# Effect of Different Computer Mouse Platform Slopes on Wrist Positions

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## ABSTRACT

*The purpose of this study was to investigate the effect of using four different computer mouse platform slopes on the wrist radial/ulnar deviation and extension/flexion postures. The four computer mouse platform slopes tested were, two horizontal slopes (with and without forearm support), and two downward tilted slopes of 10º and 20º . Thirty male students of an average age of 19.6 (±1.3) years, average height of 177.3 (±6.1) cm, and average weight of 77 (± 13.2) Kg participated in this study. Each student conducted a 'point and click' computer mouse task for 30 minutes at each of the four computer mouse platform slopes, with each slope tested at a separate day. Wrist radial/ulnar deviation and extension/flexion postures' data were collected before and after task performance. Results revealed that the use of computer mouse at the 10º downward tilted slope was associated with minimal degrees of wrist joint deviations. Conclusion drawn from the results of studying the use of the computer mouse at different platforms inclinations showed that computer mouse use at the 10 degree slope is the most preferable as it causes the minimal discomfort to the wrist joint of the user, thus avoiding related musculoskeletal disorders.*
***Keywords:*** *Computer Mouse Platform Slope, Wrist Positions, Computer Mouse Use.*

## INTRODUCTION

With the introduction of computer software packages that make primary or even exclusive use of electromechanical pointing devices such as the computer mouse over the past two decades, the demand on the use of these devices has increased tremendously[5]. Many computer operators, especially those involved in graphics and animation operations rely on the use of these devices as the primary means to communicate their goals to the computer[4]. However, despite the benefits of such devices, they were noticed to be associated with an increased incidence of carpal tunnel syndrome and other upper extremity musculoskeletal disorders[12]. The main factor that my account for the elevated incidence of these musculoskeletal disorders during computer mouse use is the awkward wrist posture adopted during maneuvering these pointing devices[17,22,23].

Using the computer mouse involves awkward postures as wrist extension and ulnar deviation[2,12]. Awkward postures include any fixed or constrained body position that is out of neutral. As a general rule, anything more than 20º degrees out of neutral position can be considered awkward[20]. Mouse users were found to spend on average 64% of working time with the operative wrist deviating more than 15º towards the ulnar side, thirty-four percent of which was in the interval 15-30º and 30% in the interval greater than 30º[12]. The average wrist posture adopted during mouse use was found to be 19.1º of extension from neutral with a standard deviation of 6.8º[3]. On the basis of this analysis, it was concluded that mouse use typically involves considerable exposure to extreme wrist ulnar deviation and extension postures.

Evidence of the relationship between wrist position and change of the intracarpal tunnel pressure may explain the occurrence of nerve entrapments and consequently the occurrence of the carpal tunnel syndrome[24]. Carpal tunnel pressure (CTP) was found to show a curvilinear increase with vertical extension/flexion hand movements and with lateral radial/ulnar deviation of the hands[11]. It was reported that extreme hand positions might prevent the free flow of fluids into the palm of the hand, whereas fluids flow freely into the palm with the hands in neutral-to-moderate extension (less than 20º) or flexion (less than 20º[9]. Additionally, the intracarpal tunnel pressure was found to increase substantially when the hand is ulnarly deviated more than 20º, or radially deviated more than 15º[10]. This gives an indication that individuals who use a mouse for long duration (e.g. computer-aided designs (CAD) operators) may be at a higher risk for developing carpal tunnel syndrome or aggravating existing symptoms. This might explain the increased risk of carpal tunnel syndrome among graphic artists who use mouse extensively[7].

An explanation for the increased carpal tunnel pressure that accompanies wrist extension was suggested to be due to distal muscle movement encroaching into the carpal tunnel space. It was concluded that with wrist extension, all extrinsic finger flexors would move distally towards or into the carpal tunnel. Incursion of these muscles into the carpal tunnel will increase the volume of its contents thereby acting to increase the intracarpal tunnel pressure. The magnitude of the effect would be dependent upon the location of the distal extent of the muscles, the thickness of the muscle, as well as the amount of incursion[13].

The increased interstitial fluid pressure causes local capillaries to collapse which causes impairment of blood flow in the compressed part of the median nerve and interferes with its profusion. This condition may cause symptoms of numbness and tingling that are consistent with CTS[8]. While short-term (2-4 hours) direct nerve compression produces reversible changes, prolonged compression may prohibit restoration of intra-neural blood flow, thereby causing irreversible nerve damage[16].

