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Tainan, Taiwan

Innovative Handle Design and Evaluation of Woks for Middle-Aged and Elderly People

Fong-Gong, Wu

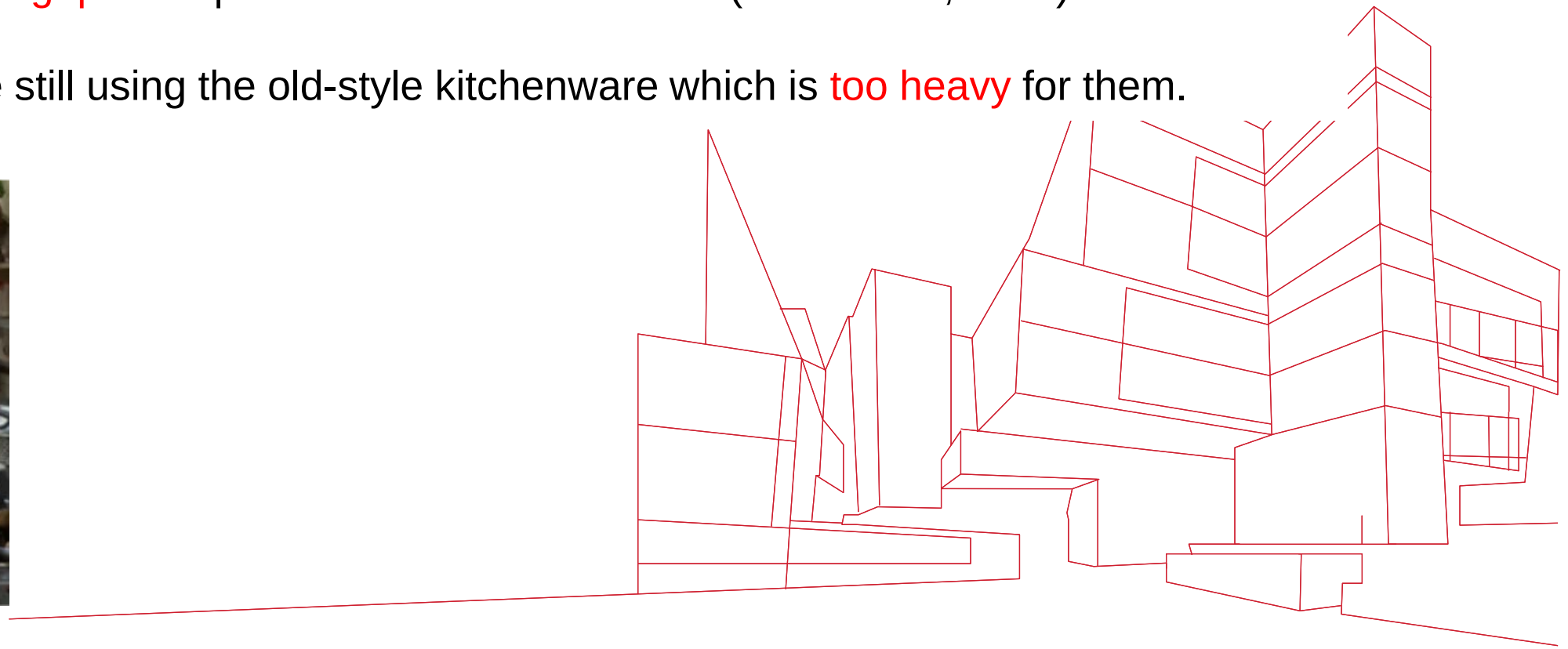
National Cheng Kung University

Background

In Taiwan, elder people do not eat out very often due to their living habits for decades and the inconvenience in mobility. Instead, they prefer cooking for themselves.

The decrease of upper body functions makes it difficult for elder people to operate kitchenware, rotate grips and perform certain fine actions (Holt & Holt, 2011).

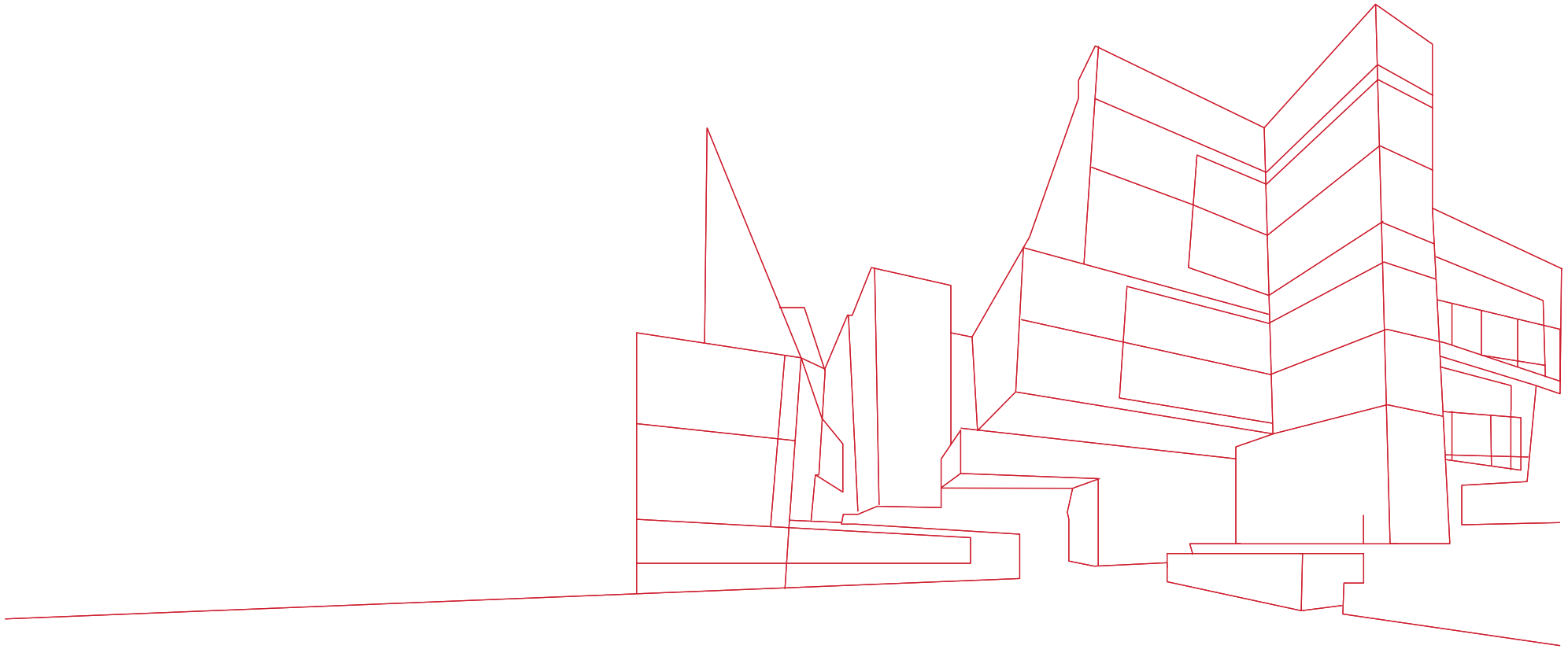
However, they are still using the old-style kitchenware which is too heavy for them.



Purposes

(1) To design aids for traditional woks and saucepans.

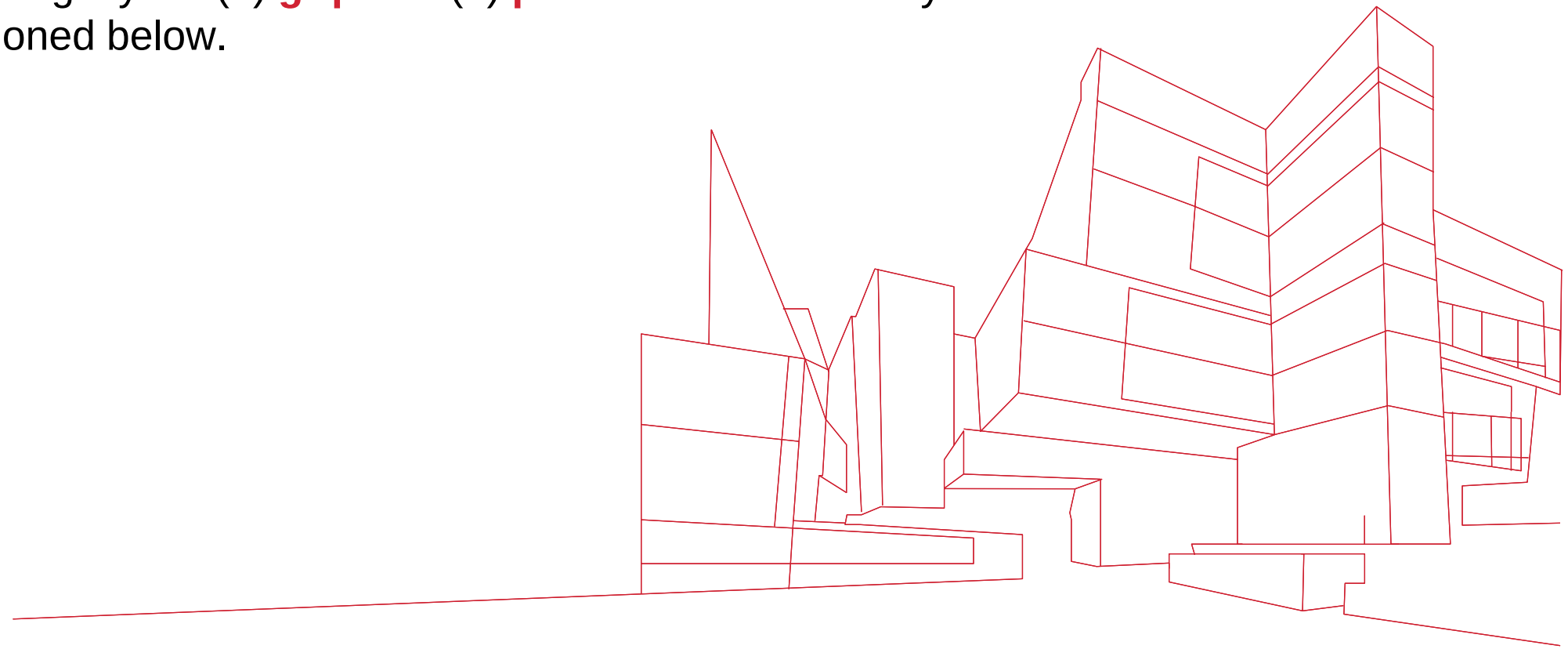
(2) To evaluate the aids designed in this research by electromyogram (EMG) and subjective questionnaire for assessment of results.



