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A Perspective of the Computer Mouse's Impact on the Musculoskeletal System

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Abstract: Personal Computers is essential need in this modern world. The major associated part linked with computers are mouse that directly affect the working and fatigue to the users. With increase in computer mouse use disorder related to mussel properly known as musculoskeletal disorders (MSDs) has increased. This paper will try to address all the efforts of different countries in different sectors, determining the effect of MSD due to computer mouse. Major body parts subjected to MDS due to mouse use like arm, wrist, back etc. are being suffering as most of the mouse available in market are not designed considering with arm support, palm length, natural curve of palm. Mouse operation require activity of upper trapezius (Trap) muscles, pronator teres (PT), extensor digitorum (ED) and carpiulnaris (ECU) mussels to a large extent, causing micro strain leading to higher disorders. Computer mouse available in different types like standard mouse, vertical mouse, slanted mouse, touch pad, roller bar, biofeedback pointer. Standard mouse is cheaper and available mouse not suitable to every palm size. Various incidence like raising the middle finger to avoid unintentional clicking increase stress at the joints, there stress is very fine in nature but leading regular and prolong use will show results. It is concluded from the revive that unergonomic mouse for more than 3-4 hr a day leads to MSDs. Alternate mouse can be preferred according to computer task. slanted mouse should be with slanting angle 30^0 to 80^0 can be used to design.

Keywords: Computer mouse; Musculoskeletal disorder; Ergonomics; slanting mouse.

1. Introduction

The continued expansion of the sector like data entry[1]), artificial intelligence bots[2]), call center service operator[3]), and with scientific advancement in the digital technology like machine learning[4]) had led to increase in the use of personal computers (PC) and laptops in every aspect of life including professional and personal applications[5]). There are many advantages of computers like easy access to information, provide time saving approach, process automation and repetition of tasks, good productivity and better storage of data which promoted their use in daily life[6]). In Europe, only 53% of workers used to exploit computers for their office use during 2011. However, over a period of time, this percentage increased in different countries like Norway (71%), Sweden (71%), Finland (72%) and Germany (61%). The percentage of computer users increased to 80 % in developed countries[7]). Currently, during this COVID-19 period[8–10]), online working system, research, meetings, laboratory work[11,12]), data analysis and online teaching-learning processes increase the value and application of computers/laptops and eventually, these are inseparable part of human life no one can expect life without these[13,14]).

The constant and excessive use of computer poses several health effects including physical and psychological effects[15)16]). The physical effects include strain on eyes, obesity, backache and carpal tunnel syndrome. In 2015, Kumar et al. reported that 40.4 % employees of bank in Punjab suffered from low-back pain, 36.8% had pain in hand/wrist, and 38.6% had pain in neck. In 2011[8]) , a surveyer conducted on 783 employed at two workplaces in Karnataka, India which concluded that 58% musculoskeletal disorders (MSDs)[17]) in hand and wrist of 69% women and 53% men. The long-term usage of computers is the cause of pain in hands, wrists, arm[18]), shoulders, upper back and neck which is mainly associated with the imperfect body posture while holding input devices such as mouse, keyboards[19,20]). Improper holding of mouse exerts pressure on neuromuscular system and causes pain. The grip strength of hands exert pressure on the muscles of hands and forearms. The fingers of the mouse users are in the position of claw hand to grip mouse. The repetitive and long-term griping poses pressure on the tip of fingers and carpel meta-carpel joint of the thumb[21)]. Therefore, the positioning of mouse and keyboard is important aspect to avoid unnecessary strain in fingers, arms, hand, jaw[22)], wrist and elbow of users[23)].

It was also reported that 76 % young among computer users are more likely to suffer from MSD. With the growth in the information technology sector in India, MSD sufferers has also increased to about 76 % till 2012[24,25)]. Sharan et al.[26)] investigated the effect of computer on 4500 employees of different IT companies of India and reported that 63% employees were suffering from pain due to excessive work on a computer. In recent years, the use of visual display units like Auto CAD[27)],CATIA and many other computer applications has increased which had a small but strong effect on neck and upper limb with continuous complain in wrist and hand[28,29)]. In the computer facility office complex in Chennai with 7,000 professionals, one out of every eight employees were reported to be suffered from MSD Chang et.al.[30)] reputed those undergraduate students working more than 20 hr. on computer suffered from musculoskeletal symptoms. The application and usage of computers has increased in the field of research due to online availability of research articles, books, writing documents, analyzing software, designing model, etc.[31)]. Exploring the correlation between specific tasks, like AutoCAD design, and mouse selection criteria unveils valuable insights for optimizing ergonomic setups. AutoCAD demands precision and frequent clicks for drawing and modifying objects, necessitating a mouse that supports both accuracy and efficiency. The number of clicks required per task is pivotal in selecting an appropriate mouse, as it directly impacts user comfort and productivity. Additionally, ergonomic considerations such as button customization and design play crucial roles in minimizing strain during prolonged usage. Understanding the repetitive strain injuries (RSI) associated with high click frequencies guides the choice towards mice with low-resistance buttons and ergonomic shapes. Moreover, customization features like programmable buttons streamline workflows, reducing the total number of clicks needed. A high-DPI mouse ensures precise movements without excessive hand strain, enhancing productivity in detailed design work. Implementation of tailored recommendations based on task-specific demands and user feedback fosters a comfortable and efficient working environment. This iterative process of analysis, recommendation, and refinement ensures that ergonomic setups remain aligned with evolving work requirements, ultimately optimizing user experience and performance in AutoCAD and similar tasks.