An increased neural tension may also appear as a secondary sequel triggered by prolonged static awkward postures. Such postures can stretch the nerves, causing increased tension within the nerves. This stretching may trigger an inflammatory response in and around the nerve trunk with subsequent swelling and impairment of the vascular supply[18]. Given that nerve trunks are mobile and gliding structures, swelling or formation of an inflammatory reaction may impair or inhibit such gliding. Thus, a cycle is induced in which inflammation, swelling, and impaired micro-circulation combined with restricted gliding lead to further events and ultimately, to nerve fiber dysfunction. Additionally, the decreased blood flow to the nerve due to chronic tension and/or direct mechanical compression encourages fibroblast invasion (fibrosis) in and around the nerve, which in turn tethers the nerve, preventing its necessary excursion during normal extremity movement[6].

The above findings drove computer designers towards designing workstations with specific criteria to eliminate the computer-related musculoskeletal disorders. From a design perspective, some options are to promote tool designs that reduce wrist extension and consequently reduce carpal tunnel pressure. One of the devices, available on the markets is the negative slope keyboard system (NSKS). A negative slope keyboard system is a keyboard tray that is downward tilted away from the computer user. In a recent study investigating the effect of different computer keyboard slopes on wrist extension angle, Simoneau and Marklin[21], observed that mean ulnar deviation angles increased significantly when the keyboard was sloped from 15$^o$ extension to 15$^o$ flexion for the left and right wrists. An increase in wrist ulnar deviation was associated with an increase of carpal tunnel pressure that consequently can cause carpal tunnel syndrome. However, these findings are still faced with contradictory findings proposing an absence of relationships between the wrist extension and ulnar deviation angles for either the left or right wrists during typing[19]. Therefore this study has been conducted to examine the controversy hypothysing whether the decrease in the wrist extension angle during computer use is beneficial or not.

## METHOD

### Subjects

A group of thirty male university students participated in this study on a voluntary basis. Their average age was 19.6 (±1.3) years. Their average height was 177.3 (±6.1) cm. Their average weight was 77 (±13.2) Kg. They were familiar with computer mouse use and they were free of any musculoskeletal disorders.

## INSTRUMENTATION

### 1- An office chair (Fig. 1)

An office chair of an adjustable height was used to ensure an optimum sitting posture for the subject. It has two forearm supports, one of which was removed and replaced with a portable forearm support. The portable forearm support was specifically designed to include two rounded pads. One pad was firm and fixed to the chair with a height adjustable stand while the other was a little bit soft, swiveling on the fixed pad to allow a free movement of the student's elbow and forearm in all directions without imposing a frictional force between the student's elbow and the forearm support. The backrest was tilted 100° backwards. A stabilizing belt was used to stabilize the participant's trunk against the chair backrest to ensure that each subject will be recorded in the same posture.

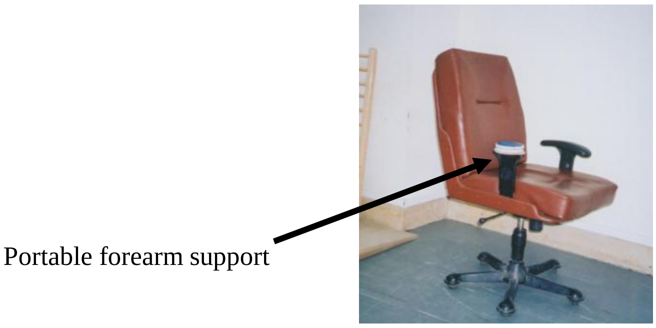


***Fig. (1): The office chair with a portable forearm support.***

2- A personal computer with a 17 inches monitor placed over a desk of a fixed height (71.5cm) and a standard mouse was used by the students to perform the mouse task.

3-A specifically designed computer mouse platform of adjustable height and slope (Figs.2 and 3). It is rectangular in shape with 25cm length and 20.5 cm width. Its height was adjusted to a height similar to that of the seated student's elbow height measured from the ground. Three different slopes were tested, a horizontal slope (0°), two downward tilted slopes (10° and 20°). The horizontal slope was tested twice, with and without the use of a forearm support.

***Fig. (2): The mouse platform slope.***

***Fig. (3): A subject while being tested at zero slope.***

4- A three-dimensional motion analysis system (Qualisys Motion Capture System). The system consisted of six infrared high speed Pro Reflex cameras with a wand-kit that was used for calibrating the system. Three passive reflective markers were used to reflect the infrared radiation imposed on them so as to allow the allocation of the tested body segments.