Observation and Literature Review

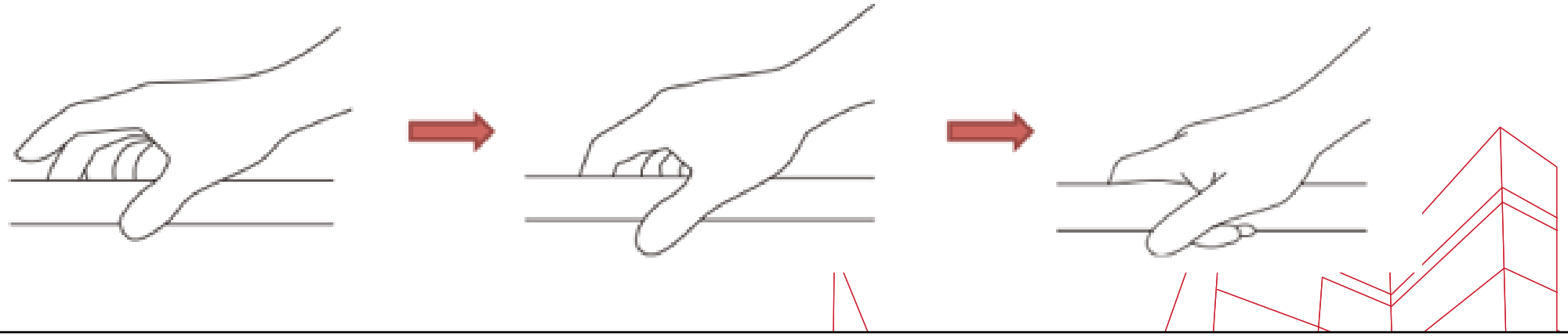
In this research, wok tasks, which involve a lot of hand motions, will be focused. When holding things, the force is mainly from our fingers and wrists (Goislard de Monsabert, Vigouroux, Bendahan, & Berton, 2014).

There are two holding styles: (1) **grip** and (2) **pinch**. The serial analyses of these two motions are mentioned below.



Observation and Literature Review

1. Gripping

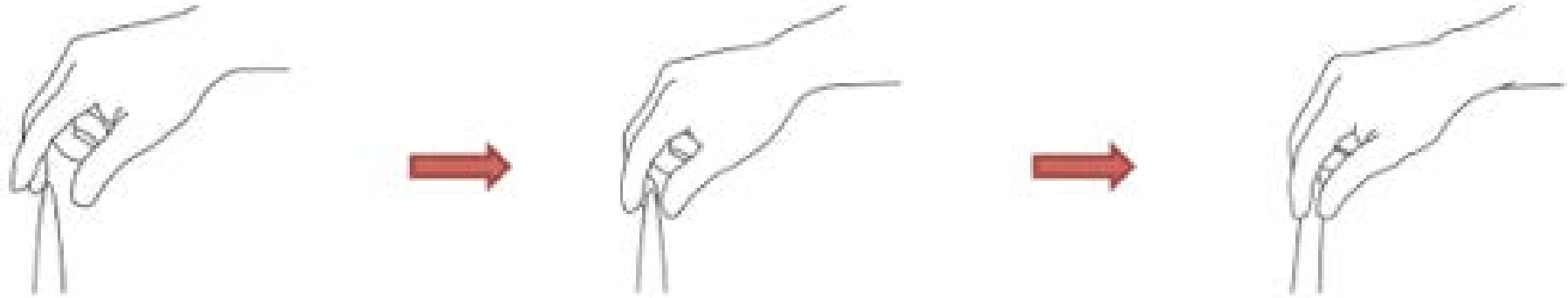


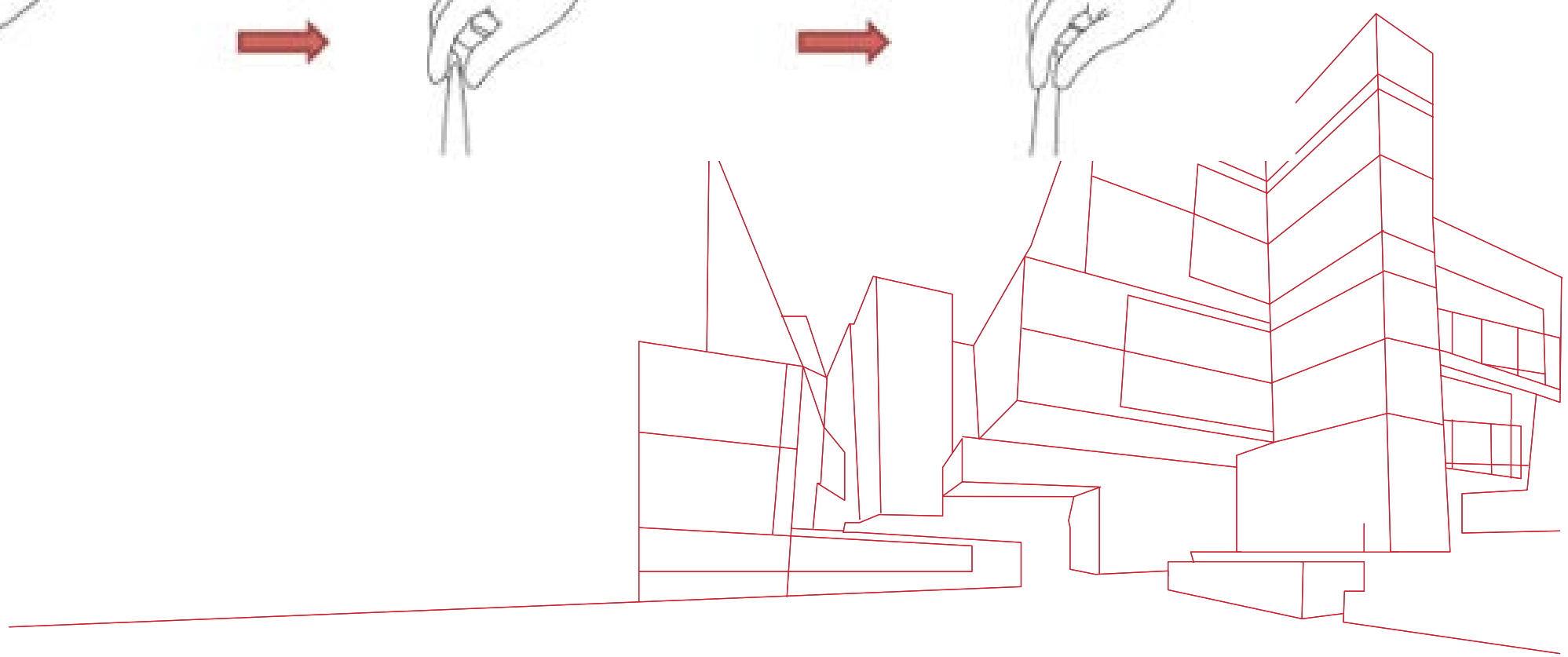
Motion description	Working Muscles
Placing fingers	Lumbrical muscles and extensor digitorum muscles.
Approaching	Finger flexor muscles control the bending of fingers; extensor carpi ulnaris and flexor carpi radialis fix the angle of wrist.
Gripping in static state	No movements at this stage. Muscles involved are isometric.