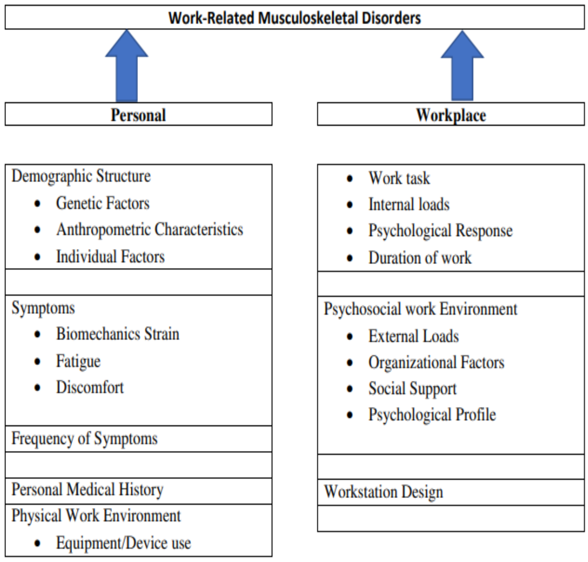

Fig. 1: Factors that lead to musculoskeletal disorder

With an increase in uses of PC at domestic as well as the workplace, the risk of musculoskeletal disorders (MSDs) has also increased[32)]. Any damage to muscle is usually leading to lifelong torment. The pain for a prolonged period causes repetitive strain injury[21)]. It is well known that 93.4% reported problems in the human hand and back are due to computer use[33)].

The second most common reason for pursuing medical attendance in several countries is musculoskeletal related complaints[34,35)]. Musculoskeletal related complaints are the most prevalent complaints among computer users. The most common practice to solve this musculoskeletal related problem is change in the workplace[17)], the work environment, and several medicines with physical corrective exercises such as 10 Chair Yoga Poses which are Upward Salute Pose (Urdhva Hastasana),Cat Pose (Marjaryasana),Cow Pose (Bitilasana) ,Camel Pose (Ustrasana), Happy Baby Pose (Ananda Balasana), King Arthur's Pose, Tree Pose (Vrksasana), Extended Triangle Pose (Utthita Trikonasana), Bound Angle Pose (Baddha Konasana), Extended Side Angle Pose (Utthita Parsvakonasana) are suggested by the medical professionals however, these provide little relief in discomfort or pain in a muscle and therefore, little improvement in the musculoskeletal health[36,37)].

It is pertinent to note that ergonomic interventions in computer and hardware design can improve the condition as well as produce less effect on the human body. The study and research to minimize the adverse effect of physical aspects like computer use on the musculoskeletal system are called ergonomics[38)]. Ergonomics works between the tool and way the user uses the tool. With better ergonomics, the impact of computer use on human beings can be reduced and any pain, discomfort, or injury can be relieved[39)]. As ergonomics is directly connected to muscular health[40)], it can provide comfortable design and environment to provide extended comfort to the computer users. Therefore, there is a need to work on ergonomic computer and hardware designs[41].

A lot of work has been done on workstations like keyboard, monitor screen size, monitor height[42]. However, there are very few research reports on the effect of the design of pointing devices such as mouse on the human interface[43]. The computer mouse and its design and efficiency have mostly been underestimated by its user and researchers. While working on computers, two-third of the time the computer mouse is in operation[44]. Mouse operation involves a high level of activity in muscle activity and extreme postures including, wrist extension[45],shoulder abduction with ulnar deviation which are the major risk factors for the development of MSDs, which are typically reported in college students[46,47].

The work-related musculoskeletal are categories in two forms that led disorder as shown in Fig. 1. One which is created due to personal factors and workplace effects. Personal factors such as poor working posture practice, Poor health habits, unsuitable diet, increased Body mass index (BMI)[48]. People who spend a lot of time working on computers may have a sedentary lifestyle, which can contribute to weight gain or an unhealthy BMI.High BMI is also a well-established risk factor for Carpal tunnel syndrome (CTS), some study shows for higher BMI CTS risk is 7.4% in both gender[49,50]. BMI and computer use are not directly linked. However, there is a significant association between computer use and the development of carpal tunnel syndrome, especially when using a keyboard and mouse extensively without proper ergonomics.

On the other hand, MSD due to work place can be due to poor workstation design which include use of unergonomic devices such as chair, table, desktop screen angle and height, mouse, lights etc.[51]

Current review is focused to generate idea to reader about the harmful effects of non-suitable computer mouse, with its proven effects on different parts of body. To ensuring clarity and organization to enhance reader comprehension and navigation. Use simple language, define specialized terms, and maintain consistency, supplemented by examples and visual aids for clarity. Organize content logically with a clear flow, starting with an overview and progressing from basic to detailed information. Employ descriptive headings and subheadings to structure sections on different ergonomic aspects. Enhance accessibility through a table of contents, internal links, highlighted text, and conclusion.

