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Virtues and Vices of Handheld Devices

Over the past five decades, there has been little change in the types of tasks performed at work. People still make products. People record and retrieve information. People move materials from one place to another. What has changed most are the processes used to accomplish these tasks. Perhaps the most important agent of change has been mass production of electronic devices used in almost every aspect of life. We are on the verge of an explosion of even more powerful technological devices that will fit in the palms of our hands. This article discusses some of the ergonomic challenges that could result from this handheld technology, and recommends strategies to control musculoskeletal disorders from using these devices.

The World As We Know It

Handheld devices have found wide acceptance in our culture. They are used everywhere--inside buildings, inside vehicles, and outdoors. There is evidence that, at current usage rates, handheld devices may be responsible for an increase in the incidence of musculoskeletal overuse disorders. In 2005, medical personnel reported numerous complaints of thumb pain related to manipulating thumbwheels on BlackBerries.[1] These reports were significant enough to prompt speculation about employer liability from job-related BlackBerry use that extended beyond normal working hours.[2]

The World of the Future

If you are anticipating the new wave of handheld devices to hit the market, you probably won't have to wait long. The discoveries that will fuel the explosion have already been made. Recently, University of Edinburgh[3] researchers invented a process to create wires that are 1/1000th the width of a human hair. This will allow a new breed of "nanochips" to be manufactured. This technology could put the power of current desktop computers inside a wrist watch. Another discovery[4] will allow a terabyte of memory to be contained within a flash drive. These and other discoveries will probably advance the design of miniature electronic devices even more than past discoveries that fostered the evolution of mobile phones from devices tethered to an automobile's power supply to cell phones that fit in the palm. Driven by an urge for convenience, buyers will flock toward the handheld communication and multifunctional devices. This will create a need for guidelines to reduce overuse injury risk.

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Identifying Risk Factors

Before considering risk management strategies, look at factors that contribute to the risk of developing musculoskeletal overuse injuries from using handheld devices. A critical contributor to injury risk from these devices is the demand for using precision movements such as pushing small buttons, writing on small screens with styluses, and manipulating small controls such as thumbwheels and joypads. Precision movements transmit more static stress to the fingers and hands. When performed briefly, the injury risk is minimal. However, longer or more frequent bouts of activity increase risk. As with data entry, the magnitude of injury risk increases with exposure time.

When using most, if not all, electronic devices, people are exposed to some type of ergonomic risk factor. Device selection often comes down to a trade-off between exposures related to the weight of a larger device and static forces associated with the postures and precision movements of a smaller device. Contrast the differences between a tablet computer and a personal digital assistant (PDA):

- The ***tablet computer*** is relatively heavy and cumbersome to cradle on the arm, but it provides a large screen for input with a stylus and a full-sized keyboard on for data entry. The tops of the keys have enough area to completely accommodate the fingertips, and key separation is wide enough to allow the user to strike adjacent keys without requiring extended reach or getting interference from adjacent keys. The design compares well to the 0.47-inch minimal strike surface (of key) width advocated by the American National Standards Institute.[5]

- Carrying the lighter ***PDA*** requires less muscle exertion than the tablet, but data entry demands more stressful precision movements on a small touch screen with either a finger or stylus. Research has shown that speed and accuracy of data input decreases along with key and screen size.

The design characteristics of a device may also increase risk of musculoskeletal injury during activities other than data entry. Screen orientation may force users to assume non-neutral postures during viewing. Often users locate handheld devices below chest level to reduce static loads on the arm. This forces the neck into severe forward flexion while monitoring the screen. Viewing small displays has also been known to stress eye muscles. Considering these problems, why do people choose to use handheld devices? To answer this, consider the occupations of the people who have most readily embraced them. Evidenced by the number of computer applications developed and journal articles written, medical clinicians are probably the most fervent users of handheld devices. They are reportedly being used for scheduling appointments, taking notes, educating patients, retrieving medical information, monitoring dietary intake, displaying radiographs, and performing various types of complex calculations. Clinicians value handheld devices because their small size allows them to be inserted into a pocket and carried wherever they may be—in offices, on patient wards, in x-ray and laboratory departments, or in emergency rooms.

The device that is ultimately chosen will depend upon the nature of the job that the person performs and the characteristics of the person using it (cognitive ability, dexterity, and prior experience with similar electronic devices). These factors typically dictate a device's usability. When considering the display function of these devices, the most important characteristic will be the surface area dedicated to showing the image. The input function of these devices is more varied and complex. The chart below lists taxonomy of different input methods along with estimates of their usability.

