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INSTRUMENTATION FOR A POSTURAL SWAY PLATFORM

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ABSTRACT

A postural sway platform has been developed for studies involving elderly fallers. It will be used to assist in determining reasons some elderly people are prone to falling and others are not. Results of these postural sway tests will be combined with other tests on both fallers and nonfallers to determine specific reasons for falling. A simple Z-axis platform has been developed that utilizes a unique hanger system and three strain gage transducers. The output of these transducers is input to an analog-to-digital conversion board in a personal computer. Software has been written to take data from the platform and display it graphically on the computer screen. This display includes real-time information on the center of gravity of the patient, as well as his/her weight. Arithmetic means are then calculated on the accumulated sway pattern data. These results and the results of other tests on patients can then be used to determine if a patient may be prone to falling.

INTRODUCTION

Falling results in injury that threatens the health of the elderly (65+) population and is the leading cause of accidental death (Rubenstein et al, 1988; Rodstein, 1985). One third to one half of the elderly have one or more falls per year. Injuries from falling may result in mortality in up to 50 percent (Cummings et al., 1985; Wild, 1980). The most common serious injury is hip fracture (Ochs, 1988). Recent reviews (Rubenstein et al., 1988; Nickens, 1985; Christiansen, 1987) suggest three main physiological factors as the major cause of falls. These are: reaction time, nerve conduction speed, and postural sway. Nerve conduction velocity slows with advancing age (Dorfman, 1979). Reaction time also increases with age, due to slower processing, movement and conduction times (Era, 1986; Gottsdanker, 1982). Balance is defined as maintenance of the body's center of gravity close to the center of its base support. The inability to maintain this or adjust it, can result in a fall. Increased postural sway, suggesting inaccurate balance control, has been shown in elderly subjects (Lichtenstein, 1988; Murray, 1975) and elderly fallers (Fernie et al., 1982).

A research project designed to test reaction me, nerve conduction and postural sway has been approved. It will be conducted at the Veterans Administration Hospital in Little Rock, using elderly patients. This paper deals with the design and development of the postural sway platform used in this project. Included is the software to acquire, display and save the data. While postural sway may play an important role in falling, this test must be used in conjunction with other tests to be considered conclusive.

EXPERIMENTAL DESIGN

The Z-axis platform is constructed of 6061-T6 aluminum and is designed to be rugged, very stable and inexpensive. It consists of a main circular platform and three bases (Fig. 1). The bases lie on the floor and the
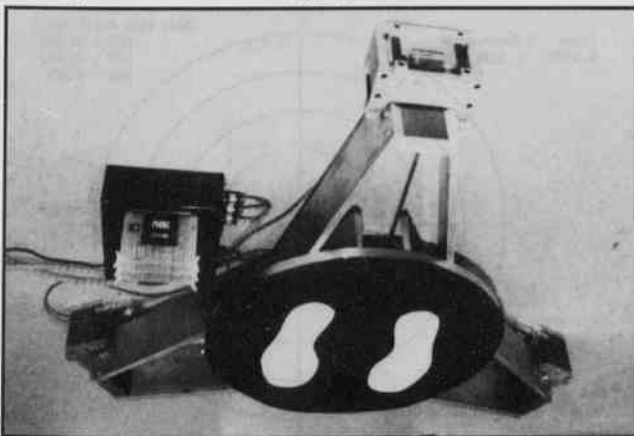

Figure 1. Sway platform system.

three arms of the platform each fit into a base. Proper alignment with the platform is obtained by using an adjustable stabilizer to connect the bases. The bases are a unique design (Fig. 2), utilizing a hanger system, so when
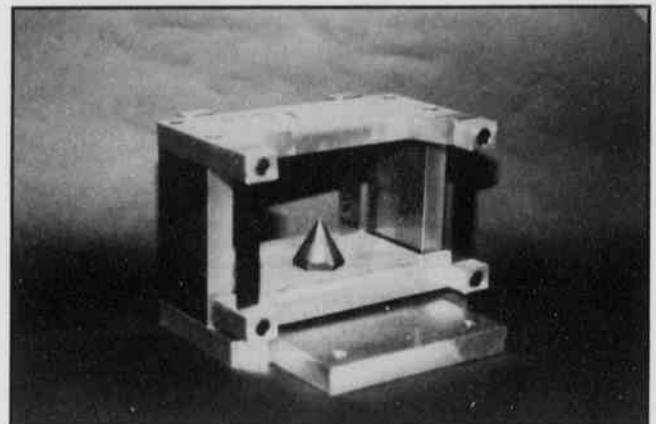

