

A Review on Ergonomic Computer Mouse Enabling Neutral Hand Position for Older People

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Summary

The main objective is to conduct review to find wrist related disorders in aged population and suggest neutral hand position computer mouse. Systematic Literature Review (SLR) is carried out that suggests that comparatively less literature is available for elderly mouse users. The results from other researchers show that two most unnatural wrist positions of Ulnar Deviation and Extension are the main cause of hand tiredness and tingling during mouse operation. Observations of other researchers for ergonomic mouse have been presented. It is also concluded that traditional mouse did little to prevent the bending or extension of the hand.

Key words:

Neutral Hand Position, Older Mouse Operators, Ergonomics, Age Related Disorder

1. Introduction

The unnatural hand position of mouse users for the aged (people aged 65 or more) is the area with comparatively less literature available. It is estimated [1] to have more than twice as many older people as youth by 2030.

There is no difference of opinion that computer mouse is one of the most common input devices used with a computer system. Computer users mostly use this input device for different pointing and drag-to-click tasks. This input device has become very famous and is considered an integral part of office work in the past decade [2]. People either prefer or they do not have alternate of mouse for performing most computer related tasks [3]. Because of ubiquitous behavior and low price; people prefer to use mouse as pointing device over Visual Display Units. Although using traditional mouse is beneficial, yet it poses some issues for frequent users especially the older people [4,5].

It is also to be noted that movements made with the mouse are significantly faster than those made with the trackball [6].

Hertzum et al [7] is of the view that mouse has higher accuracy when perform pointing tasks as compared to touch-pads and touch pads are slower in elderly participants 'index of difficulty'. However, Charness et al. show that a light pen as direct positioning device is faster than a mouse and minimize age-related performance

differences relative to the mouse in the pure pointing task [5].

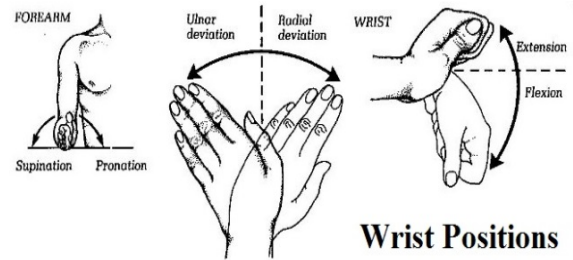


Fig. 1 Different Wrist Positions.

1.1 Extension

The Extension position of wrist is the upward and most likely to happen hand position during operating computer mouse as shown in the Figure 1. Aarås et al. [8] suggest supporting the forearm in order to decrease the muscle load on the extensors of the forearm during mouse used.

Supination: It is important to note that the most of the computer mice used are traditionally designed, resulting in more or less pronated forearm position and are moved mainly by the wrist movements [3].

1.2 Ulnar/Radial Deviations

Ulnar and radial deviations are opposite positions to each other, especially during gaming and painting. There is comparatively less literature available for older Internet users: Zajicek et al. [9] debate on the fact that there is, at present, little research available on the impact of the explosion of new technology, including the Internet into the lives of the older people.

1.3 Age Related Disorders

The process of aging is a gradual decline in motor, psychological and sociological behavior. Fear of being weak and aged count towards shaky motion which may lead to the problem in fine movements. Weakness in muscles and power [1] begins at the age of 40. Chaparro et al. [6] show that usually the normal older adults are

slower than the younger adults in performing tasks related to click and drag. The aged people usually face some problems related to consciousness and movements. Worden et al. [10] has the view that the aged people feel it challenging to click the mouse buttons. He argues that the general effects of aging may include decline in motor, cognitive and perceptual abilities. This can have the negative effect on the performance of a number of tasks including basic pointing and selection of common to today's graphical user interfaces.

Older people may encounter other age-related disorders such as arthritis, musculoskeletal disorders, pain in neck and shoulder, and disorders related to carpal tunnel syndrome, decline in motor control, hand tremor, and many others. Jastrzembski et al. [5] debate that general decline in motor control in older adults, may have greater likelihood of arthritis or after effects from the stroke. He also states that such people pose longer movement times and more errors for older adults than younger adults.

The posture of hand on the mouse is one of the significant factors that can lead computer users to encounter with carpal tunnel syndrome [11]. So prolonged mouse user may adopt unnatural hand position which is not suitable for wrist support.

