The design of a portaging apparatus for transporting bicycles

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Abstract

Commuting by bicycle has gained more and more popularity in recent years due to environmental, economic and socials factors. In Bangkok this trend is also catching on, with more and more people commuting by bicycle. Unfortunately, the traffic system in Bangkok does not facilitate this kind of transportation. Bicycle commuters need to work around traffic issues and one such issue is crossing the road which, in Bangkok, means crossing over numerous public footbridges. The purpose of this study was to find a means of assisting cyclists to overcome obstacles, such as public footbridges, when commuting. A methodology was then developed to design and evaluate a apparatus to facilitate cyclists in lifting and carrying their bicycle up and down such footbridges. Seven test subjects were recruited to participate in the testing of the designed apparatus. The aged between 28 and 39 years were in good health and exercised regularly, with some riding bicycles recreationally and three being regular users. Every test subject wore the Heart rate monitor. They were required to conduct two rounds as part of the test: one not using the apparatus and one using the designed apparatus. Based on heart rate monitor, comfort rating scale and Body map results, the apparatus designed as a lifting apparatus could facilitate a better lifting and carrying performance by reducing the use of energy. Moreover, use of the apparatus encouraged participants to employ a standardized lifting technique (i.e. every subject lifted the bicycle in a uniform manner rather than arbitrarily) which has the potential to minimize discomfort and injury.

Keywords : lifting and carrying, bicycle, injury prevention, public footbridge

1. Introduction

Big cities in Thailand do not have suitable bicycle-friendly infrastructure to support bicycle riding. Not many of the city’s footbridges or streets are designed to facilitate bicycle riding or carrying. Users need to carry their bicycles up and down the footbridge in order to get to the other side of the street. In an interview with a target user, the interviewee stated that he would like to have a bicycle that is light and easy to carry up and down stairs. As the standard footbridge design is 5.9 meters tall on average, the steep gradient can also make it a difficult task to carry a bicycle up and down the stairs. Bicycles are generally not made to be lifted and carried the correct way, primarily due to the fact that there is no obvious lifting point. If the user lifts or carries the bicycle incorrectly, this could possibly cause injury to them and to other people.

Figure 1 : Posture of lifting and carrying bicycle on public footbridge

A combination of bicycle weight and improper lifting and carrying cause possible damage to the user's spine and back muscles or Musculoskeletal disorder (Caliso et al, 2001) (Earle-Richardson et al, 2004). From the observation, many subjects do not bend the knees and their backs are not straight when lifting (see Figure 1). The spine has two erector muscles that run alongside it to give support to the spinal joints and can only carry loads of not more than 20 kg. If these muscles are incorrectly employed they can very easily be damaged. Incorrect lifting techniques are often cited as a major cause of lower back complaints (Dul and Weerdmeester, 2001).

Moreover, holding the bicycle in a wrong way cause possible damage to hand wrist both "acute" or "instant" trauma in the form of sprains or dislocations, or it could result in "cumulative" or "repetitive, overuse disorders". Subjects must bend their hands when lifting the front wheel up.

Currently, there are some lifting accessories that relates to this topic. Deutur triangle bag (Deutur, 2008) is made from Ethylene-vinyl acetate (EVA), used for cushioning, and the nylon cloth body with a zip for accessibility to storage compartment. The unit is designed to be mounted on the bicycle frame between the top and the seat tube. The drawback of this system is that having objects inside the bag can push on the user's shoulder. Another related product is Ogio Shling System (Ogio International, 2006). It was originally developed for use with golf bags in order to enhance the ease of carrying the bags around the course. It consists of a harness-like shoulder unit that helps redistribute the weight being carried over both sides of the shoulders. It has two straps attached to the unit: one strap is attached to the right front shoulder and the other one comes out of the left rear side of the unit. Although the product was designed for carrying the heavy weight, the position of the weight at the rear of the user makes this unit unsuitable for bicycle lifting and carrying.

The objectives of the study are to create a apparatus that can:

1) assist cyclists to lift and carry the bicycle in the correct way so as to prevent injury to the user; and

2) reduce energy consumption while lifting and carrying the bicycle up and down a public footbridge.

The research involves the study of the lifting and carrying of a bicycle based on the standard footbridge design in Bangkok in order to design an apparatus to assist in this issue. The validation of the study is based on a 20-inches-wheel bicycle design that can accommodate user sizes from 142 cm to 192 cm. The study focuses on working people aged between 25–40 who work in the Bangkok metropolitan area.

3. Method

3.1 Apparatus

Figure 2 : Dimension and apparatus hooked to the bicycle

A new apparatus was inspired by the Ogio Shling (see Figure 2). The load of the weight evenly between both shoulders and also makes it easier to mount and dismount. The position of carrying the bicycle is at the side of the user so as to enable the user to clear the width of the railing. The apparatus designed to fit the average 95percentiles of adults.

