INTRODUCTION

Thirty-four percent of adults in the United States are overweight and an additional 32.2% are obese (BMI >30.0) [1]. Obesity has been associated with an increased risk of disability through a range of mechanisms, including skeletal stress. In this population, the effect of mechanical stress on various joints during different activities has been documented. Sibella (2003) [2] introduced a model of the fat mass to explain limited trunk lean in obese subjects during sit to stand activity. Thigh-calf [3] and heel-gluteus [4] contact forces during kneeling and squatting have been recently reported in normal weight subjects, but no study has been done to investigate the pressure exerted by abdomen on the thigh during functional activities. The purpose of our study was to investigate the contact forces exerted by the abdomen on the thigh during functional reaching activities e.g. shoe tying in adult obese individuals.

METHODS

Six obese subjects, 4 female and 2 male, without current neurological or orthopedic ailments, aged between 40-70 years, mean BMI 39.8 kg/m² (range 32.6- 47 ) were included in this study. Contact pressure between abdomen and thigh was measured using the Tekscan conformat pressure mapping sensor (model #5330, Tekscan, South Boston, MA, USA) during forward leaning task. The subject started from the erect seated position from a custom normal height chair, then leaned over to reach their right foot (e.g. shoe tying) and were instructed to hold the position. The activity was performed three times and a maximum pressure value documented for each subject.

Figure 1: Experimental set-up. The reflective markers and the conformat pressure mapping sensor seen as the subject leans during a reaching task from a normal height wooden chair.

Triads of infrared emitting diode markers were placed on the pelvis, trunk and bilaterally on the thigh, leg, and foot. Kinematic data were collected using the Optotrak motion analysis system (Model 3020, Northern Digital Inc., and Waterloo, Ontario, Canada).Force plate data under the right foot was obtained from Kistler force plate. Tekscan supplied software was used to calculate the centers of pressure and total forces due to abdomen-thigh contact area. A water bladder, to simulate the abdominal tissue and weights, were used to calibrate the thigh mat. Trunk flexion angle, in reference to lab axis system, was determined using the marker positions of the triad mounted on cervical vertebrae C7.

Regression analyses were performed to determine the association between measures.
RESULTS AND DISCUSSION

Contact forces were maximal when the trunk was maximally flexed in all subjects. The mean abdomen-thigh contact force was 10.17 +/- 5.18 % body weight. Subject A exerted 56.7 N (4.32% body weight) and Subject B exerted 189.1 N (19.96 % body weight). (Fig 2). The magnitude of the contact force and the area of contact varied across individuals, however there was a fairly broad dispersion of pressure on the thigh for all subjects.

Subject A: BMI 47                 Subject B: BMI 32.6

Figure 2: Examples of abdomen-thigh contact pressure distributions of two subjects with extreme BMI values captured at maximal trunk flexion angle during a reaching, shoe tying task.

About 32% of the variability in the force exerted by the abdomen is explained by the body mass index (fig 3).

Figure 3: Regression plots for relationship between the force exerted by abdomen (normalized to individual body weight) and BMI.

Results show that considerable forces are exerted by the abdomen on the femur, which will potentially affect the forces at the hip joint. One subject with the highest BMI (47 kg/m²) reported the lowest force among the six subjects, indicating possible restriction by the extra abdominal mass while reaching for the right shoe. Obese subjects show limited trunk flexion during normal sit to stand movement [2] and similar trends are seen for this reaching task (fig 4). No relationship is seen for trunk lean and abdomen force (R= 0.06)

CONCLUSIONS

A considerable amount of force is exerted by the abdomen on the thigh, mean 10.17 % body weight during forward trunk lean activities. This segment contact force should be included in the biomechanical analysis of obese subjects. Further work is being done to find possible implications of this contact force and how it may affect the forces and moments across the hip joint.

REFERENCES


ACKNOWLEDGEMENTS

Department of Veterans Affairs-ICVMC