Generally pressure in the dragging is higher than the pointing task which can increase carpal tunnel pressure. Another research [2] shows that the intensive mouse use has correlation with the increased risk of upper limbs disorders including musculoskeletal, which may lead to Carpal Tunnel Syndrome (CTS). CTS is a condition in which nerves are pinched if surrounding tissues become swollen. People [12] who do extensive work on keyboards and mice are at risk of developing CTS because of strenuous and repeated use of the wrist and flexion. So it shows that chance of getting CTS is due to bending the wrist and repeated use of the keyboard or mouse over an extended period of time.

It is also to note that when a frequent computer operator has to perform writing task through mouse or TrackPoint, they report the problem of cramp in the forearm. In this way, handwriting increases the forearm muscle load and people who use mouse and write at the same time, will feel more difficulties. One solution might be a novel input pen, which can write and interact with the computer simultaneously [13].

Andersen et al. [14] states that there is a chance of minor neck and shoulder problem with traditional mouse use. While continuous use of one form of the I/O devices can lead to tiredness and can be helped by switching to another mode or alternating between two [9].

Older participants require twice as much time as the 20-39-year group for mouse input. However, by using a touch screen, they reach a performance level similar to that of younger people after practice [15].

Using a vertical mouse can decrease the risk factors for the computer mouse use-related musculoskeletal disorders. It is observed using a vertical computer mouse has resulted in less wrist pronation and lower wrist extensor muscle activity [31].

Prolonged computer mouse usage can be a minor occupational risk factor for causing Carpal Tunnel Syndrome (CTS) [32].

The mouse usage shows an increased risk of Carpal Tunnel Pressure (CTP) to harmful levels [33].

As early as 2001, carpal tunnel syndrome (CTS) was ranked sixth among the recognized occupational disease in the EU [34].

The results show that the participant begins to use the slanted mouse in order to ease neck and shoulder pain caused by an extensive use of a conventional mouse. The slanted computer mouse has significantly relieved her pain. [35].

Literatures show that the prolonged computer mouse usage might be an occupational risk factor for getting CTS. They suggest a wrist belt with a pad that can keep the wrist in neutrally relaxed posture. Without belt or wrist rest support, larger ulnar deviation and dorsiflexion was observed [36].

It is observed that the vertical mouse produces more task performance than the traditional mouse due to lower wrist extension. The results also show that the performance and the posture affect in opposite ways by different mouse designs, and that the design features that promote good performance may compromise good wrist posture. Overall, an adjustable-size slanted mouse design may offer the best combination of neutral posture and performance [37].

1.4 Neutral Hand Position

The most neutral and relaxed position for a hand is an upright position: the 80-90 degree perpendicular to the surface, while fingers and palm generally make a vertical plane. This requires a constant muscular force to be applied to the hand, wrist, and forearm to maintain their positions [16]. Such natural hand position for the ergonomic mouse is shown in the Figure 2.

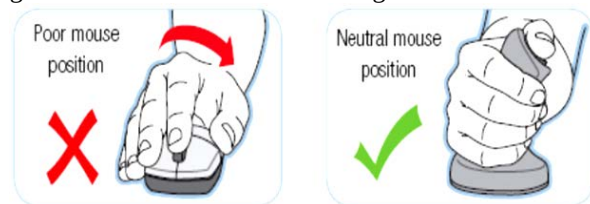


Fig. 2 Neutral Hand Position

1.5 Criteria and Scope of the Publication

Our review article can be regarded as suggestive for researchers and practicing engineers in the field of Consumer Electronics. The neutrally hand position computer mouse is best for the ease of older people use. The key factors are the emphasis placed on exploring hand related disorders and ergonomic mouse for the relaxed hand position. This article is in the scope of the IEEE Transactions on Consumer Electronics under the following areas:

- ✓ Software for Consumer Products
- ✓ Home and Personal Healthcare

We, authors strongly believe that our work is practical and best achieved by citing relevant past T-CE papers.