2. Major Body parts subjected to MDS due to mouse use.

2.1.Arm, Upper Arm, Forearm

Eggleston[52] reported in 2019, 85% of Microsoft employee in the United States experience pain/discomfort in Arm, Upper Arm and Forearm (Shown in Fig. 2 to Fig. 4 respectively). King[53] observed pain and discomfort due to mouse use and suggested researcher facilitate such research. Chen et.al[54], Cook et al.[55] and several other reported pain in Arm, Upper Arm, Forearm. Which has been very much overcame by use of support for fore arm and wrist[56], but most of the mouse available in market are not designed with arm support.

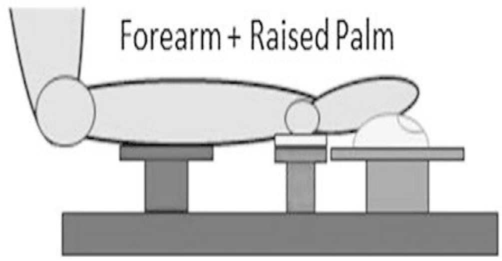

Fig. 2: Arm support for mouse operation

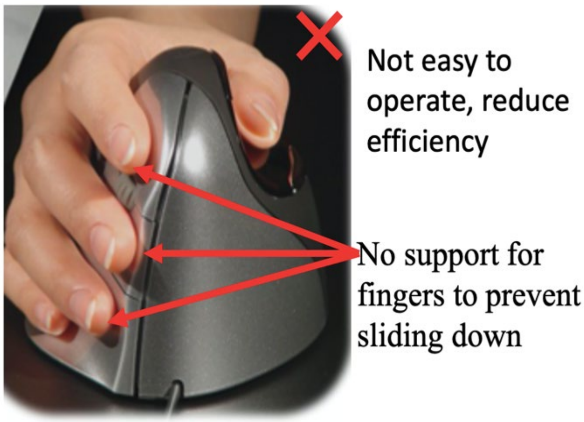

Fig. 3: Vertical mouse[56,57]

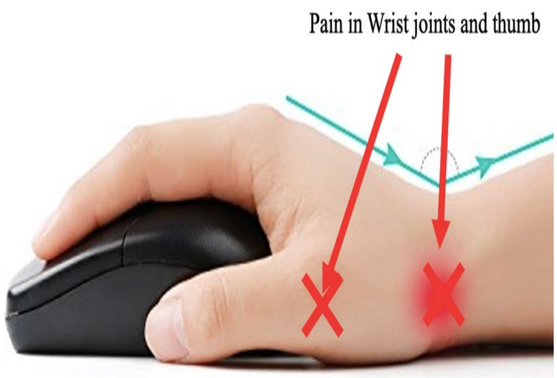

Fig. 4: Standard horizontal mouse[57]

2.2.Wrist

Qin et.al[58] studied musculoskeletal Disorders especially in wrist and observed it reduces ability to perform a task around 10.5%. Many researchers observed MSD in Wrist they also stated that high BMI (Boz C et.al[50], Siri et.al[59], Padua et.al[60]. Aoife et.al[61] mentioned that wrist pain also effects gripping and pinch strength. Dan Odell[62] studied and generated different model as shown in Fig. 5 with various wrist curve which reduces the strain in wrist. Still the unsupported wrist effects the MSD in wrist.

Fig. 5: Different model on different wrist curves.[62]

2.3.Finger

Mouse activity involve large amount of mussel activity results in MSDs in finger and thumb (Søgaard et al.[63]), Gustafsson et al.[64]). Kim et al.[65] in his investigation found that the lifting finger as shown in Fig. 6 and Fig. 7 in mouse tasking produce extreme stress in joints of finger. kim observed the pain in joints in finger and thumb and extend the left push-forward switch which reduces finger extensor activity, with making it more problematic for inadvertent switch activations to occur may have resulted in users reducing their sustained muscle activity for the task's static muscle loading requirements.

Fig. 6: Lifting behavior of index finger on clicking of right click[66]

Fig. 7: Lifting behavior of index finger on clicking of left-click[66]

2.4. Back and Neck

Gerard A. et.al[67] reported pain in the neck as most significantly associated with higher use of the mouse for a long period. Blatter et.al[68] stated that six hours per day of mouse uses is more harmful compare to Keyboard, he also observed women are more in women, and that men. Davis[69] concluded that with the use of ergonomic mouse will improve the comfort in back and improve productivity. Various other findings have found mouse usage with the incidence of pain in neck (Atkinson et al.[70], S. Ijmker[71]). Figure. 8 shows the graphical representation of MSDs reported in human body during the review of different papers.

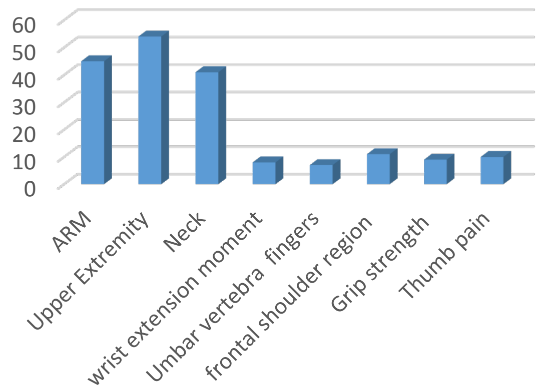

Fig. 8: Graphical representation of MSDs Reported

3. Methodological quality

To find out the research made, several research articles were searched. Out of which more than 100 paper were carefully studied. It was observed that there is an increase in the publication in recent 5 years. Figure 8 shows the number of papers founded, as we can see research in MSDs due to computer mouse has been increased as an increase in years. It is also expected soon research in this area will increase as most of works of every sector are shifted to online in this Covid-19 Situation. It's very important to know this area of research is as important as other areas as few researchers are continually trying.

