CAREGIVER MUSCULOSKELETAL DISORDERS RELATED TO POWER-LIFT OPERATION

Hyunho Choi[1], Paul Han[2], Keyoungjin Chun[1], Hansung Kim[2], Dohyung Lim[1]
[1]Gerontechnology Center,
Korea Institute of Industrial Technology, Chungnam, Korea
[2]Yonsei University, Korea
[#]dli349@gmail.com

INTRODUCTION

Caregivers are at high risk of developing work-related musculoskeletal disorders (MSDs) [1-3]. MSDs can occur when caregivers use a power-lift, which requires adopting postures such as stooping or squatting for significant periods of time [4]. The primary purpose of this study was to test the hypothesis that repeated use of power-lifts by caregivers can result in MSDs. To accomplish this, we used electromyography (EMG) sensors, a three-dimensional (3D) motion capture system, and a pressure mapping system. We expected that this analysis would help reveal the biomechanical factors that will aid efforts to reduce the risk of MSDs.

MATERIALS AND METHODS

Participants

Following Institutional Review Board approval, healthy young men of mean age, 25.5 years (standard deviation (SD) = 0.7), height, 171.5 (SD = 0.7) cm, and weight, 69.5 (SD = 3.5) kg, were invited to participate.

Power-Lift Selection

Two power-lifts (Type A; Bolero, ARJO, USA and Type B; MONA, Horcher, USA) were chosen based on factors such as market price, market share, sales volume, user friendliness, brand awareness, and test convenience.

Power-Lift Operation

Driving a power-lift on straight and curved tracks was selected based on the analysis of actual power-lift procedures performed frequently at care facilities (Figure 1). Participants operated the power-lift for 10 min and then rested for 40 min until the next operation.

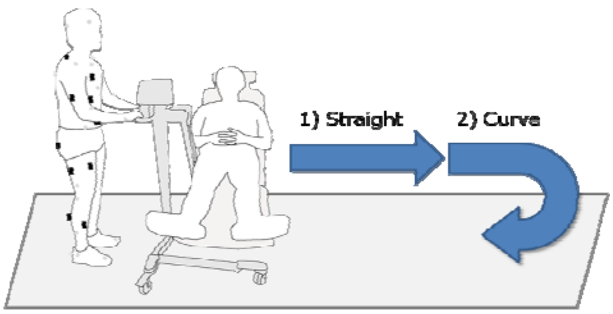

Figure 1: Straight and curved test tracks

Figure 2: EMG analysis and pressure mapping system using 3D motion capture.

Measurements and Data Acquisition

Twelve EMG sensors (Tringo Wireless EMG System, DELSYS, USA) were attached to participants' right muscles (Table 1). EMG data were analyzed by the MDF (median frequency) technique. Contact area and pressure distribution on the feet were measured by the pressure mapping system using Pedar (Novel GmbH, Germany) to identify MSD risk [5-7]. Pliance system (Novel GmbH, Germany) was used for identifying the risk of hypothenar pressure on the hand (Figure 3). Three-

Table 1: Rate of muscle fatigue

(Unit: %)			Straight		Curved	
	Function	**Muscle**	**Type A**	**Type B**	**Type A**	**Type B**
Upper Body	Protraction	Trapezius	2.5	6.5	10.5	33.1
	Adduction	Pectoralis major	—	13.7	—	14.5
	Flexion	Biceps brachii	3.2	—	6.8	4.0
	Adduction	Triceps brachii	—	7.6	—	0.6
	Flexion	Pronator teres	12.7	—	6.2	—
	Extension	Extensor carpi ulnaris	—	13.7	1.0	1.0
	Extension	Erector spinae	—	5.5	—	5.2
Lower Body	Adduction	Gluteus medius	—	0.5	8.2	7.0
	Extension	Rectus femoris	1.9	7.5	5.8	—
	Extension	Biceps femoris	—	3.0	0.7	—
	Plantar flexion	Tibialis anterior	3.1	11.9	3.3	11.4
	Plantar flexion	Gastrocnemius	1.5	12.1	10.7	11.2

dimensional (3D) motions were measured using the VICON Motion System (VICON Ltd., England) to identify the motion patterns characteristics of the power-lift.