Figure 2. Platform base utilizing hanger system.

assembled the platform suspends from the bases. Attached to the end of each of the arms on the main platform is a load cell (Fig. 3). The load cells
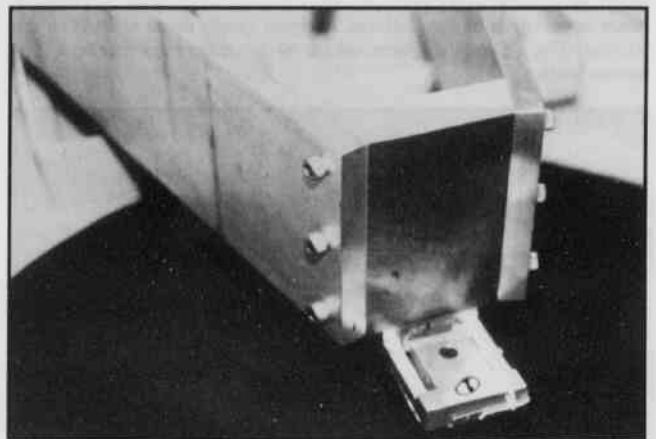

Figure 3. Load cell attached to the end of the platform arm.

attach to the bases and they measure the forces on the platform. The hangers minimize the transverse forces resulting from temperature changes and uneven floors, providing a stable system and more accurate data.

The load cells are constructed from 2024-T86 aluminum with a yield strength of 71,000 psi. They are designed to flex as a sigmoid and utilize four strain gages to measure the deflection (Fig. 4). Strain gages from each load cell are set up in a bridge configuration. The strain gages, from Measurements Group, are 350 ohms with a gage factor of 2.15. Excitation and amplification for the strain gage bridges is provided by using Analog Devices 2B31J instrumentation amplifiers. The output of these amplifiers is then input to an ADACMF-5500 12-bit analog-to-digital converter board installed in a Zenith 386 personal computer. Software has been written to acquire and graphically display a patients' sway pattern, and to store it in a data file.
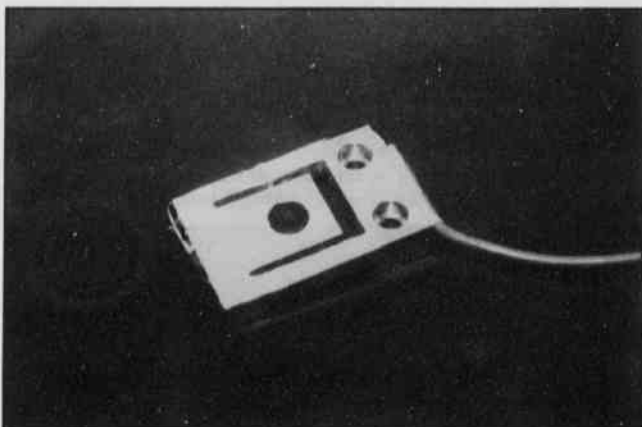

Figure 4. Strain gage load cell, with cup in center.

To determine a subjects' sway pattern, they stand on the platform and the load cells measure the force applied to each of the three bases. From the distribution of weight, the subjects' center of gravity can be calculated.

RESULTS AND DISCUSSION

Problems with many of the postural sway platforms being used today are they are large, fairly immobile and expensive. The platform that has been designed for this study is small, rugged, portable and inexpensive. This sway platform measures a person's center of gravity by using a platform that is supported by three load cells. Each load cell measures the weight on that arm of the platform, which enables us to measure where the center of gravity is on the platform. A subject simply needs to stand on the platform (Fig. 5), and the system calculates the center of gravity on a continuous basis.
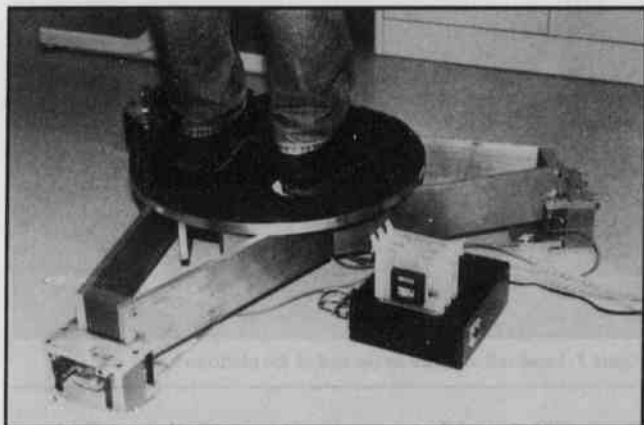

Figure 5. Subject standing on sway platform.