Observation and Literature Review

2. Pinching

Motion Description Working Muscles





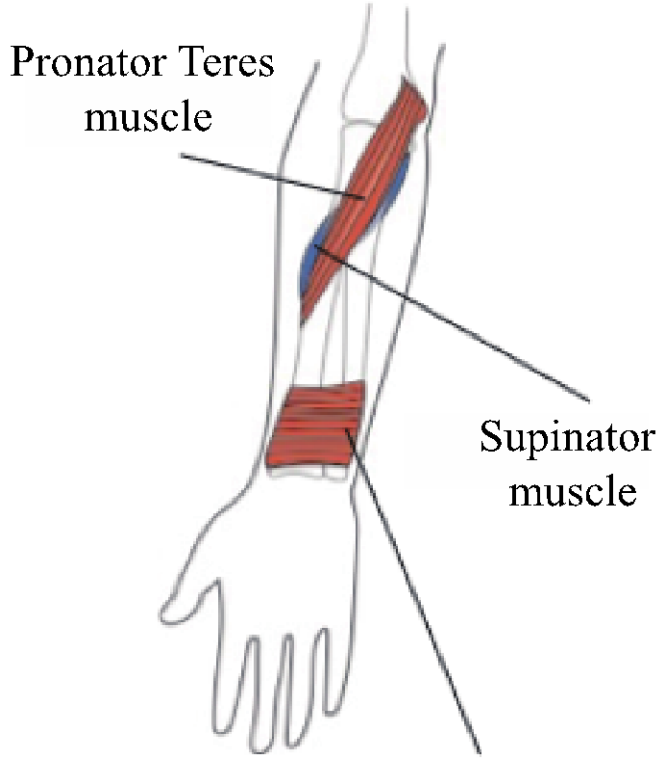
Observation and Literature Review

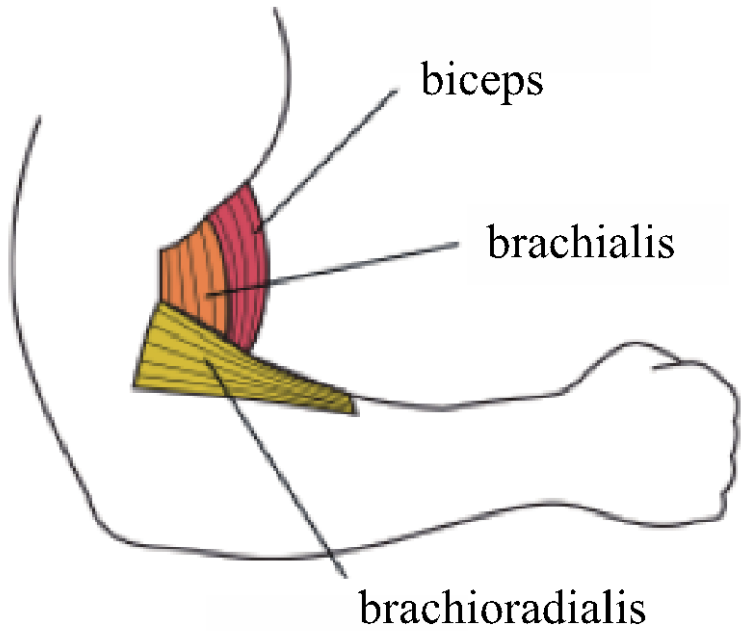
2. Pinching

Motion Description	Working Muscles
Opening	The number of fingers open depends on the shape of the objects and the intention of the action. Thu, there are unlimited combinations between lumbrical muscles and extensor digitorum muscles.
Placing fingers	Unlike gripping, when pinching, thumb is always on the opposite side of other fingers, and objects will be held by the first knuckles of fingers.
Approaching	Finger flexor muscles control the bending of fingers; extensor carpi ulnaris and flexor carpi radialis fix the angle of wrist. Usually, index fingers, middle fingers and ring fingers stay curved, and little fingers might be curved or straight.
Pinching	No movements at this stage. Muscles involved are isometric.

Observation and Literature Review

Forearm rotates and lifts objects randomly when working in a kitchen, which means there is no standard procedure for these motions. In that case, we list movements and muscles that are possibly involved.





Observation and Literature Review

Working with bending wrist for long periods will cause **pain** and **chronic diseases**, or even **permanent damages** (Tichauer, 1966).

Grip force performs the best when wrists are kept central (Kadefors et al., 1993). Thus, it is important to **keep wrists central** when designing handles.

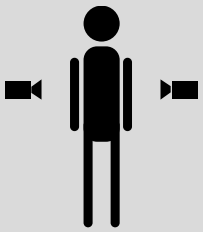
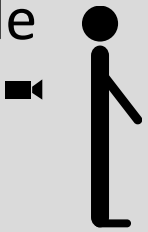
Previous findings show that compared to cylindrical handles, people feel more satisfied with the handles that fit their hands (Lewis, 1993; Harih and Dolsak, 2014).

Method

1. Observation

The participant was asked to repeat the task we assigned for several times, and videos were recorded from behind the participant, as well as her left and right-hand sides.

Method

	Content	Notes
Participant	Ms. Hung	80 years old/ Female/ Well experienced on cooking/ No upper body diseases
Environment	Kitchen	
Camera set	Front  Side 	Videos will be recorded from the participant's back, left-hand and right-hand side.
Task	To repeat the assigned task: Scoop up ingredients into dishes	Repeat for at least five times
Apparatus	Apple iPhone 5s 16G	Slow motion video

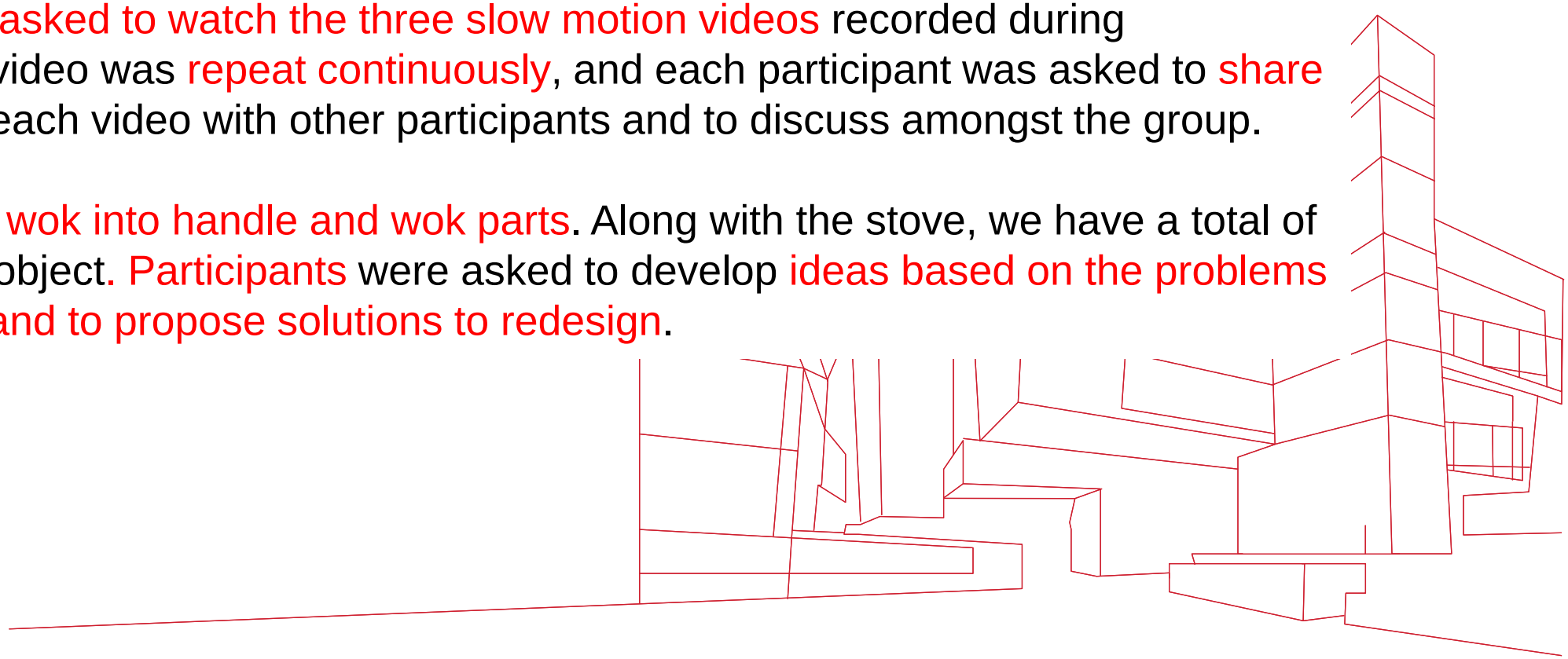
Method

2. Focus group

6 people (with an average age of 25.6 years old) with design backgrounds were invited to participate in the focus group process. Before the process, participants were asked to gain knowledge of our issue and background information.

Participants were asked to watch the three slow motion videos recorded during observation. The video was repeat continuously, and each participant was asked to share their thoughts on each video with other participants and to discuss amongst the group.

