

“Spider Cage for Physical Therapy”

Excellence BME Design Award Executive Summary

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Traumatic brain injuries (TBIs) cumulatively affected about 2.5 million people in the United States in 2010. They can be caused by a wide range of events including falls, assaults, sports injuries, and car accidents. The most severe TBIs can leave affected individuals with long-term disabilities that result in decreased cognitive and motor function. In 2010, the CDC estimated that 5.3 million Americans currently living with a severe TBI spent a total of \$76.5 billion on medical costs alone. This need for physical therapy combined with large medical costs led the BME Spider Cage team to create a 3-dimensional structure capable of elastically suspending our client's patient, or any patient, for physical therapy at a reduced cost. The client, Matt Jahnke, is the Adult Supportive Services Program Director at United Cerebral Palsy of Greater Dane County. He commissioned the design and construction of a cost efficient physical therapy device for a patient at the Madison Area Rehabilitation Center.

Currently on the market is a device called the Universal Exercise Unit (UEU). Predominantly designed for children with cerebral palsy, this current product is prohibitive both in design and cost. The UEU has a limited target audience, and therefore is incompatible with patients of varying abilities and sizes- alienating adult patients altogether. Furthermore, the device is expensive, with the cheapest being sold at just under \$5000, not including the suspension accessories, which are sold separately for around \$2000. These shortcomings shaped the problem statement for the BME Spider Cage team; the device they designed needed to be cost effective and suit children as well as adults.

In order to provide patient support, the final design consisted of an 8 foot (2.4 meter) cubical frame constructed from 12 gage perforated square tubing. Additional diagonal bracing, consisting of two eyebolts joined by an adjustable turnbuckle, is bolted the upper corners of the tube. The construction of the cage requires nothing more than attaching nuts and bolts- a simple design that will be made available on United Cerebral Palsy for Greater Dane County's website, so anyone can purchase the parts and construct it themselves. Patient suspension is accomplished by eyebolts attached to the frame of the cube. The tubing is readily available and manufactured by TELESPAR. The team modeled the entire design in a structural design software, SAP2000, in order to measure the structural stability of the cage and the deflections after load placement. A finite element analysis program, ANSYS, was utilized to model the stresses and deflections of the bracketry connecting the members of the cage. The simulation results were validated by comparing a simulation of a three point bending test with an actual test performed on an MTS machine. The materials tested were one foot samples of the perforated square tubing specified in the final design, courtesy of Decker Supply Company. The results of the simulation compared very favorably to the data obtained from the MTS test, thus providing validation for the cage. Once constructed, the device will undergo testing. This will consist of applying multiple loading scenarios to the cage and experimentally measuring the deflection under each scenario. This will then be compared to our theoretically calculated results using the software platforms SAP 2000 and ANSYS.

The final device will be placed at the Madison Area Rehabilitation Center where it will be used by not only the patient for whom it was designed, but also for about 55 other patients with physical therapy needs ranging from TBIs to cerebral palsy. Any patient up to 350 pounds will be able to be safely suspended from the cage at a fourth of the cost of current models. Since physical therapy basically stops being provided for those older than 18, this device will be able to benefit many members of our community and increase their wellbeing and quality of life.