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INFLUENCE OF DISTANCE, PACE, BOX HEIGHT AND MASS ON THE BACK LOADING DURING MANUAL MATERIAL HANDLING

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SUMMATIVE STATEMENT
Transfer distance, work pace, box height and handled mass were related to back loading. Distance increased cumulative back loading over 1 m. Faster pace reduced cumulative back loading, but increased asymmetric load. Handled mass increased back loading, but had less influence at greater heights.

KEYWORDS: lifting; musculoskeletal disorders; spine; speed; box transfer

PROBLEM STATEMENT
The relationship between low back disorders and manual materials handling is well established. Strenuous activities such as lifting heavy loads are considered an important risk factor of low back pain. Handled mass, the height and distance of the load have been studied to determine their importance on the physical exposure of the workers (Hoozemans, Kingma, de Vries, & van Dieen, 2008; Lavender, Andersson, Schipplein, & Fuentes, 2003). However, these effects were often observed during symmetric lifting with feet maintained static, which hampers the representativeness of a work context.

RESEARCH OBJECTIVE/QUESTION
The objective was to determine the influence of combinations of external conditions on the back loading during box transfer with free feet position and technique.

METHODS
Whole-body kinematics of seventeen handlers (mean experience of 2.2±1.3 years) were recorded with an Optotrak system where clusters of markers were fixed to body segments. Kinetics were retrieved from a large homemade force platform. The box transfer task was from a pallet to another one on the opposite side. The controlled experimental conditions were two heights of pick or deposit of 16 cm and 116 cm, three distances between the pallets of 0.5 m, 1.0 m and 1.5 m, two masses of 10 kg and 20 kg and free or fast pace. The natural free pace of the subjects was recorded and then a 25% faster time was imposed.

Three digital cameras were used to determine the lift and deposit instants. Anatomical landmarks respecting the ISB recommendations were identified with a probe and a multibody kinematic optimisation was used (Lu & O'Connor, 1999). The back L5/S1 resultant (3 planes) and asymmetric (2 planes) moments were used to compute the peak and the angular impulse. Separate four-way repeated measures ANOVA were conducted with factors height, distance, handled mass and pace ($\alpha \leq 0.05$).

RESULTS
Main effects of handled mass and height were observed on all variables ($P < 0.001$) where the low to high lift and 20 kg box induced more peak and cumulative back loading. Main effects of distance ($P < 0.001$) were observed on the two angular impulse variables ($P < 0.001$) where

distance increased cumulative back loading. Main effects of pace ($P < 0.05$) indicated that faster task execution lowered cumulative back loading and increased peak asymmetric.

DISCUSSION

The results on height and mass confirmed previous findings that lower lifting and heavier boxes rapidly increase back loading (Hoozemans et al., 2008; Lavender et al., 2003). Interestingly, a distance of 0.5 m, which could be considered a space constraint for box transfer, obtained 14 Nms less resultant angular impulse than a mid-range transfer without much affecting peak loading. The faster work pace also showed reductions of 34 Nms in the resultant angular impulse. However, the faster pace increased the peak asymmetric moment by 8 Nm.

CONCLUSIONS

Transfer distance increases cumulative loading, but a short distance of 0.5 m induced postural asymmetry. Hence, the recommended transfer distance is between 1.0 and 0.5 m. The findings suggest that reducing mass and increasing height remain are relevant interventions to reduce back loading. Working pace affects differently the spine where a trade-off between cumulative and peak loading appears to be present.

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