CHAPTER 18

UNIVERSITY OF WISCONSIN AT MILWAUKEE

College of Health Sciences
Department of Occupational Therapy
212 Hartford Avenue
Milwaukee, Wisconsin 53211

College of Engineering and Applied Sciences
Biomedical Engineering Systems Laboratory
3200 North Cramer
Milwaukee, Wisconsin 53211

Principal Investigator:
Bertram, N. Ezenwa (414) 229-3184
bezenwa@uwm.edu
ACCESSIBLE WEIGHT SCALE

Designers: Brad Brochtrup*, Adam Lukic*, Rochelle Mendonca**, and April Lauer**
*Department of Mechanical Engineering **Department of Occupational Therapy

Supervising Professor: Dr. Bertran N. Ezenwa
College of Engineering and Applied Sciences
College of Health Sciences
University of Wisconsin-Milwaukee
Milwaukee, WI 53211

INTRODUCTION
A platform weight scale was designed and developed to be universally accessible to people with various types of disabilities. A county department serving elderly people has several health care facilities and a fitness center. Representatives requested a scale to accommodate all of their clients. A picture of the prototype is shown in Figure 18.1.

SUMMARY OF IMPACT
The design criteria were that the weight scale be: convenient in home, long-term care and hospital settings; cost effective; safe; quiet; portable; low maintenance; able to measure weight accurately and reliably to the nearest ½ lb; able to determine weight within 30 seconds; able to provide output in alternative formats; and easy to use with individuals who have varying disabilities. It will be appropriate for users who are sensitive to having others know how much they weigh.

TECHNICAL DESCRIPTION
The scale was designed with a 32" by 32" weighing platform. Universal design features for the ramp and platform include: a high contrast between the ramp and platform so that both can be easily seen; less than a 2” slope on the ramp for ease of maneuverability; tactile grooves to prevent slipping and to alert a person to a change in surface; a platform surface area large enough to hold most standard sized wheelchairs; a platform that raises and lowers through the use of a toggle switch; and automatic shutoff once the platform is raised. To address portability criteria, the device is made of lightweight material, and is set on wheels, and the ramp folds up for easy moving and storage. Audio output and digital display of weight are available, and an adjustable visual display screen is adaptable to persons of varying heights. Controls are

Figure 18.1. Universally-Accessible Weight Scale
accessible to the user. The device runs on DC power. Figure 18.2 shows how to use the weight scale.
A. Approach the scale from the right.  
B. Press the button to lower platform.  
C. When invited use the ramp in the front.  
D. Adjust visual and voice feedback.  
E. Back out after at goodbye.  
F. Press the button to raise the platform.

Figure 18.2. Steps to use the weight scale A-F.
ACCESSIBLE EXERCISER: HANDGRIP ASSIST

*Department of Mechanical Engineering
**Department of Occupational Therapy
Supervising Professor: Dr. Bertram N. Ezenwa
College of Health Sciences
College of Engineering and Applied Sciences
University of Wisconsin-Milwaukee
Milwaukee, WI 53211

INTRODUCTION
The purpose of this project is the design and development of an adaptation to the NUSTEP exerciser, (Figure 18.3) to assist with handgrip during exercise. In some cases, people who have experienced a stroke have limited use of the left or right side of their body. Although the extent of the disabilities caused by stroke varies, the affected side experiences diminished muscular strength. Combined arm and leg cycle exercises using the NUSTEP can help maintain and improve their cardiovascular and muscular systems. Due to diminished muscular capability on the affected side, an individual who has had a stroke may have reduced handgrip on the affected side. This could result in accidental collision of the head with the exercise system.

SUMMARY OF IMPACT
The new design addresses the potential loss of handgrip and associated safety concerns for NUSTEP users. It also prevents excessive leg adduction so that clients can engage in appropriate and safe exercise.

TECHNICAL DESCRIPTION
Figure 18.4 shows an initial design of the Handgrip Assist.

The device is attached to the NUSTEP handle by means of a tightened screw. The user’s grip rotates 90 degrees on the adjustable handle. The user’s forearm can rest on the support platform, which is attached by means of straps to minimize slippage and provide force transfer through the forearm. The rotated handle grip is a promising design feature, although only for users with complete inability to maintain grip because of exercise symmetry disruption. Lack of adjustment of the angle of the device relative to the handle could result in injury and discomfort to the user.
Although the device is structurally sound, there were problems with actual use of the assist. The bar for the handgrip turned the grip 90 degrees away and did not adequately support combined arm and leg exercise. As a result, an alternative design was developed, and is shown in Figure 18.5. It was developed to conform to the NUSTEP device handgrip shown in Figure 18.3, and to maintain forearm support. This allows for body symmetry and provides more support for users with physical abilities. This concept features three adjustable rotations between the handle and wrist attachment, which allows the device to adjust to the natural forearm angle of different users. Due to machine shop limitations, the handle connection was modified. As illustrated in Figure 18.6, it consists of an off-center hole that is bored from a short cylinder. A slice is removed to allow for tightening it onto the NUSTEP handle.

To test the new grip connection, design analysis of a finite element model, illustrated in Figure 18.7, was competed in ANSYS.

After establishing functionality and structural integrity, the prototype was developed. To maintain the forearm on the Handgrip Assist device, the forearm was secured with loose Velcro. This allows the forearm to coast if forearm strength is lost. Maintaining the forearm with and without muscle strength is illustrated in Figure 18.9.

