



Investigation of hand postures in manufacturing industries according to hand and object properties



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ABSTRACT

The aim of this study was to investigate the hand postures commonly used in manufacturing companies, according to the use of either the right or left hand and the object properties. Operations taking place over 1636 s were reviewed to record hand postures, right and left hands, object shapes, object locations, and object directions and to classify them according to a hand posture classification system developed in this study. The classification system considers R (resting), G (grasping), P (pinching), and T (touching), which are further subdivided based on the number and use of fingers—(T) thumb, (I) index, (M) middle, (R) ring, or (L) little-and palm (P). The hand postures classified as 5G (TIMRL), 3P (TIM), 5P (TIMRL), 2P (TI), and 4G (TMRL) were the most commonly used postures; however, their frequencies of use depended on whether the right or left hand was used and the object properties. The most commonly handled object shapes were cylinders, rectangles, and sheets, and the most common location for objects of these shapes was on a table. The use of hand postures depends on the type of activity. Unlike activities of daily living, which often require pinching an object, grasping is more often used in the manufacturing industry to manipulate hand tools and parts with force. The results of this study are anticipated to be useful in designing future research studies on hand postures.

Relevance to industry: The investigation of commonly used hand postures is of special interest in ergonomics because of its association with musculoskeletal disorders of the hand. Information on commonly used hand posture can be used in designing future hand posture research studies to estimate and reduce hand stresses.

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1. Introduction

The hand has a complex structure of bones and muscles that allows humans to perform various functions (Taylor and Schwarz, 1955). Hand functions facilitate diverse activities: manipulating devices, picking up objects, playing musical instruments, pointing, climbing, drawing, etc. Many researchers are attempting to understand how humans utilize their hands (Kyota and Saito, 2012). Research on hand functions is mainly conducted from the perspectives of biomechanics, hand clinics, and rehabilitation. Hand functions are also important in occupational safety, humanoid robots, animation, and ergonomics.

Grasping and pinching are common postures investigated in hand functions (Slocum and Pratt, 1946). McBride (1942) first

classified hand postures based on the parts of the hand used: grasping with the entire hand, grasping with the thumb and fingers, or grasping with the palm and fingers. Griffiths (1943) used object shapes as a reference to categorize hand postures into cylindrical, ball, ring, pincer, and pliers grasps. Napier (1956) suggested power and precision grasps based on the anatomical and physiological aspects of the hand. He defined the power grasp as holding an object with the thumb, fingers, and palm, whereas he defined a precision grasp as holding and manipulating an object with the tips of the thumb and fingers. Kamakura et al. (1980) identified four categories of 14 specific hand gestures by examining the finger locations and contact areas used to hold 98 objects used in occupations, sports, and the arts. The four categories identified were the power grip, intermediate grip, precision grip, and grip involving no thumb. Armstrong et al. (1982) proposed six hand postures defined by the hand shape and contact area between the hand and object, based on observations at a poultry processing plant. The six hand postures proposed were the pulp grasp, medial

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grasp, pulp pinch, lateral pinch, palm pinch, and finger press. Hwang et al. (2010) and Wang et al. (2012) identified 14 different hand postures for touching, wrapping, and pinching based on palm use and the number of fingers used to evaluate farm work.

