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Title: Measurement of Spatial Stability in Precision Grip

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Author Questionnaire

1. Microscopy: Does your protocol involve video microscopy, such as filming a complex dissection or microinjection technique? **N**

2. Software: Does the part of your protocol being filmed demonstrate software usage? **Y**

3. Filming location: Will the filming need to take place in multiple locations (greater than walking distance)? **N**

Protocol Length

35 steps

56 shots

Introduction

1. Introductory Interview Statements

REQUIRED:

1.1. **Bumsuk Lee**: To obtain a comprehensive understanding of the grip force control of grasping, it is important to evaluate finger force direction **[1]**.

1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

REQUIRED:

1.2. **Bumsuk Lee**: We suggest a new, simple technique for measuring spatial stability in precision grasping to evaluate finger force direction in a clinical setting **[1]**.

1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

Introduction of Demonstrator on Camera

1.3. **Naoto Noguchi**: Demonstrating the procedure will be Ryoto Teshima, a PhD student from our laboratory **[1][2]**.

1.3.1. INTERVIEW: Author saying the above

1.3.2. Named demonstrator(s) looks up from workbench or desk or microscope and acknowledges camera

Ethics Title Card

1.4. Procedures involving human subjects have been approved by the Institutional Review Board (IRB) at Gunma University.

Protocol

2. Sensor Cable Connection

2.1. Before beginning an analysis, connect two sensor connector cables to the USB ports of a computer **[1]** and pull up the lever attached to one sensor connector **[2]** to allow insertion of the sensor tab into the insertion slot **[3]**.

2.1.1. WIDE: Talent connecting cable to USB port

2.1.2. Talent pulling up lever

2.1.3. Tab being inserted

2.2. Return the attached lever to its original position **[1]** and open the sensor software in the computer **[2]**.

2.2.1. Talent replacing lever

2.2.2. Talent opening software, with monitor visible in frame

2.3. If the sensor sheets are correctly connected, real-time pressure distribution maps will appear on the monitor **[1]**.

2.3.1. SCREEN: 1.2.: 00:05-00:09

3. Pressure Adjustment

3.1. To adjust the pressure, insert the sensing areas of the sensor sheet one by one into a compressor rig **[1]** and turn on the air valve of the compressor controller **[2]**.

3.1.1. WIDE: Talent inserting sensing area into compressor rig
3.1.2. Talent turning on air valve

3.2. Begin applying the pressure **[1]** and adjust the regulator to the appropriate load value **[2]**.

3.2.1. Talent applying pressure
3.2.2. SCREEN: 1.3.2.

3.3. While pressure is being applied, select **Tools** and **Equilibration** and click **Equilibrate-1** and **Start** in the equilibration dialog box. The color of equilibration of the window should change to gray **[1]**.

3.3.1. SCREEN: 1.4.1.: 00:00-00:26 *Video Editor: please speed up*

3.4. At the end of the equilibration, select **Save Eq. File**, enter the file name, and click **Save** to save the equilibration. Click **OK [1]**.

3.4.1. SCREEN: 1.4.2. *Video Editor: please speed up*

3.5. Select **Tools** and **Calibration** and click **Add** to enter the load value in Newtons in the **Applied Force** box **[1]**.

3.5.1. SCREEN: 1.4.3. *Video Editor: please speed up*

3.6. Click **Start** and check the calibration result to confirm that the calibration was performed correctly. Here the **Newton** value is 134.33 and the value of the **loaded Cells** matches that of the sensor sheets being used **[1]**.

3.6.1. SCREEN: 1.4.4. *Video Editor: please speed up; please indicate Newtons data in white box*

3.7. Then click **Save Cal. File**, enter the file name, and click **Save** to save the calibration **[1]**.

3.7.1. SCREEN: 1.4.5.: 00:00-00:26 *Video Editor: please speed up*

4. Measurement Preparation

4.1. ~~**[1]**~~ Place 3-5-millimeter-long pieces of double-sided tape onto each of the four corners of the iron cube **[2]**.

~~4.1.1. WIDE: Talent opening files, with monitor visible in frame~~

4.1.2. Talent placing tape

4.2. Use the tape to attach the pressure-sensitive parts of the two sensor sheets to both sides of the iron cube **[1]** and place the iron cube on top of a setting stand on a table **[2]**. Set up the devices for a measurement **[3]**. Then, open the equilibration and calibration files in the software **[4-added]**.