## PROCEDURE

As a preparation for the 3D motion capture, the camera system was calibrated to detect the volume at which the cameras would pick up the markers position. To achieve this, a wand-kit was used. After calibration, the students were prepared for 3D measurement by placing three passive reflective markers on the 1) olecranon process, 2) midway between the radial and ulnar styloid processes and finally, 3) on the head of the third metacarpal bone. This placement was conducted only for the right upper limb.

Considering the workstation setup, the chair height was adjusted such that the top of the seatpan was leveled with the student's upper border of the patella. The height of the seatpan was recorded to be considered for each student in each session. The student's trunk was supported and stabilized against the backrest using a stabilizing belt. The student monitor distance was kept at an armlength from the center of the monitor's screen for each student. The forearm support was adjusted to the seated student elbow height with both shoulders leveled. The height of the mouse platform was adjusted to a height similar to that of the forearm support such that the student's forearm was oriented horizontally in a forward reaching position.

These heights were to be considered at each of the four tested sessions.

Wrist posture was being captured for 5 seconds at the start of the computer mouse task while the student was resting his hand on the computer mouse with no wrist joint movement. Two wrist postures were measured, extension/flexion and radial/ulnar deviation. The student was allowed to play a unified game “virtua-cup” which involved a “point and click” computer mouse task for 30 minutes on each trial. Wrist motion capture was repeated after finishing this 30-minute duration task while the student was performing the task. After motion capture, the 2D data created by the tracker was automatically transferred to the 3D data by the Q view software. After identifying marker list (elbow, wrist and hand markers), the data file was exported as TSV (Tab Separated Values) file format to the Q tools software for measuring the wrist angles. The maximum wrist extension/flexion and radial/ulnar deviation angles were calculated.

Each student underwent four sessions at four separate days with a different computer mouse platform slope at each session. The four tested slopes were a horizontal slope, once in the presence of a forearm support and another in its absence, and a downward tilted slope, once of 10° and another of 20°. The order of the four computer mouse platform slopes was randomized among the four sessions for each student.

## RESULTS

**1- Wrist radial/ulnar static postures and extension/flexion static postures at the four computer mouse platform slopes (CMPSs) before task performance**

Results showed that grasping the computer's mouse statically resulted in ulnar wrist deviation of a mean degree of 14.8˚, 14.1˚, 14˚ and 10.9˚ at the horizontal mouse platform without forearm support (Horiz), horizontal platform with a forearm support as a new design (HND), the 10˚ and the 20˚ downward tilted mouse platforms respectively. Statistical analysis using one way ANOVA test revealed that there was a significant difference ($p<0.05$) among the four tested computer mouse platform slopes. Meanwhile, paired comparison using Duncan’s multiple comparison test was used to compare between each pair (table 1 and figure 4).

Regarding the extension/flexion wrist posture, the results showed that grasping the computer mouse statically resulted in an extended wrist joint with a mean degree of 9.9º, and 9º at the horizontal mouse platform in the absence and the presence of the forearm support respectively. However, grasping the computer mouse at the 10º and 20º downward tilted mouse platforms resulted in a flexed wrist joint with a mean degree of 0.7º and 11.9º respectively. Statistical analysis using one-way ANOVA test revealed that there was a significant difference ($p<0.001$) among the four tested mouse platforms for the mean degrees of wrist extension/flexion angles. Also, Duncan’s multiple comparison test was used to compare between each pair of the tested slopes (table 1 and figure 4).

***Table (1): Wrist ulnar/radial and extension/flexion static posture at the four mouse platforms during computer mouse grasp (before the task).***

| | Radial/ulnar static posture (R/U) | | | | Extension/flexion static posture (E/F) | | | |
|---|---|---|---|---|---|---|---|---|
| CMPSs | Horiz | HND | Sl 10 | Sl 20 | Horiz | HND | Sl 10 | Sl 20 |
| X±SD | 14.8 ±4.6 | 14.1± 2.8 | 14±5.8 | 10.9 ±5.3 | -9.9 ±3.7 | -9 ±3.4 | 0.7± 3 | 11.9± 4 |
| | ANOVA | | | | ANOVA | | | |
| | F value = 3.02 | | p value = 0.03 | | F value = 197.7 | | p value = 0.0001 | |
| | Duncan's multiple comparison test (p value) | | | | Duncan's multiple comparison test (p value) | | | |
| Horiz vs HND | | | | 0.6 | Horiz vs HND | | | 0.4 |
| Horiz vs Sl 10 | | | | 0.6 | Horiz vs Sl 10 | | | 0.0001 |
| Horiz vs Sl 20 | | | | 0.007 | Horiz vs Sl 20 | | | 0.0001 |
| HND vs Sl 10 | | | | 0.9 | HND vs Sl 10 | | | 0.0001 |
| HND vs Sl 20 | | | | 0.03 | HND vs Sl 20 | | | 0.0001 |
| Sl 10 vs Sl 20 | | | | 0.03 | Sl 10 vs Sl 20 | | | 0.0001 |

