to form a sealed cupping condition;

2) The motion between the cupping mechanisms is independent of each other, which can effectively carry out synchronous or asynchronous cupping on the back of the human body and improve efficiency; The cupping mechanism has a cushioning effect, which can improve the comfort level on the basis of meeting the tight fit with the human back.

3) The design of gas pipeline realizes the automatic shedding and removal of the cup body in the process of cupping, with a high degree of automation;

4) To realize the standardization and unification of cupping in sitting position, so as to avoid the adverse effects and stimulation of cupping caused by improper and illegal operation during operation.

Acknowledgements

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