

## Article

# Influence of Mouse Grip Type on Flicking and Tracking Tasks Performance

Roberto Sanchis-Sanchis , Alberto Encarnación-Martínez \* , Ignacio Catalá-Vilaplana ,  
Jose Ignacio Priego-Quesada , Inmaculada Aparicio  and Pedro Pérez-Soriano 

Research Group in Sports Biomechanics (GIBD), Department of Physical Education and Sports, University of Valencia, 46010 Valencia, Spain; roberto.sanchis@uv.es (R.S.-S.); ignacio.catala@uv.es (I.C.-V.); j.ignacio.priego@uv.es (J.I.P.-Q.); inmaculada.aparicio@uv.es (I.A.); pedro.perez-soriano@uv.es (P.P.-S.)

\* Correspondence: alberto.encarnacion@uv.es

**Abstract:** The First-Person Shooter is a very popular genre in electronic sports (esports), where there are different aiming techniques such as Aim Flicking and Aim Tracking. Although the mouse grip is suggested as one of the most important factors in gaming performance, there is a lack of evidence on this topic. Therefore, the purpose of the present study was to determine the performances of three types of mouse grips (palm grip, claw grip, and fingertip grip) in two different tasks (flicking and tracking tasks) by analyzing kinematic and scoring variables. Twenty-two participants performed the tasks on a computer with the same monitor and mouse, each using their preferred grip: palm grip, claw grip, and fingertip grip. The aim400kg was used to perform the tasks, and a camera system (Optitrack's Flex 3) was used to capture the mouse movement. The results from the flicking task indicated significant differences in the minimum cursor trajectory, with higher values observed in the claw grip compared to both the palm and fingertip grips. However, no significant differences were observed in the tracking task in terms of velocity, acceleration, or hand movement. Moreover, only high correlations were observed in the flicking task between Score and Reaction Time ( $r = -0.911$ ) and between Score and Total Distance ( $r = 0.724$ ). In conclusion, the mouse grip does not affect the *Aim Flicking* or *Aim Tracking* task performance. This study has revealed interesting results related to performance, including correlations between the *Score*, *Reaction Time*, and *Total Distance* in flicking tasks.

**Keywords:** aiming; tracking; electronic sports; cursor; grip



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## 1. Introduction

The popularity of playing video games has increased continuously in the past decades, in some cases replacing traditional games [1]. Electronic sports (esports) have experienced a great increase, both economically and socially [2]. The revenue forecast in the esports market for 2024 is more than one and a half trillion USD and the number of viewers is expected to grow from almost 500 million to 600 million in the next 3 years [2]. Moreover, some worldwide players are considered professionals, and esports have been considered a sport by the International Olympic Committee since 2013 [3].

Esports can be organized into the Multiplayer Online Battle Arena (MOBA), First-Person Shooters (FPSs), Real-Time Strategy (RTS), Card Games, and Sports Games [4], where factors like a low-latency system (software and hardware) directly affect the player's response time [5–7]. There are also several aspects, like motivation, experience, training positive feedback, and support for autonomy, that have been identified as influential factors in optimizing performance in esports [5,8]. Different domains, such as musculoskeletal, visual, auditory, psychomotor, cardiorespiratory, nutritional, cognitive, and psychological optimization, have also been related to performance optimization in esports and health [9]. Also, ergonomics play a key role in this type of sport since the player's posture in the

gaming chair, prolonged exposure to the screen, and hundreds of repetitive movements during gaming sessions can increase the injury risk [9].

FPS video games are characterized by fast gameplay, where reflexes and skills when using input devices are essential [10]. For computer gamers, these are the mouse, which is used for aiming, and the keyboard, which is typically used for movement [11]. In FPS video games, the way to aim at the target involves rotating a 3D world to match the center of the screen with the target [12]. Here, the mouse controls the movement of a peephole that is always located in the center of the screen, and the movement of the mouse becomes the way of aiming within the game [12]. It is considered that there are two main aiming techniques: aim flicking, which consists of quick and accurate shots from a neutral point to the target, and aim tracking, which refers to the aiming style where the crosshairs remain above the target [7]. In this sense, the mouse grip is an important factor in ergonomics, which can be categorized according to parameters like the degree of wrist extension, the fingers used for left and right clicking, the level of support of the wrist/forearm on the table, and the level of grip behavior [13]. Three of the most employed grip types among gamers are the palm grip, which is the most common, the claw grip, and the fingertip grip [14].

