Design Research of Self-help Shearing Traction Treatment Bed

L. Pan[1]
[1]College of Mechanical and Vehicle Engineering, Changchun University,Changchun, China
Email: panli636@126.com

Y. Song[1] and C. He[1]
[1]College of Mechanical and Vehicle Engineering, Changchun University,Changchun, China

***Abstract*—With the rapid development of social economy and the constantly improvement of people's quality of life improving, health has become a topic that can't be ignored. As a result of long-term by their own body weight, age, aging and other out-of gravity, pressure, professional habits of posture and other factors make neck, lumbar struggled more and more people's health. Aiming at the shortcomings of the existing traction equipment, in this paper， designed a self-help traction treatment bed has been designed which was adopted the purely mechanical traction method, the drive and work principle of treatment bed has been discussed. By its unique folding function and structural design of adjustable lathe bed, fixed bracket, rotate type-driving handle, the bottom rail sliding, it made up for a lack of the design of traditional traction treatment bed. Through the force analysis and calculation of each part structure, it implemented the overall operating functions safety and comfort.**

***Index Terms*—Traction treatment bed, Self-help, Jack, Working principle, Design calculation**

I. INTRODUCTION

Since the anthropoids stood up from the ground for human evolution, spinal cord has the effect of decision, but also under tremendous pressure. Because of the effect of long-term weight, aging, and other external factors such as gravity, pressure, professional habitual position, it would make the spine and each part of the joints supporting human body extrusion or bending deformation phenomenon, lead to all kinds of different types of lumbar, cervical vertebra disease, bring pain and discomfort to patients. Medical experts in the world have surveyed vertebra and a variety of physical ailments discomfort of the human body. The results found that the incidence of neck lumbar disease was 45-50% in men and women over the age of 40; More than 60 incidence was 80%; after the 70 was almost 100%. The waist dish outstanding, bone hyperplasia and cervical stenosis oppressed nerves, blood vessels and spinal cord, the light person were in numbness of neck, shoulder, arm, waist pain, and hands and feet, the serious person were dizzy, mobility, even paralysis [1]. At present, the clinical treatment of spinal disease mainly adopted two methods: surgery and non-surgical treatment [2]. Surgical treatment was adopted when the symptom was serious, and the surgical treatment has certain hidden danger to the health of the patient's body, security couldn't get effective guarantee. And an effective method of non-surgical treatment was traction treatment, by adding or the body's own gravity, gap between pushing vertebral body has been broadened, so was helpful to highlight the nucleus pulpous reply, back to normal vertebral body was arranged, flabby ligament tension, thereby reducing compression, stimulation of spinal cord and spinal nerve root [3].

At present, in the treatment methods of lumbar, cervical vertebra disease, the traction therapy was widely used because it was simple, safe, painless and effective. However, the traction treatment bed was still used in hospitals, structure of the tractor was complicated, the operation of the tractor was inconvenient, volume was huge, and it wasn't easy to tear open outfit and expensive. Currently on the market there are many traction therapeutic apparatus, such as computer micro control multi-functional traction bed, cervical traction chairs, with self-regulation traction bed, neck massage pillow and so on, each has its advantages and disadvantages [4].

Aiming at the shortcomings of the existing traction therapy apparatus, in this paper, a simple type, folding, self-service traction therapy bed has been designed. And its structure and the structure and each main part have been designed and calculated to make it not only be applied to hospitals, clinics, also could be used at home.

II. DESIGN SCHEME AND PRINCIPLE OF TRACTION TREATMENT BED

A. Determination Of Transmission Scheme of Traction Treatment Bed

Traction therapy was one of important rehabilitation treatment methods of neck and lumbar disease. The effect

of traction therapy depends on four factors: traction angle, traction weight, traction time and traction lead position.

The main technology of the traction bed was driving part. At present, some traction bed was been used meshing transmission, the meshing transmission rack and turning column were as shown in Fig.1, 2. Drive part of some traction bed included the vertical screw, gear rotating device and the hand wheel. Vertical screw was freely through the bed surface, the top of screw connected accessories, bevel gear was installed on the screw, the bevel gear meshing bevel between gear and the hand wheel were shown in Fig. 3, 4. But the first kind of circumstance was in use process, at the same time of traction, it still needed human help reset, was generally the thumb jacking force, it was difficult, and not easy to control, and not easy to master. The second actuator adopted bevel gear drive way, not easy processing, requirement of high precision, and not easy to control in the process of traction. Bevel gear by pin connection. If the connection was not fixed, transmission would not be smoothly and the security of traction had certain security-hidden danger [5-6].

