LEST (Lower Extremity Strength Tester)

Product Design Specifications
Client: Dr. Bryan Heiderscheit and Dr. Rita Deering
Team: Sam Parmentier, Dan Wildner, Kaitlin Lacy, Brittany Glaeser, Noah Nicol
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Function:

During and after pregnancy, it is common for women to experience a loss of strength in the muscles of the pelvic girdle. This can cause serious pain and discomfort, and new methods are continually being researched to relieve women of this condition during their already challenging pregnancy. A device is needed that can assess a maximal voluntary contraction (MVC) of the hip flexor (iliopsoas) and knee extensor (quadriceps, rectus femoris) muscles during a straight leg raise task to assess this loss of strength, which can be a sign of pelvic instability, in the lower extremities of women both during and after pregnancy. The subject will first perform a fatiguing task with one leg, and will then lay inside of the apparatus quickly after completing this task. The fatigued leg will perform a straight leg lift, and the MVC produced by that leg will be recorded near the ankle of that leg. The leg that did not partake in the fatiguing exercise will press down into a separate force plate, and the MVC it produces will also be recorded. Therefore, our design must span the width of two force plates, allowing for both legs to be inside of it.

Client requirements:

- Portable between UW Health Research Park Clinic and Badger Athletic Rehabilitation Training Center
- The device must be strong enough to withstand an MVC from an adult female performing a straight leg lift.
- The device must be in place and ready to use within a minute after subject's fatiguing task to prevent muscle recovery.
- Comfort of the test subject must not limit the amount of force able to be produced.
- A budget of $1000 must be kept.
- The device must be designed so that it can be used when the patient is supine (lying on the floor).
- The subject should not be able to hold onto the device in any way, and secondary help from a doctor or different test subject should not be required to hold the device in place.
- Force plates will be provided for measuring the MVC's.
- The device must span the width of two force plates (one to recognize the MVC of the leg lift, and one to recognize the MVC of the foot pushing downwards.

- The surface of the design that the subject will press against with their ankle must not be uncomfortable to the point of causing pain, but must also not be too soft as to absorb the force of the MVC.

Design requirements:

1. Physical and Operational Characteristics

a. Performance requirements:

- The device must attach to a force load plate via four bolts to obtain a vertical force reading of the MVC of a female leg.
- The device will be used frequently in UW-Health Research Park as well as other lab setting locations during the lifetime of the research project.
- Able to withstand the force of a straight leg raise at maximum effort for an adult female
    - Muscles involved: iliopsoas, quadriceps, and rectus femoris.
- The device must consistently and accurately measure the force of a lower body MVC.

b. Safety:

- Comfortable for patients to exert force without pain
- Able to easily accommodate patients of varying sizes, with the lower body size being of particular concern.
- Sturdy enough to avoid collapse and/or fracture from a lower body maximal muscle exertion of an adult female.
- No sharp or rough edges or protruding parts that could injure subjects as they use the device or the clients as they put the device in place.

c. Accuracy and Reliability:

- The device needs to contribute to an accurate reading from the force plate over multiple tests with varying patients (within 5% accuracy). This may require the ability to adjust on a per patient basis (in terms of height of apparatus).
- The device should limit the area the patient can be situated in order to maintain the position of the straight leg lift.

d. Life in Service:

- Needs to be easily transported from UW-Health Research Park Clinic to Badger Athletic Rehabilitation Training Center.
- Needs to be available at any time of the day for extended periods of time. The number of cycles of MVC measuring is still yet undetermined.

e. Operating Environment:

- The device will be used and stored in a clinical setting.
- The largest chance for damage will likely occur during transport between clinics or while under stress from force applied by patient.
- Possible causes of failure could arise when subject is trying to quickly get inside the apparatus and their leg/body collides with the apparatus in some way.

f. Ergonomics:

- Must be strong enough to easily withstand maximum contortion of hip flexor and knee extensor muscles of an adult female.
- Must allow a wide range of adult females to place feet into device
    - The interacting force bar needs to have enough space to accommodate a wide range of adult female ankles

g. Size:

- The apparatus must be wide and high enough to comfortably fit the lower legs/feet of any size adult female between its frame.
- The frame of the device will largely be sized based upon the layout of already existing holes in the force plate. These will be measured during the next client meeting.

h. Weight:

- The maximum weight of the device is 50 lbs, as it will need to be lifted and transported by one person between locations.
    - Ideally, the design will weigh much less than this.

i. Materials:

- No materials restrictions have been placed on this project as far as incompatibility with other equipment being used during the testing procedure.
- The frame will likely be comprised of extruded aluminum.
- The part of the device interacting with subject needs to be comfortable but not so soft that it absorbs the force of their MVC. A harder rubber material will likely be used.

j. Aesthetics, Appearance, and Finish:

- All seams, joints, and welds should be neat and aesthetically pleasing.
- There should not be any unfinished edges or contact points.
- No extraneous materials should be hanging down, protruding from, or in any way seen on the device.
- The device's appearance should be comparable to the professional exterior of exercise equipment.

2. Production Characteristics

a. Quantity:

- One LEST will need to be produced.

b. Target Product Cost:

- A budget of $1000 dollars for this project has been set. Other competing designs have a cost of around $1000 dollars, so it would be preferred that our design does not reach that cost level.

3. Miscellaneous

a. Standards and Specifications:

- No FDA approval is required.
- Some lab standards may need to be met based on the policies of our client's lab environment.

b. Customer:

- This design is not intended for commercial sale. For concerns of subjects utilizing the designs, please look below to "patient related concerns."

c. Patient-related concerns:

- Patient data confidentiality must be considered. The numerical value of MVC's of patients will be recorded, which is private information between the patient and the doctor performing tests.
- This device will be used for pregnant and postpartum women, so comfort is a major concern.
    - Subject must easily be able to position themselves inside the frame of the apparatus and perform the test quickly after completing a fatiguing exercise.
- The testing of the apparatus involves creating a maximum force with certain muscles, so we want any surface of the device that a subject is pressing against to not cause them any pain or discomfort.

d. Competition:

- MICROFET 2 MANUAL MUSCLE TESTING (MMT) HANDHELD DYNAMOMETER - $1,054
    - The Microfet 2 is an ergonomically-designed dynamometer that accurately measures the force produced by a certain muscle.
- Doctor's test-

    - A simple test that doctors use to measure if a patient has pelvic instability is to press against the sides of their hips and ask if that makes it easier for them perform the leg lift. If they say it does, they are considered to have pelvic instability.
- Training of whole leg waist abdominal muscle of lying on back power and test system - CN # 201520291327
    - This patent seemed to describe an apparatus that measured forces created similar to the ones in our testing procedure.