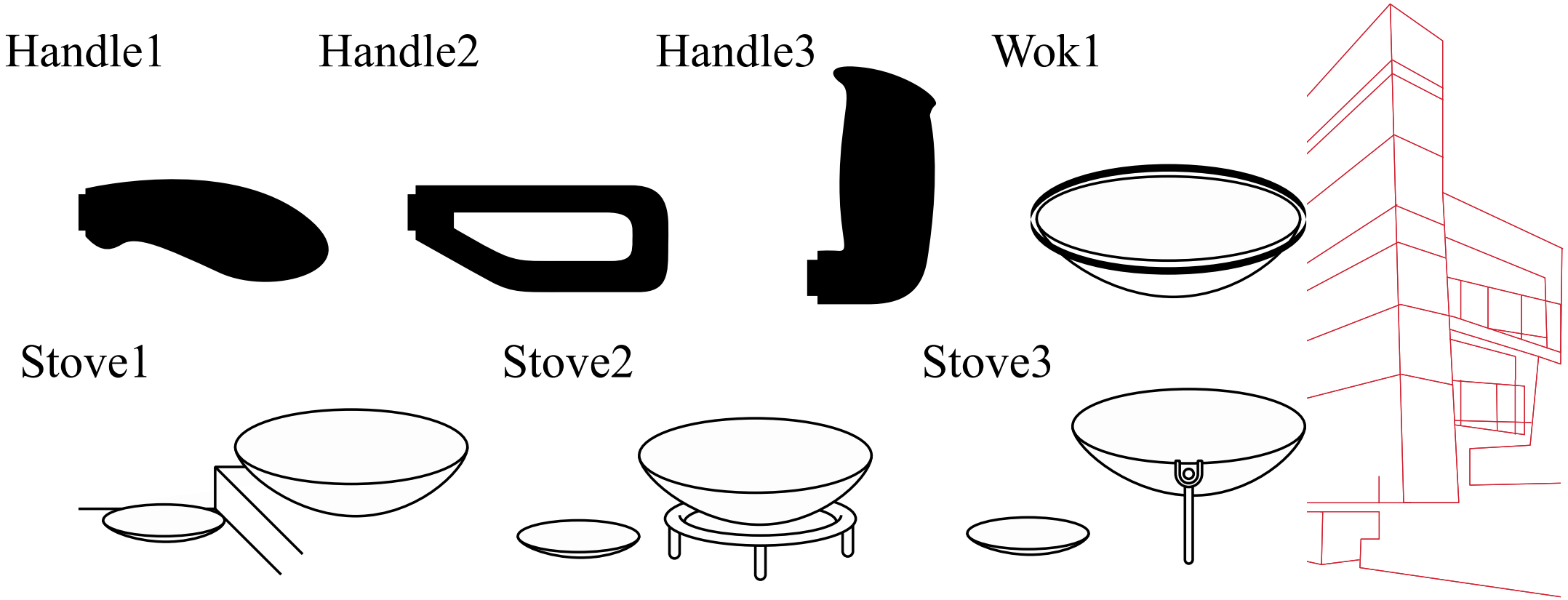
We separated the wok into handle and wok parts. Along with the stove, we have a total of three parts of the object. Participants were asked to develop ideas based on the problems they pointed out, and to propose solutions to redesign.



Method

3. Design Development

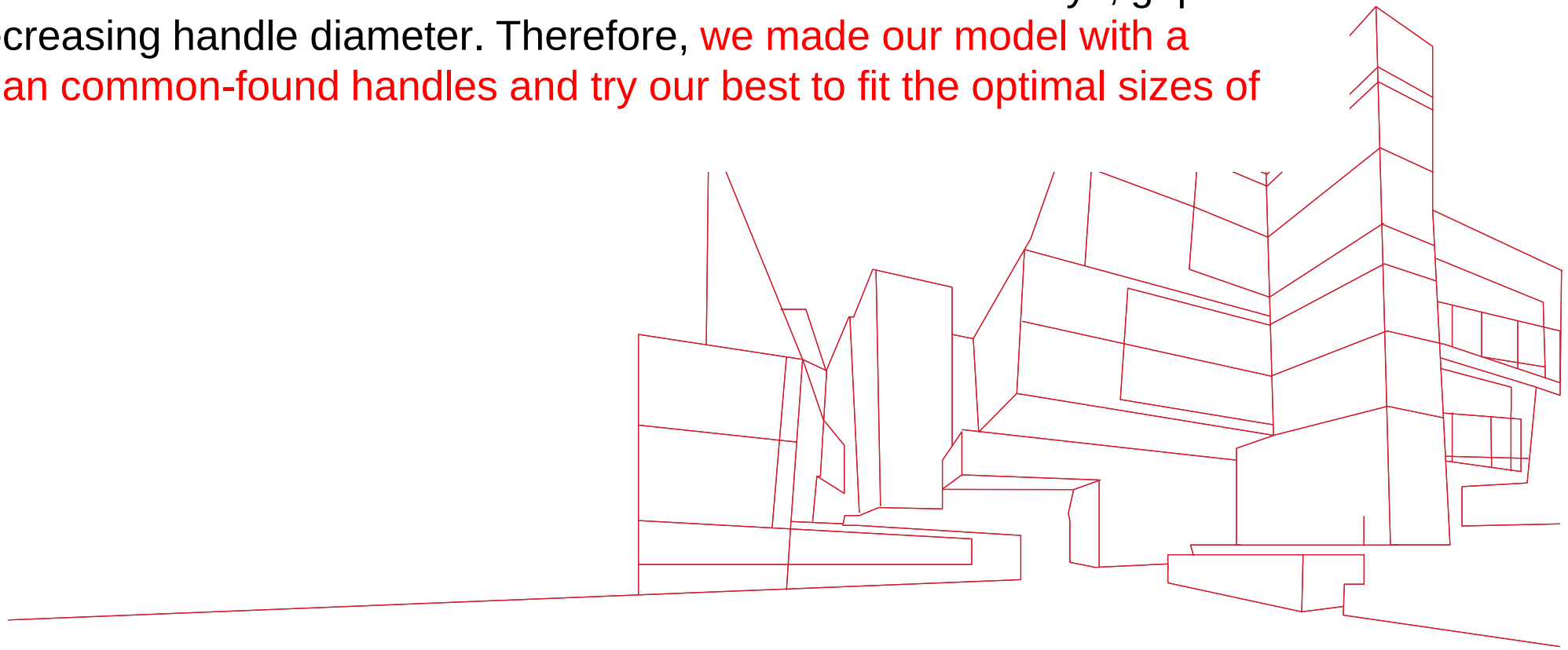
We chose three handles (thick handle, hollow handle and upright handle), one wok (anti-flipping wok) and three stoves (stove plate, rounded stove and stove stand) as our solutions. The reasons we chose these solutions are due to the feasibility and our technology limitations.



Method

3. Design Development

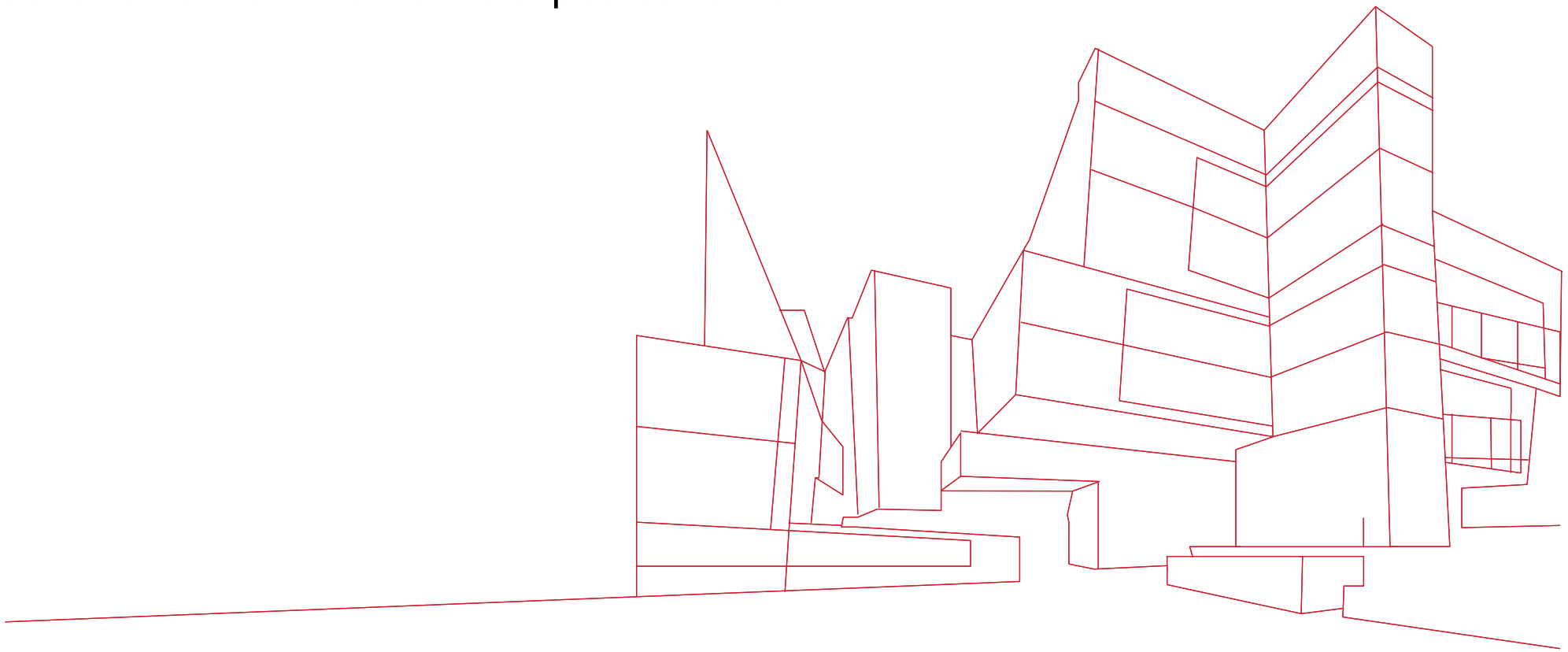
The concept handle models are made with PU foam. With the concept models we can make little adjustments to the handle shape so as to fit the hands. As for the sizes, Seo and Armstrong (2008) mentioned that if the hand optimal size is bigger than the handle diameter, which is the common situation for woks that are available nowadays, grip force decreases with decreasing handle diameter. Therefore, we made our model with a diameter bigger than common-found handles and try our best to fit the optimal sizes of hands.