The mouse grip may influence gaming performance in esports. For this reason, the purpose of this study was to determine the performances of three types of mouse grips (palm grip, claw grip, and fingertip grip) in two tasks (flicking task and tracking task) by analyzing kinematic and scoring variables. It was hypothesized that (a) the claw grip and fingertip grip would lead to a greater performance in *Aim Flicking* than the palm grip, (b) the palm grip would lead the gamer to perform significantly better in *Aim Tracking* than the claw grip and fingertip grip, and (c) certain performance variables related to flicking tasks would correlate with a better score.

## 2. Materials and Methods

### 2.1. Participants

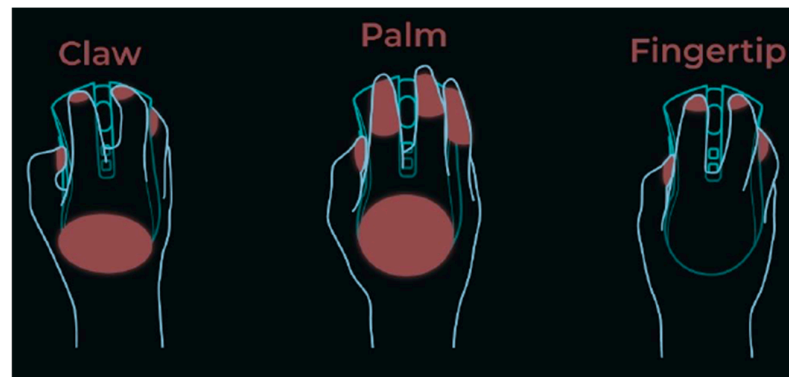
Twenty-two male players (age:  $25 \pm 3$  years, years of playing:  $12 \pm 5$  years, hours played per week:  $28.8 \pm 4.5$  h) participated in this study, with their preferred grip types as follows: three palm grips, nine claw grips, and ten fingertip grips. Participants were required to play regularly with a mouse and keyboard, for at least 20 h per week, and to be free from upper limb injuries for at least six months prior to testing. All participants were right-handed. All participants gave written informed consent, which was approved by the Ethics Committee of the University of Valencia (registry number: 1617529, date: 10 May 2021).

### 2.2. Study Protocol

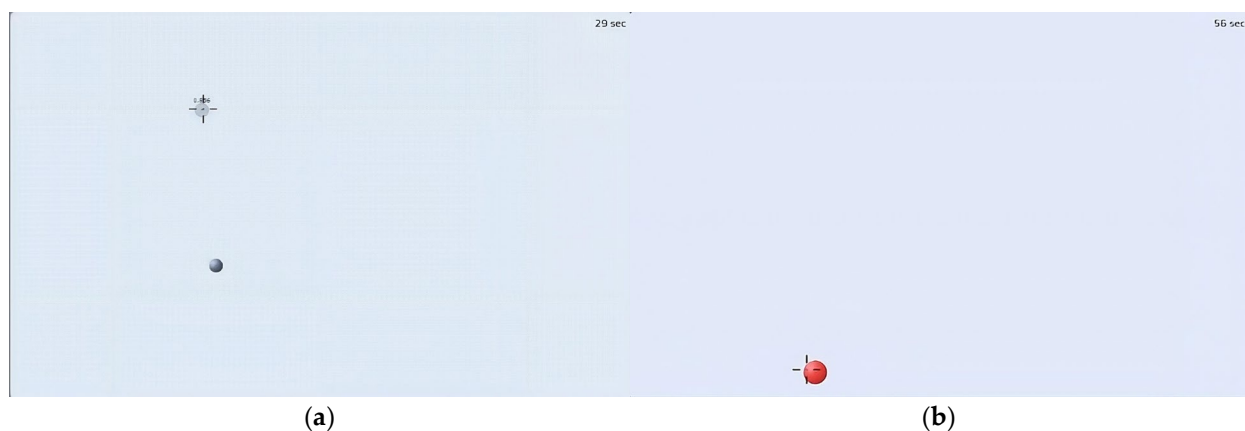
Firstly, participants performed a 5 min warm-up of the upper limbs following a guided video prepared by the researchers with the following movements: finger and wrist flexion–extension, forearm pronation–supination, wrist adduction and abduction, and wrist rotation in both directions. Once the warm-up was completed, the participant was encouraged to adjust both the chair and the monitor to adopt the most comfortable position. Participants used their own mouse grip, which was classified based on the following definitions [14]: (a) the palm grip consists of resting the entire palm on the mouse surface, (b) the claw grip combines features of the palm grip and the finger grip (where part of the palm and the fingers are in contact with the surface of the mouse), and (c) the fingertip grip involves using the fingertips to control the mouse (but the palm is not in contact with the mouse) (Figure 1).

