Evaluating the Impact of Mouse Curvature Design on Hand Ergonomics and Comfort in E-Sport Players Through EMG and 3D Kinematics Measurement Methods

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Keywords: Mouse Design, Carpal Tunnel Syndrome, Gaming Mouse, Wrist, EMG, Kinematics, Clicking Rate.

Abstract: This research compares the impact of two different mouse curvature designs on comfort parameters, wrist muscle fatigue, and E-sport performance. Sixteen elite male right-handed E-sport players participated in the study, testing five different mouse models. Click performance, muscle activation signals, finger pressure, and 3D motion data were recorded. The testing involved five different mouse models (BenQ Zowie, FK1, FK1+, FK2, S1, S2) to compare hand ergonomics and comfort, with peak position and length as the parameters. Click performance was tested. Analysis revealed no significant difference in click performance between mouse models, but FK1 showed reduced fatigue after 60 seconds of clicking. Different curvatures resulted in varying wrist angles and fatigue levels. The results showed that bigger length and height on the back for symmetrical mouse did not provide a performance advantage, with the back tall design exhibiting higher fatigue. The mid-tall design showed less fatigue and could potentially reduce wrist extension and stress on the carpal tunnel. This study provides insights into the impact of mouse curvature on hand ergonomics, comfort, and muscle fatigue in E-sport players, aiding mouse design improvements and consumer guidance.

1 INTRODUCTION

In the past, there were few studies on the impact of E-sports equipment parts on the human body. For example, mice designed for shooting-based e-sports have specific requirements. In addition to considering factors such as Hz, DPI, FPS, G-force, and IPS, which are important indicators for identifying the level of a mouse, the selection of mice for such esports is influenced by the prolonged duration of gameplay. This prolonged duration is associated with fatigue in finger control, which affects the coherence of elbow and wrist movements and subsequently impacts performance (e.g., a CS: GO match lasts approximately 40 minutes). With long time use on the E-sport with gaming mouse bring some uncomfortableness on wrist. One side is that the symptoms of Mouse Elbow can be chronic muscle fatigue and/or soreness, persistent muscle tension that won't subside with rest. In the other hand, size down and light weight become an important issue to fit moving fast in the game. However, the downsize can be negative or positive effect on the consumers are still unknown. From the perspective of human biomechanics, it is crucial to understand the impact of different types of mouse designs on finger control and the coherence of movements between the hand, wrist, and elbow. Empirical research on related product designs is also essential in this regard. To help users to define a suitable and comfortable game mouse in a good size in design through biomechanics measurement method may help to clarify this issue. Thus, the aim of the research is to compare two major mouse back type and slope with height and length sub changes on the tail design and the parameters which is related to comfortableness and muscle fatigue on the wrist and E-sport performance, thereby to understand how the curvature can influence the performance and the finger movement and wrist joint tension in order to provide some reference for mouse design and also help to give some advice for consumers to choose for specific purposes.

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2 MATERIAL AND METHODS

2.1 Subjects

Sixteen well-trained male right-handed elite E-sport players (age: 21.5±3.1 yrs.; hand size: 19.08±0.99cm) volunteered to participate in this study. All participants gave their consent before the experiment and had no history of lower extremity pain within the last half year. All participants were fully informed of the benefits and risks of the investigation before signing. The research design was approved by the Institutional Review Board of Fu Jen Catholic University in Taiwan.

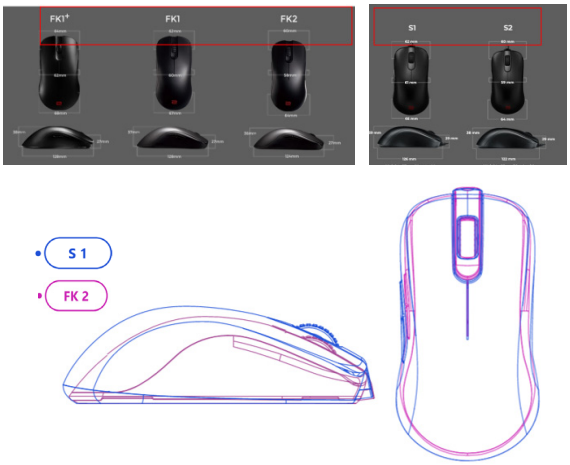
2.2 Instruments

2.2.1 E-Sport Mouse

The testing mouse mode were BenQ Zowie FK1, FK1+, FK2(mid tall), S1, S2(back tall) to compare the Hand Ergonomics and Comfort effect of length, mice back, mice back slop, front height(FH), middle height(MH) of 5 mouse (Table1, Figure 1).