The total materials and labor cost of the Handgrip Assist was $230.
Figure 18.8. Finite Element Results
Figure 18.9. Top: Photo of Handgrip Assist with Hand Engaged; Bottom: Hand Support without Handgrip
ACCESSIBLE EXERCISER: LEG SUPPORT

*Department of Mechanical Engineering
**Department of Occupational Therapy
Supervising Professor: Dr. Bertram N. Ezenwa
College of Health Sciences
College of Engineering and Applied Sciences
University of Wisconsin-Milwaukee,
Milwaukee, WI 53211

INTRODUCTION
Many people who have a stroke experience limited use of the left or right side of their body. Combined arm and leg exercise can help maintain and improve their cardiovascular and muscular systems. The NUSTEP, illustrated in Figure 18.10, is a common exercise system. However, due to diminished muscular capability along the affected side, people who have had a stroke may execute excessive abduction of the affected leg, which may cause dislocation at the hip. The purpose of this project was to design and develop an adaptation to the NUSTEP to support the affected leg so that people who have had a stroke can engage in exercise without causing further injury.

SUMMARY OF IMPACT
Preventing excessive adduction during use of the NUSTEP exerciser will prevent injury to the hip or knee.

TECHNICAL DESCRIPTION
The NUSTEP device as sold on the market has no leg support. The mechanism for the added leg support consists of a slide bearing attached to a swivel, as illustrated in Figure 18.11. This allows the device to adjust through the motion of the user, while providing support against excessive abduction. For the initial mock-up, a linear ball bearing for a drawer was used. Data regarding the life of the bearing suggested 50,000-70,000 cycles and weight capacities in excess of 150 pounds. The expected force on the mechanism based on observation is not expected to exceed 40 pounds. The remainder of the design focused around incorporation of the drawer bearing.

Attachment to the NUSTEP was achieved through two holes on each side of the device matched with two holes under the seat of the NUSTEP. Initial calculations regarding the stress of the material suggested that the device should be made from steel. To match the swivel motion of the user's leg, a rotational bearing was selected. The bearing was able to handle forces in excess of 1,100 pounds, which is far beyond the maximum forces expected. The abduction limitation was made by means of a stop-plate, limiting the maximum swivel motion of the device. The maximum abduction for this type of exercise motion is 0° relative to the side of the body. In order to adapt to people of differing hip widths, a series of holes with a removable adjustable pin was added. The prototype of the leg abductor, shown in Figure 18.12, allows for complete uninhibited motion of the leg in every direction while providing restriction on the adduction motion. The weight of the device is supported primarily by the attachment to the machine, and the device is hardly noticeable to users. The linear ball bearing slide allows for people of varying heights to use the device. Although the natural motion of the leg in the
machine requires little need for the extension of the device, active extension is made possible by the bearing.

The material and labor cost was $200.
TRANSFER LIFT ASSIST FOR PEOPLE WHO USE WHEELCHAIRS

Designers: Cosmina Soaita*, Jeff Nowak *, Amit Sethi **, and Abigail D’souza **
*Department of Mechanical Engineering, **Department of Occupational Therapy
Supervising Professor: Dr. Bertram N. Ezenwa
College of Engineering and Applied Sciences
College of Health Sciences
University of Wisconsin-Milwaukee, Milwaukee, WI 53211

INTRODUCTION
The Transfer Lift Assist was designed for independent use by people who use wheelchairs. It is light enough to be taken from place to place.

SUMMARY OF IMPACT
The lift transfer assist device is safe, sturdy and portable.

TECHNICAL DESCRIPTION
The platform is capable of continuous height adjustment, uses a quiet DC-driven actuator and has a scissors structural arrangement. Pro/Engineering Wildfire was used to model all the components and assembly of the design concept, illustrated in Figure 18.13. The base and top of the device are rectangular shapes. L-shaped and U-shaped extrusions were used for both the base and top frames. The scissors links are made of U-shaped extrusions because this shape is able to withstand heavier loads compared to a flat piece of aluminum stalk. Aluminum material was selected over steel because it is lighter. Heavy-duty rollers were attached to the scissors’ links. The rollers move on the U-shaped base and top channels as the device is raised or lowered. The U-shaped extrusions in base and top frames hold the rollers in place and protect them as they slide. The electromechanical pillar is attached to the base L-shaped extrusion and to a steel rod that connects the backrest at a halfway point. Mounting brackets were used to secure the fixed ends of the scissors’ links and the pillar.

Pro/Mechanical and Finite Element Analysis (FEA) were used to analyze two critical components of the device: the scissors’ links and the mounting brackets, shown in Figures 18.14 and 18.15. When applying a maximum load, the link withstands $3.221 \times 10^4$ pounds per square inch maximum principal stress and it deflects by only $4.15 \times 10^{-3}$. When applying a maximum load, the mounting bracket withstands $6100$ pounds per square inch maximum principal stress and it deflects by only $1.8 \times 10^{-6}$. Overall, the safety factor is greater than 2, which is in accordance with biomedical standards. The prototype is shown in Figure 18.16.

The cost was $650.
Figure 18.14. Testing of Aluminum Links

Figure 18.15. Testing of Mounting Aluminum Brackets

Figure 18.16. Picture of Prototype Transfer Lift Assist System

- Seating Surface
- Electromechanical Pillar
- Clavis Pin
- “U” Shaped AL Extrusion
- L-Shaped Extrusion