The frequency of hand posture use is also considered as a criterion for hand posture classification of activities of daily living (ADL). Sperling and Jacobson-Sollerman (1977) analyzed the frequency of several grasps used during serving, eating, and drinking. They found that grasping with the fingers (finger grasp) accounted for 37% of hand postures, grasping with the web of the thumb in contact with an object being held (web-of-thumb grasp) accounted for 33%, and grasping with the palm in contact with an object (volar grasp) accounted for 30%. Sollerman and Sperling (1978) investigated ADL and identified the hand postures most often used in terms of percentages: 33% for volar grasp, 20% for pulp pinch, 20% for lateral pinch, 15% for five-finger pinch, 10% for tripod pinch, and 2% for extension grasp. Sollerman and Ejeskar (1995) reported that the percentages of common hand postures in ADL were 25% for power grasp, 20% for lateral grasp, 20% for tip grasp, 10% for spherical grasp, 10% for tripod grasp, and 10% for extension grasp. Zheng et al. (2011) found six postures that accounted for approximately 80% of the working time in daily household tasks: medium wrap (27%), index finger extension (17%), power sphere (13%), lateral pinch (12%), precision disc (7%), and thumb–index finger (4%). Vergara et al. (2014) observed the following frequencies for grasp types: 38.3% for pinch, 12.7% for non-prehensile grasp, 12.3% for cylindrical grasp, 9.7% for lumbrical grasp, and 8.8% for lateral pinch. Kilbreath and Heard (2005) studied the frequencies of hand grasp types of healthy older persons. They observed no significant differences between the frequency of use of a pinch grip to manipulate objects and the frequencies of use of a power grasp or the most commonly used digital grasp or whole hand grasp. Recently, Lee and Jung (2014) investigated common voluntary hand postures according to object properties. They found that seven hand postures were grasping with the thumb and four fingers, grasping with four fingers, grasping with three fingers, pinching with the thumb and four fingers, pinching with four fingers, pinching with three fingers and pinching with two fingers.

In addition to the aforementioned criteria for hand posture classification, hand postures can be affected by object location (Schot et al., 2010), object direction (Cuijpers et al., 2004), object size (Wong and Whishaw, 2004), and task (Light et al., 2002). Schot et al. (2010) found that the front and back sides of a sphere are pinched with the thumb and index finger when the sphere is located on the left side of a subject but the left and right sides of a sphere are pinched when the sphere is located on the right side of a subject. Wong and Whishaw (2004) showed that pinching an object with the thumb and index finger is a common hand posture, but its use decreases with large object sizes. Light et al. (2002) classified natural grasps used for various actions as a tip grasp for picking up coins, a power grasp for moving a jar, a spherical grasp for removing a lid, an extension grasp for turning a page, a lateral grasp for pouring water, and a tripod grasp for cutting food.

The previous studies mentioned focused mainly on ADL and utilized predefined hand posture classifications, without a thorough investigation of which fingers were involved in object–hand coupling. Furthermore, there is little information available on common hand postures used with various object properties (shape, location, and direction) in manufacturing industries. Based on these concerns, this study was conducted to investigate hand postures commonly used in 12 manufacturing industries and to develop a hand posture classification system for identifying the involvement of specific fingers in object–hand coupling.

2. Methods

2.1. Manufacturing tasks

Twelve manufacturing companies were visited to film workers' hand postures and object properties with a digital camcorder (Table 1). One of the companies performs automobile repair, another is an iron foundry, and the remaining ten manufacture air conditioners, automobiles, automobile panels, compact discs, electric irons, liquid crystal display (LCD) frames, light-emitting diode (LED) panels, light fixtures, plastic films, and refrigerators. The work carried out at these companies involves 17 operations: assembling, cleaning, fastening, gluing, inspecting, labeling, liquating, loading, marking, moving, packing, painting, setting,

Table 1
Twelve manufacturing companies and operations.

No.	Company	Operation	Figure	No. of frames
1	Air conditioner	Assembling, painting, storage		88
2	Automobile	Assembling, fastening		186
3	Automobile panel	Assembling, gluing, painting		76
4	Automobile repair	Assembling, painting, setting		69
5	Compact disc	Labeling, packing, sorting		42
6	Electric iron	Assembling, fastening, inspection, labeling, welding		367
7	Iron foundry	Liquating, packing, painting, tamping		79
8	LCD frame	Assembling		27
9	LED panel	Assembling, fastening		151
10	Light fixture	Assembling, marking		323
11	Plastic film	Loading, packing		61
12	Refrigerator	Assembling, moving, welding		167

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