3.2 Heart rate measurement

The method of testing the effectiveness of the apparatus designed required a heart rate monitor, Polar S 610, to verify the energy used. The chest transmitter reads the heart rate and transmits the signal to the watch. After testing the subjects, the user fills in the form of body map which is an information on comfort and pain in an area of the body.

For this research, the 20-inches-wheel folding bicycle was chosen as the preferred apparatus. It is compact size of the frame and wheels. Participants were asked to lift the bicycle up the public footbridge stairs. When they reached four locations – starting point, the top of bridge, other side, and down, they were asked to press the lap button when reaching the locations. Subjects rest around 20 minutes before going to the next round of testing. The test was conducted with participants between 10.20 to 11.50 a.m. At the time the temperature was between 32 to 35 degrees Celsius.

3.3 Assessment of discomfort in various parts of body

A 6-point scale was used in this study to assess body part discomfort experienced by the subjects during the lifting and carrying a bicycle. The scales used were 0 (no discomfort), 1 (little discomfort), 2 (moderate discomfort), 3 (pain), 4 (much pain), and 5 (extreme pain). The body was divided into 13 parts including upper shoulders, lower shoulders, neck, upper back, lower back, hip, legs, feet, upper arms, elbows, lower arms, wrists, and fingers.

4. Result

4.1 Heart rate monitor

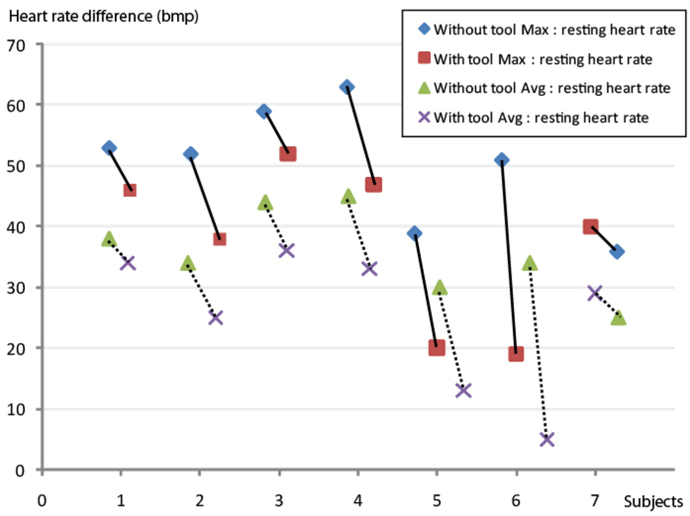

Figure 3 : Individual heart rate between using and without using apparatus

According to Porges and Byrne (1992), average heart rate during task performance compared to rest-baseline measurements is a fairly accurate measure of metabolic activity. The difference between the maximum heart rate minus the resting heart rate and the average heart rate minus the resting heart rate has the same direction (see Figure 3). The heart beat tends to incline when using the apparatus. Comparing the heart rate when using and without using apparatus, six out of seven subjects have less heart rate difference. Subject numbers 5 and 6 show the significant difference. Their heart beat is less when using the apparatus.

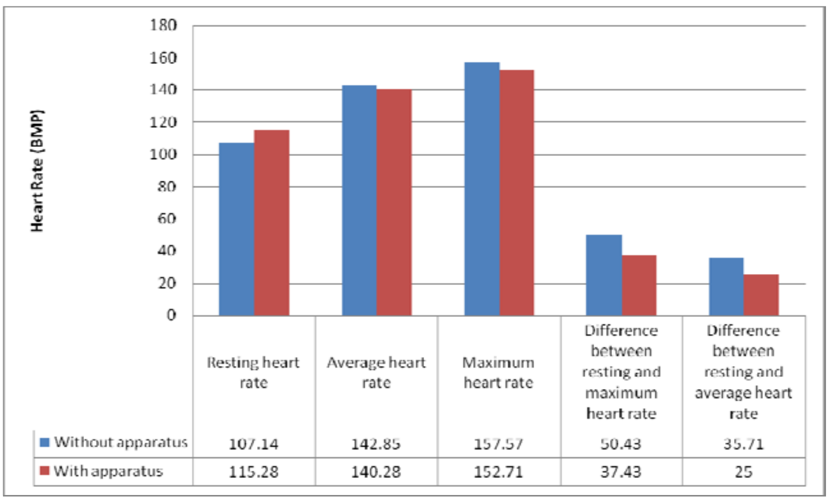

Figure 4 : Average heart rate comparison with and without using the apparatus

The average of heart rate without using apparatus and using apparatus is 142.85 bpm (beats per minute) and 140.28 bpm is not significant difference (see Figure 4). On the other hand, the difference between resting heart and maximum heart rate is different when without and with apparatus 50.43 bpm and 37.43 bpm respectively. The maximum heart rate when not using the apparatus is higher than using the apparatus. By not using the apparatus, many subjects are tired and heart rate is quite high. The difference between resting and average heart rate for not using the apparatus and using the apparatus is 35.71 bpm and 25 bpm respectively. The result shows that the apparatus could assist subjects in term of energy consumption.