Table 1 shows an article published in the last three years, showing the problems in MSDs have not been resolved completely and there is still scope for improvement. Table 1. represents the intervention, outcomes measured by the author followed by observed conclusion were briefly highlighted.

Table 1. Published observation on MSD

Author (Year)	Intervention	Outcome	Conclusion
Gaudez Clarisse, et al.[72]	Repetitive task of pointing-clicking and dragging were performed on standard, the vertical mouse with 650 from the horizontal and slanted mouse with 350 from horizontal	Pain and discomfort were recorded for every task. Duration of the task was measured for all three-mouse model and the data obtained were statically analyzed using ANOVA	Discomfort and pain are less in slanted mouse and decision making is good in slanted mouse
Yasser Labbafinejadet al.[73]	An electrical test on mussel activity like EDC, FDS, ECR, EDU, PFL, and PQ were tested using EMG while performing a task on slanted mouse, trackpad, vertical and trackball	Results show no measurable difference in PQ, FPL, and FDS mussel activity while operating all four types of the computer mouse. A magnified difference was observed in FPL, EDC and ECR mussel activity on slated mouse	Using a slanted mouse has a reducing effect on musculoskeletal disorders accruing in hand and wrist of operated. Its long term use can save hand from serious surgeries.
H Soewardiet al.[74]	Studied range of angle up to which a wrist cam move witch least mussel compression in the wrist. Max Voluntary Contraction was observed on Abductor Pollicis Brevis and Flexor Digitorum Superficialis	Abductor Pollicis Brevis and Flexor Digitorum Superficialis are two muscles which innervate the nerve moves to carpal tunnel (CT)	With an increase in wrist angle, the fatigue in muscle also increases. The maximum range no more than 20° flexion, and 20° radial,30° extensions, and 20° ulnar, especially in prolonged use
Theo Bodin et al.[75]	Lower arm muscles and upper trapezius muscle activity was measured bilaterally.	Electromyography (EMG) was used to abstain mussel activity. EMG data were analyzed using MATLAB	Muscle activity in the neck and solder was observed during mouse use. which shows a PC mouse effect on the neck.
Xue Wu et al.[76]	Studied the effect of change in mouse on the error occurrence rate	Factors evaluated were mouse click strategies (double-click vs single-click.), mouse drop strategies (down vs. up), and level of urgency (urgent vs. non-urgent).	A high error in mouse click strategies, no difference was recorded in mouse release strategies and level of urgency
Kiana Kia et al.[77]	The moment in the extrinsic finger, neck (splenius ca- pitis), wrist posture performance was measured.	Neck and fingers have a notable amount of moment and stress, with reduced posture and performance.	Neck and fingers have a notable amount of moment but may effect huge if subjected to prolong the time
Camilla Zetterberga, et al.[78]	Used virtual software to test ergonomic setup.	It helps in establishing a relation between set up and creating a comfortable environment to reduce the negative effect of hand posture to eliminate MSDs	This technique, called VERAM, fills the demand for an effective and trustworthy instrument for identifying risks related to the visual work environment.
Richelle Baker et al.[79]	The study was to observed the effect of working on the computer for 2 hours.	Kinematics, mechanisms, mental state, muscle fatigue, state were also measured	Observed a pain in the area of back, neck, and knee. deteriorated in the mental state was noted.
Anne R. Wright MD et al.[80]	The author discussed, diagnosis, pathophysiology, and anatomy of CT syndrome, treating their patients in the primary stage.	Symptoms to identify CTS at an early stage are pain, numbness, and/or paresthesia in the radial finger, index, thumb, middle fingers.	One's patient is tested positive with CTS, a treatment referred to is medicine and surgery. Even at its earlier stage, it can be treated with exercise and change in the design of the machine causing it.
Rahul Jain et al.[81]	Impact of upper limb muscle activity and Posture on grip strength (GS) of manual workers.	A digital handgrip dynamometer was used to determine GS at a different angle of elbow and hand.	Upper limb muscles (i.e., wrist, forearm, and elbow) when subjected to use prolonged period losses it's GS.

