



DYNAMIC BALANCE DEVICE

PRELIMINARY PRODUCT DESIGN SPECIFICATIONS

BME 200/300

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Function: Patients that have had a stroke and suffer from the subsequent stroke neglect syndrome have long-lasting symptoms including loss of awareness of one side of the body and aphasia (loss of ability to speak and interpret speech). Regaining static and dynamic balance is critical for reducing the risk of injury from falling. Our client, Dr. Dan Kutschera P.T., seeks to develop a device that improves upon the current method of dynamic balance training. Instead of a simple yard stick with a colored dot attached to the end, a more professional device with a telescoping rod and a light-up disk displaying multiple colors and symbols will be developed. The overall goal for the device is that it will be multifunctional across several therapies for patients recovering from stroke. These therapies include visual scanning training for regaining dynamic and static balance, speech therapy for patients with aphasia, and for performing functional reach tests.

Client requirements:

- Retractable, telescoping rod to aid in patients improving static and dynamic stability
- Must have a display disk of 3-inch diameter at the end of the telescoping rod to display shapes and colors to patients
- Device must measure distance for functional reach test and should have ability to change and sustain colors and shapes with a button control attached to the device itself
- Length of telescoping rod must be at a minimum 2 feet and a maximum of 3 feet; device must weigh 5 lbs or less
- Device must be easily storable, professionally built, and easily sanitized as it will be used everyday by physical therapists

Design requirements:

1. Physical and Operational Characteristics

- a. *Performance requirements:* The main performance requirement of this device is to assist physical therapists in helping patients regain static and dynamic balance to prevent falls after they have experienced a stroke. This device must improve upon the client's existing device of a yard stick with a colored dot at the end. The device will be a telescoping, retractable rod that displays measurements to target the functional reach test. There must be button controls on the handle to display colors and shapes on the end of the rod to aid with cognitive therapy. Additionally, the device must be resistant to wear from daily usage.
- b. *Safety:* The model will be constantly used throughout the day with several patients, so the device must have components intact and not cause any harm to users. The device will be lightweight and easy to carry around for the therapists. The device should maintain structural integrity and durability.

- c. *Accuracy and Reliability:* The device must accurately display measurements in inches and feet on the side of the rod in order for therapists to perform the functional reach test on patients. The rod must have at least one year long shelf life and should be reliable structurally and electronically, for the therapists to use everyday. The control on the device must reliably display the correct colors and shapes when therapists click on the corresponding buttons.
- d. *Life in Service:* The device ideally should be functional for at least 1 year of use, given general repairs such as battery changes or replacing small parts (lanyard, IR remote, etc.). “Small” parts exclude parts integral to the basic design of the device, including the rod, handle, disk, and disk electronics. The device should be functional for constant use during the typical 40 hour work week (8 hour days for 5 days).
- e. *Operating Environment:* The device will be entirely used indoors under standard room temperature (68-77 °F or 20-25 °C) and pressure (1 atm) [1]. The device will be wiped down with medical-grade disinfectant in between uses and should thus be electronically water-sealed and erosion-proof from products containing 70% isopropyl alcohol [2]. The rod will be stored by being hung from the handle on a hook attached to a wall and should be resistant to wear and tear from repeated removal and replacement from storage hook between 20-50 times a day based on average number of appointments per day.
- f. *Ergonomics:* The length of the rod should be able to be adjusted with two hands. The handle controls for lighting and display should be feasibly controlled with a single hand. A lanyard will be attached to the handle to increase the secureness of hold on the handle. The device should be able to be sanitized in its entirety in between uses.
- g. *Size:* The size of this device should mimic that of a yardstick, with 3 feet being the maximum length and 2 feet being the minimum retractable length. The diameter of the retractable pole should be a maximum of 1 inch. To achieve adequate projection sizes, the display screen should be 3 inches in diameter.
- h. *Weight:* The device should be able to be held in one hand for long periods of time without causing the therapist discomfort. The therapist will be supporting the patient with one hand, while the other hand will be holding on to the device. Therefore, the weight of the device should be kept to an absolute minimum, with a maximum 5 pounds.
- i. *Materials:* Materials used should be lightweight, durable and waterproof. The telescoping rod should be made of a material with adequate tensile strength and a high strength to weight ratio, such as plastic or carbon fiber [3]. The display and display controls should have materials that are watertight, sterilizable, and enduring of daily use, such as lightweight metals or plastics.