Method

3. Design Development

Working models are made by Up Plus 3D printer using ABS as our material. The thickness of layer was 0.2 mm, and the print speed was medium. The handle is replaceable, so we can change the handles we printed to evaluate their effectiveness. The figure is the illustration of how the wok is expected to work.



Method

3. Design Development

Figure (a) is the wok used in this research. The diameter is 38 centimeters, and the weight is 1.5 kilograms. The handle is replaceable, so we can change the handles we printed to evaluate their effectiveness. Figure (b) is the wok design. This structure is expected to make users avoid flipping the wok.

(a)

(b)

Method

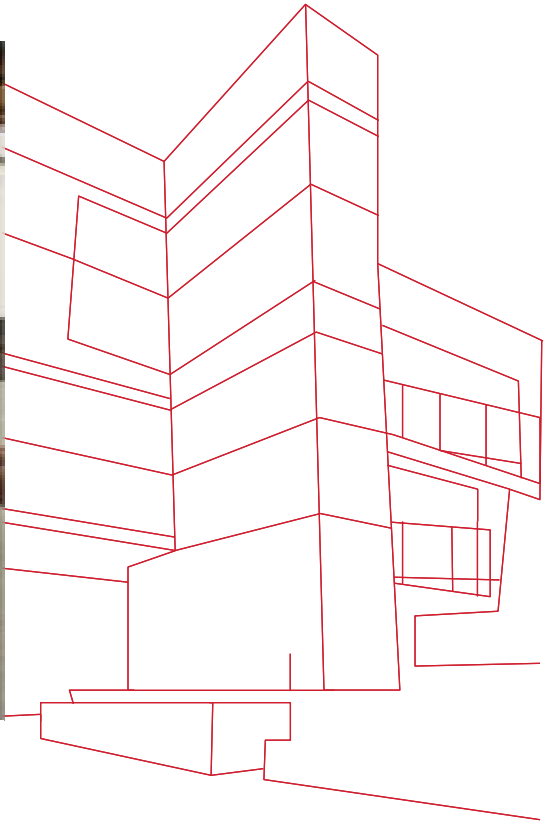
3. Design Development

Figure 8(a) is to make the dish lower than the stove. Figure 8(b) is to add a circle base around the stove so that the wok can rotate smoothly along the base. Figure 8(c) is to provide a standing stand so that users can place the wok after they lift them in the air, which could make flipping woks easier to accomplish.

(a)

(b)

(c)



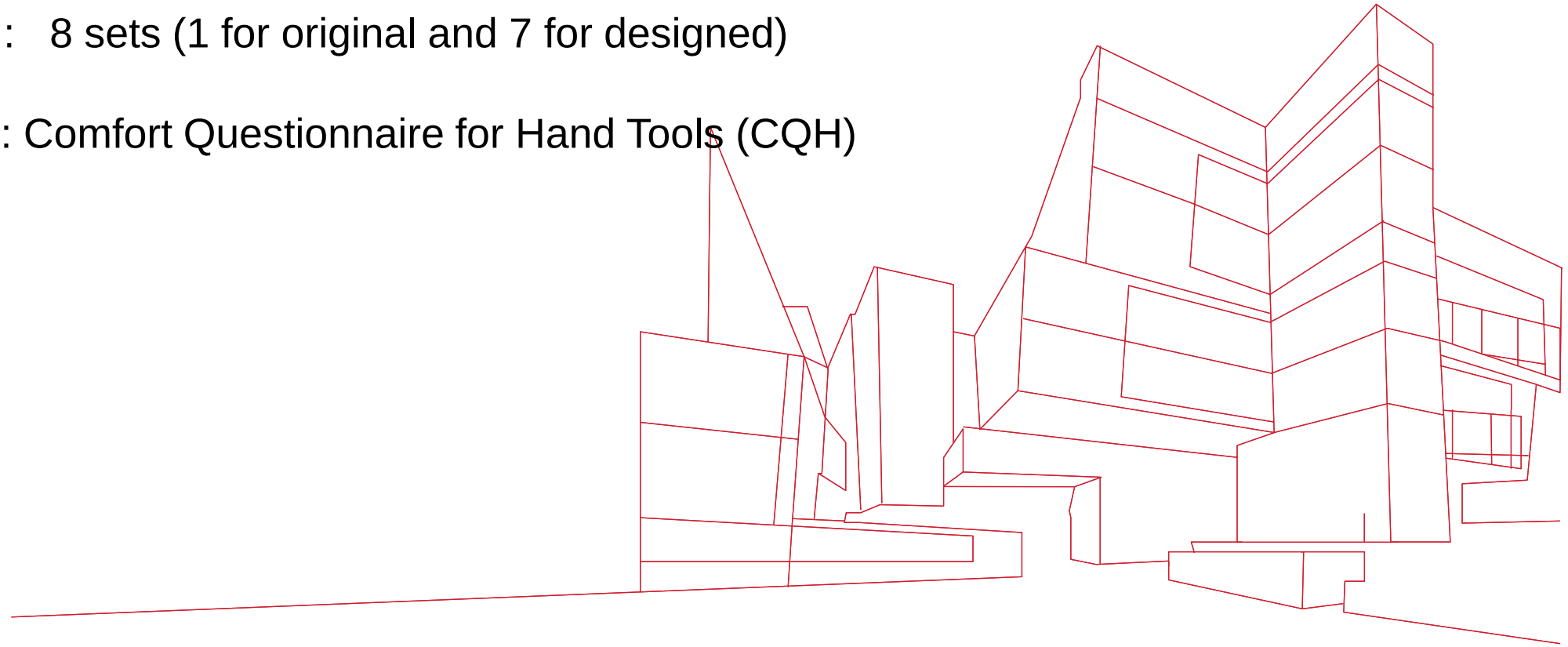
Method

4. Pre-test

(a) Participants : x7

(b) Tasks : 8 sets (1 for original and 7 for designed)

(c) Questionnaire : Comfort Questionnaire for Hand Tools (CQH)



Method

Items		Pavg	Navg	Pavg/Navg	Rank
Thick handle		4.81	2.333	2.061	3
Hollow handle		5.27	2.667	1.976	4
Upright handle		4.524	3.238	1.397	6
Anti-flipping wok		4.679	3.982	1.175	7
Stove plate		6.071	1.911	3.178	1
Rounded stove		4.964	3.107	1.598	5
Stove stand		6.179	2.036	3.035	2

Method

5. Experiment

(a) Participants :

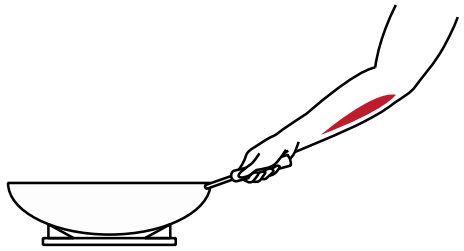
(b) Apparatus : EMG & Short-focused projector

(c) Environment : Shown as figure

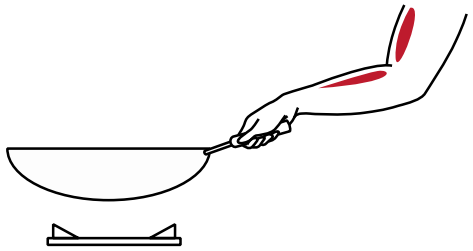
Method

5. Experiment

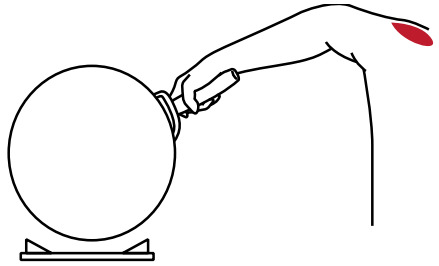
After the pretest, we chose 4 solutions, including 2 handles and 2 stoves. With the original handle, a totally of 5 sets of experiments were conducted. The evaluation of this research is the EMG data for using these models. 8 middle-aged participants were invited as the participants. Participants were asked to perform the task we chose from the questionnaire.