**(-) = extension and (+) = flexion.**

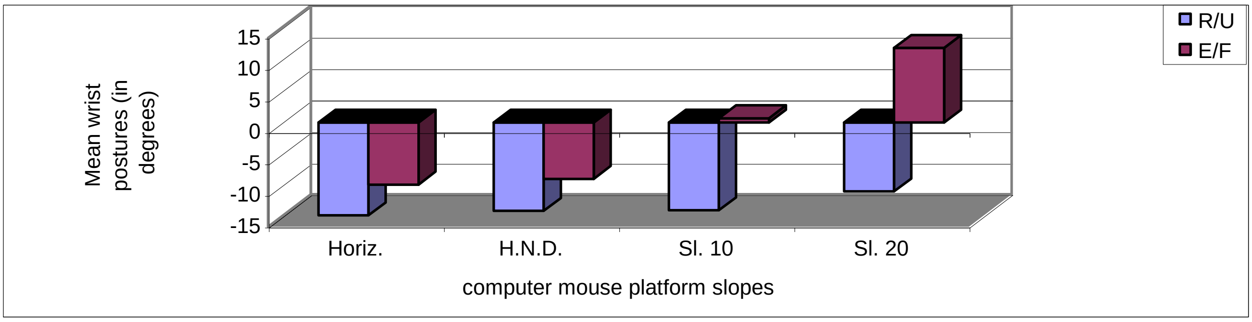


***Fig. (4): Mean values of the wrist radial/ulnar deviation and extension/flexion postures at the four CMPSs during computer mouse grasp (static posture).***

**2- Wrist radial/ulnar and extension/flexion dynamic postures at the four computer mouse platform slopes (CMPSs) during computer mouse use (after the task)**

Results revealed that using the computer mouse resulted in ulnar wrist deviation of a mean degree of 18.2˚, 20.9˚, 17.2˚ and 15.9˚ at the horizontal mouse platform, horizontal platform with a forearm support, the 10˚ and the 20˚ downward tilted mouse platforms respectively. Statistical analysis using the one way ANOVA test showed that there was a significant difference ($p<0.05$) among the four tested mouse platform slopes for wrist ulnar/radial deviation. Meanwhile, Duncan's multiple comparison test was used to compare between each pair of the tested slopes (table2).

On the other hand the computer mouse use resulted in an extended wrist joint with a mean degree of 8.5º, and 10.8º at the horizontal mouse platform in the absence and the presence of the forearm support respectively. However, using the computer mouse at the 10º and 20º downward tilted mouse platforms resulted in a flexed wrist joint with a mean degree of 1.4º and 11.7º respectively. Statistical analysis using one-way ANOVA test revealed that there was a significant difference among the four tested mouse platform slopes for wrist extension/flexion during computer mouse use. Duncan's multiple comparison test was also used to compare each pair of the tested slopes (table2 and figure 5).

***Table (2): Wrist ulnar/radial and extension/flexion dynamic posture at the four mouse platforms during computer mouse use (after the task).***

| | Radial/ulnar dynamic posture (R/U) | | | | Extension/flexion dynamic posture (E/F) | | | |
|---|---|---|---|---|---|---|---|---|
| CMPSs | Horiz | HND | Sl 10 | Sl 20 | Horiz | HND | Sl 10 | Sl 20 |
| X±SD | 18.2 ±5.6 | 20.9± 6 | 17.2±4.9 | 15.9 ±5.3 | -8.5 ±4.7 | -10.8 ±4.3 | 1.4± 4.7 | 11.7± 5.1 |
| | ANOVA | | | | ANOVA | | | |
| | F value = 3.7 | | p value = 0.01 | | F value = 116.3 | | p value = 0.0001 | |
| | Duncan's multiple comparison test (p value) | | | | Duncan's multiple comparison test (p value) | | | |
| Horiz vs HND | | | | 0.09 | Horiz vs HND | | | 0.1 |
| Horiz vs Sl 10 | | | | 0.5 | Horiz vs Sl 10 | | | 0.0001 |
| Horiz vs Sl 20 | | | | 0.1 | Horiz vs Sl 20 | | | 0.0001 |
| HND vs Sl 10 | | | | 0.02 | HND vs Sl 10 | | | 0.0001 |
| HND vs Sl 20 | | | | 0.002 | HND vs Sl 20 | | | 0.0001 |
| Sl 10 vs Sl 20 | | | | 0.4 | Sl 10 vs Sl 20 | | | 0.0001 |

(-) = extension and (+) = flexion.