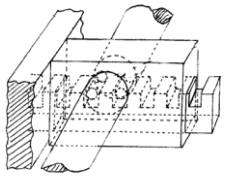

Figure 1. Diagram of rack drive

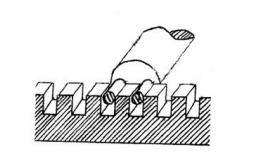

Figure 2. Diagram of rotating column meshing

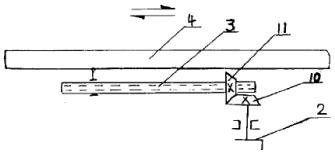

Figure 3. Diagram of screw drive

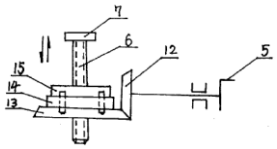

Figure 4. Diagram of gear meshing

Aiming at the problems existing in the transmission structure, the principle of car jack was adopted to the transmission structure of the traction bed. Characteristics of the scissor jack were to provide stable traction, and be easy to control the size of the force. Through the hand wheel to make scissor jack work, the underlying sliding orbit, two-way drive, pull evenly. The rotating force was small, not easy to make the wrist feel fatigue. At the same time, the hand wheel replaced the traditional rocker arm; it would be able to make users with different long arm do traction treatment. Effective traction could provide important guarantee for treatment. The shearing traction institutions could provide enough traction force. The scope of the traction force was in 0~100kg to meet the required traction treatment. But also it could be adjusted to the one-way traction of cervical vertebra head and legs. Shear jack was shown in Fig. 5.

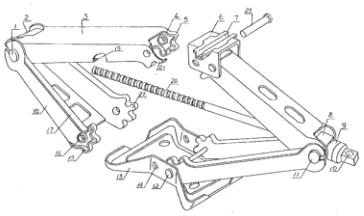

Figure 5. Schematic diagram of shearing jack

B. Working Principle Of Traction Bed

In the traditional traction treatment process, the control way of traction force was that by communicating between doctors and patients and through the patient's feedback, the pulling force was formulated what the patient could withstand. Design in this paper, principle of the car jack was adapted to traction bed. Traction power and way could be grasped easily. Hand wheel was installed in the patient's right hand, so the patient can operate by oneself, safely and scientifically. And it could be adjusted to the one-way traction of cervical vertebra head and legs. With ergonomic security caps, and adopt scientific ergonomic design, wrapped head could effectively prevent fall out of use, be more conducive to protect the cervical vertebra traction force, were allowed to reduce head and head pad friction drag could realize effective traction work safety.

Previous traction device could only be performed at the request of traction and traction weight of time; the traction angle and traction postures couldn't meet the needs of the clinical treatment. And in this paper, the traction bed has been designed to solve two important questions such as the traction position and traction angle. The patient could been treated under the supine position, this position could make the spine muscle under the biggest state of relaxation treatment. It could get better results than under the other position. According to need, the traction angle could be adjusted at treatment, greatly improving the therapeutic

effect. The 3 D modeling of the traction bed was as shown in Fig. 6. Works as follows:

(1) Before and after the brace more solid to solve the deformation that the inclined support one foot were weight before.

(2) The special support foam was adapted to flesh, more comfortable; gently back hook, convenient and quick.

(3) Principle of the car jack was adapted to crank to shake more relaxed and more powerful.

(4) The original lumbar traction belt was designed. In view of the lumbar spine traction, make stretch more balance.

(5) Two-way stretch traction and at the same time cervical vertebra, lumbar and leg were drawn, the whole drawing.

(6) Has far infrared heat device has been installed in the brain, according to the distribution of the main and collateral channels to hot compress. There were the roles such as the strong warm, promoting blood circulation to remove blood stasis, clearing damp cold, and acetanilide spasmolytic.

(7) The frames letting hands were designed to facilitate traction process.

(8) The lumbar adjustment button was designed. Through the air, it could adjust the waist height, more comfortable and more convenient processing.

