INTRODUCTION:
The computer use was reported to be associated with developing musculoskeletal disorders in the wrist, forearm, and shoulder regions. Considerations have been suggested to be paid to the ergonomics such as the postures of the upper extremity, the placing of the monitor, and the geometry of the keyboard. The mouse-handling related issues, however, were relatively less discussed.

Greater wrist ulnar deviation when using the mouse was significantly associated with more frequent discomfort and abnormalities. Increased muscle activity of the wrist extensors also has been linked to work-related injuries of the upper extremity. Minimizing the wrist ulnar deviation and the muscular efforts therefore could be important in reducing the risk of upper extremity disorders.

This study was to investigate whether the changes of computer mouse weights affect the wrist motion and the forearm as well as shoulder muscle activity during different mouse operation speeds. The results could facilitate the selection of proper weighted mouse.

METHODS:
There were 20 males (23.7 ± 1.5 years old) and 5 females (22.0 ± 1.1 years old) participated voluntarily in this study. All subjects were right-hand dominant without wrist, forearm, and shoulder musculoskeletal symptoms. The medical research committees approved this study.

The wrist radial/ulnar motion was registered by an electrogoniometer (SG65, Biometrics, Gwent, UK) which attached to the dorsal part of the right wrist with tapes. The motion data were sampled at 1000 Hz. EMG signals were recorded by BIOPAC MP150 system (Goleta, CA, USA) with bipolar Ag/AgCl surface electrodes, and were collected from the right extensor carpi radialis (ECR), extensor carpi ulnaris (ECU), extensor digitorum (ED), and trapezius (Trap) muscles. EMG signals were pre-amplified (gain 500) and sampled at 1000 Hz, band-pass filtered between 20 Hz and 450 Hz, and were A/D converted using a 12 bit National Instruments A/D card. A 15-inch LCD monitor (resolution of 1024 x 768 pixels) was used to display two target circles with 50-pixel diameters and 974 pixels apart horizontally. Five tested mice were fabricated by sticking lead bars inside the off-the-shelf computer mice without changing the size. These five mice were named mouse 70G, 100G, 130G, 160G and 190G for claiming their weights (unit: grams).

The wrist radial/ulnar motion was registered by an electrogoniometer (SG65, Biometrics, Gwent, UK) which attached to the dorsal part of the right wrist with tapes. The motion data were sampled at 1000 Hz. EMG signals were recorded by BIOPAC MP150 system (Goleta, CA, USA) with bipolar Ag/AgCl surface electrodes, and were collected from the right extensor carpi radialis (ECR), extensor carpi ulnaris (ECU), extensor digitorum (ED), and trapezius (Trap) muscles. EMG signals were pre-amplified (gain 500) and sampled at 1000 Hz, band-pass filtered between 20 Hz and 450 Hz, and were A/D converted using a 12 bit National Instruments A/D card. A 15-inch LCD monitor (resolution of 1024 x 768 pixels) was used to display two target circles with 50-pixel diameters and 974 pixels apart horizontally. Five tested mice were fabricated by sticking lead bars inside the off-the-shelf computer mice without changing the size. These five mice were named mouse 70G, 100G, 130G, 160G and 190G for claiming their weights (unit: grams).

The normalization trials included the 5-second isometric maximal voluntary contraction (MVC) of the ECR, EDU, and ED, and the 15-second isometric submaximal reference voluntary contraction (RVC) of the Trap for the physiological reason. As for the mouse testing protocols, a 5-minute normal speed task, 5-minute break, and followed by 5-minute slow speed task was performed with each weighted mouse. The subject on cue began the ‘point-and-click’ task over the two targets successively. The paces of the normal and slow speed tasks were approximately 50 and 25 repetition/minute respectively. Subjects could practice until familiar with all mice and tasks. The order of tests was randomized.

The muscle contraction level during tasks was expressed as a percentage of that during normalization trials (%MVC or %RVC). Two-way ANOVA (weight/speed) with repeated measures was used for muscle activity assessment. Post hoc comparisons were carried out by Tukey method. Statistical significance and power were set at \( p < 0.05 \) and 80% respectively.

RESULTS:
During the normal speed tasks, the 70G, 100G, and 190G trials showed similar movement pattern. The maximal angles in 160G and 190G trials (around 45°) were greater than those in 70G, 100G, and 130G trials (around 30°) (Fig. 1).

During normal speed tasks, the ECU muscle activity in 70G (median: 13.1%) and 190G trials (median: 12.9%) were significantly greater than that in 130G trial (median: 8.9%; \( p = 0.008 \) and 0.016 respectively). During slow speed, the ECU muscle activity in 190G trial (median: 12.8%) was also greater than that in 70G trial (median: 13.9%; \( p = 0.011 \)). Trap muscle activity was low during both moving speeds (Fig. 2).

DISCUSSION:
During the normal speed tasks, the aberrant motions in 70G and 100G trials were due to the overshoot phenomenon with compensation for the deviated posture when using light mice. The increased ulnar deviation when using heavy mouse (190G) could be attributed to the geometrical changes in the distal tendon length of the forearm extensors. The ECR, ECU, and ED showed a V-shape tendency with lowest activity in 130G trial (Fig. 2a). The great muscle activity was due to increased mouse weights using heavy mice, and due to increased demands in the precision using light mice. Accordingly, the subjects appeared to show wrist ulnar deviation during mouse use, while the mouse weight around 130 grams showed the best physiological efficiency. During slow speed tasks, the movement pattern and muscle activity were almost consistent since the tasks were precise and easy during gentle movements.

The limitations of this study were that only ergonomic related factors and short-duration “point-and-click” task were considered. The simplified design was to reduce the confounding factors during computer works. It should also be careful to generalize current results to populations who already show musculoskeletal discomfort.

In conclusion, this study revealed that the mouse weight would influence the wrist motion and the forearm muscle activity during normal moving speed, while such effect was diminished during slow moving speed. The results suggested that the proper mouse weight could contribute to minimize the wrist ulnar deviation and the muscle activity, and potentially reduce the risk of musculoskeletal disorders.