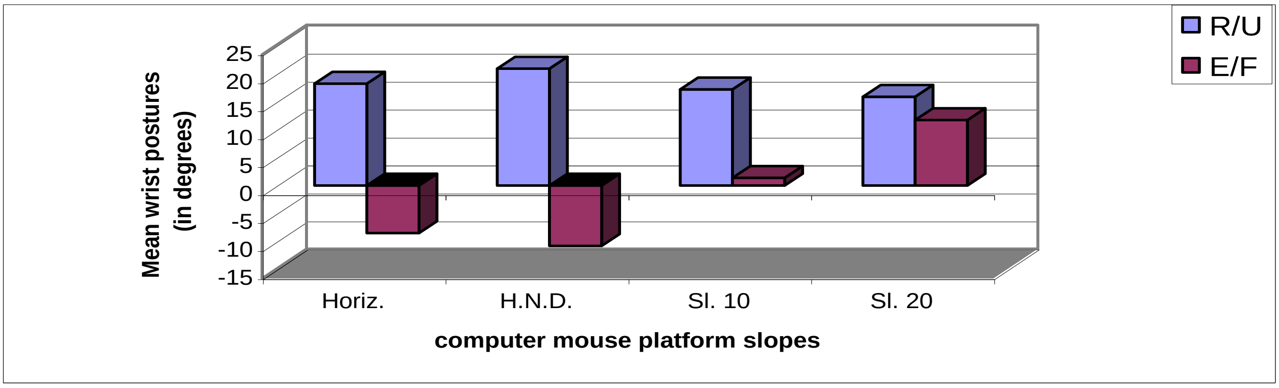


***Fig. (5): Mean values of the wrist radial/ulnar deviation and extension/flexion postures at the four CMPSs during computer mouse use (dynamic posture).***

3- Comparison between static and dynamic wrist postures at the four computer mouse platform slopes for wrist ulnar/radial deviation and extension/flexion.

The effect of computer mouse use on the static wrist posture at the four CMPSs was investigated through comparing the static wrist posture (before task) with the dynamic one (after task). Paired t-test was used for accomplishing this purpose. Statistical analysis revealed that there was a significant difference between the mean degrees of wrist ulnar deviation of the static and dynamic wrist postures at each of the four tested mouse platform slopes (table 3 and figure 6).

On the other hand, statistical analysis using paired t-test revealed that there was no significant difference ($p>0.05$) between the mean degrees of wrist extension of the static and dynamic wrist postures at the horizontal platform in the absence or presence of the forearm support. There was also a non significant difference ($p>0.05$) between the mean degrees of wrist flexion of the static and dynamic wrist postures at either the 10° or the 20° downward tilted mouse platform slopes (table 3 and figure 7).

***Table (3): Comparison between static and dynamic wrist postures (ulnar/radial and extension/flexion) at the four mouse platforms.***

| | Radial/ulnar static posture (R/U) | | | | Extension/flexion static posture (E/F) | | | |
|---|---|---|---|---|---|---|---|---|
| CMPSs | Horiz | HND | Sl 10 | Sl 20 | Horiz | HND | Sl 10 | Sl 20 |
| X±SD Static | 14.8 ±4.6 | 14.1± 2.8 | 14±5.8 | 10.9 ±5.3 | -9.9 ±3.7 | -9 ±3.4 | 0.7± 3 | 11.9± 4 |
| X±SD Dynamic | 18.2 ±5.6 | 20.9± 6 | 17.2±4.98 | 15.9 ±5.3 | -8.5 ±4.7 | -10.8 ±4.3 | 1.4± 4.7 | 11.7± 5.1 |
| Paired t-test | t = 4.3 p <0.001 | t = 6.7 p <0.001 | t = 2.8 p <0.05 | t = 5 p <0.001 | t =-1.4 p > 0.05 | t = 1.9 p > 0.05 | t = -0.9 p > 0.05 | t = 0.2 p > 0.05 |

