Research on the Design of Brake Auxiliary Device Based on the Improvement of Riding Safety

Xi Zeng, Zheheng E*
Wuhan Institute of Technology
e-mail address: 291907160@qq.com

Abstract. Purpose: In order to improve the safety of the braking action of cyclists during the riding process, to meet the diversified riding needs of cyclists, and to take care of special riding groups to achieve the purpose of improving user experience. Method: Use ergonomics to guide the design of bicycle brake assist device, analyze from the perspective of ergonomics the elements and methods for achieving safe operation during bicycle braking, and complete the design of the brake assist device based on this analysis. Conclusion: It provides a new type of braking mode, reduces the difficulty of braking, improves the riding safety and comfort, and makes the product have important application value and better base on the market.

1. Introduction
Bicycle brake is a safety device for cyclists in the process of riding. Whether they are bicycle enthusiasts, ordinary bicycle users or a few special groups who use bicycles, their action of using bicycle brake in the process of riding has an impact on the stability and comfort of their current riding state. Especially in special circumstances and special weather, this effect is particularly obvious. The existing bicycle braking methods do not fully consider the user's experience in multiple scenarios and special user groups. At the same time, the existing research on bicycle riding safety in China mainly focuses on the analysis of the safety factors between cyclists and riding environment,[1] the conflict between non motor vehicles and motor vehicles, and the cyclists' own perception of risk. [2] However, there are few studies on the safety of bicycle users in the process of riding. In this paper, through the linkage design of bicycle brake, bicycle handle and bicycle side assistant handle, the difficulty of braking process is reduced, the stability of braking process is improved, and the user has a better experience in the use process.

2. Analysis of the braking mode of existing bicycles
2.1. Braking mode of existing bicycle during riding
The brake device of bicycle can play an important role in emergency braking and protect the rider. It usually adopts the handle type brake. That is, the brake mode requires the user to extend his finger to hold the brake handle to control the brake. The existing bicycle brake is used in a single way and is not humanized in use. There are several usage situations when the rider uses it: the first is to separate the brake with the finger and hand while holding the bicycle handle in the palm of the hand, so as to facilitate the timely braking when necessary; The second is to hand grip the bicycle handle while separating multiple fingers, or four fingers all hook the brake, thumb tiger mouth to the bicycle handle when needed to quickly hook the brake; The third is to grasp the bicycle handle with the palm of the hand, and then separate the fingers to brake when the brake needs to be slowed down; The fourth is to grasp the bicycle...
2.2. Safety analysis of existing bicycle braking modes

The safety analysis of the existing bicycle braking mode is mainly carried out through online questionnaire collection and offline field investigation. First of all, through the online questionnaire collection and research to understand the problems of users in using the existing bicycle brake mode, as well as in-depth interviews with offline users, extract the characteristic problems. Through user research and on-the-spot investigation and analysis, it is found that the existing use of bicycle brake is not safe, and the use of finger control brake sometimes affects the body balance and reduces the riding stability. Especially in special circumstances, such as special weather, special scenes and special user groups (1) Special weather: when riding in rainy days, the user needs to separate one hand to take the umbrella, while the other hand needs to hold the bicycle handle and hook the brake at the same time, which will greatly increase the control difficulty (2) Special scene: if the user needs to carry the items, he needs to separate one hand to carry the items. In this case, if he can't control the bicycle faucet with one hand, the riding stability will be greatly reduced (3) Special user groups: ① a small number of users with hand disabilities have to ride with one hand. At this time, the traditional brake action is more dangerous. ② Because some children's hands are not big enough, it is very difficult for them to grasp the handle and brake at the same time. The bicycle brake should be a device to protect the safety of riders, but due to its unreasonable design, it can not protect the safety of riders in some aspects. The action of bicycle brake itself will affect the stability of riding, especially in the case of emergency.[3]
bicycle brake are as follows: (1) safety principle: stable product structure and safe use (2) Adjustable principle: the product size can be adjusted to adapt to the use of users of various height and the use of various environments (3) Comfort principle: before use, it does not affect riding comfort, and does not affect riding stability during use.