Two types of tasks were analyzed as the main test (flicking and tracking). Before the test, each participant had five practice trials for each task. Then, three trials for each task were carried out and registered. The order of the tasks was randomized using opaque envelopes [15]. Both tasks were developed by the researchers using free software (<https://aim400kg.com/> (accessed on 9 April 2024)), which has been used in a previous study [16].

The flicking task consisted of clicking on the circles that randomly appeared on the screen as quickly as possible. The duration of the task was 60 s; each time a circle was clicked on, it disappeared and another one appeared in a different place on the screen (Figure 2a). The circles had a dimension of 5 units. The tracking task consisted of keeping the cursor over the circle shown on the screen, which moved randomly with a straight path at a constant speed along the vertical and horizontal axes (Figure 2b). The duration of the task was 60 s and the circle had a dimension of 9 units. The goal of this task was to observe the participant's ability to pursue a moving target with the mouse for as long and as accurately as possible.



**Figure 1.** Participants' grip types. Figure obtained from <https://www.wepc.com/reviews/logitech-wireless-keyboard-and-mouse-buyers-guide/> (accessed on 9 April 2024).

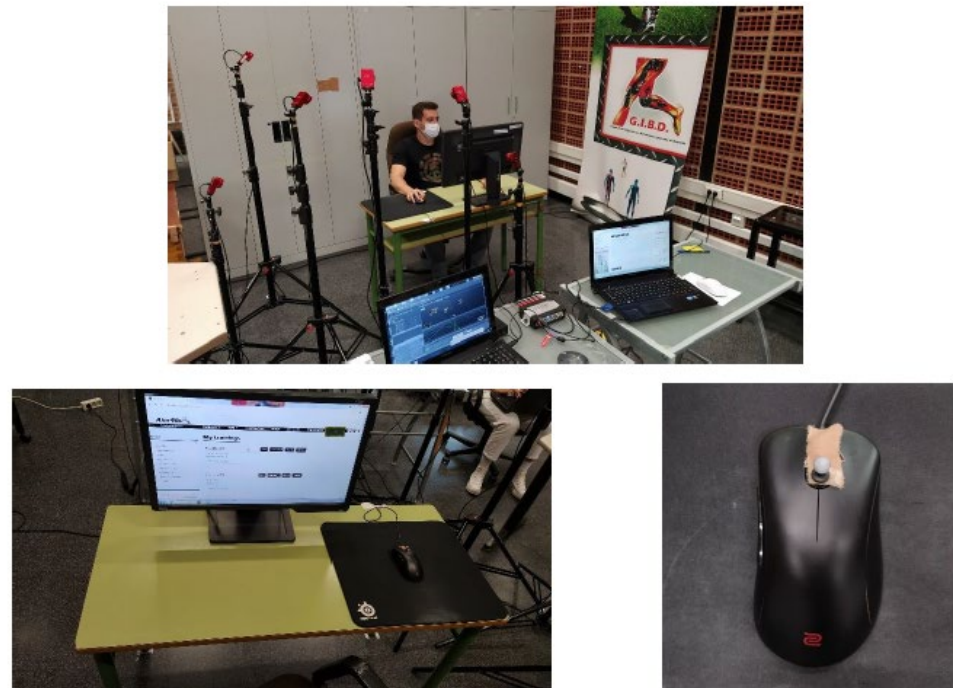


**Figure 2.** Tasks: (a) Aim Flicking, (b) Aim Tracking.

A computer connected to a 24-inch monitor (BenQ Zowie XL2411, BenQ, Eindhoven, The Netherlands) (144 Hz) was used to carry out the tasks. The participants sat in an adjustable chair and used an optical mouse at 800 DPI (BenQ Zowie EC1-A, BenQ, Eindhoven, The Netherlands) (90 g) on a rectangular mat with a smooth surface (Steelseries QCK Heavy, SteelSeries, Ballerup, Denmark). Three-dimensional kinematic analysis of the mouse during the requested tasks was performed using a 6 optoelectrical camera system (Optitrack's Flex 3, NaturalPoint, Inc., Corvallis, OR, USA), sampling at 100 fps, and a marker on the mouse (Figure 3). The recording volume space was previously calibrated.

