Effect of Two Ergonomic Designs for Shuttlecock Buckets

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Abstract. Shuttlecocks serve as one of the necessary sporting equipment to play badminton. The standard Shuttlecock buckets sold on the market are equipped with a total of 12 Shuttlecocks and the bucket body is long, which makes it time-consuming to pick up and causes palmar flexion and other usage problems. In view of this, the two brand-new designed shuttlecock buckets are introduced. This research aims to compare traditional shuttlecock buckets with two kinds of new buckets in order to find out whether they can provide users with a better experience. The experiment was evaluated by measuring wrist flexion angle and user pickup time and adopting a subjective questionnaire. The result indicated that the two new designed buckets are superior to the traditional buckets due to that they can help reduce wrist flexion angle and improve ball pick up efficiency. All in all, this study helps manufacturers to design and produce more reasonable shuttlecock buckets as it provides a new perspective on shuttlecock buckets design.

Keywords: ergonomics, badminton, industrial design, wrist flexion.

1. Introduction

With the improvement of people's living standards and awareness of fitness, more and more people nowadays are involved in sports and athletes, among which badminton is popular with the public because it is less restricted by the court as well as equipment. Meanwhile, relatively easy to master. In addition, participating in badminton over the long term has significant therapeutic effect on patients with cervical spondylosis [1]. The World Badminton Federation estimates that 220 million people play badminton world-wide [2]. And badminton is especially a very popular sport in China, Indonesia, Malaysia, and India [3]. Taking China as an example, the participation rate of badminton is 42.6%, second only to running [4]. The Shuttlecocks are an essential equipment for the badminton game. Shuttlecocks buckets currently in use on the market are long in length and narrow in inner diameter, causing users have difficulty picking up shuttlecocks and storing shuttlecock buckets. The process of picking up shuttlecocks is time-consuming and requires users to bend their wrist, therefore, prone to causing wrist flexion. A previous study stated that flexion greater than 30 degrees was risky for work-related hands [5]. And excessive wrist flexion angle can lead to wrist diseases such as carpal tunnel syndrome and wrist tendonitis [6]. Since a large number of badminton players have already suffered from severe wrist diseases, the process of picking up shuttlecocks will undoubtedly worsen their diseases and bring about irreparable harm. Therefore, it is necessary to redesign the shuttlecock buckets to improve user comfort and reduce the risk of repetitive injuries.

In order to design a user-friendly bucket, one of the most important ergonomic principles is reducing users ' wrist deviation and subsequent Musculoskeletal disorders and injuries [7]. Many products in the market or research have redesigned and evaluated their products based on this principle, such as bent-handle fabric scissors [8], the result in this study shown that it can reduce wrist deviation compared with traditional fabric scissors, thus improving the usability of scissors. On the other hand, the results of the study of paint brushes [9], which was also designed based on this principle, indicated that there was no significant difference between new and traditional paint brushes. At present, however, there was limited research and designs on shuttlecock buckets, and as mentioned above, the buckets can cause palmar flexion in users during the picking up process and then increase the risk of injuries to the user. In order to solve this problem, the study designed two shuttlecock buckets based on this ergonomic principle. The objective of this study was to determine whether the two new shuttlecock buckets can achieve better well-being and performance outcomes [10] than

traditional buckets. Well-being was evaluated by wrist flexion angle and performance outcomes were evaluated by recording the time subjects took to complete two tasks included in this study.

2. Method

2.1. Subjects

Fifteen subjects, all of them are male, were enrolled. The mean age was 21 years. The age range was 20-22 years. Among them, 2 participated in badminton frequently. 7 participated in badminton occasionally. 6 participated in badminton rarely. The subjects' dominant hand was the right hand. And the wrist had not been injured in the last 6 months. The information about the subjects was organized and shown in TABLE I.

