

Research on the Design and Function of a Protective Gear for Preventing Mouse Hand

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Abstract. Carpal tunnel syndrome is an occupational strain disease caused by long-term repetitive wrist movements leading to compression of the median nerve. Currently, the treatment methods for this disease are relatively single, and there are deficiencies in the research on related protective gear. For carpal tunnel syndrome (mouse hand) caused by long-term computer use, this article designs a support and protective gear for preventing mouse hand that integrates palm fixation, wrist support, forearm shaping, point magnetic therapy and heat therapy. This protective gear adopts a split structure, consisting of a glove body polyurethane wrist protection strap and a plastic arm support sleeve. It achieves personalized forearm fitting through thermoplastic plates, and is equipped with multi-point magnetic therapy and detachable heat compress modules. While ensuring the flexibility of hand movement, it reduces the pressure inside the carpal tunnel and alleviates muscle strain. Clinical and usage tests have shown that this protective gear is non-invasive and has no side effects. It can effectively prevent and relieve symptoms of mouse hand and is suitable for office workers and groups that frequently use mice.

Keywords: Carpal tunnel syndrome, Wearable protective gear, Magnetic therapy, Hot compress, Personalized support

1. Introduction

Mouse hand, also known as carpal tunnel syndrome, is an occupational strain disease caused by long-term repetitive wrist movements leading to compression of the median nerve. The clinical manifestations include wrist pain, numbness in the palm, and restricted fine motor skills. The prevalence rate among people who use the mouse for more than 5 hours a day is as high as 80% [1, 2]. The clinical treatment mainly relies on drug blocking and physical therapy, which have the disadvantages of long cycles, invasiveness, and high costs. The existing products such as wrist rests and wrist bands are difficult to balance support and flexibility, and lack targeted physiotherapy and personalized adaptation [3, 4]. Therefore, this study intends to design a portable wrist protector integrating multiple functions to achieve an integrated prevention, relief and rehabilitation solution, providing a lightweight, non-invasive and low-cost health protection solution for people who frequently use electronic devices.

2. Design concept and structural features

Long-term use of computers and mice can easily lead to carpal tunnel syndrome, commonly known as "mouse hand", which is mainly characterized by pain, numbness and decreased muscle strength in the wrist, seriously affecting daily work and life. Traditional treatment mainly relies on drug blocking and physical therapy, which have problems such as strong invasiveness, high costs and limited effect. Most commercially available products such as wrist rests and wrist bands have shortcomings such as insufficient support, poor flexibility, no point therapy, and no personalized adaptation. It is difficult to simultaneously relieve the pressure inside the carpal tunnel and muscle strain from both mechanical and therapeutic perspectives. In response to these pain points, the smart wrist arm protective gear that integrates support, fixation, hot compress, and point magnetic therapy has become essential equipment for office workers to prevent and relieve mouse hand.

As shown in Figure 1, in view of the shortcomings of the existing products, such as the difficulty in balancing support and flexibility, and the poor adaptability for point physiotherapy [5]. It adopts a combined solution of integrated wrist-arm structure, personalized thermoplastic support, point magnetic therapy and hot compress and it provides a non-invasive, low-cost and long-lasting protective solution for carpal tunnel syndrome. The core advantages are as follows:

(1) Personalized mechanical support: made of 65-70°C softening thermoplastic board, it can be shaped on-site to fit the contour of the forearm, forming a rigid support. It evenly distributes the pressure on the wrist and arm, reducing the risk of compression of the median nerve in the carpal tunnel from a mechanical perspective.

(2) Comfortable and stable fixation: made of polyurethane and combined with nylon adhesive tape, the tightness can be adjusted. It effectively supports the wrist without affecting the normal range of motion of the fingers and wrist joints.

(3) Traditional Chinese medicine point magnetic therapy [6]: precisely corresponding to key points for relieving wrist pain such as Yuji, Hegu, Houxi, Yangxi, and Waiguan, continuous magnetic therapy stimulation is provided to promote local blood circulation, relax muscles, and alleviate numbness and pain.