Ahmed Radwan et al.[82)]	The author investigated the literature to evident the change in the design of a computer mouse to reduce discomfort	The author investigated the advantages and disadvantages of computer mouse-like Biofeedback mouse, Rollerbar mouse, etc	Alternate mouse from standard mouse reduces discomfort in neck/shoulder, posture, mussel activity. There is no best design for all use
Vishnu Sasikumar et al.[83)]	A predictive algorithmic model was developed to predict musculoskeletal disorders	k-Nearest Neighbors algorithm, Decision Tree algorithm, Naïve Bayes Classifier, Random Forest algorithm were used to design a predictive model for risk prediction.	Naïve Bayes and Random Forest algorithm shows best results in obtaining accuracy. The model shows a relation between computer work and MSD in the back and neck.
Alireza Besharatiet al.[84)]	NASA task load index (NASA-TLX), rapid office strain assessment (ROSA), numeric rating scale, Nordic musculoskeletal questionnaire, were used to collect data of office workers	The highest discomfort observed was in the neck. Found a relation between elbows, shoulders, ankles/feet, and thighs. Age, gender, body mass index (BMI) were associated with symptoms of MSDs in different body regions.	Age is an important factor in MSDs, but the mean age to cause MSDs has increased in females than males. mostly MSDs reported were 60.16 % in the neck, 57.10 % in the lower back, and 54.03 % shoulders.
Mahpiratet al.[85)]	Designed ergonomic computer mouse	Damage to the wrist is more if the mouse position is higher, even the intersection of meridians in arm causes fatigue. mouse design for adults cause more fatigue and can cause permanent damage.	Palm length, Palm width, Palm thickness, Index finger, Middle finger length, Range of movement up and down the left mouse are to be noted for designing ergonomic mouse.
Victor Cw Hoe et al.[86)]	Investigate to find effects of ergonomic consideration in design in-office computer mouse can prevent from MSD or discomfort	Physical, Organisational, Cognitive, Multifaceted ergonomic interventions were studied in 48 articles. randomized controlled trials (RCTs) were used.	Research shows by using ergonomically design mouse risk in neck and shoulder is reduced. arm support is not the best solution for all the arm related MSDs
Monique Janneck. et al.[87)]	Studied ergonomic requirements of office workers for working without any MSDs	The design of the mouse should be effected by the anatomy of the human hand.	Prolonged use of unergonomic mouse cause cramp, strain in ankle and wrist.
Winnie Septiani et al.[88)]	Used ROSA to identify employee work postures, product design to provide proposed work facilities	The workspace diagram, based on radar, showed poor scores in five parts, with an average score of 41.75. Actions include improving ergonomic chairs, document organization, and layout.	The highest complaints occur in the lower neck (100%), buttocks (75%), back (100%) and waist (100%).

4. MSDs reported

Several designs of mouse have been developed by researchers for improving ergonomics [89)]. Many designs are available in market however, there is need of technological intervention to modify mouse by developing technically efficient design with improved performance and ergonomics for the comfort of the users. The new mouse design considers different functional parameters to improve performance as compared to normal conventional mouse. Nowadays, mouse designing is based on ergonomics involving the comfortable postures of the hand, arm, wrist and palm. The aim of new technical and ergonomic efficient mouse designing keeps its functional properties without compromising the comfort of the users.

Mouse with non-ergonomic designs is the actual causes of MSDs. Different MSDs are caused using standard mouse for prolonged periods. Several MSDs such as muscular pain in shoulder and arm/hand[90)] pain in upper extremity and neck disorder[91)] wrist extension moment[92)] , pain in lumbar vertebra section, fingers[93,94)], wrist[95,96)] forearm, frontal shoulder region, carpal tunnel syndrome[97)], extreme ulnar deviation, upper extremity musculoskeletal symptoms[98,99)], Grip strength ,neurogenic thoracic outlet syndrome (TOS), quervain syndrome[100,101)], thumb pain, pronation of forearm[102)] are associated with the ergonomic design of mouse. The details of mouse design and its associated ergonomics are shown in the table. Therefore, an inefficient ergonomic design can increase the problem of MSDs.

5. Issues associated with the ergonomics of available computer mouse.

5.1.Standard pointing device (Horizontal mouse)

The most commonly used mouse available for computer operation is a standard mouse[103)], as it offers a pleasant performance on a task, with faster work time and less rate of errors[104)].

This two-button with a roller in middle allows us for multiple actions, mouse user generally lifts (Fig. 9) and extend their finger over the button to avoid button activations by avoiding pressure on the button[105)].

Fig. 9: Standard horizontal mouse

The regular muscular activity requires lifting the finger during mouse use (Fig. 10) and unsupported palm posture may work as trigger pain in hand /wrist during prolonged use[106)].

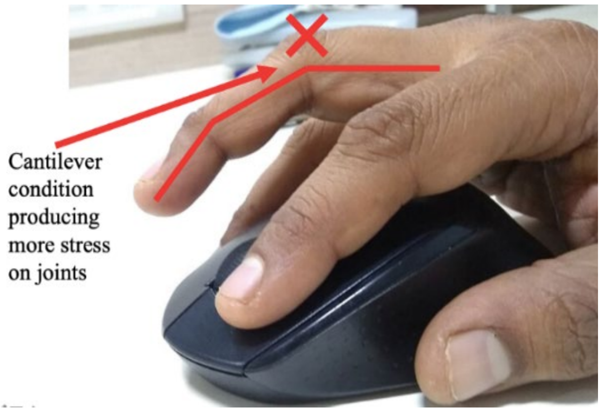

Fig. 10: Lifting behavior of index finger on clicking of right click[66)]

In Year 2000 Zatsiorsky et al.[107)] observed that while applying isometric force on one or more fingers, results on a large effect on other neighboring fingers. Index finger left button action may potentially affect on right button accidental initiations, which shows enslaving effects to the middle finger on the right button be larger than the switch activation force. Therefore, raising the middle finger to avoid unintentional clicking increase extensor activity to overcome enslaving effects during index finger force production. Müller et al.[108)] reported standard moue restrict variation in arm movement and posture. By providing such variation MSD in daily life can be reduced[109)].