4.2.1. Sensor sheets being attached to cube

4.2.2. Cube being placed onto setting stand
4.2.3. Set up the device for a measurement
4.2.4. Added shoot: Open the equilibration and calibration files [1].

4.3. After arranging the measurement environment, select **Options** and **Acquisition Parameters** in the software **[1]**.

4.3.1. Talent selecting setting and recording, with monitor visible in frame

4.4. In the data acquisition parameter dialog box, enter 36000 in the **Movie Frames** box, 0.01 in the **Period** box, and 100 in the **Frequency** box and click **OK [1]**.

4.4.1. SCREEN: 2.1.5.: 00:22-00:47 *Video Editor: please speed up*

5. Performing a Measurement

5.1. To perform a measurement, have the Participant sit in front of a table **[1]** and adjust the table height to the Participant's shoulder joint flexion of 0 degrees and a 90-degree elbow joint flexion position **[2]**.

5.1.1. WIDE: Talent gesturing while Participant sits
5.1.2. Talent adjusting table height

5.2. Set the iron cube and setting stand 30 centimeters from the Participant in the midsagittal plane on the table **[1]** and wipe the Participant's finger pulps with an alcohol swab or towelette **[2]**.

5.2.1. Talent placing cube/stand onto table 30 centimeters from the Participant in the midsagittal plane on the table
5.2.2. Talent wiping Participant finger pulps

5.3. Instruct the Participant to "Use minimal force with their thumb and index finger to grasp both sides of the iron cube to which the sensor sheets are attached" and to "Lift the cube approximately 5 centimeters above the setting stand, holding it for 5-7 seconds before placing it back on the setting stand" **[1]**.

5.3.1. Talent instructing Participant while demonstrating task *Videographer: Important/difficult step*

5.4. When the Participant is ready, **[1]** click **Record** and **Center of Force Trajectory** to monitor the center of pressure in the software and give them a cue to start the task **[2]**.

5.4.1. Talent indicating Participant should perform task
5.4.2. SCREEN: 2.2.3. 00:11-00:28 *Video Editor: please speed up*

5.5. When the task has been completed, click **Stop [1]** and save the recorded movie data **[2]**.

5.5.1. SCREEN: 2.2.3: 02:03-02:13
5.5.2. SCREEN: 2.2.3.: 02:48-03:40 *Video Editor: please speed up*

5.6. To assess task performance in the presence of visual interference, first allow the Participant to touch the sensors without exceeding 0.5 Newtons of pressure **[1]** before instructing the Participant to "Close their eyes and use minimal force with their thumb and index finger to lift the iron cube approximately 5 centimeters above the setting stand. Then hold the cube for 5-7 seconds before placing it back on the setting stand" **[2]**.

5.6.1. Participant touching sensor
5.6.2. Talent instructing while Participant closes eyes and begins performing/performs task *Videographer: Important step*

5.7. To assess task performance in the presence of cognitive interference, instruct the Participant to "As a calculation task, continuously subtract 7 from 100 as accurately as possible while using minimal force with their thumb and index finger to lift the iron cube approximately 5 centimeters above the setting stand for 5-7 seconds before placing it back on the setting stand" **[1]**.

5.7.1. Talent instructing while Participant subtracts 7 from 100 while beginning to perform/performing task *Videographer: Important step*

5.8. To assess task performance in the presence of contralateral hand movement interference, place a peg board 30 centimeters away from the Participant next to the iron cube in the midsagittal plane **[1]** and place the appropriate size and number of pegs according to the task difficulty **[2]**.

5.8.1. Talent placing peg board in front of Participant
5.8.2. Talent adding peg(s)

5.9. Then instruct the Participant to "Manipulate the iron cube with minimal force using their thumb and index finger" and to "Lift and hold the iron cube approximately 5 centimeters above the setting stand with one hand while inverting the pegs with the other hand" **[1-TXT]**.

5.9.1. Talent instructing while Participant begins to perform/performs task *Videographer: Important step* **TEXT: Have Participant repeat task with opposite hand**

6. Grip Force (GF) Analysis

6.1. To analyze the grip force, open the movie file for analysis in the dialog box **[1]**.

6.1.1. WIDE: Talent opening movie

6.2. When the recorded pressure distribution map appears, click **Multiple Windows View** to open the graph window **[1]**.