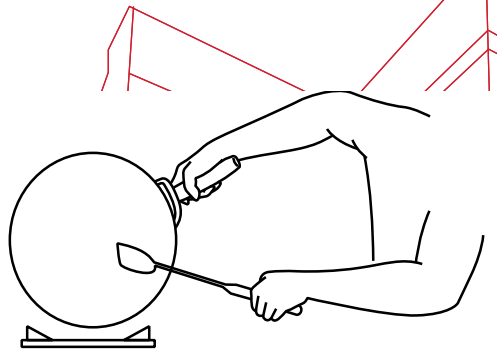
(a) Ready/ Put back



(b) Lift



(c) Flip



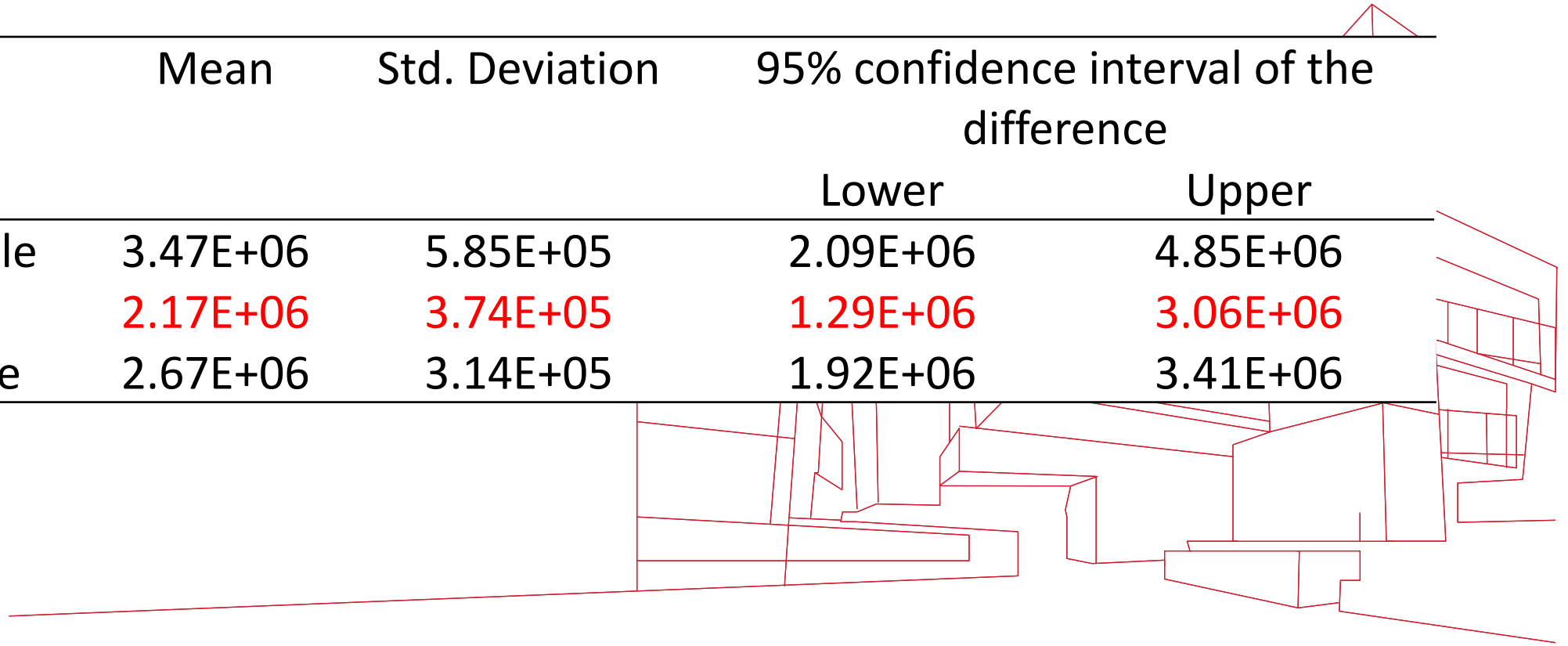
(d) Scoop up ingredients

Result

1. EMG Data Analyses of Handles

The sequence of the effect to FDS (Flexor Digitorum Superficialis) would be (from better to worse): Thick handle>Hollow handle>Original handle.

Designs	Mean	Std. Deviation	95% confidence interval of the difference	
			Lower	Upper
Original handle	3.47E+06	5.85E+05	2.09E+06	4.85E+06
Thick handle	2.17E+06	3.74E+05	1.29E+06	3.06E+06
Hollow handle	2.67E+06	3.14E+05	1.92E+06	3.41E+06

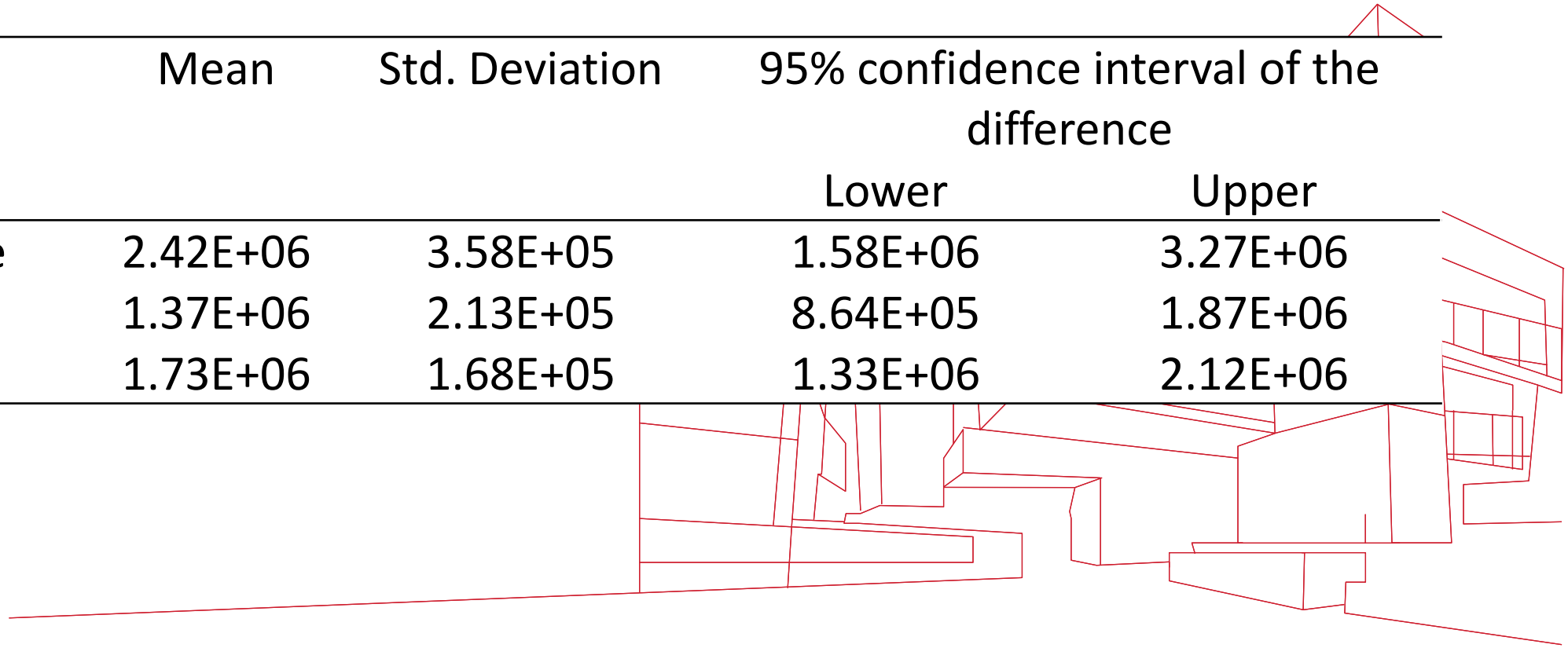


Result

2. EMG Data Analyses of Stoves

A brief trend can be seen from the mean value which shows that the two stove design solutions are lower than the original one.

Designs	Mean	Std. Deviation	95% confidence interval of the difference	
			Lower	Upper
Original stove	2.42E+06	3.58E+05	1.58E+06	3.27E+06
Stove plate	1.37E+06	2.13E+05	8.64E+05	1.87E+06
Stove stand	1.73E+06	1.68E+05	1.33E+06	2.12E+06



Result

2. EMG Data Analyses of Stoves

According to the descriptive data shown in table, the stove plate performed slightly better than the stove stand. This shows that the two stove design solutions did help the task significantly.

