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RESEARCH REPORT
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Effects of the Human Balance and Stability System's Stand-Rite Pro on Neck and Back Movement and in Overall Torque: A Pilot Validation, Utilization and Reliability Study

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RESEARCH TEAM

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PURPOSE

This study examined changes in movement at the neck and back and in the overall torque (forces on the body at the center of mass or gravity) among individuals standing at a prototype machine with and without the Human Balance and Stability System's Stand-Rite Pro (SRP). (See Photo 1 below).

Photo 1. Human Balance and Stability Systems (HBSS)
Stand-Rite Pro (SRP)

BACKGROUND INFORMATION

Individuals who stand and work in machine operations often develop neck and back pain from repetitive leaning and bending movements that place high levels of stress on muscles and joints.[1] Using the HBSS-SRP during machine operation appears to reduce stresses on muscles and joints; however, these reductions in stress have not been previously measured.

This study first measured joint movements at the neck, middle and low back to determine whether using the SRP reduced the range of motion at these joints. Second, the torque or force around each subject's center of mass was calculated with and then without the SRP. These torque calculations determined whether using the SRP contributed to overall reductions in torque at the body's center of gravity. Reductions in torque would most likely reduce stresses at muscles and joints during machine operations and theoretically contribute to reductions in pain and movement dysfunction.

SPECIFIC AIMS

This study 1) validated of the utility of the SRP by determining whether it contributes to reductions in range of motion and in overall torque on the body; and 2) determined the reliability of the measures including test-retest reliability, standard errors, and minimal detectable difference scores for confidence in the outcomes.

PROTOCOL

After obtaining Oakland University's Institutional Review Board approvals, four males and eight females (29.9 ± 13.4 years) were recruited to participate in this study. The participants were non-machine operators with no prior neck or back surgeries.

A machine prototype was built according to the manufacturers specifications for use in this study. The HBSS-SRP device was attached to the front of the machine prototype on the right side. The left side of the machine prototype was clear so it could be used as the site for measures without the HBSS-SRP. Footprints were drawn on the floor in front of the machine prototype on both the right and the left sides for consistency in positioning the subjects with and without the HBSS-SRP.

Participants arrived at the lab and the first measures were height and weight, and then age and gender were recorded. The participants were then positioned in standing within the designated footprints to acquire the measures. Baseline measures were then taken three times each at the neck, middle and low back with subjects standing upright in a relaxed posture without the SRP. These same baseline measures were repeated three times each a second time with the subjects using the SRP.

Participants were then asked to reach for the 'knobs' on the upper part of the machine prototype and measures at the neck, middle and low back were again taken three times with and then three times without the SRP device. All measures were taken with a cervical and then a back range of motion device by the physical therapist and then confirmed by the graduate student research assistants. (See Photos 2 and 3 below).

Photo 2

Photo 3

The range of motion devices used to take the measures have excellent to good validity and reliability (CROM ICC=.97-.98°; and BROM ICC=.84-79°).[2, 3] (See Figures 3 and 4 below).

Photo 3

Photo 4

ANALYSIS
Statistical differences between the baseline and reaching forward measures with and without the device were assessed using paired samples t-tests with significance at $p \leq .05$.

Torque without the SRP device was calculated in standing using the distance from the floor to the individual's center of mass, their weight in kilograms, and their degrees of movement at the lower back joint. Torque using the SRP was then calculated using the distance from the SRP to the individual's center of mass, their weight and the degrees of movement at the low back. The torque Force was calculated in kilograms per meter and reported in foot-lbs.

Test-retest reliability and inter and intra-rater reliability were determined using the Intra-Class Correlation Coefficient (ICC). The reliability of measures was determined by calculating the standard errors of the measure (SEM) and minimal detectable differences (MDD) for change in the scores. These measures were determined to support the accuracy of the measures for confidence in the findings.

RESULTS

Range of Motion
Changes in the ranges of motion at the neck, middle and low back using the SRP were only minimally lower than upright standing. These differences were not clinically or statistically significant ($t < 1.0$; $df = 11$; and $p > .56$). (See Chart 1 below). However, when combined with the torque changes, there did appear to be relevant and meaningful differences.