5.2.Vertical Mouse

The study of ergonomically designed on carpal tunnel pressure leads the designer too vertical mouse (Fig. 3), and increase comfort in shoulder and neck with improved posture. In this kind of mouse, the click buttons are on either side (Fig. 11), with users assuming a "handshake" position to hold it which makes the moment smooth, reduces strain in joints. The handshake position is referred to as a neutral position that avoids pressure on wrists and joints. It drastically reduces pain and fatigue developed due to Repetitive Strain Injury (RSI) like carpal tunnel syndrome, and increases the use of mouse comfortably, efficiently, and effectively for prolong periods[110,111)].

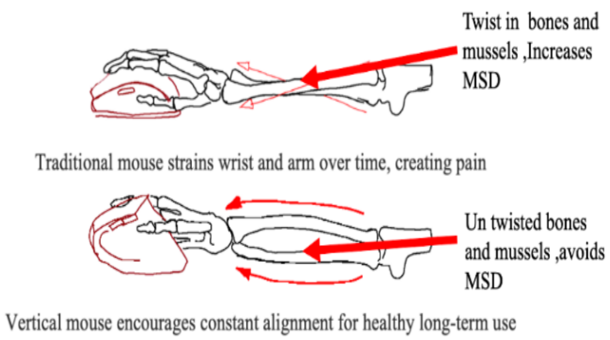

Fig. 11: Difference in forearm bone in a vertical and horizontal mouse[77)]

During the use of the vertical mouse the little finger and wrist, rest on the edge of the mouse which thereby reduces wrist abduction. A neutral position with arm support is a more comfortable position and offers low mussel activity in trapezius mussel[112)]. This vertical design is also recommended by ISO 11228-3. In spite of all advantage their vertical mouse are not common practice. Gustafsson and Hagberg with his study observed that with vertical mouse reduced productivity reduces to 24% as in comparison with a standard mouse [113)]and 10% more time in tasking,20%higher error rate[114)].

5.3.Roller bar Mouse

Roller bar mouse (Fig. 12) was developed to replace the side position of the mouse to the front of the keyboard.

Fig. 12: Roller bar mouse[105]

As unnecessary movements of harm were reduced it helps in slightly lowering MSDs like RSI syndrome and carpal tunnel syndrome, even its central location on the work desk relieves back neck, and shoulders. It also provides rest to the wrist which fulfils the need for ergonomic design[88,115]. Despite it's a fine and sleek concept it seeks several disadvantages like it keeps the hand in a horizontal position which indeed keeps a hand in a twisted position. Mobility of fingers has been increased, unconvertable to use keyboard and mouse at the same time, reduce productivity, difficult to work by designers of CAD. Burgess-Limerick et al concluded that user has more chances to wrist extension and extreme ulnar deviation.

5.4. Slanted mouse

The above review shows that musculoskeletal symptoms can cause due to the use of mice in non-neutral postures.

Fig. 13: Slanted mouse[73]

Many studies had been carried out to compare the advantage of the slanted mouse (Fig. 13) over vertical and horizontal mouse. The slanted plane is the angle between the inclined surface of a mouse and horizontal plane in the front or rear views. Gaudez and Cai in their investigation assessed the time required to complete a task and found that the time is shorter than a vertical mouse. In this mouse distribution of weight on the hand is improved, reduced over-stressing the side of the palm, besides the locations with buttons and rollers were adjusted, limiting hand movement which allows using a mouse for a prolonged duration of time. With additional feature of proper curvature on both sides of the mouse and high arched back, helps the user to rest his hand naturally. Some of the slanted mouse designs have a slight inward groove, increasing the contact area between the finger and the button, reducing pressure on fingers and fatigue, and provides a natural grip. Han-Ming Chen and Chun-Tong Leung [54]investigated on five custom-made mice with various slant angle as 300,250,200,100 and 00 and mentioned the slanted angle of an ergonomic mouse has a major influence on four mussel group like upper trapezius (Trap) muscles, pronator teres (PT), extensor digitorum (ED) and extensor carpi ulnaris (ECU).

5.5. Biofeedback Pointer

The Biofeedback Pointer is a computer device used to input graphics with use wrist motion. This pointer sense electromyograms of four muscle of wrist to navigate pointer, which is programmed by a neural network [116]. Working efficiency with Biofeedback Pointer was observed 14 % compared to standard mouse Biofeedback mouse was designed to avoid hovering behaviour of human hand and provide the user to rest his hand by giving haptic feedback, vibrating signal when the wrist is hovering and/or idle for a prolonged period.

