Introduction

According to a study of farmers health in Uppland, Sweden, approximately 60 % of the participants claimed having problems with their low back and 30 % with their hips (Torén et al., 1999). An especially important type of health problem among farmers is coxarthrosis, which means that the hip joint has degraded due to load on the hip joint. Furthermore, coxarthrosis has been shown to be significantly related to farmers who, among other activities, spend a lot of time driving tractors (Thelin, 1990). This is the background to this study where the load on the hip joint (the compressive force) has been calculated during the activation of foot pedals in a tractor mock-up. The aim of the study was to find out how much the activation of foot pedals contributed to the load on the hip joint relative to other activities, such as walking and stair climbing. The aim was also to see any correlations between two different heights on the seat and the load on the hip joint.

Methods

The load on the hip joint was calculated with data from a 3-component force sensor from Kistler (KI9017A) and postures of three male subjects simulating the activation of foot pedals, i.e. the clutch and the breaks. Figure 1 shows the tractor mock-up, here with the force sensor mounted on the breaks. The mock-up consisted of parts from a Valtra Tractor (6600 model).

![Tractor mock-up](image)

Figure 1: Tractor mock-up

The height of the seat was set to 45 cm and 55 cm above floor level with regard to the seat reference point (SRP). See figure 2 on the next page for the SRP location. The subjects were recorded with two video cameras from the above and from the side. The two views were then mixed into one screen with a Video Quad Processor and recorded on to a VHS videotape. The data from the force sensor, in this case the highest reading from each of 15 activations of the pedals, could be transformed into a force vector with both magnitude and direction. The vector was drawn in a 3D-CAD-model, which gave the moment arm length from the vector to the hip joint. This moment arm, together with moment arm lengths from six muscles that were believed to be acting on the hip joint, made it possible to calculate the compressive
force on the hip joint. Four muscles and their moment arm lengths were taken from Németh, 1984, (Gluteus Maximus, Biceps Femoris, Semimembranosus and Semitendinosus muscle) and 2 were estimated (Gluteus Medius and Gluteus Minimus muscle).

The calculation of the compressive force was made accordingly:

\[ F_p = \sqrt{(x^2 + y^2 + z^2)} \], where x, y and z are the three dimensions (equation 1)
\[ F_m = \frac{F_p \times l_p}{l_m} \], where \( F_p \times l_p = M_p \) (equation 2 and 3)

Equation 1 was used to calculate the pedal force, which in turn was used to calculate the muscle force \( F_m \) in equation 2. \( F_p \) and \( F_m \) were then added together giving the result of the hip joint load \( F_h \). Equation 3 was used to calculate the moment acting on the hip joint caused by the pedal force.

**Results and Discussion**

The results show that during normal activations of the pedals the load on the hip joint is lower than the load resulting from walking. Table 1 and 2 gives the calculated forces and moments acting on the hip joint during the activation of the clutch and the breaks respectively. Here, the subjects simulated normal activation in terms of time duration and force acting on the pedal.

**Tabell 1:** Calculated forces and moment acting on the hip joint during activation of the clutch
<table>
<thead>
<tr>
<th>Subject, seat height</th>
<th>F_p (N)</th>
<th>I_p (m)</th>
<th>M_p (Nm)</th>
<th>F_m (N)</th>
<th>F_h (N)</th>
<th>F_h (times b. w.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1, 45 cm</td>
<td>399</td>
<td>0.144</td>
<td>57.5</td>
<td>1044</td>
<td>1443</td>
<td>2.1</td>
</tr>
<tr>
<td>S1, 55 cm</td>
<td>260</td>
<td>0.088</td>
<td>22.9</td>
<td>416</td>
<td>676</td>
<td>1.0</td>
</tr>
<tr>
<td>S2, 45 cm</td>
<td>411</td>
<td>0.200</td>
<td>82.2</td>
<td>1600</td>
<td>2011</td>
<td>2.1</td>
</tr>
<tr>
<td>S2, 55 cm</td>
<td>360</td>
<td>0.129</td>
<td>46.4</td>
<td>902</td>
<td>1262</td>
<td>1.3</td>
</tr>
<tr>
<td>S3, 45 cm</td>
<td>364</td>
<td>0.142</td>
<td>51.7</td>
<td>1038</td>
<td>1402</td>
<td>1.6</td>
</tr>
<tr>
<td>S3, 55 cm</td>
<td>425</td>
<td>0.109</td>
<td>46.3</td>
<td>753</td>
<td>1178</td>
<td>1.4</td>
</tr>
<tr>
<td>Mean value</td>
<td>370</td>
<td>0.135</td>
<td>51.2</td>
<td>959</td>
<td>1329</td>
<td>1.6</td>
</tr>
</tbody>
</table>

**Tabell 2**: Calculated forces and moment acting on the hip joint during activation of the breaks

The maximum load was approximately 2000 N, or 2.1 times the body weight, during these activations, which can be compared to loads of approximately 3-4 times the body weight during walking (Paul, 1976). One of three calculated activations of the breaks, simulating a panic situation, gave a load on the hip joint reaching 7.6 times the body weight. This can be compared to the load arising when climbing stairs (Paul, 1976).

The calculated results show the maximum load at one moment in an activation. The activation of a foot pedal can last up to 10 s, which give a high dose. However, the frequency of the activations of the foot pedals is low, thus making the dose lower.

The conclusion of the findings is that the load on the hip joint is probably not high enough to cause health problems, but the effect of this activity together with other farm activities, such as milking cows, could cause health problems.

**References**


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