4.2 Body map and comfort rating scale

Table 1 : Comparison of participants without apparatus and with apparatus

Body part	Number of participants experienced discomfort in different body part											
	0		1		2		3		4		5	
	Without apparatus	With apparatus	Without apparatus	With apparatus	Without apparatus	With apparatus	Without apparatus	With apparatus	Without apparatus	With apparatus	Without apparatus	With apparatus
1. Upper shoulders	0	0	1	0	1	1	2	2	0	2	0	0
2. Lower shoulders	0	0	1	0	0	0	1	0	0	0	0	0
3. Neck	0	0	1	0	0	1	1	0	0	0	0	0
4. Upper back	0	0	0	0	1	2	0	0	0	0	0	0
5. Lower back	0	0	1	0	0	0	0	0	0	0	0	0
6. Hip	0	0	1	0	0	0	0	0	0	0	0	0
7. Legs	0	0	1	0	0	0	0	0	0	0	0	0
8. Feet	0	0	1	0	0	0	0	0	0	0	0	0
9. Upper arms	0	0	1	1	0	0	3	0	0	0	0	0
10. Elbows	0	0	0	0	2	3	1	1	0	0	0	0
11. Lower arms	0	0	0	0	1	0	0	0	0	0	0	0
12. Wrists	0	0	0	0	2	1	0	0	1	0	0	0
13. Fingers	0	0	1	0	1	1	0	0	1	0	0	0
Total	0	0	9	1	7	9	8	3	1	2	0	0

In evaluating the individual experience of the test both with and without the apparatus, the body map rating scale form was given to every participant to fill out. When not using the apparatus, the participants experienced discomfort in several parts of the body (see Table 1). There was pain in the upper shoulders, lower shoulders, upper arms and elbows. This could be due to carrying the bicycle to avoid obstacles. Three participants experienced much pain in the wrists and fingers. There was minor discomfort throughout the body, such as the hip, legs, upper arms and fingers. When using the apparatus, there was less discomfort experienced by the participants in different body parts. The discomfort experienced by participants was primarily in the upper shoulders, due to the apparatus pushing on the shoulder area. Some participants also experienced discomfort at the neck area.

In conjunction with comfort rating scale, all seven participants rated on a comfort score of 1 – 5 (uncomfortable, slightly uncomfortable, slightly comfortable, moderately comfortable and comfortable respectively) on the rating scale to evaluate their overall comfort levels. The average score of using apparatus is 3.6 more than without using 2.6.

4.3 Posture evaluation

Figure 5 : Postures of lifting and carrying before and after using the apparatus

From observation, all participants arbitrarily lifted the bicycle without a set position or posture. The particular user shown in the Figure 5 lifted the bicycle by bending her back and used her arms to lift the bicycle up. This caused a lot of strain on her shoulders and arms. When lifting the bicycle, many subjects carried the bicycle with right arm bent all the way up and down the stairs, which could also cause strain to the shoulders and forearm. After using the apparatus, all seven participants who used the apparatus to lift the bicycle had to bend their knees in order to sling the harness around the neck to lift the bicycle up. This makes the lifting activity standardized. All participants using the apparatus had the same posture when adjusted correctly. The bicycle faces the right direction alongside the user. All participants' backs were straight and their hands were free to hold the handrail.

5. Conclusion

Judging from the results of the heart rate monitor, it indicated that the heart rate performance of the participants using the apparatus was better than not using the apparatus. However, in some cases the heart rate of some participants did not indicate that the apparatus actually helped. This could be due to external factors, since the experiment was not conducted in a controlled environment such as exercising condition. In conclusion, the researcher believes that the apparatus is an effective apparatus which could be further developed to reduce energy usage and injury when lifting and carrying a bicycle over a standard Bangkok footbridge or other similar objects that require the same activity. The researcher is of the view that future development could focus on adapting the apparatus for use with other mobile loads. It is possible that this area of research would have the potential to improve the wellbeing of Bangkok's traveling salespeople, who can frequently be seen carrying heavy loads from place to place. Many of these salespeople travel significant distances from their home into the city centre, frequently using footbridges and needing to assemble and dismantle their displays from time to time.

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