2.2. Shuttlecock Buckets Elevated in the Study

The three types of shuttlecock buckets evaluated in the experiment were the traditional shuttlecock bucket, the lifting plate shuttlecock bucket, and the detachable shuttlecock bucket. The shuttlecocks in the traditional shuttlecock bucket need to be picked up one by one from the beginning to the end. Therefore, the shuttlecocks in the middle and bottom of the bucket are more difficult to pick up during the picking up process. The lift plate shuttlecock bucket can use the support plate on the side of the bucket to move the shuttlecocks, which are at the bottom of the buckets. Therefore, shuttlecocks will be sent to the top of the bucket and then users can pick up the shuttlecocks conveniently. The detachable shuttlecock bucket is designed on the basis of the traditional shuttlecock bucket, but the middle part of which can be separated. At first, the shuttlecocks are relative each to take, so the user can directly take the ball from the top of the bucket. When it is difficult to get the shuttlecocks in the middle part of buckets, the bucket can be separated from the middle. The goals of this design are to improve the efficiency of picking up and help user story shuttlecock buckets easily. The appearance and structures of shuttlecock buckets were shown in Fig.1, Fig.2 and Fig.3. The latter two buckets were both converted from the traditional buckets. The brand and model of the buckets are exactly the same. All of them are RSL NO.5 and each bucket contains 12 Shuttlecocks.

Table 1. Information of Subjects

Characteristics	Number of participants
Age range	
20-25	15
Gender	
Male	15
Female	0
Badminton Participation	
Frequent	2
Occasional	7
Rare	6
Dominant Hand	
Right Hand	15
Left Hand	0
Suffered From Wrist Disease Within 6 Months	
Yes	0
No	15

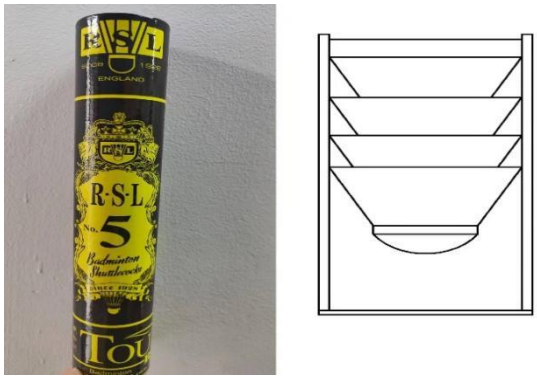


Figure 1. The structure of the traditional shuttlecock bucket.

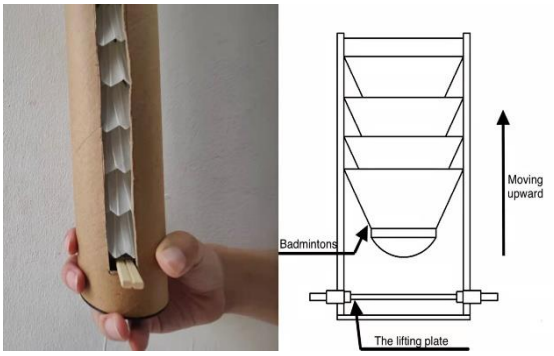


Figure 2. The structure of the lifting plate shuttlecock bucket.

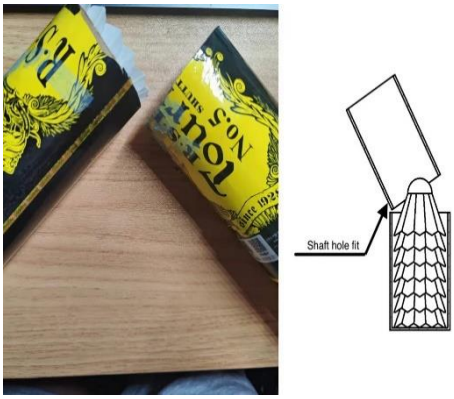


Figure 3. The structure of the detachable shuttlecock bucket.

2.3. Experiment Design and Measures

Three variables were evaluated in this experiment. 1） wrist posture, 2) time to complete the designated experiments, 3) subjective assessments.

Two different stimulated tasks were designed for this experiment. 1) Simulating the daily use of shuttlecocks. Subjects were asked to remove shuttlecock one by one in order and every time they take a ball, they need to cover the lid and then open the lid for the next pick-up. 2) Simulating the scene of badminton training, the coach needs to take out all the shuttlecock at once to ensure the consistency of badminton training. To eliminate the error, all subjects were instructed to use a same method for picking up shuttlecocks in the three different ball buckets before participating in the experiment and the experiment was conducted in the same place. The order of the three shuttlecock bucket tests was: 1) traditional buckets, 2） lifting plate buckets, 3) detachable buckets. During the experiment, we used a stopwatch to time the subjects' picking up times and four test subjects were randomly selected for wrist angle measurements, and the wrist angle were measured at three moments: picking up the first ball, picking up the third ball, and picking up the sixth ball. The wrist angle measurement method was shown in the Fig.4 and the process of this experiment was shown in the Fig.5. The less time it

takes to pick up shuttlecock, the more convenient it is for the user. In addition, a previous study, based on subjective assessment, pointed out that the greater the angle of the wrist palmar flexion, the greater the discomfort caused by the movement [11]. Therefore, the shuttlecock bucket that take less time to pick up and less angle of palmar flexion are considered as more user-friendly.

