CONTACT FORCE DETECTION DURING TAI CHI CHUAN PUSHING HANDS

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SUMMARY
Tai Chi Chuan pushing hands is a training program for perceiving the motion and force of the antagonist. The purpose of this study was to clarify the contact force between the wrists of two persons in the pushing hands training. A 3D motion capture system and the force sensor were used synchronously to collect the human motion and contact force respectively. The Visual3D and MATLAB software were used for data analysis. The results showed that the value of the contact force was small and the contact force between two persons in push-hand process varied with motion of wrist in right-left direction. The small contact force found in this study could be confirmed the training rule of Tai Chi Chuan push-hand in the ancient book which means the contact force should be as small as possible for improving the tactile sense.

Key words: Tai Chi Chuan, push-hand, perceive, contact force

INTRODUCTION
Tai Chi Chuan is a famous martial art in the world. It is a kind of training program for improving proprioception. A Tai Chi Chuan master could control his/her limbs movements precisely to keep their trajectory of the center of mass (COM) of the body moving steady. In the Chinese language, it was meant ‘know self’. For a senior master, it is more important to perceive the movement and the applied force from the antagonist, which was called ‘know opponent’ in the Chinese language. The pushing hands is a training program in Tai Chi Chuan for ‘know opponent’. In the start of pushing hands, two persons face each other in arrow-bow step or back-sitting step, and touch their wrists to another in one or two hands [1]. Then they move their hands in a cycle with hands touched, and they can learn how to perceive the motion and force of opponent by the small contact area. Therefore, the purpose of this study was to clarify the contact force between the wrists of the two subjects during the pushing hands training by biomechanics methods.

METHODS
Two male subjects participated in this study and the basic data of subjects were list in the table 1. The subjects were asked to practice fixed-steps (without moving their steps) pushing hands in one hand (Peng style, figure 1). A total of 67 reflective makers placed on the landmarks of each subject was used to define the spatial coordinate systems of fifteen segments. Then, the position of center of body mass could be calculated according to the body segment parameters. A force sensor was attached to the contact point between the wrists of two subjects for measuring the contact force. The movement of both subjects during practicing the fixed-steps pushing hands were collected by VICON motion analysis system at the sampling of 200 frames/s, and the contact force data was sampled synchronously at 1000 Hz. All data were filtered by 8Hz low-pass filter and analyzed by Visual 3D and MATLAB software. The raw data from the force sensor was displayed in voltage. Moreover, the voltage value was transformed into the force value. The movements of COM in forward-backward direction and the movements of the contact point of two wrists in forward-backward and right-left directions of each subject were compared with the contact force.

RESULTS AND DISCUSSION
Figures 2 showed the transformation between voltage and force of the force sensor in this study. It was found that the force was observed until the voltage value over than 4.75V. Figure 3 showed the movements of COM and the contact point of wrist comparing with contact force.

Table 1: The basic data of subjects.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Height</th>
<th>Weight</th>
<th>Style</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>27</td>
<td>174</td>
<td>68</td>
<td>Yang</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>53</td>
<td>173</td>
<td>82</td>
<td>Yang</td>
<td>33</td>
</tr>
</tbody>
</table>

Figure 1: Fixed-steps pushing hands with one hand, Peng style.
In the figure 3, the results showed that the contact force varied with the movement of the contact point of the wrist in the right-left direction. The results were similar to that the Tai Chi Chuan master moves his/her wrists with rotation in right-left direction to ward off opponent’s attack [2, 3]. In the pushing hands training, both persons should touch the opponent hand as lightly as possible in order to feel the opponent’s movements and not to be detected by the opponent [3]. However, the contact force between two subjects was too small to be observed by the force sensor actually in the current study.

CONCLUSIONS
The results from this study indicated that the subject avoided opponent’s attack by wrist movement in right-left direction, and the contact force was too small to be observed actually.

REFERENCES