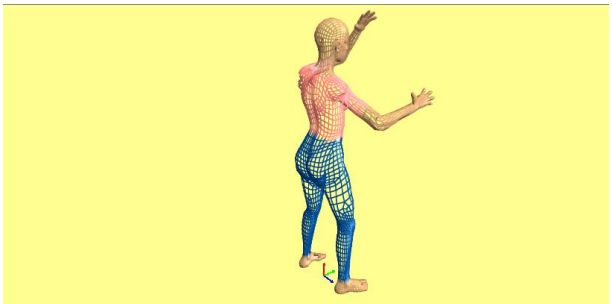
Biomechanical Model of Physical Therapist

Purpose

In order to ensure the safety of the physical therapists as they assist the patients, a biomechanical model of the physical therapist was created. The model is used to show the limits of the physical therapist in the act of assisting patients who are falling. These limits can then be used to either verify the safety and feasibility of our design, or alternatively, used to change the design.



Research

In order to ensure that the model is accurate, a physical therapist from the Nazareth College of Physical Therapy was brought in and interviewed on the techniques they use when assisting patients on the balance training bicycle. The key points were:

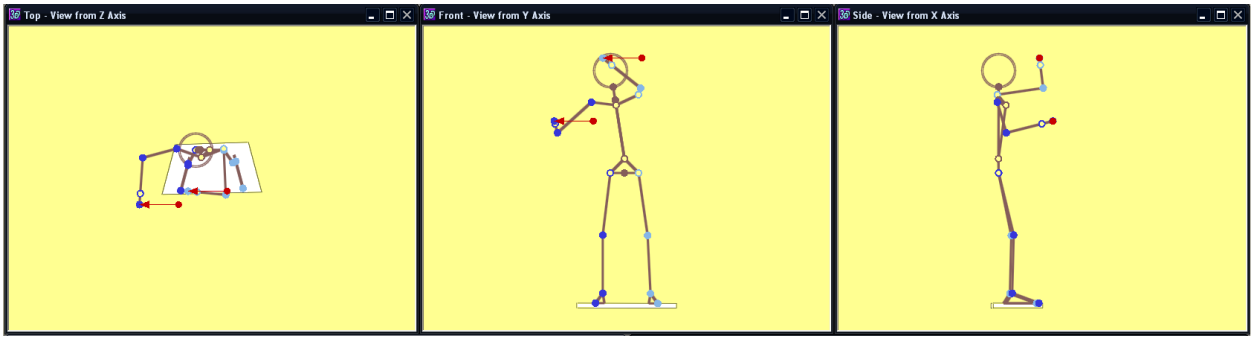
1. The physical therapist (PT) stands at a 45° angle to the patient riding.
2. The PT stands on the weaker side of the patient. This is especially important for patients with hemiparesis, who have a noticeably weaker side.
3. The PT places on hand on the patient's collarbone, and one on the opposite hip. This is because people most often use hip motion to regain their balance while following, and this setup allows the PT to cover multiple planes of the body's center.
4. When the patient begins to fall away from the PT, the hand on the collarbone switches to the other side, and both hands exert a pulling force.
5. When the patient falls toward the PT, the hand on the collarbone exerts a pushing force and the PT leans into the patient, slowing the fall with their shoulder.

The Model

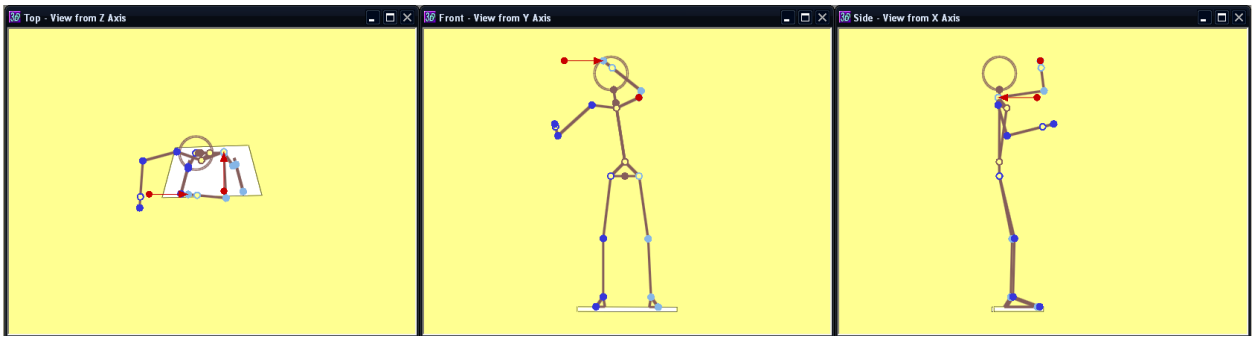
The model was created using 3DSSPP, a biomechanical modeling program developed by the University of Michigan. The model was based around a 50^{th} percentile woman and tested against a 5^{th} percentile woman. This was chosen in order to better represent the demographic of the physical therapists using the device as well as protect smaller therapists from unnecessary risk.