2. Method

In the process of literature review, we defined an initial set and combinations of keywords to explore the material available on the topic. General keywords used in scientific databases included aged, aged people, old, old people, older, elderly, elderly people, vertical mouse, vertical computer mouse, older mouse users, aged related disorders, mouse related difficulties, ergonomic mouse, wrist positions, neutral hand positions, natural mouse position, wireless mouse. Articles were accessed and downloaded through the library of Blekinge Tekniska Hogskola.

2.1 Inclusion Criteria

The English language, Google Scholar, 07 peer-reviewed articles with original data, Queries or keywords: Vertical Mouse, Vertical Computer Mouse, computer mouse + old people/elderly people, vertical computer mouse + old people/elderly people.

2.2 Study Design

Longitudinal studies: repeated observations of the same variables over long periods of time, a user feels unrest, sense of tiredness or tingling in hand due to the non-neutral hand position.

2.3 Unnatural Hand position in Older People

Ten articles were found with original data on unnatural hand position in older people. Other topics and related articles which correlate our study are:

Table 1: Unnatural Hand Position in Older People

Older Mouse Users with difficulties	07
Ergonomic Mouse and relaxed Position	06
Vertical Mouse for Neutral Position	05
Age Related Disorders	11

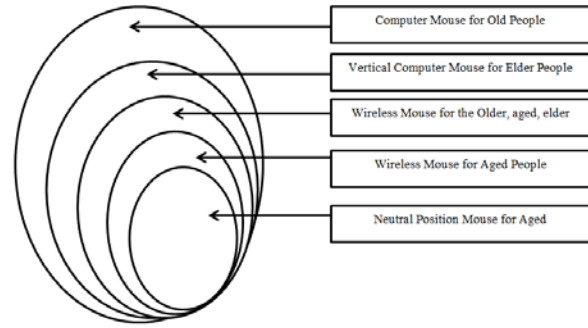


Fig. 3 Literature Review Process.

In the Figure 3, the initial query “Computer Mouse + Old People” was made to check the quantity of available material and Google Scholar yielded the healthy amount of about 178,000 results. The second query “Vertical Computer Mouse + Elder People” was objectively targeted to find the related literature in the field and it produced about 21,900 results. After refining the search query into “Wireless Mouse for Older, Aged, and Elder”, with combinations and the databases produced 5,340 articles and total 37 were selected fulfilling the inclusion criterion. A little bit similar query “Wireless Mouse for Aged People” yielded the same quantity of literature. Last query “Neutral Position Mouse for Aged” was formulated to fulfill the objectives of the study and selected only related articles based on Inclusion Criterion. In the literature review process, 07 peer-reviewed articles with original data were found with keywords: neutral position mouse for the aged. The other similar detail is given below:

The process of searching articles was primarily through On-line databases, peer-reviewed journals in English and published after 1995. Some electronic databases such as Scopus, Inspect and Compendex with the combinations of query: "Wireless Mouse" AND "older", "aged", "elderly" yielded results as 1,4 and 1 related articles respectively. However, Google Scholar was helpful to explore the related articles and it fetches material from other scientific journals as well.

Table 2: Google Scholar yielded following results with queries

Queries	Selected/Related Papers
Wireless Mouse	03
Wireless Mouse AND Aged people	04
Wireless Mouse AND Older people	03
Wireless Mouse AND elderly people	03
Base Articles	06 including 03 US Patents
Neutral Position Mouse for the Elder	03 while none related to older people
Neutral Position Mouse for Aged People	03
Repeated Articles	11

2.4 Exclusion Criteria

Articles published before 1995

Non-English

3. Results

3.1 Traditional Mouse and Hand Discomfort

Our findings suggest that tasks requiring the frequent and prolonged use of the mouse, may be associated with greater levels of discomfort (i.e. earlier onset of fatigue and greater perceived exertion) for the older computer user [17].

The sense of tiredness and discomfort is due to the abnormal hand position during operating mouse. The most common hand deviation is the upward hand position called extension. Keir et al. [2] reported that wrist extension ranged from 23° to 30° and that ulnar deviation from -3.2° to 5.2° during mouse work.

However, placing mouse pad, wrist support and thumb support can ease the situation to some extent.

3.2 Computer Mouse and the Older People

Elder group performed more slowly than the younger group [1].

Holzinger et al. [18] in their studies have found that older people have greater difficulty in using mouse to track on the screen and that, even after some practice, their performance on a computer is generally slower.