The variables analyzed were classified into two groups: (a) scoring variables, which included both flicking and tracking results, and (b) kinematic variables. The scoring variables (Trajectory, Average Cursor Trajectory, Minimum Cursor Trajectory, Score, Minimum Distance, Total Distance, Aim Time, and Reaction Time) were obtained by performing the tasks using the "aim400kg.com" software. After completing 3 trials of each task, the average of each scoring variable was calculated. For the kinematic data, automatic tracking

and processing data were obtained using Motive software (Version 2.3.7; NaturalPoint, Inc., Corvallis, OR, USA). The signal was filtered (Butterworth, second-order, low-pass, cut-off frequency = 6 Hz) and the hand movement, average velocity, and average acceleration were calculated in three axes using a customized MATLAB routine (R2022b, MathWorks, Inc., Natick, MA, USA). The accuracy of the 3D reconstruction was determined by the root mean square error (RMSE), finding systematic errors of 0.005, 0.012, and 0.037 mm for the X (mediolateral), Y (anteroposterior), and Z (vertical) axes, respectively.



**Figure 3.** Gaming space and materials employed in this protocol.

### 2.3. Statistical Analysis

Statistical analyses were carried out using the SPSS 25 statistical software package (SPSS, Inc., Chicago, IL, USA). The data normality and homoscedasticity were verified using the Kolmogorov–Smirnov test and the Levene test, respectively. Then, a general linear model of a two-way repeated-measures design was performed. The grip type was considered a within-subject factor. Post hoc comparisons were performed using the Bonferroni or Games–Howell test (depending on the homogeneous variances) to identify the locations of specific differences. The level of significance was set at  $p < 0.05$ . For significant pair differences, the effect size (ES) was assessed using Cohen’s  $d$  (0.2, small; 0.5, moderate; 0.8, large) [17]. Pearson correlation coefficient was calculated to analyze the relationships between the scores obtained on each test (flicking and tracking) and the rest of the dependent variables. The magnitudes of correlation were interpreted according to the criteria established by Hopkins et al. [18]:  $<0.1$  = trivial;  $0.1$ – $0.29$  = low;  $0.3$ – $0.49$  = moderate;  $0.5$ – $0.69$  = high;  $0.7$ – $0.89$  = very high;  $\geq 0.9$  = extremely high.

### 3. Results

The results of the flicking task score data showed significant differences ( $p < 0.05$ ) in three variables related to the trajectory (Table 1). The *Trajectory* of the claw grip ( $71.46 \pm 4.62\%$ ) was lower than that of the fingertip grip ( $77.21 \pm 5.38\%$ ) ( $p = 0.024$ , ES = 0.4), the *Average Cursor* was lower for the palm grip ( $370.66 \pm 23.06$  px) than the claw grip ( $445.82 \pm 38.55$  px) ( $p = 0.013$ , ES = 2.4), and finally, the *Minimum Cursor Trajectory* was higher for the claw grip ( $140.37 \pm 10.68$  px) than the palm grip ( $103.11 \pm 17.58$  px) ( $p < 0.001$ , ES = 2.6) and the fingertip grip ( $106.57 \pm 20.07$  px) ( $p < 0.001$ , ES = 2.1). Nonetheless, no

significant differences ( $p > 0.05$ ) were observed in kinematic variables between the different grip types (palm, claw, and fingertip grips) (Table 1).