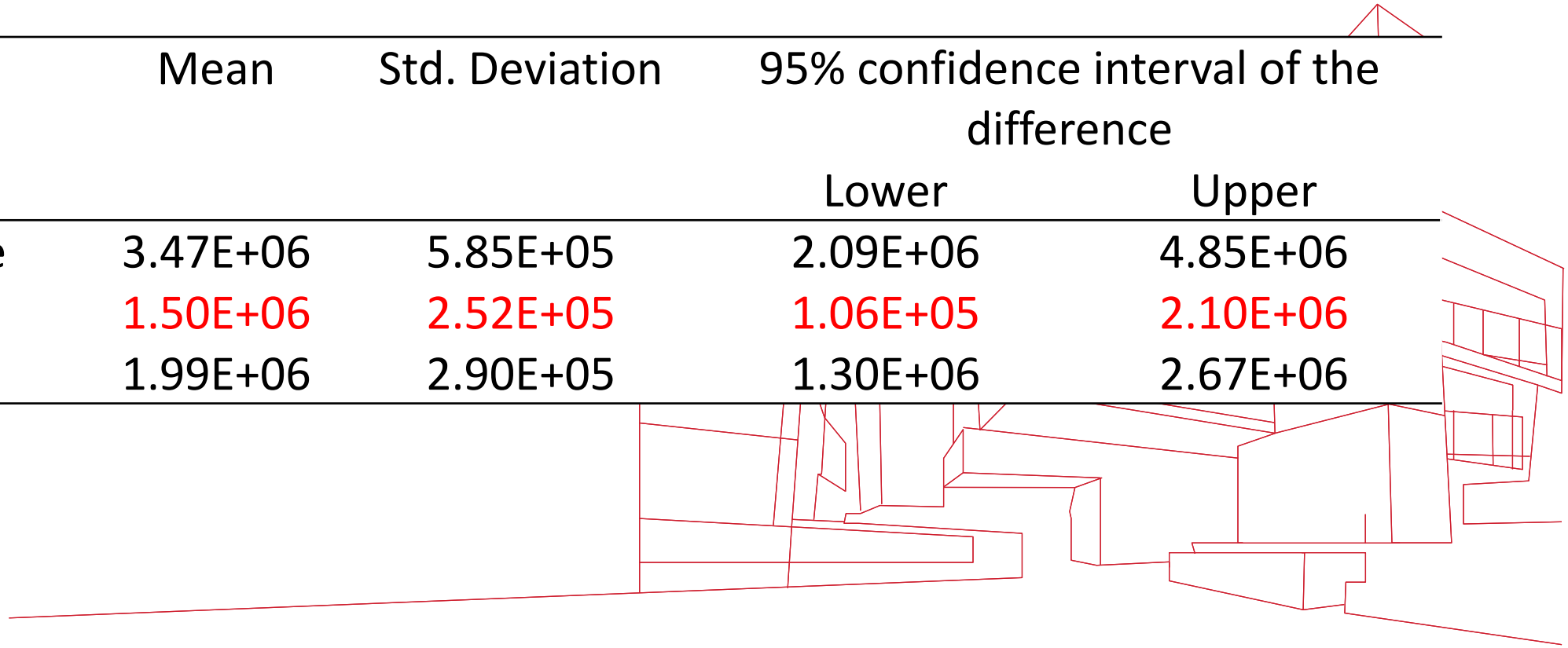
(I) designs	(J) designs	Mean Difference (I-J)	Std. Deviation	Sig.	95% confidence interval of the difference	
					Upper	Lower
Original	Stove plate	1.06E+06	3.16E+05	0.012*	3.07E+05	1.80E+06
stove	Stove stand	6.97E+05	2.57E+05	0.03*	8.94E+04	1.30E+06
Stove plate	Original wok	-1.06E+06	3.16E+05	0.012*	-1.80E+06	-3.07E+05
	Stove stand	-3.59E+05	2.17E+05	0.142	-8.72E+05	1.55E+05
Stove stand	Original wok	-6.97E+05	2.57E+05	0.03*	-1.30E+06	-8.94E+04
	Stove plate	3.59E+05	2.17E+05	0.142	-1.55E+05	8.72E+05

Result

2. EMG Data Analyses of Stoves

FDS shows the least loading when working with stove plate. The design solutions all eased the pressure of FDS. The sequence of the effect to FDS would be (from better to worse): Stove plate>Stove stand >Original stove.

Designs	Mean	Std. Deviation	95% confidence interval of the difference	
			Lower	Upper
Original stove	3.47E+06	5.85E+05	2.09E+06	4.85E+06
Stove plate	1.50E+06	2.52E+05	1.06E+05	2.10E+06
Stove stand	1.99E+06	2.90E+05	1.30E+06	2.67E+06

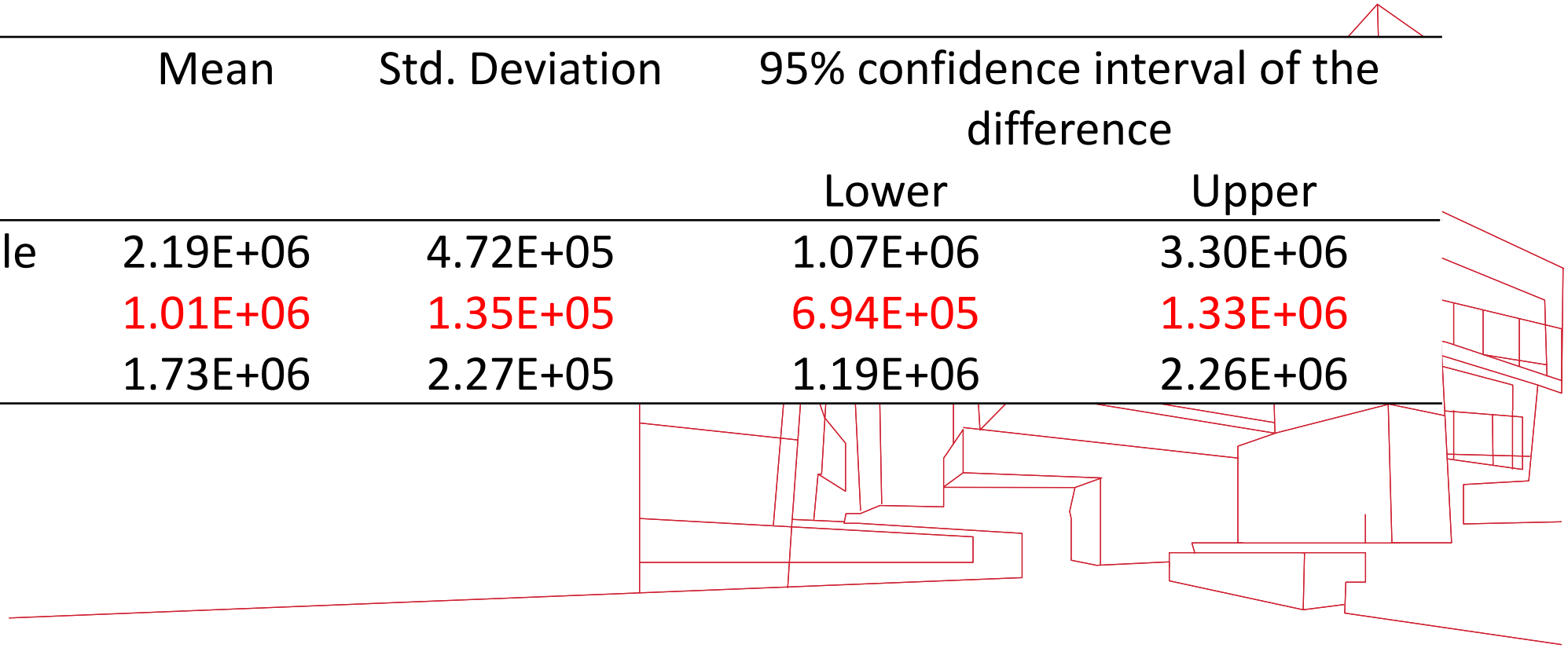


Result

2. EMG Data Analyses of Stoves

The design solutions all eased the pressure of Biceps. The sequence of the effect to Biceps would be (from better to worse): Stove plate>Stove stand >Original stove.

Designs	Mean	Std. Deviation	95% confidence interval of the difference	
			Lower	Upper
Original handle	2.19E+06	4.72E+05	1.07E+06	3.30E+06
Stove plate	1.01E+06	1.35E+05	6.94E+05	1.33E+06
Stove stand	1.73E+06	2.27E+05	1.19E+06	2.26E+06

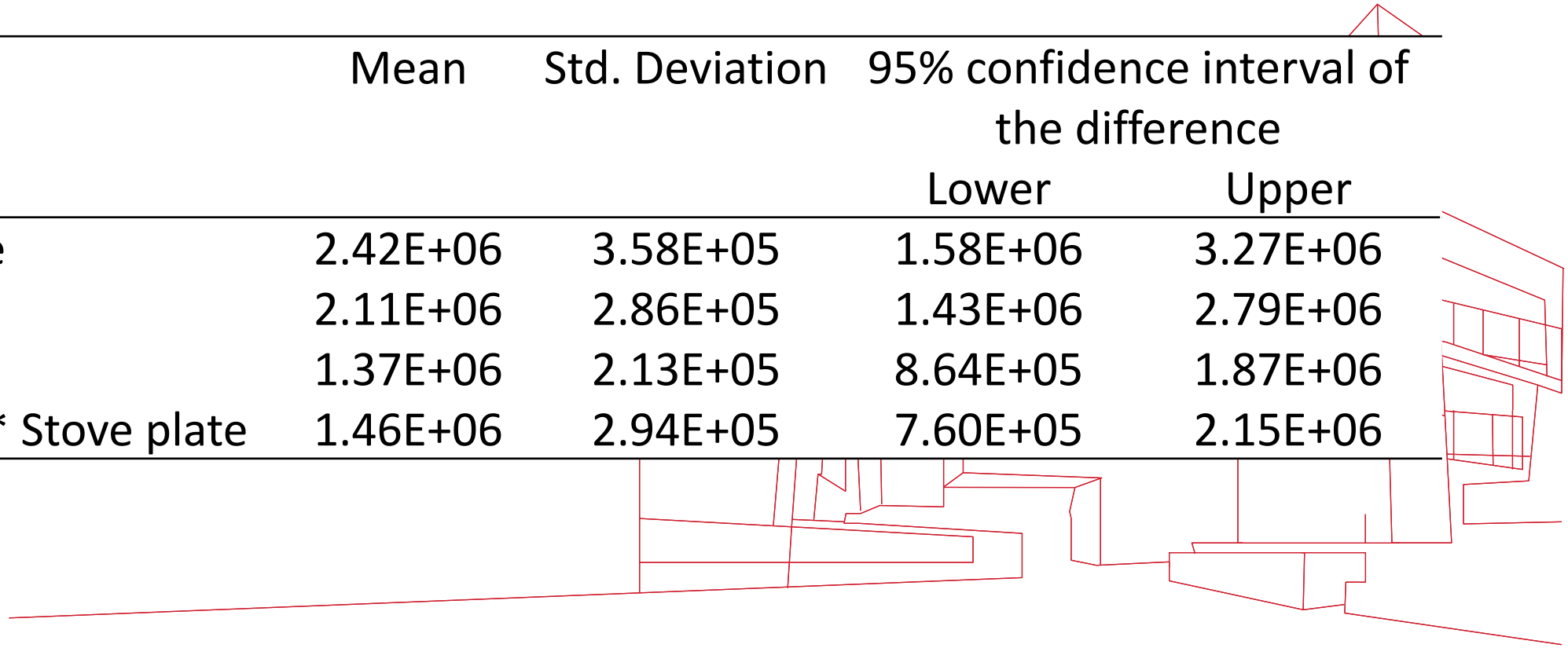


Result

3. EMG Data Analysis of Combination of Handles and Stoves

The combination of thick handle and stove plate did not show better performance than using the stove plate alone.