The data [19] show that with advanced age and disability, mouse usage becomes increasingly inaccurate and nonlinear.

3.3 Mouse Related Disorders

There are disorders related to prolonged use of computer mouse. Some people have more and some have fewer symptoms. Signs of repetitive strain injuries in the neck, shoulder, forearm and wrist are related to the increased use of mouse [20].

Cursor control tasks such as clicking and double-click are more difficult for older people [21].

People who do extensive work on computer keyboards and computer mice are among those who are most at risk of developing Carpal Tunnel Syndrome [12].

Repetitive wrist movements and extreme postures in the wrist, are associated with musculoskeletal disorders. Also that the pronation of the forearm is considered to be a potential risk factor for musculoskeletal disorders in the elbow and the forearm [3].

The overall self-reported prevalence tingling/numbness at right hand was recorded to be 10.9% [22].

There was a significant increase in Carpel Tunnel pressure when opposed to resting the hand on the mouse [2].

Symptoms of repetitive strain injuries in the neck, shoulder and forearm and wrist have been related to increased use of computer mouse [20].

Memory impairment reduces the ability to build conceptual models of the working of the interface since this activity relies on remembering sequences of actions and reasoning about them [9].

The older participants require double time as compared to the age group 20-39 years old for mouse use [15].

3.4 Ergonomic Mouse and Relaxed Position

A hand holding the ergonomic computer mouse will be naturally at a relaxed position, without requiring a twisting of the hand, wrist, or forearm. As a result, fatigue, discomfort, and pain are minimized or eliminated even after a long period of continuous use [16].

The ergonomic computer mouse is designed in such a way that the hand position required to manipulate the mouse is natural resting or neutral position. This position will allow the mouse to be used for longer periods of time minimizing pain and disability in the hand and the wrist. The hand is inclined to the horizontal plane typically at an angle of at least 50 degrees. The fingers are flexed, the thumb and index finger are opposed and in close proximity. The wrist is not pulled backwards nor drooped, nor is it angled to one side or the other. There is no deviated wrist movement. Wrist movement is in the natural plane of the wrist [23].

The operators of video display units (VDU), in a study, prefer to use the mouse on a table with arm support which is close to relaxed and neutral posture [24]. A thumb support is provided in an ergonomic mouse to aid thumb and lifting the mouse [20].

Still above papers did not discuss its use in connection with older people.

4. Discussion

Many articles are related to the older people, only few are related to study the possibility of neutral hand position for the computer mouse for the aged people.

While talking about different input devices, light pen is efficient to transfer on-screen instructions, yet computer mouse is more suitable depending upon various situations. Holley et al. in the article [25] states that overall, the mouse was rated as more acceptable input device than the light pen after trials even though the light pen was more efficient specifically for pointing tasks.

It is also a fact that there is a growing use of the computer among the elders, but they still lag far behind younger users and are often confronted with significant hurdles interacting with computers. In 2002, 58% of Internet surfers come from America, out of which, only 4% of adults belong to age 64 and older [1].

There are four common wrist positions that a mouse user has to face.

4.1 Extension

It is one of the most common unnatural wrist positions and a high cause of tiredness and tingling in forearm. It is the upward hand position opposite to Flexion as shown in the Figure 4. It is also to note that most of the users are not familiar with neutral mouse use, especially in case of task precision.

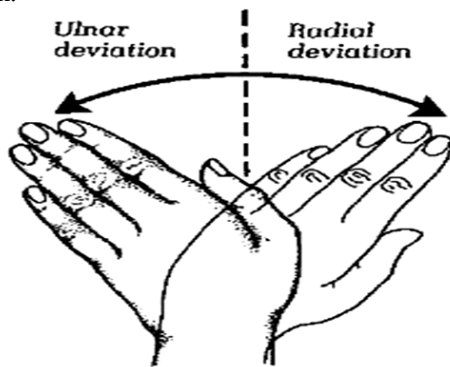


Fig. 4 Extensions, Ulnar and Radial Deviations.

The overall self-reported prevalence of tingling/numbness in the right hand was 11% and risk of possible CTS is greater if mouse use is 20h/week [22].