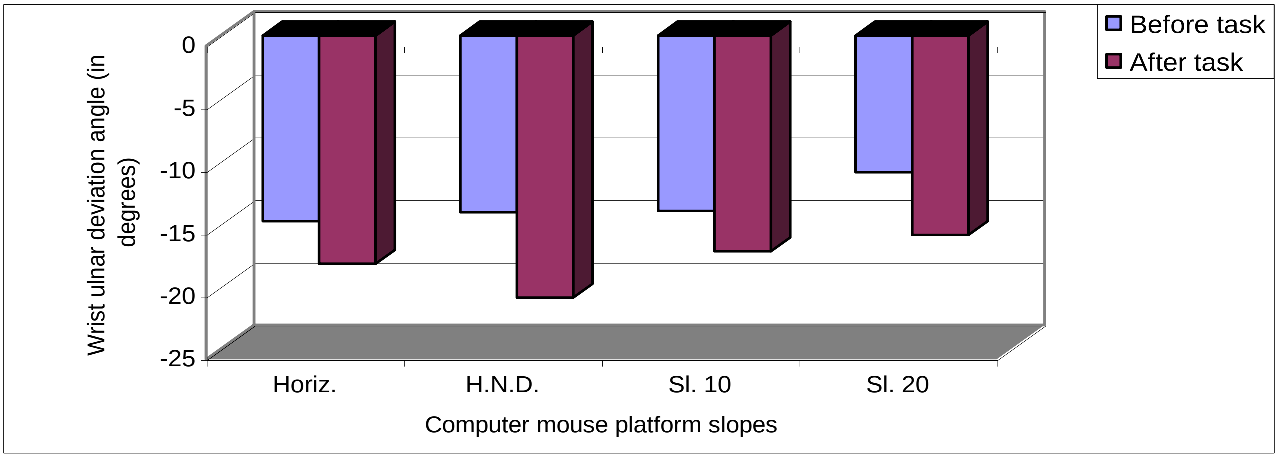


***Fig. (6): Mean values of the wrist radial/ulnar deviation postures at the four CMPSs before and after computer mouse task performance.***

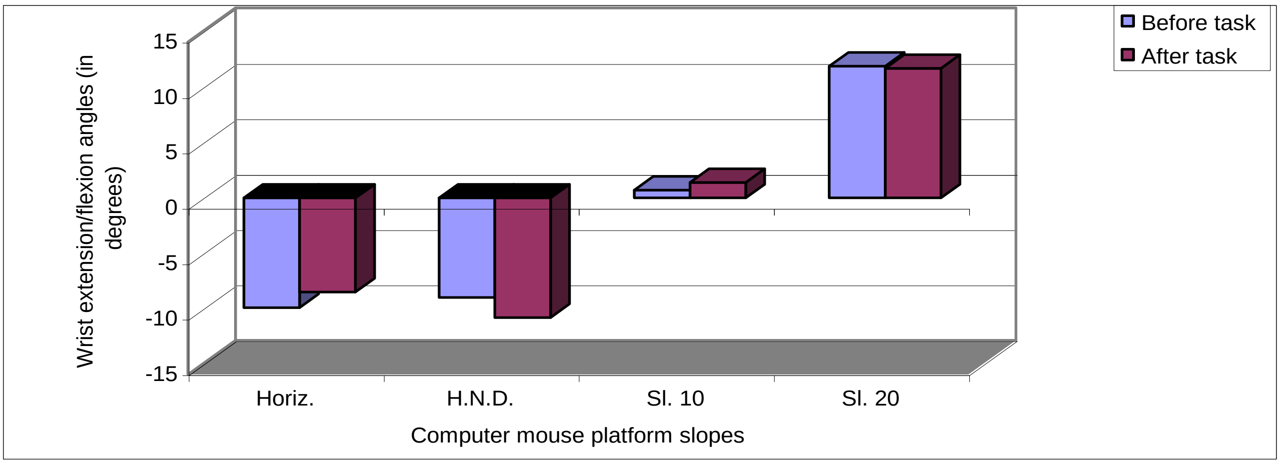


***Fig. (7): Mean values of the wrist extension/flexion postures at the four CMPSs before and after computer mouse task performance***

## DISCUSSION

This study investigated the effect of grasping and using the computer mouse at four different computer mouse platform slopes on the wrist joint range of motion. Wrist joint motions were recorded at two directions extension/flexion and radial/ulnar deviation. The four tested platform slopes were two horizontal slopes with and without forearm support, and two anteriorly downward tilted slopes of 10° and 20°. Comparison between the magnitude of wrist ulnar deviation range at the four tested computer platform slopes before and after mouse use revealed a significant increase in the magnitude of ulnar deviation. The significant increase in the ulnar deviation angles associated with computer mouse use is consistent with the findings of Karlqvist et. al[12]. They found that mouse users spent on average 64% of working time with the operative wrist deviating more than 15° towards the ulnar side. Thirty-four percent of the analyzed work time was in the interval 15-30° and 30% in the interval greater than 30º. The mean value of ulnar deviation was recorded to be 17.6º, comparable to that obtained in this study.