Finally, a questionnaire is used to investigate users' subjective feelings. The questionnaire consists of two parts, 1) use of comfort 2) Aesthetics of movement, which with a rating scale of 0-5(Where no comfort or aesthetics=0. Very low comfort or aesthetics = 1; Low comfort or aesthetics = 2; Moderate comfort or aesthetics = 3; High comfort or aesthetics = 4, and Extreme comfort or aesthetics = 5)

2.4. Data Analysis

The time performance in the experiments was evaluated in seconds. The data collected from the experiments was analyzed by SPSS software. One-way ANOVA analysis and LSD post hoc test were used. A significant level of $P < 0.05$ was used for all tests.

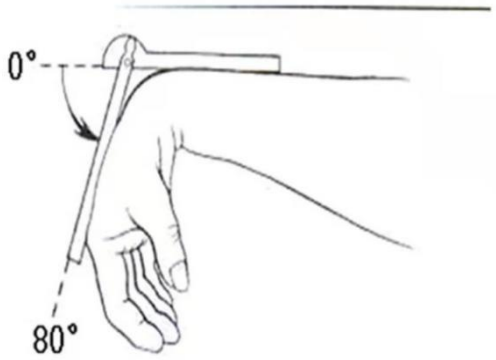


Figure 4. Measurement method of wrist. https://www.sohu.com/a/152574793_823432

3. Result

The results showed that there was a significant effect of different shuttlecock buckets designs on the time to compete the simulated tasks. As for task 1, the results showed that the mean time (SD)spent to complete the task with traditional shuttlecock buckets was 61.90(4.68) s, with lifting plate shuttlecock buckets was 52.33(5.21) s and with detachable shuttlecock buckets was 62.22(5.30) s. In addition, according to the LSD post hoc test, was shown in Table II , traditional shuttlecock buckets were significantly different from lifting shuttlecock buckets, while not different from shuttlecock detachable buckets. Meanwhile, lifting shuttlecock buckets were significantly different from both shuttlecock buckets. About task2, the results indicated that the mean time (SD) required to finish the task with traditional shuttlecock buckets was 44.57(3.45) s, with lifting plate shuttlecock buckets was

4.16(0.55) s and with detachable shuttlecock buckets was 38.08(2.25) s. Moreover, the result of the LSD post hoc test was shown in Table III, and significant differences were found for both different shuttlecock buckets.

Table 2. Results of the LSD test for task 1.

	Traditional buckets	**Lifting plate buckets**	**Detachable buckets**
Traditional buckets	——	0.863	0.000
Lifting plate buckets	——	——	0.000
Detachable bucket	——	——	——

