Beam and Mesh Deflections of 80/20 Spider Cage

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MeSH Terms
- cerebral palsy
- exercise therapy
- data interpretation, statistical analysis

OBJECTIVE. Our objective is to determine how much the mesh and beams of the spider cage deflect during certain exercises and slip scenarios.
METHOD. Five participants will perform exercises that will be executed in the spider cage during therapy using resistance bands attached to the cage. We will use a dial indicator and motion capture to measure the mesh and beam deflections during the exercises and run statistical analyses on the results to calculate the significance of the maximum deflection that the mesh and top beams experience during theses exercises.
RESULTS. n/a
CONCLUSION. n/a

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Cerebral palsy affects 17 million people worldwide [1] and 764,000 of those individuals are from the United States [2]. The incidence of cerebral palsy in children is 3.1 in 1000 across the United States, and 2.6 in 1000 in Wisconsin [3]. Different therapies and treatment techniques are being developed to aid those with the disability and to ultimately allow them to become more independent.

Cerebral palsy is a group of non-progressive, non-contagious motor conditions caused by a delay in physical development. Almost 80% of cases are acquired prenatally and arise from abnormal brain development of the fetus. Premature and low birth weight babies are most at risk for developing cerebral palsy and the disease affects 0.2 - 0.35% of all live births [4]. Perinatal and postnatal causes each account for 10% of cerebral palsy cases and are caused by infection and head trauma [5]. The disorder affects each individual differently and can cause complications in one limb, two limbs, or even the whole body. The two most common forms of cerebral palsy are ataxia, which is defined as a lack of motor control with voluntary movements, and spasticity, which is categorized as stiff or tight muscles and exaggerated reflexes [6]. Aside from interfering with physical movement of the body, cerebral palsy can also cause disturbances in sensation, perception, communication, and behavior. Currently there is no cure for the disorder but there are treatment options to help make the lives of those affected as independent and manageable as possible.

Forms of treatment for cerebral palsy include surgery, medication, and therapy. Surgery can be performed to release tight muscles and to correct anatomical abnormalities, leading to reduced pain. Medications are taken to control spasticity, seizures, and to reduce pain. Physical therapy is another, less invasive, treatment option. The goal of therapy is to help individuals gain bodily function by helping them learn to control gross motor functions. Therapy equipment includes, but is not limited to, resistant bands, orthotics, and an exercise unit called a spider cage [6].

The notion of spider cage therapy was first introduced in Poland by Norman Lozinski in 1994. The therapy is set up by attaching a set of elastic cords to a customized suit worn by the patient as well as attaching the cords to the cage of the structure. The cords may have varying stiffness depending on the needs of the patient and the specific exercises performed. The goal of spider cage therapy is to help patients improve balance, gain muscle strength, and develop coordination [7]. Ideally, the therapy will help the patient learn/build skills to perform daily tasks and gain independence.

In this study we built a spider cage out of 80/20 aluminum and plan to test the deflection of the mesh and top members. The goal of the experiment is to determine if there is significant deflection and permanent deformation on any part of the cage. Exercises will be simulated using resistance bands, steps, and a harness. Our hypothesis is that the spider cage will not experience significant deflection. The top beams are expected to deflect no more than one inch and the mesh is to deflect no more than two inches with no permanent deformation.

Method

Research design

The five authors of this paper will perform exercises and tests within the cage to determine the functionality as well as the structural stability of the cage. The authors will be used as participants for the exercises in this study in order to forego the Institutional Review Board while still testing the functionality and stability of the cage. The exercises will include a slip test, balance board, step up, walking in place while supported, and kicking a ball while supported. Additional tests will be performed to ensure the integrity of the fasteners on the frame, as well as how the position of the mesh retainers impacts the maximum mesh deflection. Using beam deflection calculations, it is estimated that the top front member of the cage will deflect 0.4 inches with a 300 lb point load applied. The maximum load expected to be applied to the cage when in use is 200 lbs. The beam deflection calculation increased the factor of safety by increasing the load and ensuring that the cage will withstand the forces applied. These calculations will be physically tested in the upcoming experiment.