6.2.1. SCREEN: 3.1.2.: 00:09-00:14

6.3. Locate the point in time at which the load starts to be applied in each lift and note the time with reference to the graph **[1]**.

6.3.1. SCREEN: 3.1.2.: 00:32-01:10 *Video Editor: please speed up; please indicate INCREMENT time in sec on right of frame one second vertical line in place*

6.4. Save the grip force data in ASCII format **[1]** and open the movie file **[2]**.

6.4.1. SCREEN: 3.1.3.: 00:39-01:30 *Video Editor: please speed up*
6.4.2. SCREEN: 3.1.5.: 00:02-00:08

6.5. Locate the frame number at which the load started to be applied in each lift in the spreadsheet **[1]** and note the frame number in reference to the time point at which the load was applied **[2]**.

6.5.1. SCREEN: 3.1.5.: 00:08-00:34 *Video Editor: please speed up*
6.5.2. SCREEN: 3.1.5.: 01:12-01:27

6.6. Then calculate the total grip force used in a range, which is the sum of the values from the cell that was applied **[1]**.

6.6.1. SCREEN: 3.1.6.: 00:06-00:36 *Video Editor: please speed up*

7. Center of Pressure (COP) Analysis

7.1. To analyze the center of pressure, open the movie file for analysis **[1]** to display the center of pressure trajectory on the pressure distribution map **[2]**.

7.1.1. WIDE: Talent opening movie, with monitor visible in frame
7.1.2. SCREEN: 3.2.2.: 00:06-00:11

7.2. With the recorded pressure distribution map active, click **Play Forward** to play the movie **[1]**.

7.2.1. SCREEN: 3.2.2.: 00:12-00:28 *Video Editor: please speed up*

7.3. Click **Stop** and advance frame by frame until the frame at which the center of pressure begins to appear in each lift on the pressure distribution map **[1]**.

7.3.1. SCREEN: 3.2.2.: 00:29-00:57 *Video Editor: please speed up*

7.4. Note the frame number **[1]** and save the center of pressure data in ASCII format, making sure that **Center of Force** and **Whole Movie** are selected **[2]**.

7.4.1. SCREEN: 3.2.2.: 00:57 *Video Editor: please indicate Frame 511 of 11568 in bottom left of frame*
7.4.2. SCREEN: 3.2.3.: 00:18-01:05 *Video Editor: please speed up*

7.5. Open the movie file **[1]** and locate the frame number at which the center of pressure begins to appear in each lift on the spreadsheet with reference to the noted frame number **[2]**.

7.5.1. SCREEN: 3.2.4.: 00:02-00:07
7.5.2. SCREEN: 3.2.4.: 01:06-01:20 *Video Editor: please speed up*

7.6. Then calculate the center of pressure trajectory length between frames **[1]**.

7.6.1. SCREEN: 3.2.5.: 00:00-00:53 *Video Editor: please speed up*

Protocol Script Questions

A. Which steps from the protocol are the most important for viewers to see?
5.3.1., 5.6.2., 5.7.1., 5.9.1.

B. What is the single most difficult aspect of this procedure and what do you do to ensure success?
5.3.1.

Results

8. Results: Representative Dominant Index Finger COP Trajectories and GF Traces

8.1. Here the center of pressure trajectories **[1]** and grip force traces **[2]** of the dominant index finger in single **[3]** and dual tasks for representative young and elderly adults are shown **[4]**.

8.1.1. LAB MEDIA: Figure 3 *Video Editor: please emphasize images*
8.1.2. LAB MEDIA: Figure 3 *Video Editor: please emphasize graphs*
8.1.3. LAB MEDIA: Figure 3 *Video Editor: please emphasize Single task images*
8.1.4. LAB MEDIA: Figure 3 *Video Editor: please emphasize Double task images*

8.2. In this representative analysis, the grip force increased in the contralateral hand movement interference **[1]**, while the center of pressure trajectories tended to decrease **[2]**.

8.2.1. LAB MEDIA: Figure 3 *Video Editor: please data line in Dual task graphs*
8.2.2. LAB MEDIA: Figure 3 *Video Editor: please white lines in Dual task images*

Conclusion

9. Conclusion Interview Statements

9.1. **Naoto Noguchi**: Be sure to inform the participants to use minimal force when performing the tasks, otherwise they will tend to use a relatively strong grip force to avoid spatial instability **[1]**.

9.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera (5.3.)