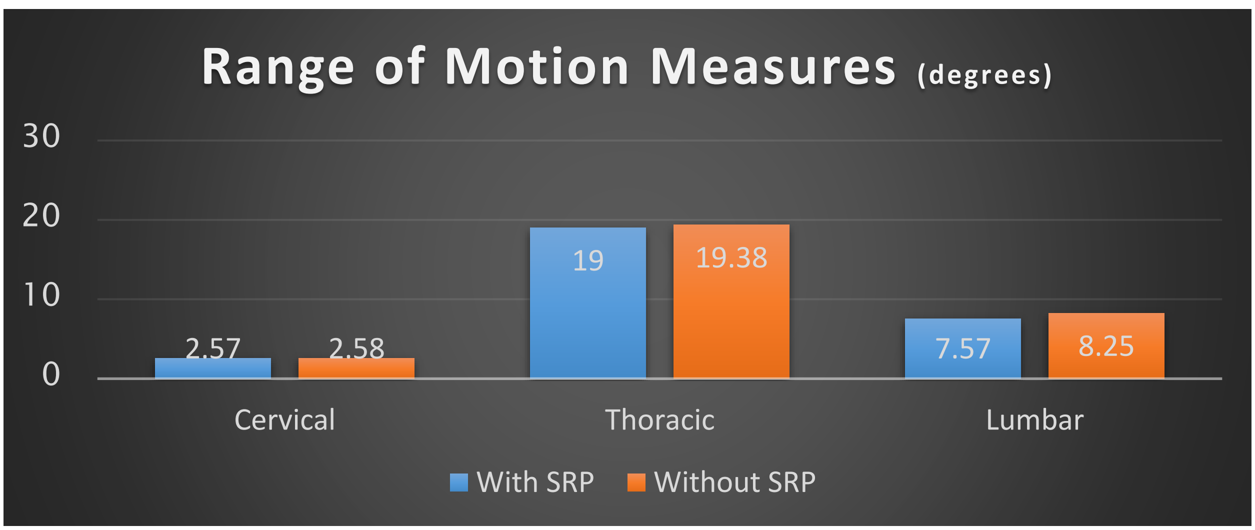

Chart 1: ROM Measures

Torque

In physics, the center of gravity represents a point where the entire body weight is concentrated. This point is used to describe the motion of a body. The center of gravity of the human body is located in front of the second sacral vertebra of the low back. Therefore, this point was used in the study to approximate the forces on the body with and without the SRP. (See Figure 1 below).

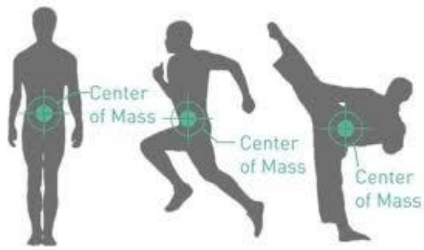

Figure 1: Center of Gravity

Torque was calculated by multiplying the Force (weight or mass) times the angle the force was applied, times the perpendicular distance to the point where the force is applied. (See Figure 1 below). For this calculation the body weight was the force, the distance was to the individual's center of gravity, and the angle was the range of motion measure at the low back.

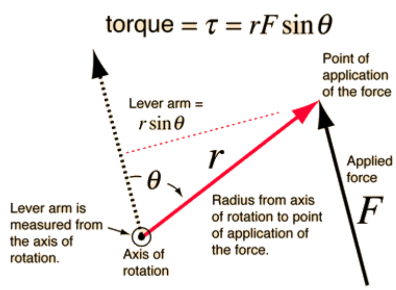

Figure 1: Torque

For the torque calculation without the SRP, the force was the body weight; the distance was from the floor to the center of gravity; and the angle was the degrees of incline measured at the low back. The torque for the SRP was the body weight minus 18% (from the McIntee, Latcha et al. study)[7]; the distance was from the SRP to the individual's center of gravity; and the angle was the degrees of incline measured at the low back. From the McIntee et al. study, the most common weight reduction was 18%; however, the range was from 3.0% (for a light touch) to 20.0% of an individual's body mass.

The changes in torque at the center of mass with the SRP were clinically and statistically different (t = 10.36; df =11; p = <.001). The torque at the center of gravity without the SRP was 120.93 Nm. (93.14 ft-lbs.) while the torque using the SRP was 96.43 Nm. (74.25 ft-lbs.). This represents an average reduction of 24.50 Nm, which translates to an 18.87 ft-lb reduction overall on the body. Based on the ranges of reductions of weight from 3.0% to 20.0% from the McIntee et al. study, the ranges of reduction in torque would have been between 3.15 ft.-lbs. to 20.97 ft.-lbs. for the subjects in this study. (See Chart 2 below).

