MECHANICAL WORK ANALYSIS OF TWO SNOW SHOVEL DESIGNS UNDER NO-FATIGUE CONDITIONS

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INTRODUCTION

Snow shovelling is necessary in many areas of the world, but occasionally results in back pain and/or cardiac sudden death even for healthy people. The bent-shaft shovel allows for a more upright posture [1], but whether it helps reduce fatigue and back pain is questionable. Investigations on muscle activity while snow shovelling have shown that there in an increase in biceps brachii EMG, a decrease in biceps femoris EMG and no change in lower back erector spinae EMG while shovelling with a bent-shaft shovel compared to a straight shaft shovel [2]. The present study aimed to expand upon these findings by assessing joint kinetics while snow shovelling. The purpose of this study was to compare the bent-shaft shovel to a typical straight-shaft shovel by assessing the mechanical work done in the lower extremities and lower back while snow shovelling.

METHODS

Nine subjects participated in this study where 7 Vicon MX cameras captured marker trajectories of the lower extremities. Subjects stood on two force platforms and shovelled a 3-kg load to simulate an average load of snow. This was repeated for 3 trials with both straight and bent-shaft shovels (Figure 1).

Net moments and powers were computed for the ankle, knee, hip and L5/S1 joints using Visual3D. Powers were then integrated over time to determine the work done by each joint. For each joint and axis, the percent contributions were determined by comparing with the total body work done (external+internal). Paired-sample *t*-tests were performed on the works that contributed over 5% of total body work in the either *x* (sagittal), *y* (frontal) or *z* (axial) directions.

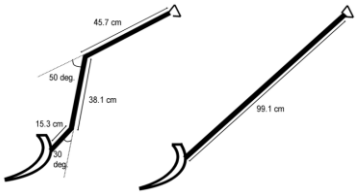

Figure 1: The bent-shaft and the straight-shaft shovels.

RESULTS

Figure 1 shows the averaged lead (coloured) and rear (black) hip and L5/S1 angular velocities, moments and powers to a typical subject using the straight-shaft shovel. Table 1 holds the mean-difference work results, *P*-values and percentage contribution of the five major moments of force. Difference values represent the bent-shaft value minus the straight-shaft value, where a positive difference indicates the bent-shaft shovel required more work. No statistical significances were found between shovel designs for the amounts of work needed at any of the joints tested (arms were not tested).

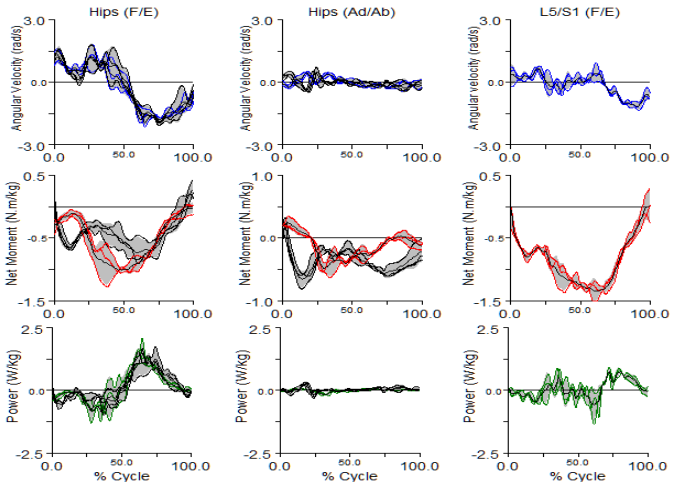

Figure 2: Mean lead (coloured) and rear (black) hip and L5/S1 angular velocities (top), moments (middle) and powers (bottom) for the straight-shaft shovel.

DISCUSSION AND CONCLUSIONS

The hip extensors collectively contributed 36.5% of the total work; the L5/S1 moment contributed 29.0%; while all the other moments collectively added 34.5%. Results of this study are consistent with our previous work[2] on the L5/S1 joint where no significant differences in lower back muscular activity (erector spinae and gluteus maximus) were detected with these shovel designs. This occurred even though there was the potential for larger lower back moments because the bent-shaft shovel does not allow for hand positions near the blade. This lack of statistical differences between the two shovel designs may be a due to a compensatory mechanism produced by the biceps brachii muscles or trials being too brief to observe the effects of muscle fatigue. The present study concludes there were no significant differences between the bent and straight-shaft shovel designs in terms of the amount of mechanical work done by the lower extremity and L5/S1 moments.

REFERENCES

[1] Huang C, Paquet V. (2002). Kinematic evaluation of two snow-shovel designs. *Int J Industrial Ergon.* Vol **29**. p. 319-330.
[2] Lewinson R *et al*. (2009). EMG comparison of two types of snow shovels. *ISB XXII*, Cape Town, South Africa. p. 39.

Table 1: The statistical *P*-values (α=0.05) are displayed below along with their respective mean difference values.

	L5/S1 *x*	L5/S1 *y*	L5/S1 *z*	Lead hip *x*	Rear hip *x*
Mean Diff. Work Percent (%)	1.58%	0.22%	0.13%	-1.64%	0.10%
***P*-values**	0.1532	0.739	0.867	0.1423	0.895
Mean component contribution (%)	14.6%	7.5%	6.9%	20.1%	16.4%