CHAPTER 1. INTRODUCTION

During pregnancy the female body must accommodate the enlarging gravid uterus and increased mass. Therefore the maternal musculoskeletal system is required to adapt in both morphology and functional workload. After childbirth there is a rapid change, in both mass and dimensions, requiring further adaptations. As pregnancy is a part of the normal life history for many females, the effect of these adaptations on posture and the ability to perform tasks is important. Furthermore, these adaptations represent a normal life process rather than a disease or result of trauma and as such are an important part of understanding the complexity of the human musculoskeletal system.

The effect of gravity on the increased anterior lower trunk mass may affect the spinal posture in standing, however the effect may not be consistent across all spinal segments (Bullock et al 1987, Dumas et al 1995, Franklin and Conner-Kerr 1998, Moore et al 1990, Ostgaard et al 1993). Individual subjects have also showed different postural behaviours with some increasing and some decreasing their lumbar lordosis (Bullock-Saxton 1991, Moore et al 1990). Quiet standing postural adaptations may therefore be individual in nature. In sitting, the increased size of the lower trunk and its apposition with the thighs may restrict the anterior tilt of the pelvis and thus affect the posture of other trunk segments. The effect of increasing abdominal dimensions on spinal posture during upright sitting is currently unknown.

As pregnancy progresses body segments show increases in mass, circumference and inertial characteristics, although the changes are not uniform across all body segments (Jensen et al 1996b). Increases in body mass may be expected to cause increases in joint forces and moments that would require additional work to be performed during daily activities (Ellis et al 1985, Jensen et al 1996a, Paul et al 1996). Increased trunk dimensions during
pregnancy limit the range of forward and side to side movement of the hip joint and lumbar spine in standing (Dumas et al 1998b). The magnitude of the limiting effect of pregnancy on the motion of individual trunk segments and the possible development of strategies to minimise the impact is, however, largely unknown. It is possible that as the gravid uterus would resist motion of the lower trunk, different effects on motion may be seen in the upper and lower trunk. Different effects on some segments may cause more musculoskeletal demands on some areas of the trunk than on others. An understanding of the effects of morphological changes, due to pregnancy, on the range of motion of the trunk segments may also facilitate appreciation of the implications for functional tasks where trunk segment motion is required.

During rising to stand from a chair, hip joint angular motion is critical to the generation of forward horizontal velocity of the whole body (Yu et al 2000) and the trunk segment is the major contributor to the maximum linear horizontal momentum (Pai and Rogers 1991a). Therefore restricted trunk forward movement may hinder successful rising. Compensations may include increasing the trunk angular velocity or increasing propulsion from other sources. Limited trunk forward motion may also result in increased knee joint moments as seen in obese subjects (Galli et al 2000). Compensations for restricted forward motion and increased mass may also be three-dimensional and therefore affect the symmetry of the motion, stability during rising and the transverse and coronal plane motions.

Feelings of instability when performing functional tasks during pregnancy have been reported (Nicholls and Grieve 1992a) and this may limit or modify task performance. Strategies such as increasing the size of the base of support, however, may be used to increase stability. The effect of perceived instability and the strategies used to maximise stability during functional tasks during pregnancy is unknown.
Post-birth, the gravid uterus and its contents no longer exhibit such a major influence on the maternal musculoskeletal system. It therefore may be logical to assume that any adaptations, which have occurred, would be reversed post-birth. This is an implicit assumption where reported changes in pregnancy are based on post-birth comparisons. Reversal of adaptations to pregnancy and increased adipose tissue, however, may not be complete in the early postbirth period (Bullock-Saxton 1991, Dumas et al 1995, Gillear and Brown 1996, Otman et al 1989, Ridzon et al 1998). Biomechanical effects of pregnancy may continue after the postbirth period and therefore influence any subsequent pregnancies. Many investigations of the effects of pregnancy, however, have used a subject population of convenience consisting of a mixture of primigravida and multiparous subjects. Thus the continuing effects of a previous pregnancy may confound the results. In addition, although longitudinal studies tend to have the first test session late in the first trimester it is possible that biomechanical adaptations may have already occurred (Dumas et al 1995). In order to more fully understand the effects of pregnancy a longitudinal data collection consisting of nulliparous, primiparous and multiparous data is required.

Investigation of possible biomechanical changes as pregnancy progresses requires multiple retests. Differences between test sessions may be investigated with a repeated measures ANOVA using linear and quadratic contrasts (Winer et al 1991), which would show any systematic change within the maternal group. Variability associated with retesting and the normal intersubject variability must also be established in order to ascertain the extent of the changes due to pregnancy.

During a single data collection session and subsequent processing, errors may be introduced such as those related to the calibration procedure and automated digitisation (Kofman et al 1998, Vander Linden et al 1992, Wilson et al 1999). With subsequent test
sessions these motion analysis system errors may be compounded by small differences in the position of markers when reapplied for a later test. Also, the possibility of changes in habitual activity over long retest periods such as those used to investigate pregnancy may affect the consistency of performance. Similarly the stability of biomechanical data may vary with the measurement device and type of motion. Reproducibility of the measurements should therefore be established under the environmental conditions particular to the study (Vander Linden et al. 1992, Wilson et al. 1999).

The objectives of the study were to investigate seated and standing upper body posture, the kinematics of seated and standing trunk motion, and the three dimensional kinematics and kinetics during rising to stand from a chair as pregnancy progressed and in the early post-birth period. It was recognised that changes apparently resulting from the progress of pregnancy might actually result from differences found with repeated testing and from the natural variability of human subjects which may occur over time. In view of this, nulliparous subjects were used as controls to provide standard descriptive data and to investigate the stability of the selected variables with repeated testing.

Specifically, the aims of the study were to investigate:

a) sagittal plane postural alignment of the pelvic and thoracic segments and the thoracolumbar and cervicothoracic spine during quiet standing and upright sitting,
b) displacement of the thoracic and pelvic segments, the range of motion of the thoracolumbar spine and the mediolateral width of the base of support during seated and standing forward trunk flexion and side to side flexion and seated axial rotation,
c) temporospatial descriptors of rising to stand from a chair, including the width and depth of the base of support during rising, and the duration of the whole movement and pre-extension and extension phases,
d) peak vertical, anterior, posterior, medial and lateral ground reaction forces (GRF),
timing of peak vertical GRF, the right to left side GRF symmetry and the stability of the
medio-lateral and antero-posterior GRF during rising to stand from a chair,
e) three dimensional kinematics including initial angle, angle at seat-off, peak angle,
range of motion, peak angular velocity and timing of peak angle of the ankle, knee and
hip joints, and pelvic, thoracic and head segments and thoracolumbar and
cervicothoracic spine and shoulder joint during rising to stand from a chair,
f) peak external applied moments for the ankle, knee and hip joints in the sagittal,
transverse and coronal planes,
g) effect of the first pregnancy and a subsequent pregnancy on selected biomechanical
variables for a single subject.

It was hypothesised that as pregnancy progressed:

a) sagittal plane postural alignment of the trunk in sitting and standing would be altered,
b) trunk segment range of motion in forward flexion, side to side flexion and axial
rotation would be restricted,
c) gravid uterus would primarily restrict motion of the lower trunk thus leading to a
motion differential within the trunk,
d) restricted trunk forward flexion and increased body mass would make rising to stand
more difficult to achieve, thus decreasing stability and altering the normal three
dimensional kinematics and kinetics of the motion.