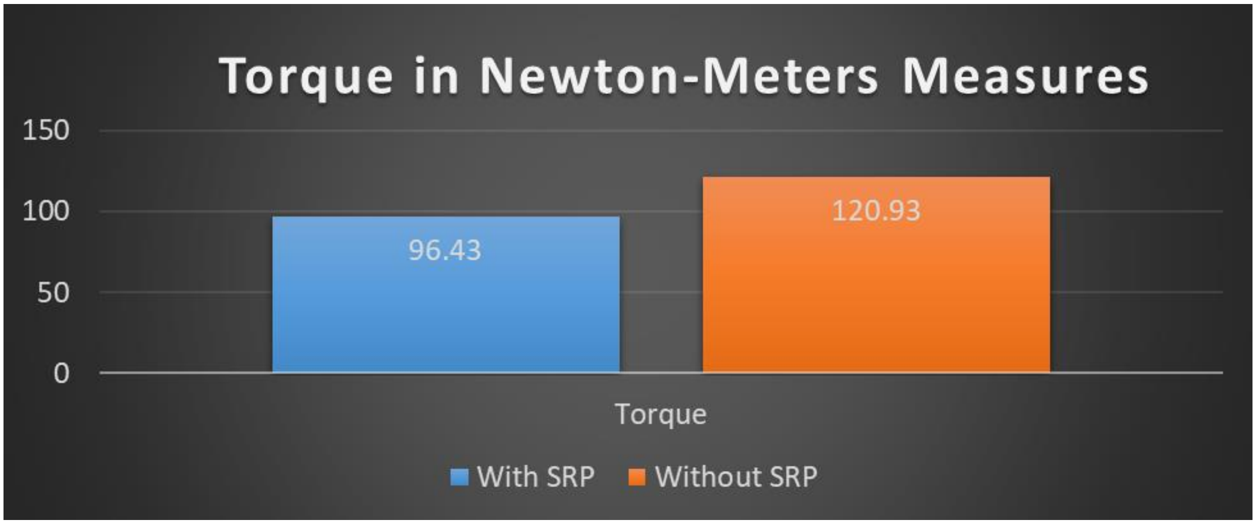

Chart 2. Torque

Reliability and Standard Errors

The reliability of the ROM measures were very good for test-retest reliability (ICC = .99; p <.001) and intra and inter-rater reliability (ICC >.96; p=.015). The standard error of the ROM measures was very good at less than one degree each for the neck (0.88 degrees), the middle back (0.46 degrees) and the lower back ((0.78 degrees) measures. The minimal detectable change, which represents actual change and not measurement error, were also low at 2.44 degrees for the neck, 1.29 degrees for the middle back, and 2.16 degrees for the low back. For the torque measures, the standard error of the measure was 1.64 Nm. and the minimal detectable difference was 4.54 Nm. These outcomes indicate that the measures were accurate. It also indicates that the change score in torque using the SRP exceeded the error range of 4.54 Nm.

Discussion

This study found that using the SRP produced valid reductions in the overall torque of 18.87 ft.-lbs. on the body. This supports the utility of this device to reduce overall forces on the body. This reduction of the overall forces could account for reductions in stress on the body that have the potential to reduce muscle and joint pain and dysfunction. However, this requires further study for confirmation. (See Figure 2 below).

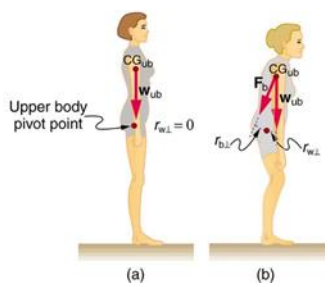

Figure 2: Reductions in Stress at the Overall Body
From Properly Aligned Postures.

Using the SRP also appears to lower the center of gravity of the body and increase the base of support. This could contribute to increases in stability at the joints to reduce abnormal stresses that contribute to pain and dysfunction. Again, this requires further study for confirmation. (See Figure 3 below).

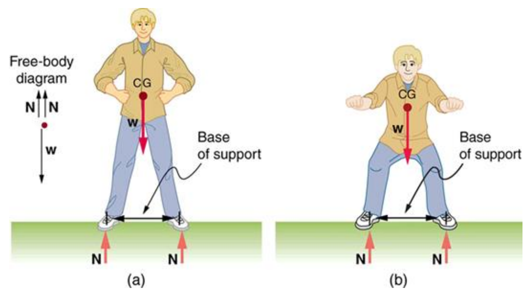

Figure 3. Lowering the center of gravity and increasing the base of support

Areas for future investigations could include an epidemiological study that tracks reductions in reports of pain and dysfunction among machine operators who use the SRP. A quantitative study could also measure changes in the magnitude of repetitive forces over time to determine reductions in cumulative stress to specific joints and tissues during machine operation.

Although the study did not find significant changes in movement at the neck, middle and low back, further study is recommended to determine whether there are significant changes at other joints in other planes of movement such as at the hip, knee or ankle. These studies could determine whether there were notable reductions of forces at each joint using more sophisticated biomechanical measures such as force plates, electromyography, and 3-dimentional kinematic films. (See Figure 4 below). Studies could also be performed that assessed biochemical markers for inflammation at key joints such as at the low back, the neck, the knees, and the shoulders.

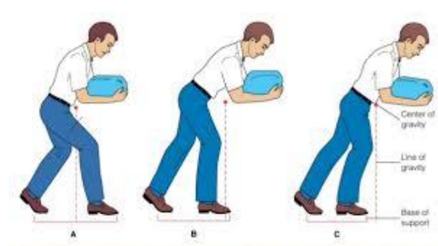

Figure 4. Increases in Stress from Unstable Postures

CONCLUSIONS/OUTCOMES:

The study determined that using the SRP during movements at a prototype machine significantly reduced the overall forces on the body in study participants by 18.87 ft-lbs. These reductions support the validity and utility of the SRP for individuals who stand and work in machine operations.

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