An accurate assessment of the amount of time patients spend sitting in their wheelchairs during a hospital rehabilitation program is important for both research and clinical purposes. On a clinical level, the number of hours a patient sits each day can be used to index how well the patient is progressing and, more specifically, may reflect the patient's overall level of activity. On a research level, accurate and reliable methods of monitoring a patient's sitting program are essential for gaining a better understanding of the relationship among sitting time, tissue tolerance, and the development of pressure sores. Although most clinicians would agree that an accurate assessment of wheelchair sitting time is important, until now there has been no method for obtaining such data in a convenient, quantitative manner. Buzzers and other devices, which are variations of the kitchen timer, have been used as reminders of excessive sitting, but they have not measured how long the patient actually sat. In most rehabilitation settings, information on sitting time is based on staff estimates or patient schedules, or both, which lack objectivity and reliability.

This paper describes a simple, practical device called the Sit Time Monitor (STM) for obtaining objective, quantitative information on the number of hours a patient sits in a wheelchair.

**Device Description**

The STM (Figure 1) consists of three components: 1. a pressure-sensitive ribbon switch pad located under the seat cushion; 2. a digital electronic timer contained in a small box attached to the back of the chair; and 3. a two-part cable that connects the switch pad and timer. The switch pad is constructed with four 12-ounce pressure-sensitive ribbon switches (available from TapeSwitch Corporation, Long Island) connected in parallel and enclosed in a polyethylene envelope, and placed between two sheets of acrylonitrile butadiene styrene (ABS) to form a sandwich. The switch pad is positioned under the patient's seat cushion, where it is out of sight and not in contact with the patient. When the patient sits on the cushion, the switches are automatically closed, completing the circuit and activating the timer. The sensitivity of the switches is purposely selected to require the weight of a patient.
(100 pounds or more) to close the switches. This avoids false positive closures when miscellaneous objects are placed in the chair. More sensitive ribbon switches can be obtained for use with lighter subjects.

The timing device consists of two integrated circuit chips, a printed circuit board, a quartz liquid crystal display that shows hours and minutes in numerals 2.5 cm (1 inch) in height, a 9-volt alkaline battery, and a reset button. These parts are housed in a tapered, polypropylene box (approximately 6×2×1 inches, or 15×6.2×2.5 cm), which is attached to the long vertical frame of the chair with a metal bracket (Figure 2). The display accumulates elapsed time whenever the switches are closed by the weight of the patient. A blinking colon indicates the unit is accumulating time and functioning properly. The clocking stops when the patient gets out of the chair; the display retains the time accumulated to that point. The reset button returns the display to zero and permits readings to be obtained at specified intervals.

The cable that connects the switch pad and time display box is in two parts. The first part, which is attached to the switch pad, is made of retractable coiled wire. The second part is ordinary reinforced non-coiled wire that runs through a protective polyvinyl sleeve attached to the metal upright before connecting to the display box. The coiled wire helps minimize slack in the cable and yet provides the necessary flexibility when the cable is caught or stretched during rough handling.

Of all three components, the display box is the heaviest and weighs 12 ounces (42 gm). Because the power consumption is extremely low with the liquid crystal display, the STM can operate for many months without a change of batteries. Low voltage is indicated by a gradual fading of both the numerals and blinking colon. Extensive laboratory and clinical testing during the past 36 months has shown the STM to be a highly reliable and accurate measurement tool.

**Advantages and Disadvantages**

The primary advantages of the STM are: it provides an objective measure of an important patient activity, it is relatively unobtrusive, it is easy to install, and it is simple to use. When attached to the frame of the wheelchair behind the seat back and adjacent to the handle (see Figure 1), the display box is protected but still easy to read. The large liquid crystal display is well suited to this application because it has extremely low power requirements and because it provides a continuous numerical readout of accumulated sitting time that can be seen at a distance of 10 to 15 feet (3 to 4.5 m).

The main disadvantages are those associated with any monitoring device intended for extended or continuous use. The component parts, although fairly durable, can be broken or damaged. The most common cause of malfunction has been cable disconnections at the display box or between the coiled and straight portions of the cable. Another disadvantage is the fact that the STM is nonspecific (i.e., it cannot distinguish between the patient and some other individual sitting in the chair). This has not been a significant problem in our institution since wheelchairs are assigned to individual patients for the duration of their hospitalization or until they obtain their own wheelchair.

The development of the STM...
progressed from a complex to a more simple device. Initially, an audio-alarm feature was included to remind the patient when a prescribed interval of sitting time had elapsed. Also, at one point, a cumulative memory independent of the display function allowed retrieval of the total sitting time accumulated over an extended period. Although theoretically attractive, both of these features made the unit more difficult to operate in the clinical setting and led to recurrent technical problems with the electronics.

Application

During the past 3 years, the STM has been used with more than 60 patients for more than 180 "patient weeks" to monitor their sitting time while they were undergoing a comprehensive inpatient rehabilitation program. This initial experience has been encouraging and suggests that there is a definite place for patient activity functional monitoring devices of this type in rehabilitation care and in clinical research. Occupational Therapy Department members, who are in charge of monitoring the progress of each patient's sitting program, obtained daily recordings. They reported the number of hours a patient sits in weekly team conferences and compared the number to the scheduled sitting time prescribed by the therapist or physician. Because there can be large fluctuations from day to day, sitting time is usually reported in terms of weekly means and ranges.

For some patients, we found it helpful to plot the daily readings to make the fluctuations as well as the overall progress of the patient's sitting program more graphic for other team members. Figure 3 shows a comparison of actual versus scheduled sitting time for a 14-year-old C3-4 quadriplegic patient during a treatment period of two 5-day weeks (Monday through Friday). The mean daily sitting time for the first week shown was 2.8 hours, with a range from 1.4 to 3.6 hours; the mean daily sitting time for the second week was 3.6 hours, with a range from 0.8 to 5.2 hours. The discrepancy between expectations of the staff (scheduled time) and performance of the patient (actual sitting time) can be seen. It appears the staff was expecting more than the patient was ready or able to do. In retrospect, the long sitting times in the second week of 5.2 hours on Tuesday and Wednesday may have resulted in excess fatigue and may have led to the sharp drop to 0.8 hours the following day. Displayed in this fashion, STM data can help sharpen the staff's understanding of how the patient is performing, which in turn can lead to more realistic planning and the development of strategies to help modify patient behavior when indicated.

Conclusion

This paper has described the Sit Time Monitor, a compact electronic elapsed-time counter, designed to measure and record the amount of time a patient spends sitting in a wheelchair. It is simple electronically and operationally and is well suited to a patient's rehabilitation program as a standard evaluation tool. It is anticipated that the use of such a device will provide treatment teams with more accurate, quantitative information regarding an important patient activity and also will assist researchers in investigating the influence of sitting time upon pressure-related tissue tolerance problems.

Note: Schematics and other information required for assembling STM units can be obtained from the authors.

Acknowledgment

This study was supported in part by Research Grant #28-P-578886 from the National Institute of Handicapped Research, Department of Education, Washington, DC 20202.