Design of Weight Distribution Monitoring System
Product Design Specifications
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Function: Stroke is a major issue in the United States with more than 800,000 yearly occurrences and 133,000 deaths annually. Many stroke survivors experience brain damage that can result in permanent disabilities, such as hemiplegia. Last semester, a device was fabricated in order to help one hemiplegic individual monitor their lateral balance by providing audio-biofeedback. After consulting a physical therapist, it is evident that there exists need for a more general-purpose balance device, as balance issues are not limited to only hemiplegic individuals but are common with most neurological disorders. Kim Skinner from the Tactile Communication and Neurorehabilitation Laboratory (TCNL) at UW-Madison is using a combination of physical therapy with tongue stimulation in order to train subjects to balance and retain their sense of balance. We are developing a portable device that will allow her subjects to practice proper weight distributions at home. We hope that our device will supplement the physical therapy done at TCNL and allow subjects to have better balance training retention and improve their overall quality of life.

Client Requirements:
- The device must be portable enough to carry with two hands (less than 5 kg)
- The device must be thin, so that a subject can easily step onto the device (less than 5 cm)
- The device must not require the subject to look downwards or hold onto an external object, which can disrupt balance

Design requirements:

1. Physical and Operational Characteristics

a. Performance requirements: The device must be able to perform numerous tests with up to 900 N (200 lbs.) of force.

b. Safety: The device should not present considerable risk of falling or harm to the subject.

c. Accuracy and Reliability: The device should be accurate enough to discern changes in weight distribution but not too precise as the body is never in rest, even when standing. A threshold of

20% will be adapted to allow the subject to practice weight distribution.

d. Life in Service: Physical therapists recommend up to two 20-minute practice sessions per day. To allow for such frequent operation, the device will operate off household wall power to avoid the high costs that might be incurred from battery-powered operation.

e. Shelf Life: The device must be able to be stored and easily retrieved for further use over a period of at least a year.

f. Operating Environment: The device will be used in standard living environments with minimal weather effects. It will be placed on a flat surface and can be operated at room temperature (20-25 °C). The device must be able to grip to a variety of surfaces without the risk of damaging sensitive flooring (i.e. hardwood). As the device is audio-based, the device will be used in an environment with ambient noise up to 60 dB.

g. Ergonomics: There should be minimal user interaction beyond interpreting the biofeedback while using the device. The device will contain two foot-shaped outlines to aid in the subject's foot placement. After the setup is complete, the subject then only needs to stand and attempt to balance using the feedback mechanism.

h. Size: The device length and width must not exceed 50 cm to maintain portability. Additionally, it must be thinner than 5 cm, as some subjects may have difficulty lifting their feet off the ground.

i. Weight: The device must weigh less than 5 kg to maintain portability

j. Materials: The materials must be lightweight yet durable enough to withstand the subject's weight. Device platform material should be rigid to increase accuracy of the measured force.

k. Aesthetics, Appearance, and Finish: The body of the device will be compact and have no external parts that present safety issues.

2. Production Characteristics

a. Quantity: There must be at least one prototype fabricated for the TCNL.

b. Target Product Cost: The device must cost less than $200 to fabricate.

3. Miscellaneous

a. Customer: The device is being created for many patients who all suffer from balance issues.

b. Patient-related concerns: Since the device will be used to supplement physical therapy sessions, it needs to conveniently provide weight distribution analysis for at-home practice.

c. Competition: Similar products have been designed to measure a person's weight distribution. The Wii Balance Board has been proven to be extremely effective in assessing weight distribution. It utilizes four force sensors to calculate the center of a given weight distribution. However, this device is bulky, too tall, and requires external components. Clinically, a few devices are used. One clinical device, the SMART Balance Master®, provides balance retraining in a box-like device on an 18" by 18" force plate through visual feedback on either a stable or unstable support surface and in a stable or dynamic visual environment. However, the device costs $100,000. Other clinical devices, such as the AMTI OR6-6 force plate, use auditory biofeedback. However, this system interfaces with a laptop computer to acquire signals from the sensor and generate a stereo sound, providing body-sway information.

References

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