(4) Hot compress relaxation function [7]: a detachable heating pad is installed on the forearm area. Relieve tension in the thenar eminence and forearm muscles through a hot compress, further reducing the pressure on the carpal tunnel and enhancing the long-term wearing comfort.

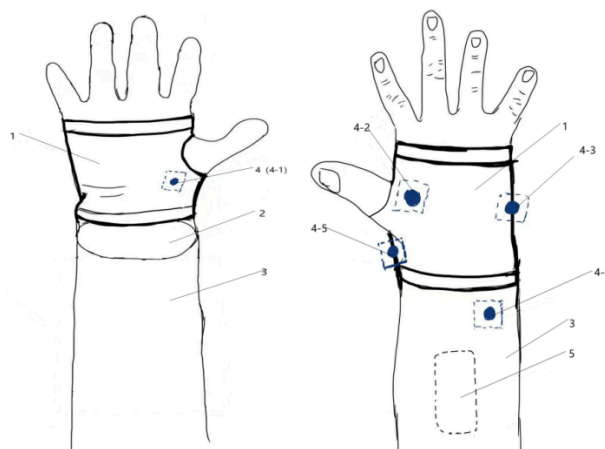


Figure 1. Schematic diagram of the protective gear structure

In Figure 1: 1. Glove body; 2. Polyurethane wrist protection area; 3. Arm support covers; 4. Magnetic therapy patch area; 4-1. The magnetic therapy patch area at the Yuji point; 4-2. The magnetic therapy patch area at the Hegu Point; 4-3. The magnetic therapy patch area at the Houxi point; 4-4. The magnetic therapy patch area at the Waiguan point; 4-5. The magnetic therapy patch area at the Yangxi point; 5. Heating board.

3. Protective gear structure design

3.1. Structural composition and working principle

This mouse hand prevention support protective gear is an integrated wrist and arm protection structure, mainly composed of a glove body and an arm support cover. The entire structure combines flexible fabric and plastic components to balance supporting performance, fitness and wearing flexibility.

The glove body is made of flat fabric pieces, with thumb holes provided on the fabric pieces for easy positioning when the thumb is inserted. The edges on both sides of the fabric piece are equipped with nylon adhesive tapes, which can be wrapped around and fixed to the palm area. The wrist protection area is fixedly connected to the lower edge of the glove body. Nylon adhesive tapes are also installed on both sides, which can be wrapped around the wrist to provide stable support and even pressure distribution. Polyurethane material is preferred to enhance wearing comfort and durability.

The arm support sleeve is connected to the lower edge of the wrist protective strap. It is composed of an outer fabric piece, an inner fabric piece and a thermoplastic board. The inner fabric piece is stacked above the outer fabric piece, and the corresponding positions of the edges of the two are sealed. An opening is made at the very top, which can stably limit the rectangular thermoplastic board between the two layers of fabric pieces. The edge of the outer fabric piece is equipped with a support sleeve adhesive tape, which can be wrapped and fixed on the forearm to ensure overall wearing stability.

The protective gear is equipped with magnetic therapy patches at the corresponding points on the glove body and the arm support sleeve. The glove body covers the Yuji, Hegu, Houxi and Yangxi acupoints, and the arm support sleeve corresponds to the Waiguan point. Through magnetic therapy, it promotes local blood circulation, and alleviates the pressure inside the carpal tunnel and muscle tension. The inner side of the outer fabric sheet has a detachable interlayer with an internal heating pad, which can be used to apply heat to the forearm and wrist, further relaxing the muscles and improving local metabolism.

Wearing and shaping process: immerse the thermoplastic board in 65-70° C hot water to soften it [8]. Take it out, dry it, and place it between the inner and outer fabric pieces. Press the inner fabric pieces against the surface of the forearm to shape it. Once the thermoplastic board cools and sets, a personalized support effect that perfectly matches the contour of the forearm can be achieved.