It is mentioned in ergonomics that incorrect working posture not only easily causes fatigue, but also affects the work efficiency. Meanwhile, monotonous working posture will produce physical and psychological fatigue for operators. Because the same body parts are always used, local muscle fatigue will affect the working efficiency. From the point of view of cycling, the incorrect riding posture will make the rider more tired and affect the emergency response of the rider in case of emergency. Meanwhile, the riding action in the process of riding also needs to be adjusted in time to alleviate the fatigue of riding.[4]

For the ergonomic research of the existing bicycle braking mode, the emphasis should be on the braking mode under different riding conditions, ① braking speed under different conditions is analyzed; ② Stability of normal riding; ③ Riding comfort; ④ The influence of braking action on the stability of current riding state; These dimensions are analyzed.[5]

Table 1 Formatting sections, subsections and subsubsections.

| Riding style                  | Braking speed | Stability of normal riding | Riding comfort | The influence of braking action on current riding stability |
|------------------------------|---------------|----------------------------|----------------|----------------------------------------------------------|
| Single finger on bicycle brake| 1             | 4                          | 4              | 1                                                        |
| Multiple fingers on the bicycle brake | 2         | 3                          | 3              | 2                                                        |
| Grasp the bicycle handle with the palm of your hand | 3         | 1                          | 2              | 3                                                        |
| Grasp the bicycle side handle with the palm of your hand | 4         | 2                          | 1              | 4                                                        |

According to the ergonomics analysis table of braking modes under different riding states in Table 1, the performance of braking modes under different riding postures in different evaluation indexes can be obtained. Through the comparative analysis of horizontal and vertical, the most ergonomic braking mode can be obtained. In the subsequent research, how to give consideration to riding comfort, braking safety and efficiency should be considered.

After analyzing the braking of various riding postures in Table 1, it can be seen that there is a contradiction in the existing braking modes, that is, multiple fingers hook the brake and a single finger hook the brake. These two riding modes can brake quickly, and the riding posture has little influence on the stability of the current riding during the braking process, Because there is no significant change in the riding posture of the rider's body. However, the movement is not stable in the normal riding process, because the rider does not have enough control over the bicycle handle, which reduces the safety of the riding process; However, holding the bicycle handle and holding the bicycle auxiliary handle are more stable in the normal riding process, but they can't brake quickly. In the braking process, the fast posture switching will affect the stability of the current riding posture, and the braking delay will be caused by the posture change before braking. This also reduces the safety of the braking process.
From the perspective of ergonomics, the horizontal forward and backward movement of human trunk is faster than the left and right movement, and the rotation movement is more flexible than the linear movement; The operation in clockwise direction is faster than that in anticlockwise direction, and is used to it; The movement towards the body is faster than that away from the body; In the follow-up research, we should consider how to improve the braking efficiency on the premise of ensuring the safety of braking action in the process of riding. [6] By analyzing the maximum frequency of hand action and the minimum average time of action in Table 2, combined with the stability of braking in riding posture, we can design a more reasonable and safe braking device.

### 4. Design scheme of bicycle brake auxiliary device

Combined with the previous analysis of the braking mode, braking safety and braking comfort in the process of cycling, it is found that the braking mode of the existing bicycle is single, and the braking process is not safe in the process of cycling. Through the ergonomics research, two design directions are summarized: (1) to ensure the comfort of holding the handle while riding, reduce the difficulty of braking and improve the comfort of braking action; (2) Consider how to improve the efficiency of braking on the premise of ensuring the safety of braking during riding.[7]

#### 4.1. Scheme of bicycle handle linkage brake auxiliary device

The bicycle handle linkage brake scheme is to upgrade the traditional bicycle brake handle. The load-bearing steel pipe structure on the handle is sheathed with a handle that can rotate 30 degrees towards the user. At the same time, a connecting piece is set between the rotating handle and the linkage device. When the handle is rotated, its connecting structure will drive the linkage device, In order to achieve the purpose of pulling the bicycle brake rod to brake, Figure 6 shows the contrast effect before and after braking in detail. At the same time, after braking, the internal spring traction structure will guide it to reset, so as to achieve a complete braking process.