**Table 1.** Score and kinematic variables in the flicking task according to mouse grip type.

| Parameter                                | Mouse Grip Type | Mean (SD)                                | F      | p-Value          |
|------------------------------------------|-----------------|------------------------------------------|--------|------------------|
| Score (n)                                | Palm Grip       | 6711.11 (258.38)                         | 1.081  | 0.358            |
|                                          | Claw Grip       | 6618.50 (506.17)                         |        |                  |
|                                          | Fingertip Grip  | 6918.30 (428.93)                         |        |                  |
| Reaction time (s)                        | Palm Grip       | 0.82 (0.03)                              | 0.299  | 0.745            |
|                                          | Claw Grip       | 0.83 (0.06)                              |        |                  |
|                                          | Fingertip Grip  | 0.81 (0.06)                              |        |                  |
| Precision (%)                            | Palm Grip       | 51.57 (2.88)                             | 1.565  | 0.235            |
|                                          | Claw Grip       | 54.46 (3.35)                             |        |                  |
|                                          | Fingertip Grip  | 55.40 (3.31)                             |        |                  |
| Aim Time (s)                             | Palm Grip       | 0.85 (0.03)                              | 1.085  | 0.327            |
|                                          | Claw Grip       | 0.86 (0.06)                              |        |                  |
|                                          | Fingertip Grip  | 0.81 (0.09)                              |        |                  |
| Total distance (px)                      | Palm Grip       | 20,693.67 (1210.84)                      | 0.855  | 0.441            |
|                                          | Claw Grip       | 21,833.96 (1588.70)                      |        |                  |
|                                          | Fingertip Grip  | 22,074.37 (1703.33)                      |        |                  |
| Minimum distance (px)                    | Palm Grip       | 37.70 (7.77)                             | 1.341  | 0.285            |
|                                          | Claw Grip       | 42.07 (9.04)                             |        |                  |
|                                          | Fingertip Grip  | 34.70 (10.84)                            |        |                  |
| Trajectory (%)                           | Palm Grip       | 78.98 (1.02)                             | 4.585  | <b>0.024</b>     |
|                                          | Claw Grip       | 71.46 (4.62)                             |        |                  |
|                                          | Fingertip Grip  | 77.21 (5.38) <sup>palm</sup>             |        |                  |
| Average cursor trajectory (px)           | Palm Grip       | 370.66 (23.06)                           | 5.448  | <b>0.013</b>     |
|                                          | Claw Grip       | 445.82 (38.55) <sup>palm</sup>           |        |                  |
|                                          | Fingertip Grip  | 404.40 (39.56)                           |        |                  |
| Minimum cursor trajectory (px)           | Palm Grip       | 103.11 (17.58) <sup>claw</sup>           | 11.784 | <b>&lt;0.001</b> |
|                                          | Claw Grip       | 140.37 (10.68)                           |        |                  |
|                                          | Fingertip Grip  | 106.57 (20.07) <sup>claw</sup>           |        |                  |
| Average velocity (m/s)                   | Palm Grip       | 0.026 (7.69 <sup>−5</sup> )              | 0.201  | 0.820            |
|                                          | Claw Grip       | 0.028 (0.005)                            |        |                  |
|                                          | Fingertip Grip  | 0.028 (0.004)                            |        |                  |
| Average acceleration (m/s <sup>2</sup> ) | Palm Grip       | 5.27 <sup>−4</sup> (4.58 <sup>−6</sup> ) | 0.160  | 0.853            |
|                                          | Claw Grip       | 5.61 <sup>−4</sup> (1.02 <sup>−4</sup> ) |        |                  |
|                                          | Fingertip Grip  | 5.54 <sup>−4</sup> (8.59 <sup>−5</sup> ) |        |                  |
| Hand movement (mm)                       | Palm Grip       | 133.00 (0.98)                            | 0.250  | 0.782            |
|                                          | Claw Grip       | 143.30 (24.25)                           |        |                  |
|                                          | Fingertip Grip  | 140.47 (21.67)                           |        |                  |

Note: Pair differences are marked by the name of the condition that is different in the column of the Mean (SD) value.

Among the tracking task results, no significant differences ( $p > 0.05$ ) in any of the score data variables analyzed were found between the three types of mouse grips (Table 2). Similarly, no significant differences ( $p > 0.05$ ) were observed in kinematic variables (Table 2).

On the other hand, the Pearson correlation in the flicking task showed (a) an inverse, extremely high correlation between the *Score* and *Reaction Time* ( $r = -0.91$ ), (b) a direct high correlation between the *Score* and *Total Distance* ( $r = 0.72$ ), and (c) a direct moderate correlation between the *Aim Time* and *Minimum Cursor Trajectory* ( $r = 0.64$ ) (Table 3). Nevertheless, no correlation was found in the tracking task (Table 3). This occurred since most of the variables could not be calculated, which arose because at least one of the variables was constant.