A similar significant increase in the wrist ulnar deviation during computer mouse use has also been obtained by Keir et. al.,[14]. They examined the effect of using a Microsoft Serial mouse on the wrist posture during the performance of a ‘point-and-click' computer mouse task, similar to that conducted in this study. They concluded that the ulnar deviation ranges of motion increased significantly during computer mouse use as compared with those recorded when the operators' hands were only rested on the mouse before task performance (static posture). This significant increase in ulnar deviation angle associated with computer mouse use might indicate that prolonged computer mouse use could increase the incidence of computer related musculoskeletal disorders.

Changing from a horizontal computer mouse platform slope to a downward tilted computer mouse platform slope of 20º in the presence of a forearm support resulted in a gradual decrease in the degree of ulnar deviation. Results also revealed that the downward tilted computer mouse platform slopes of either 10º or 20° involves a significant less degree of ulnar deviation than that involved in the HNDCMPS with the least ulnar deviation degree reached at slope 20°. While comparing the difference between the Sl.10º CMPS and Sl.20° CMPS for the wrist ulnar deviation angles, results revealed that there was no significant difference between both slopes.

The wrist extensors activity during wrist flexion might provide an explanation to the decrease in the ulnar deviation angles associated with the downward tilt of the CMPSs. During flexion of the wrist, the extensor carpi ulnaris (ECU) muscle was found to show marked activity as an antagonist to the wrist flexors. The reactive cocontraction of the ECU muscle is to stabilize the wrist joint. This doesn’t occur with the extensor digitorum and extensors carpi radialis muscles[1]. As the wrist is moved downwards with gravity towards flexion, the ECU muscle is considered to contract eccentrically, which implies that the muscle will be elongated producing wrist flexion and radial deviation. This indicates that there would be a decrease in the magnitude of ulnar deviation. Consequently, this finding might support the results reported by this study. Moreover, the decrease in the ulnar deviation angles associated with the downward tilt of the CMPSs might be attributed to the change of the forearm position from pronation towards supination as the degree of wrist flexion increases while grasping the computer mouse. However, this hypothesis needs further investigation as the forearm posture was not tested in this study.

Comparison between the mean degrees of wrist extension/flexion angles of the four CMPSs of the static wrist posture with those of the dynamic wrist posture indicated that active mouse use is not associated with a significant change in the extension/flexion angle. The absence of significance between the static and dynamic wrist postures for the extension/flexion angles could be substantiated by the findings of Keir et.al.[14]. As it was mentioned above, these authors used a Microsoft Serial mouse to carry out a "point-and-click" computer mouse task and they tested wrist radial/ulnar deviation angles together with wrist extension/flexion angles. They studied these wrist angles during hand placement on the computer mouse (static posture) and during active computer mouse use (dynamic posture). Their observations regarding wrist extension/flexion angles revealed no significant difference between the degrees of motion for both the static and dynamic wrist postures.

Comparison of the mean degrees of wrist extension/flexion angles of the horizontally oriented, 10° downward tilted and 20° downward tilted computer mouse platform slopes showed that the downward tilted slopes, in the presence of a forearm support, are associated with a decrease in the degree of wrist extension. The mean degrees of wrist extension/flexion angles during computer mouse use were -10.8°, 1.4° and 11.7° for the horizontal, 10° downward tilted and 20° downward tilted slopes respectively, with the negative sign (-) referring to extension and the positive sign(+) referring to flexion. According to the reviewed literature, a downward tilted platform whether for keyboard or mouse use is beneficent with its consequent decrease in the degree of wrist extension. As previously mentioned, an increased wrist extension angle is determined to be a risk factor for the causation of computer related musculoskeletal disorders[10,21].

Results of this study revealed that there was a significant difference between the 10° downward tilted and either of the other three tested mouse platform slopes for the wrist extension/flexion angles. Based on the mean degrees of wrist extension/flexion, it is obvious that slope 10° is associated with minimal vertical deviation. The mean degrees of wrist extension/flexion in the horizontal, horizontal with a forearm support, 10° downward tilted and the 20° downward tilted slopes were -8.5°, -10.8°, 1.4° and 11.7° respectively with the negative sign (-) referring to wrist extension and the positive sign (+) referring to flexion. Thus, it might be concluded that the slope 10° of CMPS is associated with a nearly vertical neutral wrist posture which is significantly less than wrist deviation angles associated with the use of any of the other three tested slopes.