After building the load cells, calibration showed each to give approximately 2 millivolts/volt output for a full scale load of 150 pounds. Designed to withstand a 100 percent overload, the load cells can support 300 pounds on each, before the yield point of the metal is reached. The design of the platform is such that a 300 pound subject could stand anywhere on the platform and not produce a load greater than 200 pounds on a transducer.

The construction of the bases utilizing a hanger system assures that the platform is not affected by uneven surfaces, temperature factors, or other detrimental factors. Each load cell has a cup that fits on a cone in its base hanger (Fig. 4). This cup and cone design allows placement on somewhat uneven surfaces. Each of the hangers is suspended from its base by four metal straps, this allows movement perpendicular to the tangent of the platform. This insures there are no lateral forces applied to the load cells.

Software was written to acquire the sway pattern data, display it graphically and to store it in a data file. First the program has an automatic tare, to account for the weight of the platform itself. The subject then stands on the platform and the system takes 1000 data points over a period of 50 seconds and displays it on the computer screen (Fig. 6). Means are
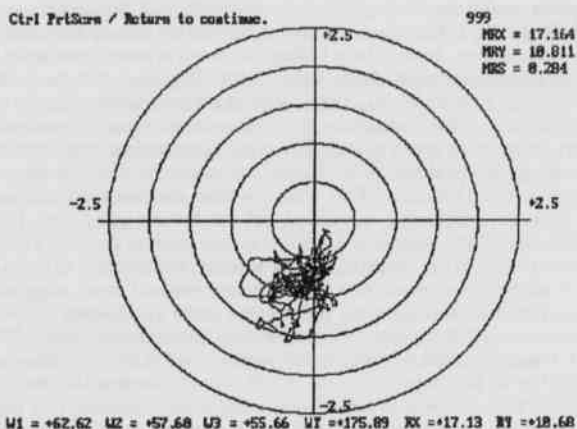

Figure 6. Sway pattern data.

calculated from the data, and the center of the sway pattern is found. Also computed is the mean radius. The data are then centered on the screen, the mean radius drawn and a least-squares line is drawn through the data (Fig. 7). Included on the screen is the percentage of time the subject spent in
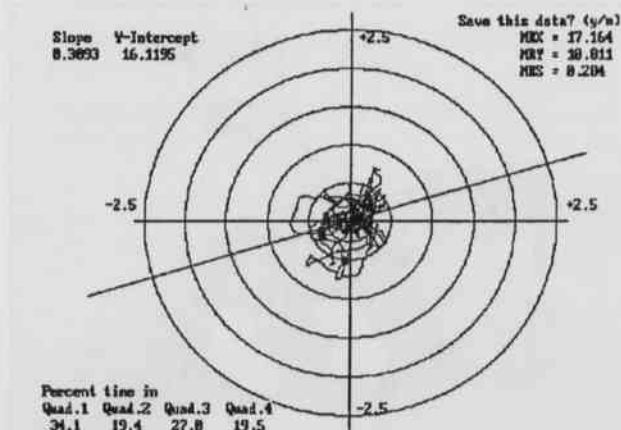

Figure 7. Redrawn data with mean radius and least-squares line.

each quadrant of the display, the subjects weight, and the calculated means. These factors and the area of the sway pattern can be used to determine if a subject has an excessive sway pattern. A prompt is then given to the user to ask whether he wants to print the data and whether to save the data in a file. The software is written in Microsoft C 6.0.

CONCLUSIONS

Compared to postural sway platforms of the past, the design and implementation of this postural sway system is an improvement. It is rugged, portable and inexpensive. The platform should prove to be a useful tool in determining the amount of postural sway a subject exhibits. This test, with others, will be used in the falling study to determine if a subject may be prone to falling.

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