**Table 2.** Score and kinematic variables in the tracking task according to the mouse grip type.

| Parameter                                | Mouse Grip Type | Mean (SD)                                | F     | p-Value |
|------------------------------------------|-----------------|------------------------------------------|-------|---------|
| Score (n)                                | Palm Grip       | 1412.78 (321.15)                         | 1.684 | 0.212   |
|                                          | Claw Grip       | 1606.70 (242.68)                         |       |         |
|                                          | Fingertip Grip  | 1671.97 (148.42)                         |       |         |
| Average velocity (m/s)                   | Palm Grip       | 0.027 (0.004)                            | 0.669 | 0.525   |
|                                          | Claw Grip       | 0.025 (0.003)                            |       |         |
|                                          | Fingertip Grip  | 0.025 (0.002)                            |       |         |
| Average acceleration (m/s <sup>2</sup> ) | Palm Grip       | 5.32 <sup>−4</sup> (8.26 <sup>−5</sup> ) | 0.846 | 0.446   |
|                                          | Claw Grip       | 4.92 <sup>−4</sup> (4.96 <sup>−5</sup> ) |       |         |
|                                          | Fingertip Grip  | 4.90 <sup>−4</sup> (4.29 <sup>−5</sup> ) |       |         |
| Hand movement (mm)                       | Palm Grip       | 135.55 (24.25)                           | 0.532 | 0.596   |
|                                          | Claw Grip       | 127.18 (16.42)                           |       |         |
|                                          | Fingertip Grip  | 125.12 (11.54)                           |       |         |

**Table 3.** Pearson correlations between variables in the flicking task.

| Parameter    | Reaction Time | Total Distance | Minimum Cursor Trajectory |
|--------------|---------------|----------------|---------------------------|
| Score (n)    | −0.911 *      | 0.724 *        |                           |
| Aim time (s) |               |                | 0.643 *                   |

\* Significant correlation at 0.01 (bilateral).

#### 4. Discussion

The main objective of the present study was to analyze the influences of three types of mouse grips (palm grip, claw grip, and fingertip grip) on video game performance by analyzing kinematic and scoring variables in two different tasks (flicking and tracking). In FPS video games, two aiming techniques (Aim Flicking and Aim Tracking) stand out as the most important. However, to the best of our knowledge, no previous research has analyzed the effect of the mouse grip type on gaming performance. Based on the results achieved here, while trajectory parameters were affected, no differences were found in performance in any of the aiming techniques. Nonetheless, interesting correlations between the Score, Reaction Time, and Total Distance in flicking tasks were observed.

Concerning the Score, the type of mouse grip did not affect the flicking ( $p > 0.358$ ) or tracking task ( $p > 0.212$ ). However, in esports, a good reaction capacity is essential, since fast response times offer a fundamental advantage to performance [5]. Accordingly, an extremely high correlation ( $r = -0.911$ ) between the Score and Reaction Time was observed in this study, indicating that participants with a better Reaction Time achieved a better Score. Furthermore, a very high correlation ( $r = 0.724$ ) between the Score and Total Distance was also detected, which could have been due to the relationship between the Total Distance and the number of targets hit in the task: the more targets shot, the greater the distance travelled by the mouse cursor. Meanwhile, the non-difference in the Score in the tracking task suggested that the type of mouse grip is not a factor that influences the tracking performance of a moving target. Moreover, for the Trajectory variable, although significant differences were observed between the claw grip ( $71.46 \pm 4.62\%$ ) and the fingertip grip ( $77.21 \pm 5.38\%$ ), the effect size observed was small. Regarding the tracking task, some of the factors that may influence this kind of task are the type of response, the sensitivity of the mouse, and the start procedure, while the grip type seems not to be considered a determining factor [19]. This idea is in agreement with the results of the present study, suggesting that in video games belonging to the Hero Shooter genre, such as Overwatch, Quake, or Apex Legends, where Aim Tracking predominates, the use of a specific mouse grip will not give any advantage.