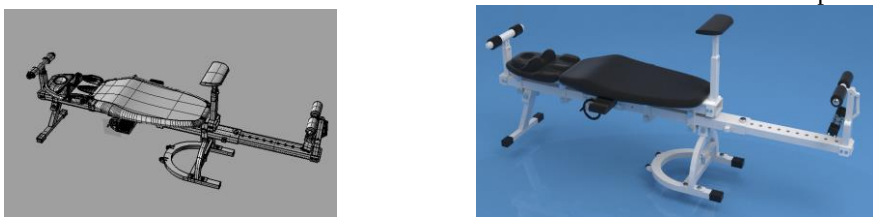

Figure 6. 3D model of the traction treatment bed

III. DETERMINATION OF DESIGN SIZE OF TRACTION BED

In the paper, the traction bed was physical therapy equipment what designed for adults, so all sizes were formulate according to adults. According to the human body sizes in GB- 10000-88[7], size and size range of the traction bed have been determined. The human body sizes were shown in table 1.

TABLE I.
THE HUMAN BODY SIZES ACCORDING TO GB-10000-88

Height	1550mm-2000mm	Upper body length	615mm-780mm
Head length	175mm-201mm	Bent leg height	410mm-540mm
Head width	135mm-170mm	Thigh length	387mm-523mm
Neck width	100mm-200mm	Leg length	300mm-419mm
Neck length	50mm-150mm	Hip-leg length	385mm-495mm
Shoulder width	380mm-475mm	Upper arm length	387mm-523mm
Lumbar curvature	140 °-160 °	Forearm length	185mm-268mm

Through the above data statistics, the design parameters of traction treatment bed were formulated as shown in table 2.

TABLE II.
THE DESIGN PARAMETERS OF TRACTION TREATMENT BED

weight	≤150kg	Bed width	500mm
Front seat cushion	400 mm	Cushion leg frame	Height 400mm，5files
Back mattress	850mm	Height adjustment tube	2000mm， 10 files
Total height	600mm	Head adjustment tube	280mm，3files
Total length	2150mm		

IV. FORCE ANALYSIS OF THE MAIN PARTS OF TRACTION BED

A. Force Analysis Of Bedstead

The design problems what the square steel involved were that it should not only meet the strength requirement, and meet the requirement of stiffness. Firstly, draw a

torque M diagram, which was shown in Fig. 7. The maximum bending moment [8] :

$$M = \frac{ql^2}{2} \tag{1}$$

In the formula, M was bending moment, MPa; q was force, N; l was length of the square steel, m.

By intensity conditions the normal stress:

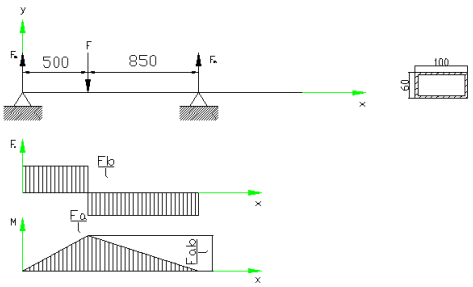

Figure 7. Force analysis of the square steel

$$\sigma_{\max} = \frac{M_{\max}}{W} \leq [\sigma_c] \tag{2}$$

In the formula, $\sigma_{\max}$ was maximum tensile stress, MPa; σ_c was the allowable tensile stress, MPa; W was the bending section coefficient (m^3).

$$\sigma_{\max} = \frac{ql^2/2}{bh^2/6} \leq [\sigma_c]$$

$$q \leq bh^2[\sigma]_{=} \frac{60\times100^2\times10^{-9}\times120\times10^6}{3\times3^3} = 8.9(\text{kN}) \tag{3}$$

By the conditions of stiffness

$$v_{\max} \leq [v] \tag{4}$$

By looking up the table, the maximum deflection

$$v_{\max} = \frac{ql^4}{8EJ_\tau} \tag{5}$$

So ,

$$\frac{ql^4}{8EJ_\tau} \leq \frac{l}{250}$$

Among them

$$J_T = \frac{bh^3}{12} \tag{6}$$

So, q

$$\leq \frac{2Ebh^3}{3l^3\times100} = \frac{2\times200\times10^9\times60\times100^3\times10^{-12}}{3\times3^3\times100} N/m$$

=7.9(kN)

From what has been discussed above the results, the q value was calculated by stiffness, it was what beam could carry the permission of the load. [q] = 7.9 kN/m, it could meet 100×60 the pressure what the square could carry. So, after checking, it met the conditions.