![Figure 3 Scheme structure analysis diagram and comparison diagram before and after use](image-url)
The traditional bicycle braking method will affect the balance of the riding process in the braking process, and it is not comfortable to ride with the finger handle to control the brake. However, in the whole braking process, because the hand does not leave the grip of the bicycle, the whole braking action is stable and comfortable. And from the perspective of ergonomics, the brake mode of turning the bicycle handle is more scientific and efficient. Only when the bicycle handle starts to rotate, it can start to brake. When the handle rotates to the inside to 30 degrees, it can completely buckle the bicycle brake. Compared with the previous braking method which needs to stretch out fingers to grasp the bicycle brake lever, the way of turning the handlebar is more relaxed and natural, and the efficiency of subconsciously turning the handlebar in an emergency is higher, especially in the special cases mentioned above, the braking method of turning the handlebar can ensure the stability in the process of riding, Even if the user is riding on one hand.

4.2. Scheme of bicycle side handle linkage brake auxiliary device
The auxiliary handle of a bicycle is commonly used in mountain bikes, which is generally used by cyclists and professional cyclists. The additional handle position added by installing the auxiliary handle on the outside of the handle is particularly important in long-distance riding, because the straight handle of a small wheel folding bike is similar to that of a mountain bike, It is impossible to change the body posture, adjust and move the center of gravity by changing different handlebars, just like a road vehicle with curved handlebars. It is very easy to make the waist, back, shoulder, arm and other parts of the body tired quickly when riding in the same posture for a long time. After installing the bicycle auxiliary handlebars, the rider can change the handlebars at any time on the way, and adjust the riding posture in time to alleviate the fatigue.

The scheme of bicycle auxiliary handle linkage bicycle brake is to upgrade the traditional bicycle auxiliary handle. A rotatable auxiliary handle is set on the load-bearing steel pipe of the bicycle handle. At the same time, a connecting piece is set between the bicycle auxiliary handle and the linkage device.
When the bicycle auxiliary handle is pulled backward, its connecting structure will drive the linkage device, in order to achieve the purpose of pulling the bicycle brake rod to brake.

When the traditional bicycle uses the auxiliary handle in the process of riding, if it needs to brake, the user needs to change the riding posture first, and then grasp the handbrake of the bicycle handle to achieve the purpose of deceleration. However, in the whole braking process, because the riding posture is not changed, the braking action becomes more simple, and the whole braking mode is more comfortable and efficient. From the perspective of ergonomics, the significance of the bicycle auxiliary handle is that when people ride for a long time, they can change their posture for a more comfortable ride. However, if they need to change their posture frequently for braking in the process of use, it will undoubtedly increase the burden of the rider. Therefore, on the premise of ensuring the comfort, the bicycle auxiliary handle linkage braking function should be added, the utility model can make the use of the bicycle auxiliary handle more humanized.

5. Conclusion
As a safety device, bicycle brake should not affect the comfort and stability of users when no braking is needed. The existing bicycle brake does not take this into account. And the design of the product should take into account the physiological and psychological factors in the user use process, and do not design the product in isolation, which leads to the use of the product contrary to the design expectations. The user should fully consider the process of user use, control the design in an all-round way, and truly achieve the humanized design.

The design of brake linkage reduces the difficulty of rider braking, increases the efficiency and comfort of the brake, and the two brake modes of the handlebar and the auxiliary handle linkage brake make the user more likely to ride. In design, not only the user's normal riding needs are taken into account, but also the use of the brake lever in special circumstances is possible. It can make the brake lever from a single device to the linkage use of the integrated system, so that it has better application value.

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