Table 1: Two types of curvature of E-sport mouses with sub-variations.

Name	Length (mm)	Mice Back Type	Mice Back Slope	Front Height (mm)	Middle Height (mm)
FK1+	128	low	small	27	38
FK1	128	low	small	27	37
FK2	124	low	small	27	36
S1	126	median	median	29	39
S2	122	median	median	29	38



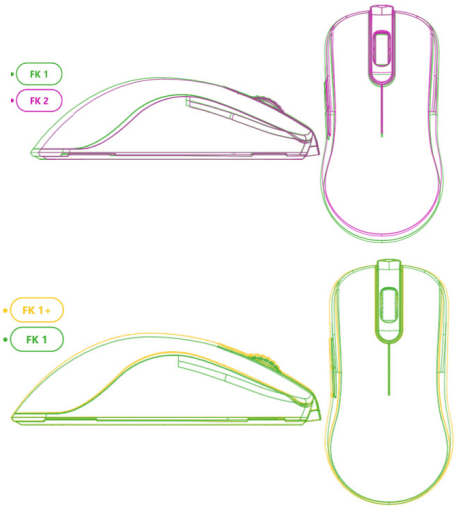


Figure 1: Two main types of E-sport mouse from side view and top view and structure lines for S1, FK2, Fk1 and Fk1+.

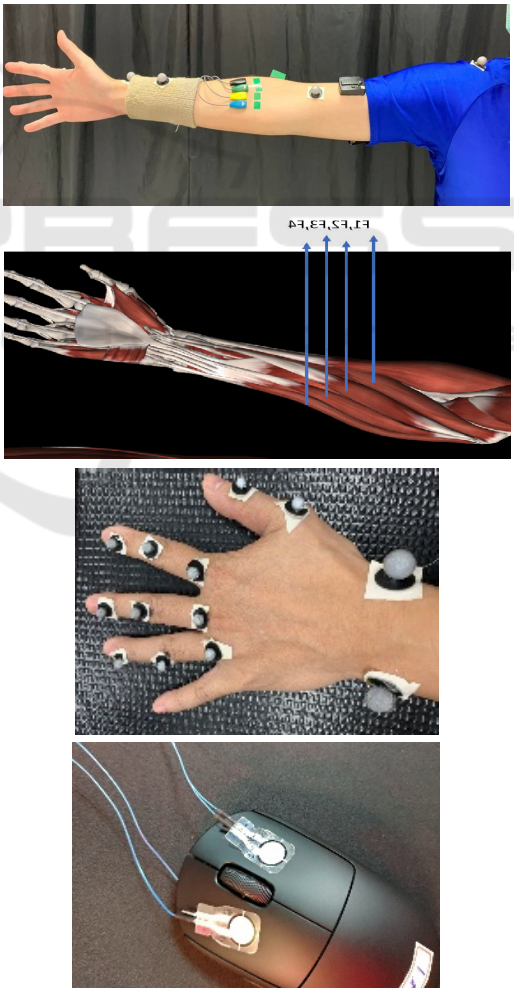


Figure 2: Passive markers setting and EMG attachment and pressure sensors.

2.2.2 EMG and 3D Motion System

The click performance was tested for 30s. The highest click rate is calculated. The muscle activation signals of the triceps, biceps, wrist flexors, wrist extensors were recorded in the right arm with the Delsys-16 EMG system (Delsys Inc., Natick, MA, USA) at 2000 Hz as well as the 3D motion analysis system and pressure sensor system (Figure 2). The pressure sensors were used to measure finger pressure for clicking (60Hz). The Motion Analysis System with 9 high-speed cameras (200Hz) were used to collect motion data and processing with Cortex7.1. Twenty-nine reflective markers attached on the participant according to the manual guideline.

2.3 Procedure

After a 5 min standardized warm-up consisting of practice to ensure they familiarize themselves with the process and the environment, two maximal isometric voluntary contractions (5-s duration) were then performed with 2 min rest between them. Participants performed clicking task 30s as fast as they can for two times as pre-test and post-test to examine fatigue resistance. E-sport in height-adjustable desk and chair (Figure 3). EMG data were filter band-pass-filtered (20–450 Hz, telemetry device property) and derived median frequency every 5 s.