The working principle of the system: the glove body stabilizes the palm posture, the wrist protection strap disperses the pressure on the wrist, and the thermoplastic board provides rigid support for the forearm. The three work together to reduce the risk of compression of the median nerve within the carpal tunnel. Magnetic therapy and hot compresses act on key points and muscle groups, relieving strain and promoting circulation. The overall structure does not restrict the normal movement of fingers and wrist joints, and can continuously prevent and relieve the symptoms of mouse hand (carpal tunnel syndrome) during long-term office use.

3.2. Critical component

The glove body is mainly made of flat fabric pieces, with thumb holes provided for quick positioning. The nylon adhesive tapes on both sides can be adjusted to fit the tightness of the wrapping, adapting to the corresponding positions of the Yuji, Hegu, Houxi and Yangxi acupoints on fabric pieces of different palm shapes. The wrist protection straps are made of polyurethane material, which has good elasticity and support. They are fixed to the wrist by winding with nylon adhesive tape, effectively limiting excessive palmar flexion and dorsiflexion of the wrist, maintaining the wrist joint within a comfortable range of motion (palmar flexion 40°, dorsiflexion 40°, radial deviation 10°, foot deviation 20°), reducing the friction between tendons and nerves, and lowering the pressure on the carpal tunnel.

The arm support sleeve is composed of an outer fabric piece, an inner fabric piece and a thermoplastic board. The core is a thermoplastic support structure that can be softened at low temperatures and quickly set. After being heated and softened at 65 to 70 degrees, it can directly fit the forearm for shaping. After cooling, it forms a personalized rigid support, evenly distributing the pressure on the forearm and avoiding the wrist and arm from being suspended and subjected to force during office work, preventing mouse hand from a mechanical structure perspective. The outer fabric sheet is equipped with a detachable heating pad inside to achieve the function of a hot compress .

The specific physical picture is shown in Figure 2.



Figure 2. Internal physical picture of the protective gear

4. Clinical application and effect evaluation

4.1. Usage of the product

This study adopted the convenience sampling method to select people who frequently use their wrists as the subjects.

Inclusion criteria included daily wrist use more than 4 hours and voluntary participation in continuous wearing tests. Eventually, 13 subjects were included, covering three occupations: medical staff, office workers, and hand workers. The basic demographic characteristics are shown in Table 1. Among them, there were 11 cases under the age of 45, accounting for 84.61%, and the

male-to-female ratio was 8:5. In terms of daily wrist usage duration, there were 4 high-frequency users who used their wrists for more than 6 hours, accounting for 30.77%. Among them, 46.15% had a clear history of mouse hand, which was basically consistent with the characteristics of the target user group.

All subjects received uniform wearing instructions. They wore protective gear continuously for 6 days, with a daily usage duration of 4 to 5 hours, covering both daily office operations and rest scenarios. During the trial, participants were not allowed to use other wrist protectors or receive any wrist-related treatments, to eliminate interference from confounding factors.

Table 1. Basic information of the research subjects (n=13)

Research project	Sort	Number of people	Proportion (%)
Sex	Male	8	61.54
	Female	5	38.46
Age	19–30	5	38.46
	31–45	6	46.15
	46–60	1	7.69
	More than 60	1	7.69
	<2h	2	15.38
The daily wrist usage duration	2–4h	4	30.77
	4–6h	3	23.08
	>6h	4	30.77
Medical history of mouse hand	Yes	6	46.15
	No	7	53.85

4.2. Feedback on wearing experience

The subjects filled out the experience questionnaires on the 2nd, 4th and 6th days of wearing respectively, and evaluated them from four dimensions: wearing convenience, fit stability, hot compress sensation and impact on daily activities. The results are shown in Table 2.

