SPINE MOVEMENT DURING HALF SQUAT EXERCISE

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INTRODUCTION

The effect of lifting on the lumbar spine has been analyzed via different investigation methods. Anderson (1982). **Chaffin** and Anderson (1984) had examined the myoelectric activity of the spine musculature. Mc Gill and Norman **(1986),** Poumarat and col. (1989) developed biomechanical models in order to calculate the forces acting on the spine. But, the displacement that occurs on the different trunk levels have received little attention. The aim of this study is to describe the movement of the different vertebral segments during half squat exercise.

Postural variations of the spine can be studied using radiological technique **(Lindhal, 1966),** but there is also the risk of subjects being overexposed to ionizing radiations. Invasive methods using implanted wires (Norton and Brown, 1957; Gregersen and Lucas, 1967) give accurate results but induce ethical and technical problems. To avoid these drawbacks, we suggested **(Vanneuville,** Poumarat and col, 1994) the use of a non-invasive method of measurement, based on the recommendations of Flint (in Troup,1968)

MATERIAL AND METHOD

As described previously external markers are glued to the projecting contours of the spinous processes on T7, T12, **L1,** L3, L5 and **S1** vertebra levels. This technique was designed to locate angular displacement.

Our previous studies have shown that the extend of the markers' displacement on the skin was similar to the one observed by radiography. There is only a slight displacement of the skin around the spinous processes. During flexion or extension **trunk** movement, there was little difference between radiological and photographic methods **($P<0.05$)** in the angular variation, in the sagittal plane of the markers. These results were obtained with in vivo and post-mortem experiments.

From slides, the following items were measured in the sagittal plane :

- the angular variations corresponding to the displacement of the sticks,
- the absolute values of the angular variations at each vertebral segment.

From a Mac Reflex Motion Measurement system we measured the spacial coordinates **(X,Y,Z)** of the markers (50 Hz) in order to obtain displacement and angular variations in the sagittal plane.

Ground reaction forces acting on both feet were measured on an **AMTI** force plate. Therefore we obtained the displacement of the center of pressure

20 subjects, **beginners** on weight training gave their informed consent. The experiments with slide control were **carried** out on 10 males and 10 females aged from 19 to 22.6 trained subjects were studied with the motion analysis system.

For "slide" experiment three positions were studied : neutral (vertical trunk, without additional **charge),in** charge (vertical trunk + 5 0 kg) and half squat with 50 kg on the shoulders. For motion analysis we collected data for all the range of the movement.

RESULTS

In **standing** position the barbell weight induces a general flexion on the cervical and thoracic levels. A **verticalization** of **S1** with an extension of L5 is **noticed.(Figure** 1)

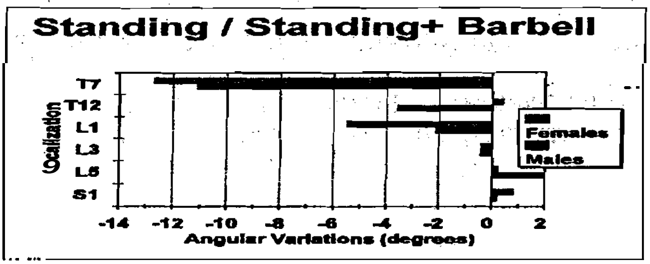

Figure 1 : Angular variations of the spinous processes during upright standing with and without barbell ou the shoulders

In squat position, comparatively to the standing position without barbell, the main displacement occurs in S1 according to the important movement of the coxo - femoral joint.L5 remains in a quite constant position. An important flexion is noticed in L3 aud L1. T12 seems well fixed. T7 angulation depends ou bead position aud general trunk flexion.(Figure 2)

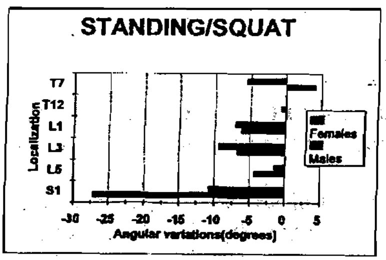

Figure 2 : Angular variations of the spinous processes : comparison between upright standing without barbell aud half squat position