Usability Estimates for Common Electronic Input Devices

Keyboards (KB)

- Full	Excellent
- Mini	Excellent
- Micro	Excellent
- Sub-Micro	Good

Other Large Devices

Mice	Excellent
Trackballs	Excellent
Joysticks	Good
Touchpads	Good

Touch Screens

- Finger Input	- - -
-- QWERTY	Good
-- Screen Objects	Good
- Stylus	- - -
-- QWERTY	Fair
-- Screen Objects	Good
-- Handwriting Recog	Good

Microphones

- Speech Recognition	Good

Other Small Devices

- Buttons	Good
- Joypads	Good
- Thumb Wheels	Fair

Virtual Input Devices

- Virtual LASER KB	Good
- Motion Trackers	Fair

Excellent Fair
Good Poor

Keyboards may be organized into four classes: full-sized with integrated number key pads, mini keyboards that have a full QWERTY keyboard without the number key pad, micros that have a QWERTY keypad with smaller keys that lack a number key pad, and sub-micro keypads that have much smaller keys such as those used on Blackberry devices. Touch screens allow input via a fingertip or stylus. PDAs often provide QWERTY keyboards to enter characters and a special handwriting recognition program that interprets cursive input. Speech recognition software is available for use on both desktop and handheld computers. Most handheld devices offer hardware keys or other input devices for data entry. Various types of virtual input devices are available for use, provided the correct software drivers are installed. Virtual input devices are common in gaming applications and many are available for special populations such as the physically handicapped. For a more detailed look at design features for data input devices, see Zingale, Ahlstrom, and Kudrick (2005).[6]

What the Future Will Bring

Considering the fact that overuse injuries have already been noted at present usage levels, injury incidence may be expected to increase as technological innovations expand the user base. But is the increase inevitable?

Several other inventions may allow the design of handheld devices that offer full-sized keyboards and large area displays. This can be made possible through the magic of lasers. The dream keyboard is similar to the virtual keyboard, already on the market, that uses a laser to project an image of a keyboard on a surface and translates the positions of the fingers into keystrokes.[7] The large area display is currently under development. It will consist of a holographic projector capable of projecting a screen image the size of a standard computer monitor or a wall-sized image for large group presentations.[8] These inventions will allow handheld devices to be manufactured that provide two modes of input and display: small scale hardware components for brief periods of viewing and data input and laser-powered full-sized virtual keyboards and projectors for long periods of use. The more powerful central processing units of future handheld devices will also be able to support integrated voice recognition systems for vocal input.

Risk Management and Assessment

There are two ways users can avoid sustaining injury from current and future use of small devices: selecting appropriate devices and establishing and adhering to proper usage guidelines. Follow three simple steps to ensure that devices are appropriate. Select a device that is:

- ***Step 1: Select a device that is capable of performing the required tasks.*** Identify the task requirements and compare these to the hardware specifications of the device to determine a match. For example, if the task requires an individual to communicate with others via telephone, there are a multitude of devices capable of performing this function, including a standard telephone, an internet phone, and a cellular phone.

- ***Step 2: Select a device that is compatible with the work being performed.*** Identify the nature of work and the important aspects of the work environment where the device will be used. This information will help narrow the list of applicable devices. For example, if a person must be able to call from many locations (at the office, at the airport, and on the road), a standard phone and internet phone can be eliminated from consideration. A cellular phone would be more appropriate.

- ***Step 3: Select a device that is compatible with the user.*** This is the most difficult step because various decision-making criteria can be applied, including aesthetics, comfort, and objective human-machine compatibility analysis:
  - Aesthetics involves selecting a device that looks appealing.
  - Comfort is the "Goldilocks" criterion—selecting a device that feels good.
  - While these first two criteria may have merit, injury risk cannot be controlled without objectively analyzing human-machine compatibility to determine how the use of the device will impact the health of human tissue. The risk of injury may be appreciated by performing an ergonomics evaluation of the person using the device and factoring in the exposure factors of the frequency and duration of use.

A good starting point for devising your assessment is the Occupational Health and Safety Administration's eTool for Computer Workstations.[9] Your assessment should focus on the following:

- How much does the device weigh?
- Do users assume non-neutral postures when using the device?
- How much time do users spend performing repetitive, precision movements when inputting data?

If the assessment indicates a basis for concern about the exposures, then it might be appropriate to develop usage guidelines for the device. Guidelines can specify the number of hours of exposure allowed per day or the length of exposure allowed for each period of activity.

Conclusion

The virtues and vices of handheld devices are rooted in the same cause—small size. This feature allows them to be portable but also increases the likelihood of being exposed to ergonomic risk factors. However, there are technological innovations on the horizon that can make these devices more powerful and mitigate some of the exposure risks. In the meantime, use the information in this article to identify some of the more important risks that should be controlled.

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Endnotes

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