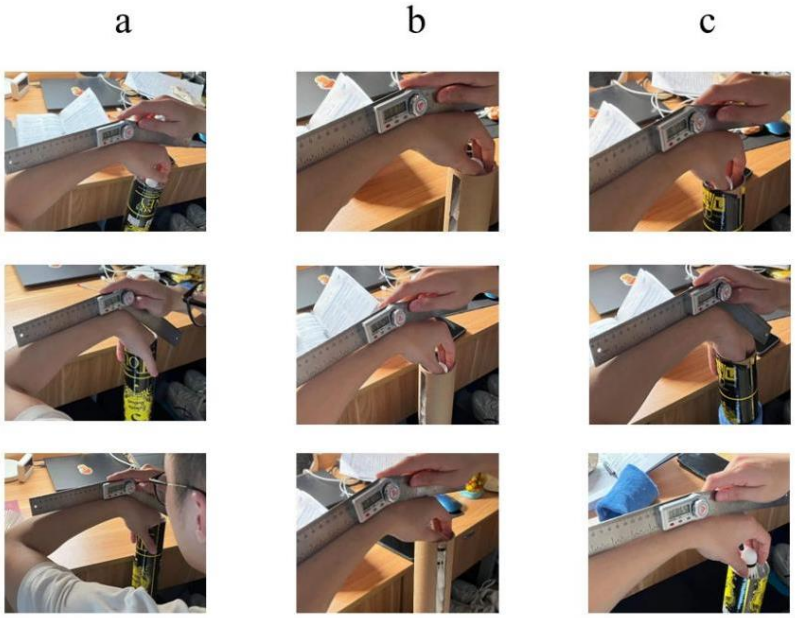


Figure 5. a-c: show the wrist position when picking up the first, third, and sixth shuttlecocks in order. Fig.5.a is the traditional shuttlecock bucket, Fig.5.b is the lifting plate shuttlecock bucket, and Fig.5.c is the detachable shuttlecock bucket.

Table 3. Results of the LSD test for Task 2.

	Traditional buckets	Lifting plate buckets	Detachable buckets
Traditional buckets	——	0.000	0.000
Lifting plate buckets	——	——	0.000
Detachable bucket	——	——	——

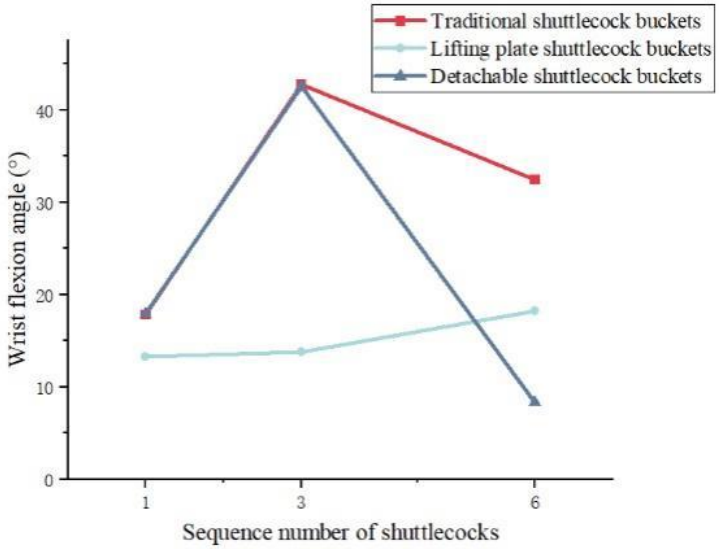


Figure 6. Mean wrist flexion angle when picked up shuttlecocks from buckets.

With regard to wrist flexion angle, Due to the small sample size, we only calculate the mean flexion angle. The results were shown in Fig.6. When packing up the first ball, the wrist flexion angle of subjects with traditional shuttlecock buckets was 17°51′, with lifting plate shuttlecock buckets was 13°18′and with detachable shuttlecock buckets was 17°57′. When packing up the third ball, the wrist flexion angle of subjects with traditional shuttlecock buckets was 42°42′, with lifting plate shuttlecock buckets was 13°45′and with detachable shuttlecock buckets was 42°30′. When packing up the first

ball, the wrist flexion angle of subjects with traditional shuttlecock buckets was 32°27′, with lifting plate shuttlecock buckets was 18°15′and with detachable shuttlecock buckets was 8°23′.

Finally, according to the results of the questionnaire, in terms of comfort, subjects gave a score of 4.57 for lifting shuttlecock buckets, 2.79 for traditional shuttlecock buckets, and 3.5 for detachable shuttlecock buckets. On the aspect of aesthetics of movement, subjects gave a score of 4.02 to lifting shuttlecock buckets, 2.07 to traditional shuttlecock buckets and 2.98 to detachable shuttlecock buckets. Similarly, the results showed there were significant differences between three kinds of shuttlecock buckets concerning user subjective experience.

4. Conclusion

In conclusion, both of new design shuttlecock buckets, especially the lifting plate shuttlecock bucket, are more user-friendly compared to traditional shuttlecock buckets since they can achieve better well-being and performance outcomes, i.e., they can reduce unnatural wrist flexion so that prevents user suffering from wrist diseases and reducing the time user consume to pick up shuttlecock. This study provided an insight into the design of shuttlecock buckets and perhaps it could be used for future production to help users use the shuttlecock bucket more easily.

However, there are still some limitations existed in this study. Since two new shuttlecock buckets were converted from traditional shuttlecock buckets, they can achieve fundamental functions but have disadvantages in their structure.

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