- j. *Aesthetics, Appearance, and Finish:* This device should resemble a professional medical device. It should look aesthetically clean with a waterproof model and sterilizable material. The light-up disk should be bright and any designs/numbers it projects should utilize the whole 3” diameter in order to be seen by the patient. The finish of the device should work as a customizable light-up target for patients to observe or reach for.

Production Characteristics

- k. *Quantity:* One prototype of the model is all that is required for this project. More quantities can be established after the design model has been approved by the client and agreed to proceed further with practical usage for the rehabilitation center.
- l. *Target Product Cost:* As of now, the goal for the total cost is set to be under \$300. Considering the cost of materials, design specification, size dimensions, technical functionalities, and electronics, the estimated cost is ranging from \$200 to \$300. Currently, the client is managing two other BME design projects and the actual budget for the product also depends on two other groups’ product cost which will be confirmed soon.

2. Miscellaneous

- a. *Standards and Specifications:* There is no FDA approval required for devices aiding in physical therapy exercises and assessments. Specifically for this dynamic balance device, there are no specifications or federal regulations that would need to be followed in order to be produced.
- b. *Training-related concerns:* There will be minimal training for the device because it will be created in a way that is intuitive for the client and other physical therapists. The people who will be working with the device are familiar with the proper usage of the device as they have been previously using a similar design. The device will be controlled by button(s) on the handle and the rod can be extended by unlatching locks and pulling.
- c. *Competition:* Currently, there is a device named, Biodex Balance System SD [4] that is in practical use for patients and provides multiple features for static and dynamic balance training. It serves not only visual and auditory biofeedback for documentation that further specifies a patient's needs during the course of training. It is the only existing device that provides a fast, accurate fall risk screening and conditioning program. Although the program itself is easy to follow and does not require additional staff member’s assistance, its capable features such as the reach test system along with customized analysis can be further simplified into a design that can be mobile, lightweight and controllable with a single hand. There are many other devices on the market used for the functional

reach test, however these devices typically have a singular use and do not have the design flexibility to be used in other therapies as well.

3. References:

[1] “What is the average room temperature?,” ADT Security Systems,
<https://www.adt.com/resources/average-room-temperature> (accessed Sep. 18, 2023).

[2] “Why 70% isopropyl alcohol is a better disinfectant than 99% isopropyl alcohol,” Mun Global,
<https://munglobal.com.au/resources/knowledge-base/pathogens/why-70-isopropyl-alcohol-is-a-better-disinfectant-than-99-isopropyl-alcohol/#:~:text=As%20a%20disinfectant%2C%2070%25%20concentration,percentage%20will%20be%20less%20effective> (accessed Sep. 18, 2023).

[3] J. Lee, “What is the strength-to-weight ratio? an overview for Engineers,” Gensun Precision Machining,
<https://www.china-machining.com/blog/strength-to-weight-ratio/#:~:text=Strength%2Dto%2Dweight%20ratio%20is,any%20given%20material%20or%20component.> (accessed Sep. 20, 2023).

[4] “Biodex Balance System SD.” *IPRS Mediquipe*, [Online]. Available:
<https://www.iprsmediquipe.com/products/biodex-balance-system-sd/#features>. Accessed 13 Sept. 2023.
[Online]. Available:
https://www.gtsimulators.com/products/ultrasound-guided-thoracentesis-and-pericardiocentesis-simulator-kk-mw17?variant=36902148309141&gclid=Cj0KCQjw7KqZBhCBARIsAI-fTKIprA0nJ7_8tCX626AqhhR1q6tcsNY3pjlilPbGD7rms0vmVa-niAcaAu3qEALw_wcB. [Accessed: 21-Sep-2022].