UPPER LIMB MOTION DURING SNOW SHOVELING WITH REGULAR AND MODIFIED SHOVEL

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INTRODUCTION

Snow shoveling is a hard labor routine in a cold northern region in the winter. The task should be considered a physically intensive activity and associated with local muscle pain of the lower back. Freivalds [1] stated in his review that a second handle on a shovel might improve shoveling performance by reducing the amount of stooping. We confirmed that the amount of the thorax forward tilt, the lower limbs flexion and the center-of-gravity distance traveled were significantly smaller when using a shovel with a second handle [2, 3]. However, the effects of the second handle on the upper limbs have never been studied. Thus, this study attempted to determine how different types of shovel affect the motion of the upper limbs during the shoveling of snow.

METHODS

Five right-handed male subjects volunteered to participate in the laboratory experiments. The mean values ± *SD* of their heights, weights, and ages were 1.68±0.06 m, 66.3±10.6 kg, 28.2±8.7 yrs., respectively. They received an explanation of the experimental protocol and provided informed consent prior to testing.

Two types of shovel were compared in the study, a regular shovel and a modified shovel with a second handle. The regular shovel is a commonly used one and consists of a 1.5-m main shaft and a plastic blade. The modified shovel resembles the regular shovel in its blade and main shaft but an additional second handle is mounted perpendicularly to the main shaft.

Subjects shoveled simulated snow with the two different shovels in the laboratory. The simulated snow was stuffed bags with shredded paper in three different weights. For each bout, subjects used one of the two shovels, and were required to scoop up one bag placed diagonally left in front of their left foot and throw it onto a 0.7-m-height box 1.75 m away from them.

The measurements of kinematic data during the shoveling were established using the VICON 460 motion analysis system (Vicon Motion Systems, UK) with six cameras at 120 Hz placed on the laboratory ceiling. The flexion angles of the elbow joints were chosen in order to describe the motion of the upper limbs while shoveling. The shoveling was divided into the three phases; squatting, lifting and throwing according to the previous study [2, 3].

The kinematic data during the shoveling were expressed as mean ± *SD*. A Student's paired *t*-test was used to determine significant differences between the two types of shovel on measured variables. The *p*-value was considered significant when it was found to be less than the usual level of significance 0.05.

RESULTS AND DISCUSSION

Table 1 shows the flexion angles of the elbow joints during the shoveling with the regular and modified shovel. The minimum left elbow flexion angle was significantly smaller in the squatting phase when the subjects used the modified shovel than when they used the regular shovel. Although the maximum left elbow flexion angle was slightly larger when using the modified shovel, there was no significant difference between the two shovels. Moreover, the angular displacement of the left elbow joint was significantly larger when shoveling with the modified shovel. The right elbow flexion angles were significantly smaller both in the squatting and the lifting phases when using the modified shovel. Bending the left elbow would be needed to keep the blade horizontal with the ground so as not to let the snow slip off. Consequently, more stresses may be imposed on the left elbow flexor muscles when using the modified shovel. In order to reduce the amount of the left elbow flexion it may be necessary to increase the lift angle between the blade and the main shaft or to lower the second handle height. Further shovel modification would help users shovel snow more comfortably.

REFERENCES

1. Freivalds, A., *Ergonomics* **29**, 3-18, 1986.
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Table 1: Flexion angles of the elbow joints during shoveling with the regular and modified shovel.

				Regular shovel	Modified shovel
Elbow Flexion Angle [deg]	Left	Squatting	Minimum	35 ± 2 *	32 ± 2
		Lifting	Maximum	45 ± 4	49 ± 7
	Right	Squatting	Minimum	38 ± 7 **	35 ± 6
		Lifting	Maximum	42 ± 6 **	39 ± 5

** and * indicate significant differences between the two shovels at $p < 0.01$ and $p < 0.05$, respectively.