EFFECT OF TILTING THE LOAD IN THE FRONTAL PLANE ON LOW-BACK MOMENTS DURING MANUAL LIFTING

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SUMMARY
This study investigated the effect of tilting the load in the frontal plane on peak L5/S1 extension moments (PEM) in nine male subjects. PEM was estimated using a bottom-up inverse dynamics model. Four lifting techniques were studied: the free-style (FR), stoop (ST), squat (SQ) and weight lifters technique (WL). Using these lifting techniques, boxes without handles were lifted without tilting them (grabbing the box at the lower side-edges) and using an instructed box tilting technique.
An effect of load tilting on PEM was found only for the WL and SQ lifting techniques (about 10% reduction) and was related to changes in trunk posture.

INTRODUCTION
Manual lifting can result in high low-back loading [1] which is probably the main reason why it is also an important risk factor for low-back pain [2]. Therefore, several research groups have studied the effects of a variety of lifting strategies on low-back loading [1, 3, 4]. In this study, we investigated the effect of a lifting strategy involving load tilting in the frontal plane on low-back loading (L5/S1 moments). Because previous studies have shown that lifting technique can alter the effects of ergonomic interventions [5, 6], load tilting was investigated in four different lifting techniques.

METHODS
While standing on a force plate, nine healthy subjects lifted a large box without handles from a platform in front of them. Using four different lifting techniques (Figure 1), subjects lifted the box once without tilting it (grabbing the box at the lower side-edges, see Figure 1) and once by using a specific box tilting technique as shown in Figure 2. Ground reaction forces, body segment anthropometrics and kinematics were measured and peak extension L5/S1 moments (PEM) were calculated using a bottom-up 3D inverse dynamics model [7]. Student t-tests were used to test the effect of load tilt for each lifting technique. In addition, to explain possible differences in PEM, trunk inclination and horizontal L5/S1-box distance were calculated at the instant of PEM.

Figure 1: The four lifting techniques. From left to right: the free-style (FR), stoop (ST), weight lifters' (WL) and squat (SQ) techniques. More detailed description can be found elsewhere [6].

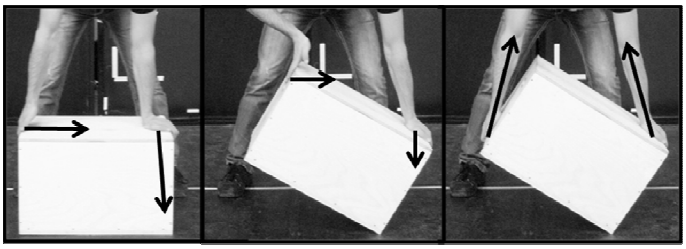

Figure 2: Box tilt technique used in the current study. Arrows indicate the forces exerted to the box.

RESULTS AND DISCUSSION
In figure 3, the effects of load tilt on PEM are presented for all four lifting techniques. No significant effect of tilting was found for the FR and ST lifting techniques. For the WL and SQ techniques, load tilt resulted in a significant reduction in PEM of about 10%.

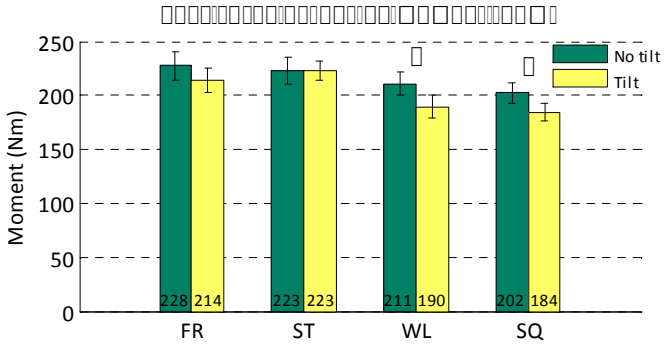

Figure 3: Effect of load tilting on peak L5/S1 moments.

The effects of load tilt on PEM can be explained by its effect on trunk posture at PEM (Figure 4): load tilt resulted in a significant reduction in trunk inclination angle at PEM for the ST, WL and SQ techniques. The reason that this reduction in trunk inclination did not affect the PEM for the ST lifts is probably that the trunk inclination angle was close to 90˚ in this lifting technique. Hence, variations in trunk inclination had little effect on the horizontal moment arm of the trunk segment and the resulting moments. For the horizontal L5/S1-load distance no substantial effects of load tilt were observed.

Other studies previously reported the effect of load tilt on low-back moments in free-style lifts. In line with the results of the current study, no significant effect of a sideward load tilt was found [8]. For free-style lifting, only load tilting techniques involving tilting towards the body (reducing horizontal L5/S1-load distance) appear to be effective in reducing low-back loading [3, 9].

CONCLUSIONS

Load tilting was effective in reducing low-back loading for the weight lifter and squat lifting techniques (about 10% reduction in peak L5/S1 extension moment) but not for the free-style and stoop lifting techniques. Observed effects could be explained by changes in trunk posture.

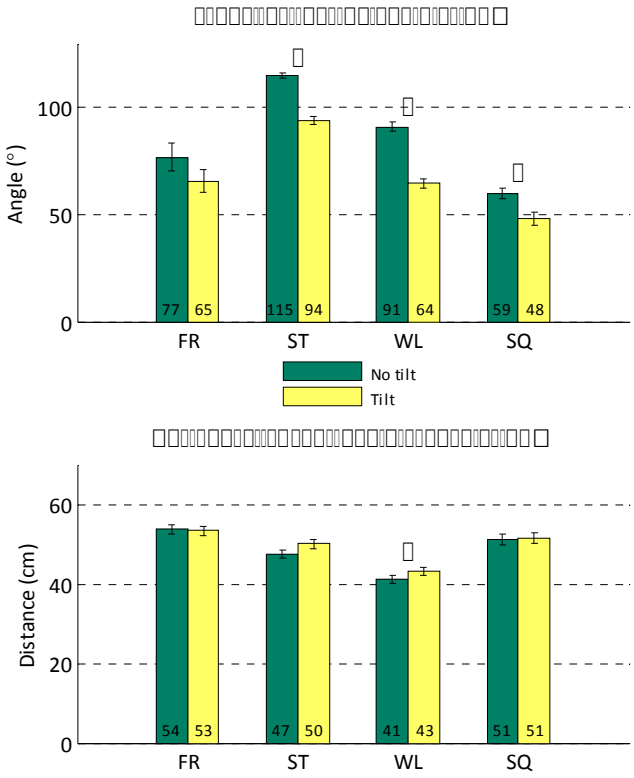

Figure 4: Effect of load tilting on the trunk inclination and horizontal L5/S1-load distance at PEM

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