



Nail clipper ergonomic evaluation and redesign for the elderly



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ABSTRACT

This study designs and evaluates a new nail clipper for the elderly using ergonomic methods. The nail clipper usage problems and requirements were collected first. After requirement analysis we applied ergonomic simulation in redesigning the nail clipper and developing a pedal plate. A usability test was conducted to evaluate both typical and newly developed nail clippers using 20 elder participants. The dependent measures were the total number of nails clipped, completion time and discomfort and satisfaction subjective ratings. The experimental results indicated that the newly developed nail clipper was superior to the typical one in subjective ratings for discomfort and satisfaction. The performance of the newly-developed nail clipper is similar to that of the typical clipper. Some important nail clipper design implications for the ageing population are discussed.

Relevance to industry: With the increase in the elderly population, problems caused by aging have gradually emerged. Aging may cause the elderly inconvenience in using many household objects that are not specifically designed for the elderly. Therefore, industrial designers should try to redesign household objects to enhance living quality for the elderly. This study used nail clipper design as an example to show how to apply ergonomic methods in product design.

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1. Introduction

The average life expectancy of human beings has increased yearly due to rapid progress in medicine and technology. However, the birthrate in some advanced countries has decreased (Economist, 2010). There is now an ever increasing proportion of elderly in the national population. Taking Taiwan for example, the proportion of elderly in the population was 10.4% in 2008. It is estimated that the proportion of elderly will increase to 14% by 2017 and to 20.1% by 2025. It takes approximately eight years to transform an aging society to a super-aging society, suggesting that the speed of population aging in Taiwan is increasing (Council for Economic Planning and Development, 2008). The problems caused by aging have also gradually emerged in Taiwan. The phenomenon of population aging is not only common in Taiwan, but has serious influence in many developed countries around the world.

Aging is usually accompanied by physical function decline, i.e., physical inconvenience, such as reduced muscle endurance, joint

stiffness and decreased activity. (Harma, 1996). The disability prevalence in activities of daily living (ADL) and instrumental activities of daily living (IADL) increases with age as well. For IADL, cooking, cutting toenails and doing housework, the functional disability rate rise sharply with the increase in age for Chinese elderly (Tang et al., 1999). Moreover, a high prevalence of foot problems had been reported among aging adults with most of them unable to care their own feet (Ebrahim and Sainsbury, 1981). All of these changes may cause the elderly inconvenience in using many household objects that are not specifically designed for them. Therefore, ergonomists should try to redesign household objects to enhance living quality for the elderly.

If aging problems and requirements can be considered in household object design, the elderly can be made more comfortable at home. Taking the nail clipper as an example, it is more difficult for the elderly to clip their own nails compared with young adults (Wu and Hou, 2009). Hand pinch strength decreases with aging and the finger and toenails of the elderly become thicker, harder and more dry (Tsai, 2002). Based on the previous investigation (Wu et al., 2012), most respondents (81.7%) used the “two-point pinch” to clip their fingernails. The thumb and forefinger were the major parts experiencing discomfort. In toenail clipping the

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patient's neck and lower back were the major parts experiencing discomfort. These are the main problems for the elderly in clipping their nails. In order to resolve these problems this study focused on designing a proper nail clipper for the elderly.

The main purpose of this study is to design a new nail clipper that can be used easily and comfortably by the elderly. The ergonomic principles for good design (Stanton, 1998) and computer simulation technology were applied to amend the inappropriate postures of traditional nail clipping, thus, further avoiding discomfort and pain to the fingers, wrist, neck or lower back. The specific expectations of this study are as follows: (1) to reduce over-bending in the wrist and lumbar vertebra during nail clipping and (2) to prevent the elderly from feeling discomfort during nail clipping.

2. Collecting nail clipping postures

2.1. Typical nail clipping postures

To understand the nail clipping postures assumed while using a traditional nail clipper, the posture of 24 elders' was photographed while clipping their finger and toenails. No strict regulations were imposed on the subjects, allowing them to cut their nails freely. Based on the collected photographs, three categories of nail clipping postures were identified. They are two-point pinch, lateral pinch and grasping hold, as shown in Fig. 1. 'Two-point pinch' means using front thumb to press the nail clipper and the forefinger and thumb to hold the nail clipper. Performing the two-point pinch when using a nail clipper is the most frequent posture. 'Lateral pinch' implies placing the nail clipper above the forefinger, middle finger, ring finger and little finger, and using the thumb to press the nail clipper, where the knife edge and the exterior of the little finger are in the same direction. 'Grasping hold' means placing the nail clipper on the palm and using the little finger, ring finger and middle finger to press, where the knife edge and the exterior of the little finger are in the same direction.