B. Force Analysis Of Bed Legs

When the front bed leg strength was calculated, and stress state of the dangerous point was plane stress. The cross section was supposed into a circle, it would be derived that with the rate of the internal force deformation could strength theory conditions as follows:

$$\sigma_r = \frac{1}{W}\sqrt{M^2 + 0.75T^2} \leq [\sigma] \tag{7}$$

$$\frac{32\sqrt{M_t^2 + 0.75T^2}}{\pi d^3} \leq [\sigma]$$

So

$$m^3 d \geq \sqrt[3]{\frac{32\sqrt{M_t^2 + 0.75T^2}}{\pi[\sigma]}} = \sqrt[3]{\frac{32\sqrt{(1\times10^3)^2 + 0.75(1\times10^3)^{22}}}{3.14\times100\times10^6}}$$

=44.6

Taking d = 45mm. the size of the bed legs was 60×45 mm, it was enough to reach the supporting purpose. Both bed legs were selected the more size.

When strength of the back bed legs was calculated, stress state of the danger point was plane stress state. The cross section was supposed into a circle, it would be derived that with the rate of the internal force deformation could strength theory conditions as Type 7.

Taking d=38mm. the size of the bed legs was 60×38 mm, it was enough to reach the supporting purpose. Both bed legs were selected the more size.

CONCLUSION

To sum up, in this paper, the drive structure of traction bed has been compared and analyzed, and the design scheme of the traction bed has been determined to use the working principle of car jack. on the basis the analysis of the whole structure working principle of the traction bed, its main parts have been designed, calculated and analyzed. The advantages of the traction bed were security and self-service operations. It was very suitable for family. It could make the patient to avoid the movement of before and after treatment. After traction treatment, patients could be on the bed lay down for a period of time to consolidate curative effect, it is highly advantageous to the patient's recovery, avoiding that after the traction treatment in hospital, it is the disadvantages of vertical activities from the bed. Tear open outfit of the traction bed was convenient; it could be "self lumbar traction treatment", "self traction treatment", "self body traction treatment" and "self exercise". It was without electricity, without being limited by the conditions, strong enough, and strong security.

REFERENCES

[1] Y. Wu, “Cervical Disease Non-operative Therapy”, *Anhui University* in press.
[2] H. D Sunders, “Use of spinal traction in the treatment of neck and back condition”, *Clin Orthop, England*, Vol.17, pp. 30-31, August 1983.
[3] Y. Zhao, “Diagnosis and Non-operative Therapy Cervical Vertebra Disease”, Shenyang Bashan in press.
[4] J. Li, “Study Overview about Therapy of Cervical Spondylosis by Traction”, *MEDIAL RECAPITUATE, Beijing*, Vol. 12, pp. 1016-1018, August 2007.
[5] J. Zhang, F. Jin, “Structure and Application of Joints Traction Bed Controlled by Micro-processor”, *INFORMATION OF MEDICAL EQUIPMENT, Beijing*, Vol. 22,pp. 8-40, May 2007.
[6] J. Zhang, F. Jin, “Structure and Application of Adjustable Multi-functional Traction Bed”, *CHINA MEDICAL EQUIPMENT, Beijing*, Vol.23, pp. 101-103, April 2008.
[7] Y. Ding, “Ergonomics”, *Beijing Institute of Technology* in press.
[8] H. Liu, “Mechanics of Materials”, Beijing Higher Education in press.

Liai Pan

Liai Pan was born in 1979 and got a master's degree from Jilin University in 2006. Now she is working in college of Mechanical and Vehicle Engineering, Changchun University, and she is mainly engaged in teaching and research related to mechanical engineering. She mainly teaches mechanical manufacturing technology, hydraulic and pneumatic transmission courses etc. published more than 10 papers. She is interested in the design of the main mechanical and electrical products, and hopes to become their future research direction.

Yumei Song

Yumei Song was born in 1971 and graduated from Jilin University. Now she was working in College of Mechanical and Vehicle Engineering, Changchun University, senior laboratory. She was mainly engaged in many courses of experimental teaching, such as "numerical control technology", "CAD / CAM technology", "CNC machine tools and programming", "machinery manufacturing equipment design", "mechanical manufacturing technology foundation" and so on. Teach professional involving mechanical engineering and automation, mechanical design, industrial design, industrial engineering. The main research direction is mechanical design.

Chunshan He

Chunshan He was born in 1969, graduated from Jilin University. Now he work in Changchun University College of Mechanical and Vehicle Engineering, associate professor, and mainly engaged in mechanical engineering related teaching and research work. He mainly teach Engineering Graphics, CATIA and other courses, published 17 papers. The main research direction is mechanical engineering and automation.