The hand positions were measured using a six foot patient and found to be 62 inches and 45 inches above the ground, for the left and right hands, respectively. The forces used were the calculated force needed in order to lift a 350-lb patient from a 10° angle. Using the designed tilt mechanism, the PT

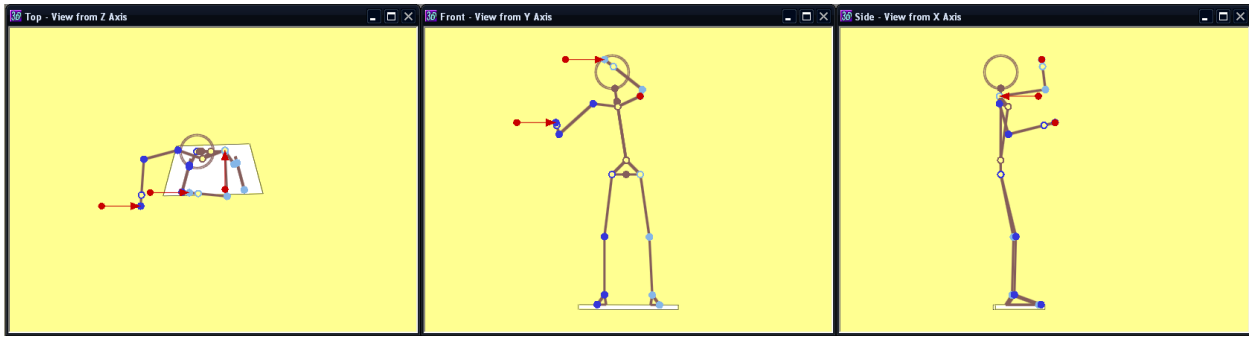
would need to pull with 46 pounds of force in order to right the patient. Below are images of the PT in the position where a patient is falling away from them:



And the case when a patient is falling towards them:

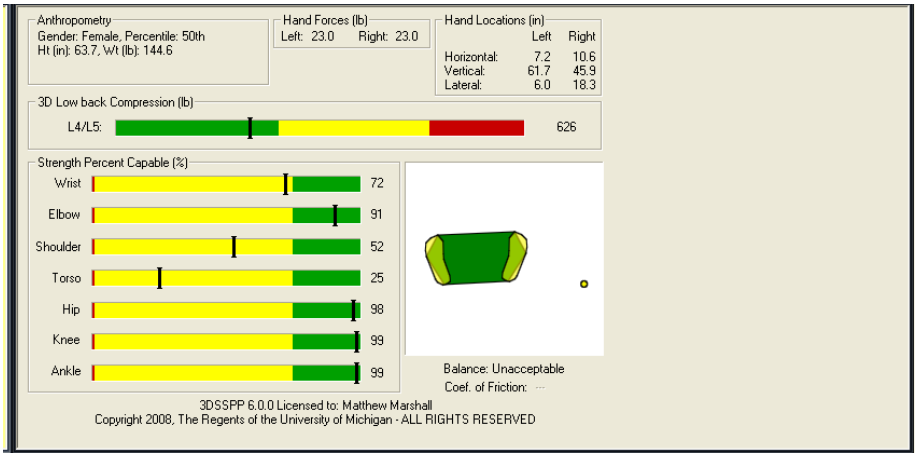


The major difference is that in the case where the patient is falling towards the physical therapist, the weight is transferred from dual hand loads, to a single load on the left hand and a load on the left shoulder. In the model, the hand and shoulder are bearing equal loads, although this may not be true in most cases and more likely the shoulder bears the majority of the weight. This case is shown below:



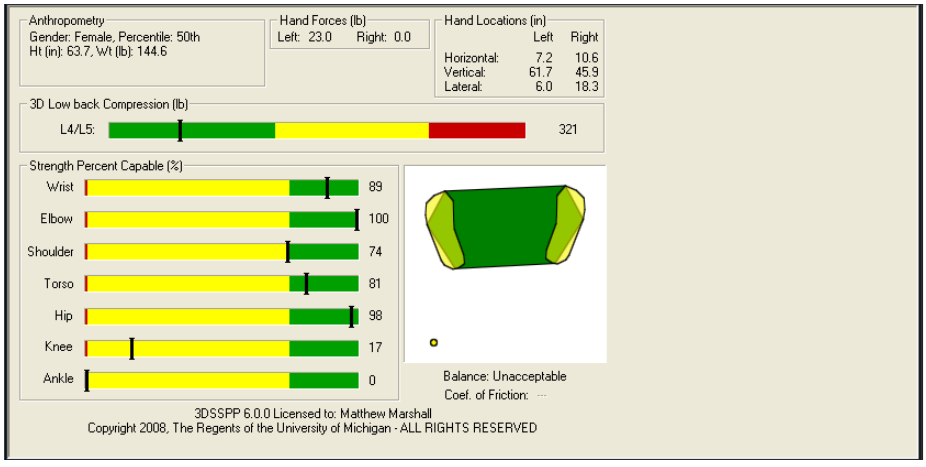
Results

3DSSP works by taking into consideration the loads placed on the body, the position of the body and any actions needed to take place while bearing the load. It then calculates the Strength Percentile Limits based on NIOSH recommendations. NIOSH recommends strength limits that can be met by 99% of the male population and 75% of the female population. These strength percentile limits are shown in the charts below for 50th percentile women. The first case is when the patient falls away from the PT.

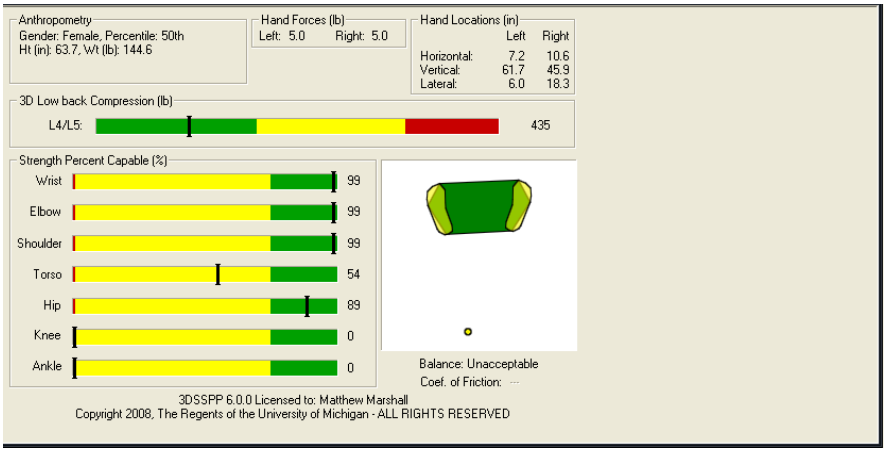


In this case, the major area of concern is in the torso. For the trunk muscles, approximately 25% of women could perform the necessary function of keeping the patient from falling and 50% of women would have the shoulder strength needed. All other numbers are well within the acceptable limits.

The next set of charts is for the pushing action when a patient begins falling toward the PT:



In this case, all the strength limits are within an acceptable range. The final set of charts is for when the full load of the patient is on the PT's shoulder, with small forces exerted by the hands:



In this final case, the torso is the only group of muscles that limits the ability of the physical therapist. Approximately 50% of PTs would be able to assist a patient in this way.

Conclusions and Limitations

The quality of the modeling above depends heavily upon the numbers used. The assumption of a force of 46 pounds is correct based on the design calculations of our system and apply only when the patient has fallen over to a displacement of 10°. This does not take into consideration any inertia that may be present during the process of falling. This model is also limited by the area of the body being exerted upon. In the above charts the knees and ankles were singled out as weaknesses in the pushing example, however the joints of the wrists, ankles and to an extent, the knees, are too complicated for the modeling program to accurately predict. Further research could be done into what areas the physical therapists feel are most strained, and is knees or ankles surfaces as a common problem, then more analysis of the leg positions would be required.

This analysis was done assuming a worst-case scenario of a small female and a very large male, and the physical therapist was still at very low risk of suffering an injury. From the interview with the physical therapist, it was garnered that for very large patients, two physical therapists are often used in order to better assist the patient and reduce the risk of injuries. Taking all of this into consideration, it could safely be concluded from this analysis that the designed tilt mechanism provides adequate resistance to falling and sufficient assistance in returning to a sitting position.