KINEMATICS OF MOUSE SCROLLING

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INTRODUCTION

One of the most common computer peripherals is a two-button scroll mouse. Studies have shown that the risk of upper extremity musculoskeletal disorders can be increased by intensive mouse use such as clicking and dragging, wheel scrolling, cursor movement, and awkward wrist posture [1-2]. Previous studies on mouse use have focused on finger forces [3-4], wrist positions [5] and hand motion [6] during pointing and dragging. The purpose of this study was to examine the joint kinematics of the index finger during mouse wheel scrolling.

METHODS

Five subjects aged 26 ± 3 years without any musculoskeletal disorders of the upper extremity participated in the study. All subjects were familiar with using a computer mouse. Five reflective markers of 5 mm diameter were placed on the index finger: the center of the nail, distal and proximal interphalangeal (DIP and PIP) joints, metacarpophangeal (MCP) joint, and the midpoint of the 2nd metacarpal bone. A motion capture system (VICON 460, Oxford, UK) was used to collect the marker motion data. Each subject comfortably gripped a two-button scroll mouse (Microsoft® Intellimouse®, Redmond, WA) with their right hand with the index finger over the wheel. They were instructed to maintain a neutral wrist posture. The subjects performed full forward and backward scrolling tasks at 1 cycle/second following a metronome. Ten cycles of scrolling data was collected at 60 Hz. The range of motion and the coefficients of correlation for the DIP, PIP, and MCP joints were calculated. A two-way ANOVA was used to examine the difference in joint range of motion (ROM).

RESULTS

During backward scrolling, the DIP, PIP and MCP joint movements were highly correlated (Figure 1). The DIP and PIP joint moved in phase with correlation coefficient of 0.996 ± 0.025. The MCP joint was correlated in anti-phase with the PIP or DIP joint. For example, the correlation coefficient between the MCP and PIP joint movements was -0.916 ± 0.066. Each backward scroll cycle began with the minimal flexion of the DIP and PIP joints (5.3 ± 2.5° and 14.6 ± 7.4° respectively) and maximum flexion of the MCP joint (21.9 ± 6.9°) and ended with maximum flexion of the DIP and PIP joints (38.1 ± 8.8°and in 57.2 ± 8.5° respectively) and minimal flexion of the MCP joint (8.4 ± 6.1°). A similar, but reverse, pattern was observed during forward scrolling. In backward or forward scrolling the PIP joint ROM was greater than the DIP joint ROM and was more than twice the MCP joint ROM ($P < 0.05$, Figure 2). The scrolling direction did not significantly affect the ROMs of the DIP, PIP or MCP joint.

DISCUSSION

Mouse use requires controlled and stereotypical movements of the DIP, PIP and MCP joints. The negative correlation between the MCP joint and the interphalangeal (IP) joints (i.e. IP joint flexion with MCP joint extension) is advantageous as it prevents excessive muscle shortening or lengthening, preserving optimal muscle lengths for effective force production. On the other hand, our results show that the DIP, PIP and MCP joints move in the ranges of 5-38°, 15-57°, and 8-22°, respectively, during a typical mouse scroll. These motions comprise approximately 40% (DIP), 50% (PIP), and 15% (MCP) of their respective full ROM (see also [7]). In addition, these motion ranges do not surround the functional neutral positions of these joints, which may place these joints under more-than-minimum stress throughout mouse use. Mouse use can account for over 20% of computer use time and more than 78 uses per hour [3]. This repetitive stresses on finger joints could lead to musculoskeletal disorders of hand muscles and finger joints. Further biomechanical studies of mouse usage could help design ergonomic mice to minimize musculoskeletal strain.

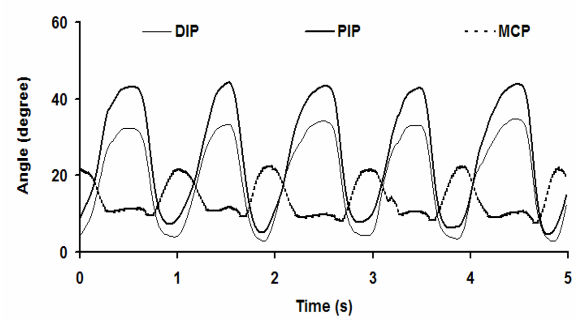

Figure **1**. Representative joint angular motion during 5-cycles of backward scrolling.

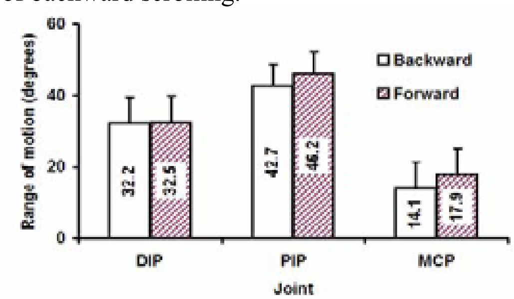

Figure 2. Range of motion of individual finger joints during backward and forward scrolling.

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