Regarding kinematics, in the flicking task, our results showed significant differences ( $p < 0.05$ ) in the Minimum Cursor Trajectory between the claw grip ( $140.37 \pm 10.68$  px) and the fingertip grip ( $106.57 \pm 20.07$  px), and also between the claw grip and the palm grip ( $103.11 \pm 17.58$  px). These differences between the claw and palm grips were also found in the Average Cursor Trajectory ( $445.82 \pm 38.55$  px vs.  $370.66 \pm 23.06$  px). The Minimum

Distance in this task represents the smallest distance between two consecutive targets in a straight line, measured in pixels, while the Minimum Cursor Trajectory indicates the pixels that the cursor has travelled between these targets [20]. These two variables are related, and our results suggested that for the same Minimum Distance, gamers who used a fingertip or palm grip traced a more optimal trajectory than those who used a claw grip. This outcome is in line with the findings of Phillips and Triggs [20], who asserted that the distance between targets can influence the cursor's trajectory, and that the type of mouse grip is one of the most influential factors on minimum distances. Furthermore, the difference in the Minimum Cursor Trajectory can arise due to the number of submovements performed with each grip, with researchers previously observing fewer submovements in minimum distances with the fingertip and palm grips than with the claw grip [21]. Nevertheless, further studies related to these aspects should be carried out to consolidate these results. A high correlation between the Aim Time and Minimum Cursor Trajectory was also found in this study ( $r = 0.643$ ). The Aim Time refers to the time between shots and the Minimum Cursor Trajectory indicates the path followed by the mouse with the shortest distance between two targets. Our results seem to be in line with those of Hwang et al. [21], who explained that the Aim Time is affected by the verification time and the number of submovements, so the higher the values of these two variables, the longer the aim time. Plus, the more submovements there are, the higher the Minimum Cursor Trajectory.

Finally, concerning kinematics in the tracking task, Engel and Soechting [22] analyzed the capacity for manual tracking in a two-dimensional plane in different experiments, in which they combined different variables such as changes in the directional trajectory, speed, and acceleration. They concluded that changes in direction generated much more similar reaction times than changes in other variables, and they also observed that reaction times to changes in target acceleration were much longer than for changes in speed or direction. The tracking task proposed in our research consisted of a target moving at a constant speed, and there were no changes in either speed or acceleration, only directional changes, which may explain the absence of significant differences in the kinematic variables. As such, it seems appropriate to investigate this aspect more deeply and verify whether or not there are differences between distinct mouse grips when the speed and acceleration of the target vary during the task.

The main limitation of this study was that all participants used the same mouse configuration (e.g., speed or pointer sensitivity). The researchers were aware that each person is familiar with their own mouse and its particular configuration, and the use of another mouse can impact performance. However, we considered that this limitation was necessary for the study, since allowing everyone to play with a different mouse and sensitivity would have increased the number of confounding factors in our assessment of the influence of the mouse grip on the results. The small number of players with the palm grip is also a limitation to be considered. Although we put all our effort into recruiting players with this type of grip, we were not able to secure many. Finally, no female players volunteered to take part in this study, leaving room for future research to work in this direction.

## 5. Conclusions

The type of mouse grip does not affect the performance in *Aim Flicking* or *Aim Tracking* tasks. Nonetheless, during flicking tasks, a strong relationship was observed between the performance (*Score*) and other scoring variables such as the *Reaction Time* and *Total Distance*, and a moderate direct relationship between the *Aim Time* and *Minimum Cursor Trajectory*. Moreover, the fingertip grip provided shorter trajectories than the claw grip for close-range targets. However, the type of mouse grip did not affect kinematic variables, neither in flicking nor in the tracking task.

**Author Contributions:** Conceptualization, R.S.-S. and P.P.-S.; methodology, I.A., A.E.-M. and P.P.-S.; software, J.I.P.-Q. and A.E.-M.; validation, J.I.P.-Q. and I.A.; formal analysis, R.S.-S. and A.E.-M.; investigation R.S.-S. and P.P.-S.; resources, P.P.-S.; data curation, R.S.-S., A.E.-M. and J.I.P.-Q.;

writing—original draft preparation, I.C.-V. and I.A.; writing—review and editing, I.C.-V., J.I.P.-Q., R.S.-S., I.A., A.E.-M. and P.P.-S.; visualization, R.S.-S. and P.P.-S.; supervision, R.S.-S. and A.E.-M.; project administration, R.S.-S. and P.P.-S.; funding acquisition, P.P.-S. All authors have read and agreed to the published version of the manuscript.

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**Institutional Review Board Statement:** This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Valencia (registry number: 1617529, date: 10 May 2021).

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in this study.

**Data Availability Statement:** The dataset generated and analyzed during the current study are available from the corresponding author on reasonable request.

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**Conflicts of Interest:** The authors declare no conflicts of interest.

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