We classed the postures of the 24 individuals into three categories for toenail clipping: leg-crossed posture, sole-supinated posture and sole-pronated posture, as shown in Fig. 2. 'Leg-crossed posture' means crossing the lower leg onto the thigh of other leg to clip nails, with the leg placed horizontally. 'Sole-supinated posture' implies supinating the sole, turning aside the body to cross the elbow over the knee, and stepping the sole forward. This was the most frequent used posture when clipping toenails. 'Sole-pronated posture' means lifting up the leg, crossing the elbow on the same side over the thigh, and pronating the sole to lift the toes.

2.2. Ergonomic simulation of nail clipping

After collecting these nail clipping postures we used JACK 4.0 software to simulate the representative nail clipping postures (according to the above collected photographs) and analyze the joint

angles of the wrist, neck and back. The purpose of computer-aided ergonomic evaluation was to understand how large the joint angle was away from the neutral position and to redesign the nail clipper for preventing the large joint angle. Fig. 3 shows the representative nail clipping postures and their simulation results. The dimensions of virtual humans were based on Taiwanese female adults' average anthropometric data. The chair height was set a little lower than the average knee popliteal height of Taiwanese female adults. The typical nail clipper was also established for ergonomic simulation in the JACK virtual environment. Table 1 shows the target joint angles under representative nail clipping postures when using a traditional nail clipper. It was obvious that wrist ulnar/radial deviation was about 24.8–36.6° during clipping hand nails and toenails. In order to prevent the wrist from ulnar/radial deviation, the structure of the traditional nail clipper should be redesigned. Suppose that we can grasp a traditional nail clipper with a neutral wrist, it is impossible to clip the nails because the cutter edge is not consistent with the nail edge, as simulated in Fig. 4(a). Therefore, a design idea of changing the cutter direction came from the simulation results. Further, it is inevitable that the torso reclined 23.5–37.8° while clipping toenails (see Table 1). To design a proper pedal plate for clipping toenails may be a good idea to improve the back bending problem. All these ideas were expected to enable users less bending angles in wrist and back during nail clipping as much as possible.

3. Designing a new nail clipper

3.1. Ergonomic principles for hand tools

The nail clipping motion involves wrist twist and pinch strength, including ulnar deviation or stretching. Shih and Ou (2005) conducted a study on the influence of three wrist postures on pinch strength and found that, regardless of the subject's gender, pinch strength is the strongest when performing a neutral motion, followed by bending and stretching. Further, Jansen et al. (2003) compared the differences in pinch strength between pinch types and forearm postures. Three pinch types, namely, the key pinch/lateral pinch, the fingertip/two-point pinch and the three-jaw chuck pinch/three-point pinch were compared under neutral, pronated and supinated forearm postures. When performing the three-point pinch motion the forearm posture does not have a significant influence on pinch strength. However, when performing the lateral pinch or a two-point pinch motion the forearm posture has a significant influence on pinch strength. Regardless of the pinch types, the strongest pinch strength originates from the neutral forearm posture, which is consistent with the conclusion reached by Halpern and Fernandez (1996). The least pinch strength originates from the lateral pinch motion. The least two-point pinch strength resulted when the arm is pronated. Therefore, it is important to maintain the neutral forearm posture while using a nail clipper.

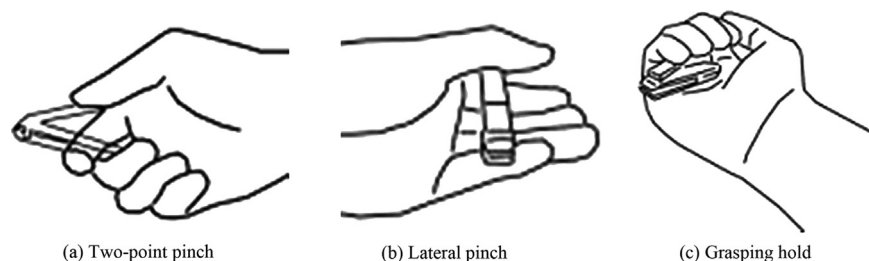


Fig. 1. Three categories of nail clipping postures.

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