If we compare the angular position of vertebra between the standing position with barbell ou the shoulders aud the half squat position we can make the saue observations but the magnitude of movements occurring ou L5,L3,and L1 is nearly the same(Fig. 3)

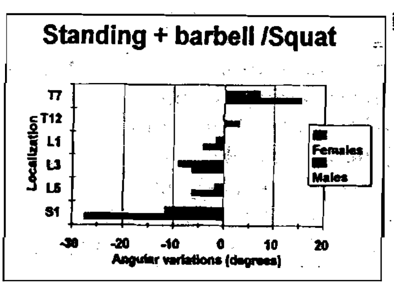

Figure 3 : Angular variations of the spinous processes : comparison between upright standing with barbell ou the shoulders aud half squat position.

The difference of magnitude of the **S1** displacement between males and females can be **explained** by the lower trunk flexion for female subjects. The trunk flexion more important for males induces a compensatory reaction at T7 level.

From motion analysis we can notice, in the sagittal plane, that the maximum displacement occurs about **S1**. For L5 and L3 the displacement represents about 50 **mm** backward. **L1** and T12 don't really move (<20 mm). T7 moves forward about 40 **mm.(Figure 4)**

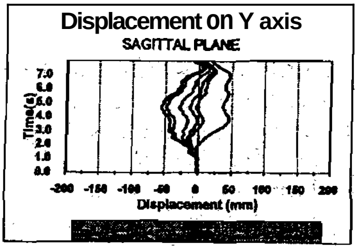

Figure 4 : displacement on the sagittal plane of the **spinous** processes during a half squat exercise. The graph presents lines, from **S1** on the left to T7 on the right.

According to the spine level vertebra flex forward from 0 to 25 **degrees.If** we consider relative angular displacement, most of the angular variations don't ovemde 5 degrees except for **S1** and T7. Figure 5)

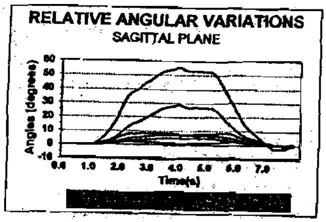

Figure 5 : relative angular variations in the sagittal **plane.The** graph presents lines, from **S1** upper curve to T7 lower curve.

The displacement of the pressure center confirm the upper values. At the beginning of the movement the pressure center moves backward (0.07 ñ 0.01 **m)** and returns to the initial position during the standing up phase. Generally this second part of the movement induces a forward displacement. Theses displacements allow the **subject's** flexion with a low **trunk** angulation. (Figure 6)

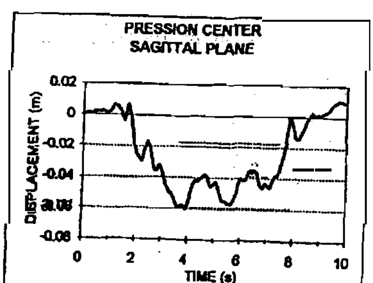

Figure 6 : Variation of the pressure center on the sagittal plane, typical curve. We can observe the slight oscillations corresponding to the postural control of equilibrium.

CONCLUSION

During half squat exercise, spine movement occurs for trained subjects on the extremities (S1 and T7 levels). During movement the thoraco-lumbar segment is fixed. For beginners we noticed angular displacement on L3 and L1 level

In physical training sessions emphasis should be laid on the voluntary development of muscles surrounding pelvis, but also of muscles allowing the fixation of thoraco-lumbar joint. An important learning programm must be introduce for the half squat exercise in order to minimise the traumatic risks. The majority of low back injuries concern the lumbar spine. The overloading of the structure dependents on the barbell weight but also on the subject posture. A greater trunk inclination induces a greater trunk extensor muscle solicitation and lumbar shear forces (Russel and Sally, 1989). During half squat exercise, loads on the L3-L4 segment vary between 6 and 10 times the body weight (Cappozo, 1985; Poumarat, 1989). These results were obtained with a rigid link model. For more accurate estimation we must take in account the spine movement especially for beginners.

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