4.2 Pronation

Rotation of the hand so that the palm faces down as shown in the Figure 4. It is also one of the most common unnatural wrist positions in which hand faces to the earth. A neutral hand keeps 0 degree pronation, no exertion & Tingling and relaxed during prolong use of mouse.

4.3 Radial

It is the hand position towards thumb and mostly mouse operators are confronted with this unnatural wrist position. This position becomes more problematic during extensive graphics, designing and drag-driven tasks.

4.4 Ulnar

Opposite to the radial, the ulnar deviation is the wrist position away from thumb. It causes more sensation of tingling/tiredness in the forearm region. Common etiology

includes drag-driven tasks, click-and-drag, gaming, painting and related tasks.

Several attempts have been made to design a computer mouse to reduce hand and wrist muscle fatigue. However, these designs generally do little to prevent bending of the wrist, cannot be adjusted to meet the needs of a particular user and would be expensive to acquire. A US Patent [12] discloses an ergonomically shaped hand controller that is molded to have various curves on the surface for supporting the hand during use. However, the device is not directed to prevent the wrist from bending during use.



Fig. 5 Neutral Hand Position.

4.5 Neutral Hand Position

A neutral hand with the horizontal plane makes an angle of 50-70° as shown in the Figure 5. Because a neutral hand possesses the characteristics of natural flexed fingers, thumb curled, nor radial/ulnar, nor dorsiflexed/drooped. This neutral mouse position for older people is so important because “most of human tools have been designed to use our ability to grip or squeeze objects almost effortlessly between thumb and fingers” [23].

Another study shows that vertical movements are easier than diagonal movements [26]. For vertical mouse or neutral mouse, the results [15] confirmed that human-computer interaction can be improved in terms of required time through using of alternative Input Devices.

The vertical mouse, which is operated mainly by whole arm movement, provides the operator an almost neutral hand position whereas the thumb is used as the main button controller. The study shows that the muscle load on the forearm was significantly reduced with the vertical mouse as compared to the traditional mouse. Gustafsson et. al. [3] show that half of the subjects report that the neutral mouse has less precision and more difficult to move than the traditional mouse used. This inconvenience in the neutral mouse is because subjects have relatively less experience and training for such input device.



Fig. 6 Anir Neutral Hand Mouse in Supplementary Data.

Another neutral hand position mouse is presented by Anir™ from the Norwegian company AnimaX International as shown in the Figure 6. The Anir vertical mouse has a joystick on wheels as shown in the figure. Its novel orientation moves the hand in pronation and supination positions avoiding mainly ulnar and radial deviations which are more annoying. Another significant difference from the traditional mouse is the use of the thumb placement as the main button controller. Prior research suggested the Anir mouse may be an improvement over the traditional mouse for symptomatic workers, but there may be some cost to this in terms of loss of performance [27].

After using the Anir mouse for 6 months, there were significant reductions in pain for neck, shoulder, forearm, wrist and hand. Whereas the control group using the traditional mouse reported no significant changes in the pain level [8].

A novel ergonomic computer mouse is presented [28] having an external contour that conforms to the smoothed-out mean of the contour of the palm or an inside surface of the hand when the hand is in a neutral state. The weight of the neutral mouse is vertically oriented so that the hand and the forearm of the person operating the mouse are maintained in a neutral disposition in order to avoid radial and ulnar deviations.

4.6 Motor Control and Aging

Research examining age differences in motor control shows that older adults have more difficulty during deceleration. They perform tasks more slowly in all cases, especially with the mouse [21].

Muscle strength and power begin declining by the age of 40. The older people feel inconvenience for executing

more fine movements. It is estimated [1] that by the end of year 2020, 18.2% of the American population will suffer from arthritis and many of them will be aged 55 and older. Another study shows that error rates are higher for the elderly people than young adults during double-clicking and demand for higher precision. Also, the levels of EMG activity in the elderly subjects are higher to meet the demands for precision [29].

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5. Conclusion

The process of reviewing for the adoption of the ergonomic computer mouse with the neutral hand position for older people is remarkably productive. Comparatively less literature is available on the subject of the elderly mouse operators including subjects with mouse related disorders. Traditional mouse did little to prevent bending or extension of hand. Such users feel a sensation of tiredness using unnatural mouse with Extension or Ulnar deviations at wrist position.

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