Designs	Mean	Std. Deviation	95% confidence interval of the difference	
			Lower	Upper
Original stove	2.42E+06	3.58E+05	1.58E+06	3.27E+06
Thick handle	2.11E+06	2.86E+05	1.43E+06	2.79E+06
Stove plate	1.37E+06	2.13E+05	8.64E+05	1.87E+06
Thick handle* Stove plate	1.46E+06	2.94E+05	7.60E+05	2.15E+06



Result

4. Subjective Questionnaire

Participants of the experiment were less satisfied with the design solutions than participants of the pretest.

Items		Pavg	Navg	Pavg/Navg	Rank	Pavg/Navg (pretest)	Rank (pretest)
Thick handle		3.711	3.733	0.994	4	2.061	3
Hollow handle		4.111	3.133	1.312	3	1.976	4
Stove plate		4.95	2.975	1.664	1	3.178	1
Stove stand		4.35	2.7	1.611	2	3.035	2

Discussion

Since the design solutions of this research are all based on a traditional wok, we chose a wok with a changeable handle. There were two problems with the wok:
(1) an awkward angle of handle. (2) Too heavy.

Figure 11. Awkward angle of the traditional wok

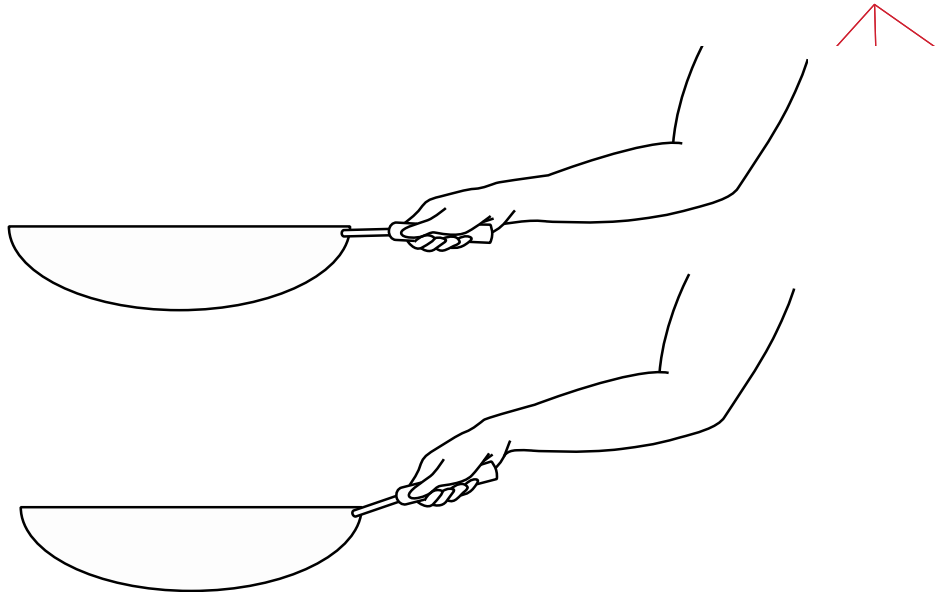


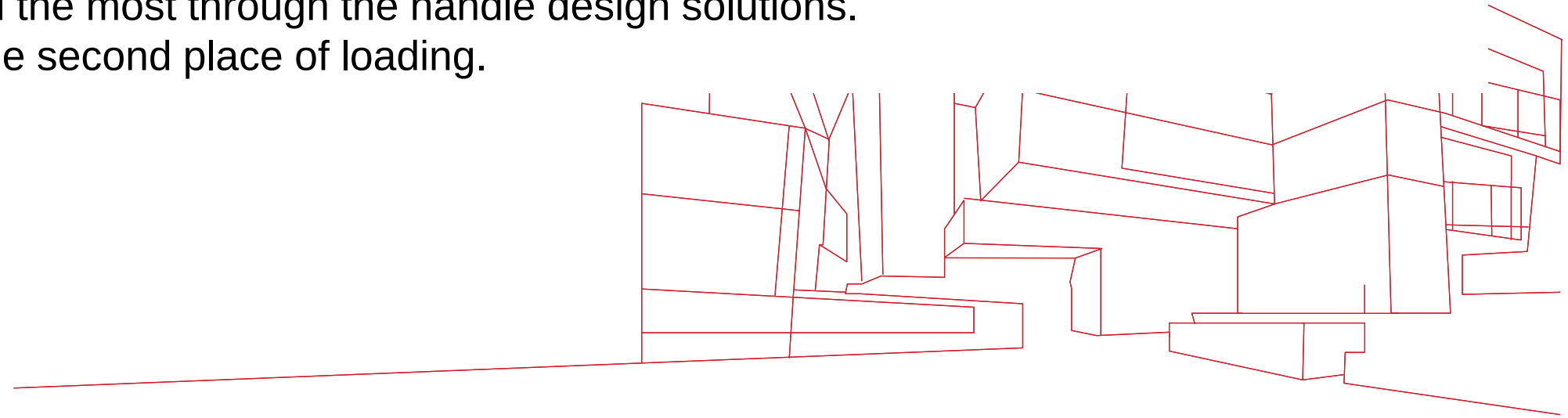
Figure 12. Ulnar deviation caused by the angle of handle

Discussion

- The factor that influenced the signal quality might be the difference between male and female :
  → Females have more subcutaneous fat which makes their muscles more difficult to show.
  → Weaker muscle performance may cause weak signals.

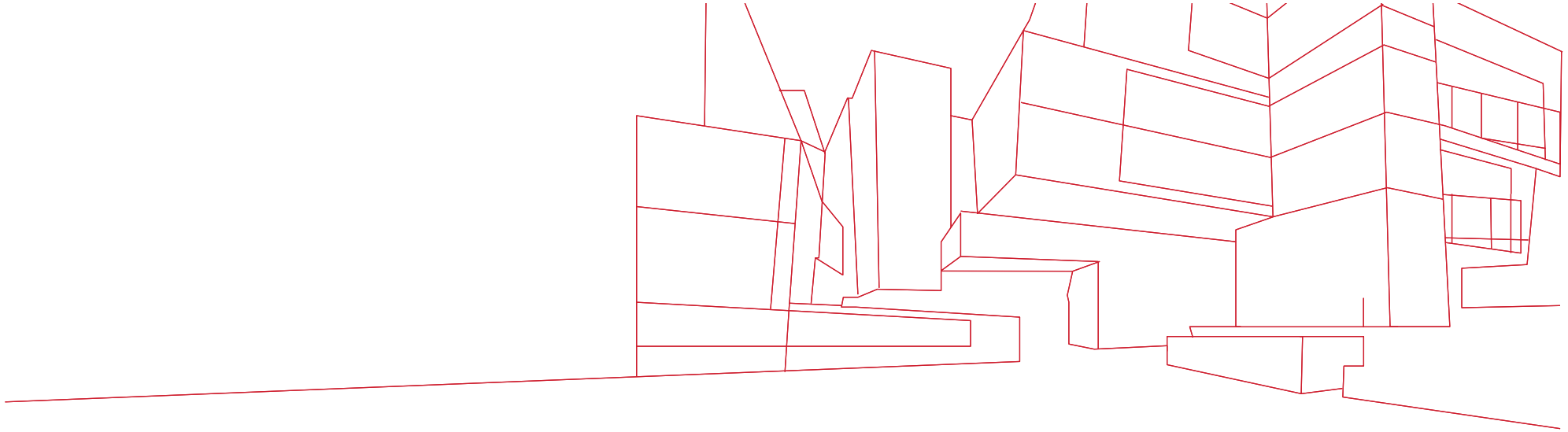
- Changing working modes might be the more efficient way to help users when designing aids :
  → Without the load of Biceps and fewer loads of FDS and FCR, the iEMG values decreased significantly.

- This research did not solve the problem of ulnar deviation.
  → FCR loaded the most through the handle design solutions.
  → FDS took the second place of loading.



Conclusion

- All the design solutions helped with performance improvement of the task in this research.
- Stove plate showed the most significant improvement.
- Design solutions for stoves performed better than handles.
- The handles did help with the gripping movement, but didn’t help with the ulnar deviation.
- The higher stove plate is strongly recommended.



Thank you for your listening.

fonggong@NCKU.edu.tw