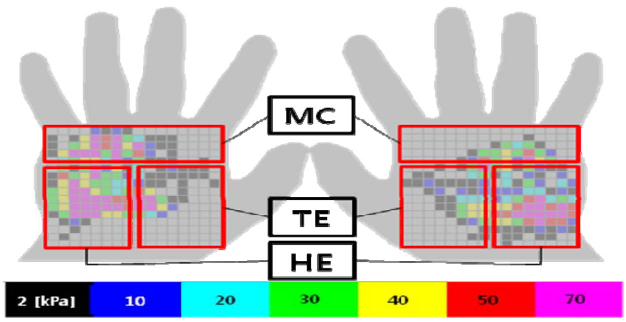

Figure 3: For hand testing, pressure on a pad was varied over the hypothenar (HE), thenar eminence (TE), and metacarpal heads (MC)

Statistical Analysis

A paired *t*-test was used to identify statistically significant differences. Here, p = 0.05.

RESULTS AND DISCUSSION

The possibility of muscle fatigue generally increased during power lifting ($p < 0.05$) (Table 1). This result indicates that our hypothesis is valid and suggests that power-lift design should be improved taking into consideration biomechanical and ergonomic factors.

The contact area and pressure generated using a Type A power-lift were, respectively, generally lower and higher, than those as using Type B power-lift ($p < 0.05$) (Figure 4).

The peak pressure on the hand on straight and curved tracks was highest for the HE (Table 2). When participants operated on the curve's right side, peak pressure was higher at the right hand's HE than that at the left. The maximum force and contact area also correlated significantly with peak pressure values on both hands. Ulnar nerve disease is likely to occur due to high pressure on the HE.

Table 2: Peak pressure distribution on hands

Type	**Hands**	**Position**	**Straight** Peak Pressure Average (kPa)	**Curved** Peak Pressure Average (kPa)
Type A	Left	HE	71.1 ± 0.4	72.9 ± 0.6
		TE	5.9 ± 0.3	10.6 ± 0.2
		MC	44.6 ± 1.4	55.1 ± 0.7
	Right	HE	88.1 ± 1.8	103.8 ± 0.5
		TE	23.2 ± 0.1	23.7 ± 0.5
		MC	21.2 ± 0.2	21.0 ± 0.2
Type B	Left	HE	68.9 ± 1.1	87.7 ± 0.5
		TE	21.6 ± 0.2	39.3 ± 0.5
		MC	45.7 ± 0.6	48.0 ± 0.4
	Right	HE	52.4 ± 2.1	57.1 ± 0.6
		TE	46.3 ± 0.2	38.7 ± 0.2
		MC	22.7 ± 0.2	22.5 ± 0.3

The pressure pattern for test subjects' feet on straight and curved tracks was similar to the pressure pattern of their normal gait (Figure 5) [8-9]. Foot pressure patterns measured in both Type A and Type B were similar ($p > 0.05$).

The results showed that contact area and pressure depended on the design of the power-lift handle, particularly with respect to handle and caster shapes. Therefore, our results suggest that improving power-lift design considering biomechanical and ergonomic factors (in this study, handle and caster shapes were tested) may help reduce the risk of MSDs.

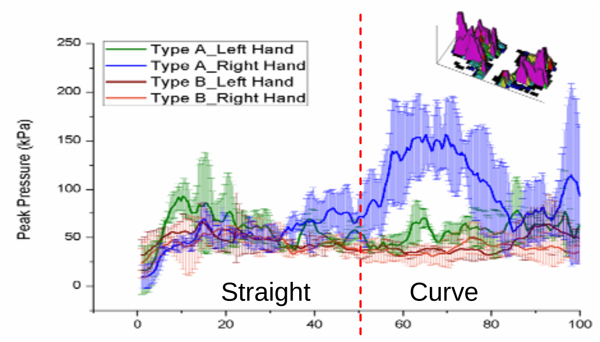

Figure 4: Peak pressure distribution of hands

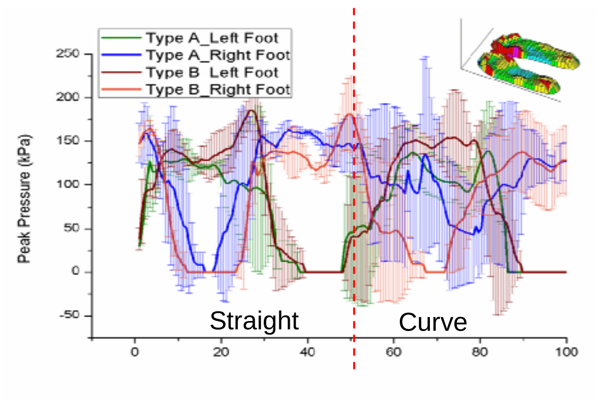

Figure 5: Peak pressure distribution of feet

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