Figure 3: The environment setup and participants on testing.

2.4 Data Analysis

The finger angle and wrist angle were derived from the position of the markers (Figure 4).

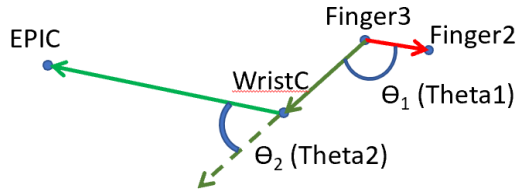


Figure 4: The joint angle derived from the marker position.

2.5 Statistics

One-way repeated measures ANOVA was used to test the different mouse on the selected biomechanical parameter. When the main effect size was significant, the Bonferroni method was used for the post hoc comparison test.

3 RESULTS AND DISCUSSION

The players have a very high click performance (>6 clicks/s). Although there is no significant difference between mouse models with different curvatures (6.35~6.37 clicks/s, $p>.05$). However, for the fatigue resistance test, FK series with low back and small slope FK1+ with high middle height has shown significantly reduced after 30 s maximum clicking speed (Figure 5A and 5B). It seems different curvature with slight changes can result in fatigue risk. FK series have flatter back curve relative to S series, which may due to the low back design to make the wrist low and more palm up to have the finger more comfortless position and gravity load to reduce the click performance. S series with median slope showed better performance fatigue resistance.

Maximum wrist angle is not significantly different between mouse during 30 s clicking pre-test task ($p>.05$), but Fk 2 have smallest maximum wrist angle during 30 s clicking post click task compared to FK1 and S2 ($p<.05$) (Figure 6). For the comparisons of different mouse on EMG fat igue of finger flexors and wrist extensor muscles during click task, only wrist extensor showed significantly difference: S2 and F1 is lower than S1 ($p<.05$)(Figure 7). The results showed that low or median back type and slope can be advantage in muscle activity economic as long as the back height is not too high to force higher wrist extension. Back tall design (S1) with higher wrist angle has higher fatigue may due to higher wrist extension. In the other hand, mid-tall design (FK1) has less fatigue.

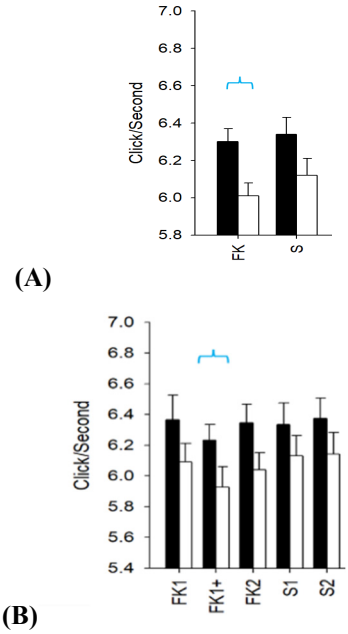


Figure 5: The average clicking performance over 30 s between mouse and pre-test and post-test.

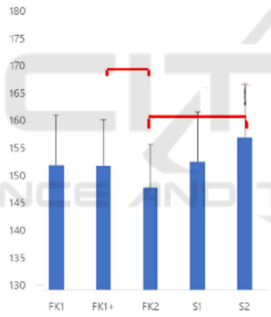


Figure 6: The wrist angle of average clicking performance over 30 s during mouse post-test.

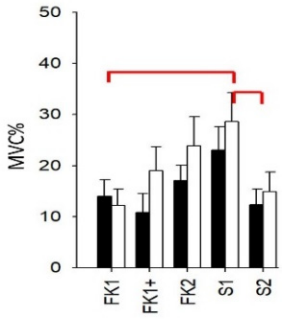


Figure 7: The EMG amplitude of wrist extensor between mouse types and pre/post-task.

4 CONCLUSIONS

The subtle changes on longer length and flat and middle peak location could possibly avoid the high wrist extension for long term, and reduce the stress on Carpal Tunnel Syndrome, though not so advantage of Engaging in prolonged periods of high-intensity mouse clicking. This study also provides an evaluation of comfort and click performance as factors in mouse design from a human ergonomics perspective.

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