5.6.Trackpad Effect

Common actions such as scrolling, clicking, and dragging require frequent, repetitive motions that can contribute to repetitive strain injuries (RSIs). The flat, pronated position often required for effective trackpad use places continuous stress on the tendons, muscles, and nerves of the hand, wrist, and forearm. This can lead to conditions like carpal tunnel syndrome, characterized by the compression of the median nerve in the wrist, causing pain, numbness, and tingling in the fingers. Additionally, the lack of ergonomic support for the wrist during trackpad use can cause or exacerbate tendonitis, which is the inflammation of tendons due to overuse. De Quervain's tenosynovitis, another common MSD, affects the tendons at the base of the thumb, leading to pain and swelling. Furthermore, the repetitive nature of trackpad tasks can contribute to trigger finger, where fingers lock in a bent position due to tendon inflammation. The continuous strain from these unnatural positions can also result in cubital tunnel syndrome, where the ulnar nerve is compressed, causing numbness and tingling in the ring and little fingers, as well as pain in the forearm. Preventive measures are essential and include using external input devices like a mouse and keyboard to reduce trackpad reliance, maintaining a neutral wrist position, and incorporating wrist rests for support. Regular breaks to rest and stretch the hands, along with exercises to enhance muscle flexibility and circulation, are also crucial. Adjusting trackpad sensitivity and speed settings can help reduce the physical effort needed for movements, thereby minimizing stress. Recognizing the early symptoms of MSDs and seeking timely ergonomic or medical advice can significantly aid in managing and preventing these.

Early detection and intervention are key to preventing MSDs related to mouse usage. By detecting some early signs as Tenderness or pain in the fingers, hand, wrist, forearm, or elbow, Reduced range of motion, Tingling or numbness. There are some early warning signs such as occasional pain or discomfort that worsens with mouse use, Swelling, redness, or warmth in the affected area, weakness or reduced grip strength.

6. Discussion

This review has adequately cover most of the computer mouse used in the offices like track review adequately cover ad, standard horizontal mouse, vertical mouse, roller bar mouse and slanted mouse. A wide range of published articles investigating risk factors related to computer mouse use were evaluated throughout this literature review. There is enough evidence to suggest the need for future research into developing or redesigning an ergonomic mouse that could reduce the above-mentioned MSDs or discomfort. The authors address following three key issues that must be consider enhancing end.

6.1.Mouse Integration

Person using horizontal (Standard) mouse are more subjected to several MSD's mentioned in the paper, subjected to hours of use. Mouse track and touch screen should be avoided. Mouse size should be considered while purchasing mouse[117)]. The mouse length should be such that it supports whole palm. Studies shows differences in muscular dynamics between the size of mouse and hand, it clearly shows smaller computer handheld pointing devices relative to hand size foster more dynamic muscular activity [118)]. Mahpirat et al. [85)] also worked with difference between palm size and mouse particularly on children considering ergonomics and skeletal growth characteristics.

Mouse should be designed with adjustable slanting angle or more neutral position which is varying between 30^0 to 90^0. Few studies have also reported that the use of support under forearm have reduced to 10% compare to use without support. Design incorporated with wrist support shows reduced pain of about 16 % and 22 % in operating hand and forearm respectively. Roller bar mouse can be recommended for general purpose as it reduces discomfort in wrist as its uses forearm mussel for its operation. Few studies state's that the chances of MSDs in women are more than men. Women tend to work with a greater ulnar wrist deviation when performing computer-related tasks because of their larger extension and range of motion. They exerted greater forces on the mouse as measured as a percentage of their maximum voluntary contraction and their right extensor digitorum had greater muscle activation.

6.2.Movement Pattern

Every input device has its level of moment causing variation of load on mussels. As track-ball provide less neck/shoulder muscle activity and lower shoulder elevation compare to standard horizontal mouse. Wrist extension and ulnar deviation are major factors effecting various mussels in hand, shoulder and neck. Griping and pinch strength can be an important index of measuring the effect of different mouse. Weight of mouse can influence the wrist motion and the forearm muscle activity during quick operating speed which are nearly low in slow operating speed. Review suggests that mouse weight around 130 gm ranges in considerably less wrist movement range and muscle activity. Moment pattern is same in both right- and left-handed operator. There are significant differences between the hands in the left-handed group and observed small but significant differences between the dominant and non-dominant hands in the right-handed group[119)].

6.3. Linked Cost

Costs associated due to use of computer mouse can be categorized into direct costs and indirect costs. Cost which are associated with medical expenses like doctors, medicines, hospitals, equipment's like neckband, lumber belt etc. are considered as direct cost. Indirect cost is mostly associated with employer like lack of productivity, absentness, missing deadlines, recruiting new employee. These losses can even lead to market reputation of company. According to the federal Occupational Safety & Health Administration In the United States, it is estimated that firms incur costs related to repetitive strain injury of between $15 and $20 billion annually. A 10% decrease in repetitive strain injuries and symptoms would result in an annual savings of $700,000. This estimate was made using data from recent research on injury rates and a hypothetical company with 500 computer users.

7. Suggestions

The following suggestion are recommended for the researchers and designers working to reduce adverse effects of computer on its users:

- Slanted mouse with different palm size should be introduced more.
- Slanted mouse with variation in slope angle between 30^0 to 80^0 can be more effective to reduce MSDs.
- Mouse with active wrist support can be designed, which is missing in all the discussed mouse.
- Hand grip strength is effective way to measure MSDs.
- Mouse weight around 130gm can be a good

consideration.

- On comparing roller bar Mouse, vertical mouse, slanted mouse and standard mouse slanted mouse is more comfortable to use.
- Author haven't found any specific computer mouse design that is best for every task like surfing, designing etc.