Table 2. Wearing experience and functional feedback (n=13)

Evaluative dimension	Evaluation result	Number of people	Proportion (%)
Ease of wearing	Very convenient or relatively convenient	10	76.92
	Common	3	23.08
Bonding stability	Fits very well or quite well	11	84.62
	Common	2	15.38
Hot compress sensation	Quite hot	7	53.85
	Common or not too hot	6	46.15
	Not affected	3	23.08
Impact of activity	Minor impacts are acceptable	9	69.23
	Clear impact	1	7.69

Data shows that the ease of wearing (76.92%) and the stability of fit (84.62%) of the protective gear have been highly recognized and are the two core advantage indicators of this product. In terms of the hot compress function, 53.85% of the subjects believed that the heat was appropriate and the overall experience of the hot compress function was acceptable. The remaining subjects reported insufficient heating or indistinct thermal sensation, implying the temperature control design can be further optimized in follow-up upgrades. 92.31% of the subjects indicated that wearing it did not affect or only slightly affected daily operations, indicating that the protective gear provided support while retaining good hand flexibility.

4.3. Clinical improvement effect

A subgroup analysis was conducted on the subjects who already had wrist pain and numbness symptoms before wearing. The results showed that 84.62% of the subjects believed that the wrist support effect was good and could effectively reduce wrist fatigue. The total symptom relief effectiveness reached 84.62%, including 30.77% with obvious symptomatic improvement, 53.85% with mild alleviation, and the remaining 15.38% showing no symptomatic variation. There were no cases of symptom aggravation. The specific data are shown in Table 3.

Table 3. Clinical improvement effect (n=13)

Improvement indicators	Improvement level	Number of people	Proportion (%)
Wrist support effect	Strong support or significantly reduce fatigue	3	23.08
	Good support	8	61.54
	Common	2	15.38
	Significantly relieved	4	30.77
Relief of pain and numbness	Slightly relieved	7	53.85
	NC	2	15.38
	Sharpen	0	0.00

The above results suggest that this protective gear has a certain alleviating effect on people with mild to moderate wrist discomfort, but the improvement effect is limited for those without obvious symptoms.

4.4. Overall satisfaction

The comprehensive scores of the subjects for the protective gear were concentrated in the range of 7 to 10, accounting for 69.23%, and the satisfaction rate with the appearance reached 84.62%. Regarding long-term usage intention, 38.46% clearly intended continuous use, whereas 53.85% held a wait-and-see stance. Their main concerns were concentrated on insufficient heat application intensity and breathability during summer wear. Overall, this protective gear has achieved a preliminary balance between functionality and acceptance. Subsequently, compliance can be further enhanced through material and structural optimization.

5. Conclusion and prospect

Based on the anatomical characteristics of the wrist and the theory of points in traditional Chinese medicine, this study designed a support and protective gear for preventing mouse hand that

integrates palm fixation, wrist support, forearm shaping, point magnetic therapy and heat therapy. The clinical wearing test results show that this protective gear performs outstandingly in terms of wearing convenience (76.92%) and fit stability (84.62%), and can provide effective wrist support while basically not affecting daily hand activities. Among participants with pre-existing wrist pain or numbness, the overall symptom relief rate reached 84.62%, verifying its auxiliary protection and symptomatic relief effects for patients with mild-to-moderate carpal tunnel syndrome.

This study still has certain limitations: firstly, the sample size is relatively small (n=13), and it mainly consists of middle-aged and young people who frequently use their wrists, with limited representativeness and thus cannot be extended to a wider population. Second, the wearing period is relatively short, and the tolerance and sustained efficacy of long-term use have not been evaluated. Thirdly, there is still room for optimization in the temperature control and individualized adaptation of the hot compress function. Therefore, future research should further expand the sample size, extend the follow-up time, and, in combination with the usage needs of different occupational age groups, iteratively upgrade the material structure and functional modules of the protective gear to enhance its clinical applicability and wearing compliance.

In conclusion, under the current test conditions, this mouse hand prevention support brace has demonstrated a good user experience and initial clinical improvement effects. It can be used as one of the auxiliary options for daily protection of people who frequently use their wrists. However, its long-term efficacy and safety need further verification via additional evidence-based clinical trials.

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