Can Digital Signals from the Keyboard Capture Force Exposures during Typing?

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Introduction

Intensive computer use has been associated with musculoskeletal disorders (MSDs) in the upper extremities (Gerr et al., 2006). Chang et al. (2009) proposed that there may be an exposure-response relationship between muscle fatigue and keystroke durations and that temporal changes in keystroke durations may be an objective surrogate measure of muscle fatigue. Since keystroke durations can readily be assessed using software programs installed on the operator's computer, the method has the potential as a simple, cost effective, non-invasive exposure assessment tool. However, the software based keystroke durations measured by the digital ON/OFF signal when a key is pressed and released may be affected by keyswitch force-displacement characteristics. Therefore, using keyboards with different force-displacement characteristics, this study used a force platform to measure the keystroke durations and compared them to software measured keystroke durations. The purpose of this study was to determine whether the software based keystroke durations derived from the digital signal could be used as a non-invasive, surrogate force exposure measure in lieu of the invasive actual force measurements.

Method

Thirteen subjects (6 males and 7 females) who were right-handed touch typists without a history of upper extremity MSDs were recruited for the study. The experimental protocol was approved by the Human Subject Committee at the University of Washington, and all subjects provided their written informed consent before the experiments. The experimental task consisted of having subjects type for 15 minutes each on the three keyboards which were mounted on top of a force platform. The workstation was adjusted based on the subject's anthropometry. The three keyboards tested, which had different keyswitch force-displacement characteristics, included: 1) a keyboard with 4.0 mm of key travel, 2) a keyboard with 2.0 mm of key travel and 3) a keyboard with 1.8 mm of key travel. The keyboard with 4.0 mm travel distance had rubber dome switches whereas the keyboards with 2.0 and 1.8 mm travel distance had scissor switches; the activation forces on all the keyboards were 0.6 N. The order of keyboard use was counterbalanced to minimize any potential confounding due to keyboard testing order. During the typing tasks, keystroke durations from the individual keystroke profiles measured from the force platform and from the digital signals from the keyboard were simultaneously collected at 500 Hz. Repeated measures ANOVA methods were used to determine whether there were differences in keystroke durations measured by digital keystroke signals and applied individual keystroke forces. In addition, a bivariate analysis was used to determine how well the digital-signal-based keystroke durations approximated the force based measures.

Result

The digital signal based keystroke durations from the 1.8, 2.0, and 4.0 mm travel keyboards were 125.4 (± 5.7), 115.7 (± 5.2), and 88.4 (± 3.2) milliseconds, respectively. The force based keystroke durations of the same keyboards were 114.6 (± 6.7), 105.1 (± 5.8), and 108.9 (± 4.4) milliseconds, respectively. The differences between the digital and force based measures on 1.8, 2.0, and 4.0 mm travel keyboards were 10.8 ($p = 0.02$), 10.6 ($p = 0.02$), and 20.5 ($p < 0.0001$) milliseconds, respectively. According to the results, the digital signal based keystroke durations showed more substantial differences than the force based measures. Despite the significant differences, the digital signal based keystroke durations were highly correlated with the force based measures (fig 1).

Discussion

Using keyboards with different keyswitch force-displacement characteristics, this study was conducted to determine whether there was an association between keystroke durations measured from applied finger forces and those measured form the keyboard's digital signal. The results showed that the force based keystroke durations were less sensitive to the force and displacement differences of the keyboards than the digital signal based measures. This is not surprising because applied force profiles are not affected by the electromechanical differences in keyswitch designs and subject to the mechanical artifacts when measuring typing force (e.g. mechanical vibrations). Although the keystroke durations measured by the digital signals depend on the force-displacement characteristics, the high correlation between the two measures (fig 1) indicates that the keystroke durations derived from the digital signal approximate the true force derived keystroke durations, regardless of the keyswitch force-displacement characteristics. Therefore, for field studies, the digital signal based keystroke durations, which can be readily measured by software programs installed on the user's computer, can be used as a surrogate, non-invasive force duration measure in lieu of the more complicated, expensive and invasive force platform derived measurements. The limitation of basing keystroke force duration measurements on the digital signal is the loss of being able to measure the actual peak and mean force exposures; the gain is the simplicity, low cost and ability to collect large samples for epidemiological purposes.

References

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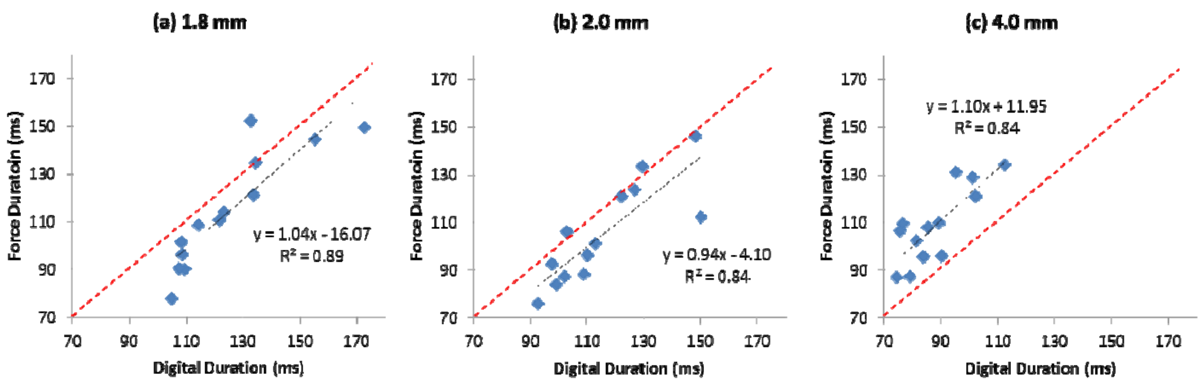

Fig. 1. Linear fits and correlations between the keystroke durations measured from digital signals and applied finger forces on 1.8, 2.0 and 4.0 mm travel keyboard, respectively. The dotted lines are the ideal identity lines.