There is can be few points which can be considered while choosing mouse

- Consider hand size and grip style (palm, claw, or fingertip) to select a mouse that fits comfortably and supports natural hand positioning.
- Ergonomic designs that minimize strain and promote comfortable usage over extended periods, such as mice with contoured shapes or thumb rests.
- Decide on the number and placement of buttons based on your usage preferences.
- If possible, assess how it feels in your hand and how well it suits your usage preferences.

8. Conclusion

As increase in use of computer professionals use of computers mouse has increased which effected the human body. There are various computer pointing device available in market, but slanted mouse was most consistently associated with reduced in stress and biomechanical force. The growth of slanted mouse in computer accessories market with slant angle: 30° or 50° may replace conventional mouse the future market in computer accessories and (slant angle: 0°).

The average level of activity in Extensor digitorum muscle, Extensor carpi radialis and primary flexor of the thumb was observed to 11.02, 7.41 and 14.93 respectively. with the same scenario the lowest level of above-mentioned mussel activity was 12.93. With more variation in slanting angle like 0°,10°,20°,25° and 30° and weights of 80.7, 80.5, 86.5, 90.1 and 100.1 g ECU and Trap muscles activity reduce with increased in angle. It is not clear that vertical mice, trackball mice, touchpads reduce biomechanical force but all studied mouse suitable for specific type of task. Alternative computer pointing devices that decrease biomechanical loading can be a best alternative to prevent MSDs. A mathematical model based on a non-linear optimizing mathematical technique with a criterion of boundary conditions and equality equations, maximized against unknown parameters to reduce and prevent MSDs can be studied to understand biomechanical loading[120)].

Review findings showed that exposure to wrist postures that deviate from neutral joint positions over an extended period or repeatedly was linked to the development of musculoskeletal pain and injury. The postures which could be possible cause of development of musculoskeletal disorders are use of muscles while shortened, increased neural tension and increased pressure on nerves at entrapment points. Using a computer mouse at improper angles can significantly impact nerve function and structure, particularly in the wrist and hand. Poor wrist positions, such as flexion (bent down) or extension (bent up), increase pressure on the median nerve, leading to carpal tunnel syndrome with symptoms like pain and numbness. Ulnar (towards the little finger) and radial (towards the thumb) deviations can strain nerves and tendons. Ergonomic mice, such as vertical models, promote a neutral wrist position, reducing strain. Improper mouse angles can also cause compensatory movements in the forearm, shoulder, and neck, leading to additional strain and nerve impingements. Repetitive strain injuries and peripheral nerve entrapment syndromes can develop, causing inflammation, pain, and weakness. Maintaining a neutral wrist position and using ergonomic mouse designs are essential for preventing these issues.

Mouse device subjected ulnar deviation and extent wrist extension are possible reason to develop MSD. Finding can also help in designing as most of office mouse are standard horizontal mouse which is major hours of MSDs, so designer should go with ergonomic study rather than looks of mouse. Review study can also help end buyer to search for better ergonomic mouse as it gives over view of which kind of mouse is better than another, although there will be some difficulty in earlier stage as mind is more adjusted to use standard mouse. But with some time, it will be overcome.

Another behavior that computer mouse users display is elevating their fingers when making the opposite click and maintaining extended finger postures while using the mouse both statically and dynamically. It was observed in a group of 100 students, 48% of student found lifting behavior, 23 % in extended postures, and 17 % in both lifted and extended postures. extended postures and prolonged static finger lifting behaviour of can put the user to greater possibility to musculoskeletal pain to the forearm, wrist, or hand.

It has become necessary to spread awareness before purchasing a correct input device as per our use. Implementing healthy work habits and use of ergonomic tool can be preventive measures for reducing musculoskeletal symptoms. It Is found that with the use of ergonomic training the goal can be achieved, with up to 69.9% of surgeons noting improvement in their symptoms. Ergonomic training can be accomplished by adopting following habits.1) Microbreaks, 1-minute break after every 20-35 minutes of continuous work. 2) chair yoga. 3) Incorporating ergonomic workstation setup. 4) Selecting proper seating and posture. 5) Desk and Work Surface Ergonomics.

This review will give you an understanding of choosing an ergonomic mouse but there may be some limitation in implementation. As comfort can vary from person to person so difficult to make tailored design for each and no proper platform to test any mouse before using it for long hours. Another problem is high cost associated with Product design and development, only big companies like

HP, DELL etc. can offered the cost, funding, and time required and instrument it. As gaming mouse are highly studied and designed to benefit the gaming, offices should think in the same manner.

As per author knowledge all the information gathered are in correct and in proper manner and did not need to omit any part in the review.

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Nomenclature

MDSs	Musculoskeletal disorders
Trap	Upper trapezius
PT	Pronator teres
ED	Extensor digitorum
ECU	Extensor carpi ulnaris
ISO	International Organization for Standardization
RSI	Repetitive Strain Injury
TOS	Thoracic outlet syndrome
CTS	Carpal tunnel syndrome

Greek symbols

δ	exergy defect (–)
η	efficiency (–)

Subscripts

2^{nd}	Second Law
Carnot	Carnot
Dis	discharge
e	exit

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