A neutral wrist posture has long been recommended in operating non-keyboard input devices such as computer trackballs or mice to avoid much of the computer related musculoskeletal disorders. As reported by Hedge and Powers[10] a neutral wrist posture defined as a wrist joint of 2-3.5° flexion is the wrist posture associated with the minimal carpal tunnel pressure (CTP). It has also been reported by Gelberman et al.,[9] that fluids flow freely into the palm with the hands in neutral-to-moderate extension or flexion (less than 20°). An awkward wrist posture of more than 20° extension or flexion is associated with an increased level of carpal tunnel pressure which is responsible for the occurrence of carpal tunnel syndrome. Thus, using the 10° downward tilted slope, which is associated with a neutral vertical wrist posture might be helpful in reducing the incidence of carpal tunnel syndrome associated with awkward wrist extension/flexion postures.

In both static and dynamic wrist postures during computer mouse grasp and use, the results revealed that there was no significant difference between both the horizontal mouse platforms (with and without the use of the forearm support) for either the radial/ulnar deviation or extension/flexion angles. The effect of forearm support on wrist extension/flexion and radial/ulnar deviation angles in the presence and absence of forearm supports during computer mouse use were investigated by Lintula et al.,[15]. Their test group used the basic Ergorest arm support with the hand that operated the mouse and the control group had no arm supports. Their results revealed that there was no significant difference for the wrist extension angles between the absence and presence of forearm supports, which supports the finding of this study. Although the findings of this study and that of Lintula et al.,[15] revealed that computer mouse use in the presence of the forearm support increased the mean degree of ulnar deviation, statistical results revealed that this increase in the ulnar deviation angle wasn't significant in both studies.

## Conclusion

The results of this study indicated that computer mouse use at a downward tilted computer mouse platform slope of 10° is associated with the least discomfort to the wrist joint as compared with its use at a horizontal slope (whether with or without a forearm support) or at a downward tilted slope of 20°. A downward tilted computer mouse platform slope of 10° enabled the use of the computer mouse with minimal vertical and lateral wrist deviations. On the other hand, when the computer mouse was used at the horizontal slope (with or without a forearm support) and also at a downward tilted slope of 20°, the results showed much discomfort at the wrist. That is because mouse operation at these slopes necessitated putting the joint in either vertical or lateral deviation at extreme range. Therefore, from the results obtained it could be concluded that when using a computer mouse, it is favorable to be supported on a downward tilted platform of 10°. Such position could decrease the computer-related musculoskeletal disorders especially carpal tunnel syndrome, wrist extensors and flexors tenosynovitis and lateral epicondylitis.

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## الملخص العربى

### تأثير استخدام زوايا ميل مختلفة لقاعدة فأرة الكمبيوتر على أوضاع الرسغ

الغرض من إجراء هذه الدراسة هو اختبار تأثير استخدام أربعة زوايا ميل مختلفة لقاعدة فأرة الكمبيوتر على أوضاع الرسغ "الثنى للأمام والخلف وللداخل والخارج". الأربعة زوايا المختبرة هى 1- زاوية أفقية باستخدام ساند للساعد، 2- زاوية أفقية بدون استخدام ساند للساعد، و3- زاوية ميل 10 درجات للأمام ولأسفل، و 4- زاوية ميل 20 درجات للأمام ولأسفل. وقد شارك ثلاثون من الطلبة الذكور فى هذه الدراسة، وقد قام كل طالب بالإشارة والنقر بفأرة الكمبيوتر لمدة ثلاثين دقيقة فى كل زاوية ميل بحيث تم اختبار كل زاوية ميل فى يوم مختلف، وقد تم قياس المدى الحركى لمفصل الرسغ أثناء الثنى للأمام وللخلف وللداخل وللخارج وذلك قبل وبعد أداء المهمة المطلوبة من الطالب. وقد أوضحت النتائج أن استخدام لفأرة الكمبيوتر عند زاوية ميل 10 درجات لأسفل كانت مصحوبة بأقل درجات فى المدى الحركى لمفصل الرسغ وبالتالى فان استخدام فأرة الكمبيوتر عند زاوية ميل 10 درجات لأسفل وللأمام هى أفضل الزوايا لتقليل اضطرابات الجهاز العضلى الحركى.