Pressure Threshold of the Hanger Reflex at the Wrist

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Abstract: While hanger reflex is known as an involuntary movement of human head, the similar phenomenon has been found at the wrist and positions that efficiently generate the movement. However, the detailed condition about the strength of the pressure has not yet studied. In this paper, we measured the pressure thresholds of the hanger reflex at the wrist. The results showed around 6N pressure presented both inward and outward rotation.

Keywords: Hanger Reflex, Pseudo-force, Force Display, Wrist

1 Introduction

While conventional force-feedback system takes large space and high cost, there were several attempts to present pseudo-force using perceptual illusion and thus to shrink space and lessen cost [1][2][3][4]. The hanger reflex is one of the perceptual pseudo-force illusion that a wire hanger worm by the head induces rotational force and involuntary rotation [5]. Sato et al. discovered that the pressure in the temporal region of the head is the trigger of this phenomenon, and developed a device that controls the pressure and the generation of the hanger reflex [6]. In our previous report, we found that the similar phenomenon occurs in the waist and wrist [7]. Especially in the wrist, we discovered the positions that efficiently generate the hanger reflex, just like an ordinary hanger reflex at the head, and developed the device that controls the generation of the hanger reflex [8]. However, the necessary pressure value and its variation among people have not yet studied. In this paper, using previously developed wrist-type hanger reflex device, we investigated thresholds of the pressure that people perceive the twisting-force during the hanger reflex at the wrist.

2 Experiment

2.1 Setup and Participants

In the experiment, we used the previously developed twisting-force device[8] to generate hanger reflex at the wrist, and measured the pressure thresholds. On the device, four linear actuators (Miniature Linear Motion series PQ12, Firgelli Technologies Inc.) are mounted, and generate the hanger reflex by pushing the "sweet spots". Also, the force sensor (FSR 400, Interlink Electronics Inc.) is attached to each linear actuator, and measured the force that the

linear actuator applied to the user. Five laboratory members participated this experiment (5 males, age range from 22 to 26 years old). Before the experiment, we confirmed that the hanger reflex occurs on their wrist, and let them remember the feeling of the twisting-force caused by the hanger reflex. During the measurement, the participants were equipped the twisting-force device on their left wrist, and kept standing with their left palm tuning inside. Also, they wore a sleep mask, and listened to white noise with noise canceling headphone to mask visual and auditory cues (**Fig. 1**).

Fig. 1. A participant during the measurement

2.2 Procedures

A method of limits was used to measure the thresholds of the pressure for the twisting-force caused by the hanger reflex. In the measurement, seven force levels (4.43N, 4.65N, 5.63N, 6.01N, 6.81N, 7.75N, and 8.82N) were prepared, and applied in ascending or descending order by the twisting-force device until they started to feel the rotation or the felt the rotational force disappeared. For each participant, the measurement of outward rotation was conducted first, and inward rotation was conducted consecutively.

For each trial, we asked the participant to answer if he perceived the twisting-force or not (forced choice). We let them move their wrists to confirm their feeling. Hence we obtained upper and lower thresholds for each condition, and the threshold was obtained by averaging the two.

2.3 Results and Discussion

Fig. 2 and **Fig. 3** show the average of upper and lower thresholds of each participant, and the average of them. In the outward rotation, the thresholds ranged 5.73N and 7.28N, and the average and its standard deviation were 6.47N and 0.63N respectively. In the inward rotation, the thresholds ranged 5.03N and 7.28N, and the average and its standard deviation were 5.86N and 0.92N respectively. The result indicates that the hanger reflex at the wrist can be generated by the commercial actuators. Because around 6N can be generated by small actuators, the twisting-force device can be implemented in small size also.

Comparing the averaged thresholds, the inward rotation had around 0.6N lower thresholds than that of the outward rotation, but t-test did not show significant difference between the two

(p=0.12). However, most participants commented that the inward rotation was easier to detect, which might be due to the initial posture.

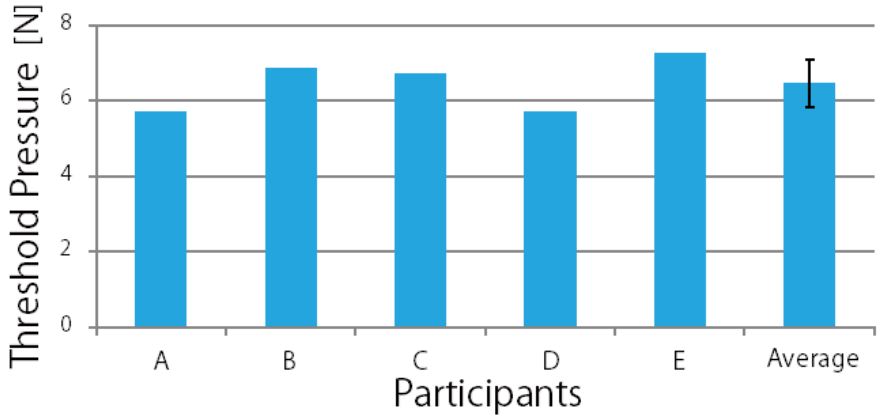

Fig. 2. Results in the measurement of the external rotation

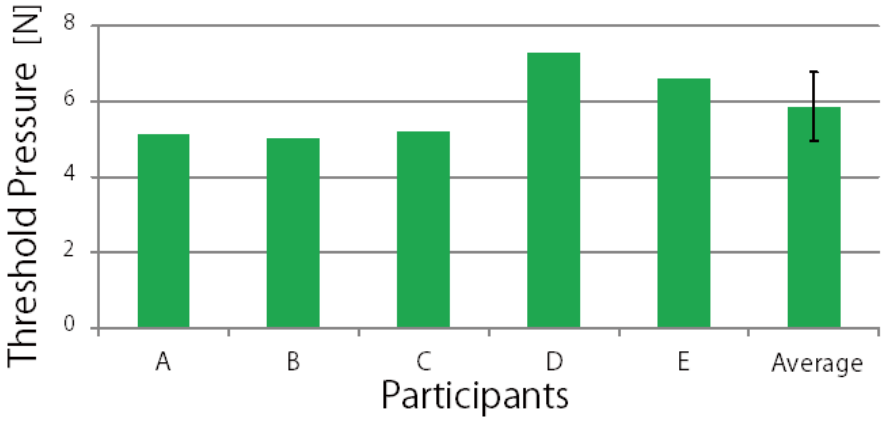

Fig. 3. Results in the measurement of the inner rotation

3 Conclusion

In this paper, we measured the pressure thresholds of the twisting-force caused by the hanger reflex at the wrist. The results showed the hanger reflex needs around 6N to generate, which can be presented by the commercial actuators. Comment from participants showed the inward rotation might have lower threshold than the outward rotation, but it might be due to the initial posture of the experiment.

Our future work will include measurement with different posture, more accurate thresholds measurement using a method of constant, and the measurement of the torque that the user perceive during this illusion. We will also work on revealing the mechanism of the illusion by closely observing skin deformation, bone deformation, and applied force.

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