Participants

Five participants with weights ranging from approximately 100 to 200 lbs and heights ranging from approximately 5 to 6 feet will complete the exercises. Details on each individual can be found in Table 1. Though the participants were mainly chosen because they are the authors of this paper, the group possesses a wide range of heights and weights. More participants may be added later on if they are needed.

Table 1: A list of the five study participants' heights and weights.

Name	Height	Weight (lbs)
Darcy	5' 3"	128
Sheetal	5' 6"	130
Breanna	5' 7"	135
Stephen	6' 1"	195
Kevin	6' 3"	194

Instruments

Dial indicator

Dial indicators measure small amounts of deflection with a higher precision than other methods, such as using a measuring tape or observing deflection with the naked eye. The amount of deflection expected for the frame of the cage may be difficult to observe, so the dial indicator will be used to precisely measure the deflection on different parts of the cage. The dial indicator that will be used has a resolution on the scale of one thousandths of an inch.

Motion Capture

Motion capture transforms movement in real life to digital characters [8]. Due to the thin cross sectional area of the wire mesh, physically measuring the deflection of the mesh with a dial indicator will be difficult. Therefore, motion capture technology can be used in this experiment to accurately measure mesh deflection. Motion capture markers would be placed on different areas of the cage on the mesh while the exercises are performed. The markers would then be translated into digital characters and measured using the motion capture software. The maximum mesh deflection can be determined from that.

Data collection

The beam deflection data will be collected using a dial indicator. The dial indicators will give an accurate measurement of how far the beam is displaced from its initial location. To test deflection of the top members, we will clamp the indicators on the top horizontal members, measuring deflection in the vertical direction. To get the maximum deflection, the indicators will be clamped at the center of the bar or at the point of observed highest deflection. Beam deflection will also be tested on the vertical side members. Measuring at the center height of the middle side members and the front members will provide the maximum deflection on the most susceptible vertical members. Beams will also be tested for racking by attaching the dial indicator to the front members near the base. This will show if the cage moves horizontally while tested.

The motion capture technology would be used to gather data on the mesh deflection. Deflection of the mesh is not as easily measured as the beams because it has a much thinner cross section. It is also expected that each part of the mesh will somewhat deflect so there is not a static attachment point. In order to make sure we are measuring the maximum deflection we can use the motion capture to find the point where the mesh deflects the most per each test. Each mesh section would be tested using motion capture.

Statistical Analysis

A one sample t-test will be used to provide a statistical analysis for both the beam deflection and the mesh deflection because we are concerned with mean values from the experiment. The t-test will be carried out using R which is a software program specifically used for statistical analyses. The one sample t-test will allow us to determine if the sample mean of the beam or mesh deflection varies significantly from the acceptable deflection. For the beam, the expected deflection value is 0.4 inches and the maximum acceptable deflection value is 1 inch. The maximum mesh deflection has yet to be tested, but is expected to be around 1.5 inches. For each data set, the null hypothesis states that there will be no significant change from the acceptable deflection. The alternate hypothesis states the opposite; there will be significant change from the acceptable deflection. A p-value will be found for each data set and compared to a 95% confidence interval with an alpha value of 0.05. If the p-value is less than 0.05 then the null is rejected because there is a significant difference between the acceptable value and the mean experimental value. However, if the p-value is greater than 0.05, the null fails to be rejected concluding that there is no significant difference between the acceptable value and the experimental mean [9].

Results
n/a

Discussion
n/a

Implications
n/a

Acknowledgements

This research was supported by the University of Wisconsin-Madison, specifically the biomedical and mechanical engineering departments. We would like to thank our advisor Dr. Towles for his guidance and unwavering support throughout the duration of the experiment. A thank you also goes to Travis Dick for his guidance during the design stage of the spider cage. We would also like to thank Matt Jahnke for providing us with a meaningful project.

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