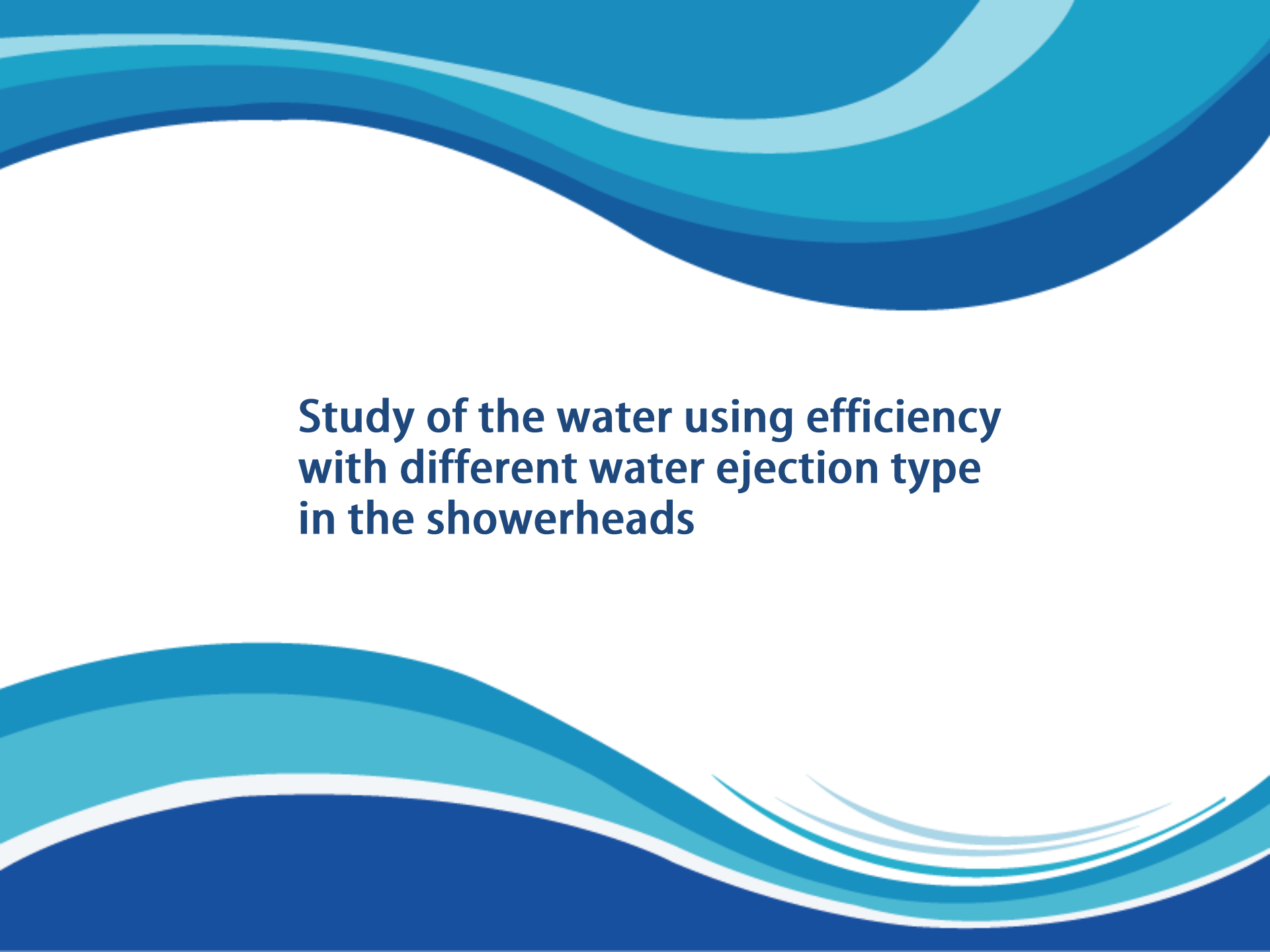


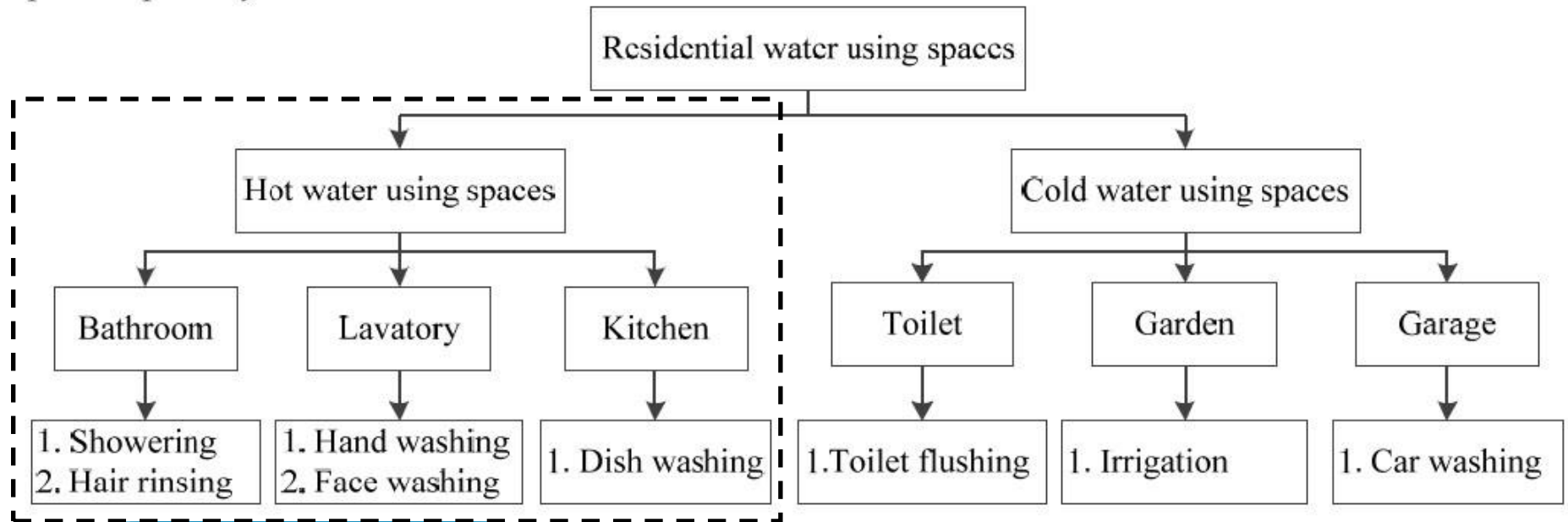
The background of the slide features abstract, flowing wavy lines in various shades of blue, creating a sense of movement and water. The waves are layered, with some appearing as solid bands and others as more ethereal, overlapping shapes. The overall effect is clean and modern, with a focus on the color palette of blues and whites.

Study of the water using efficiency with different water ejection type in the showerheads

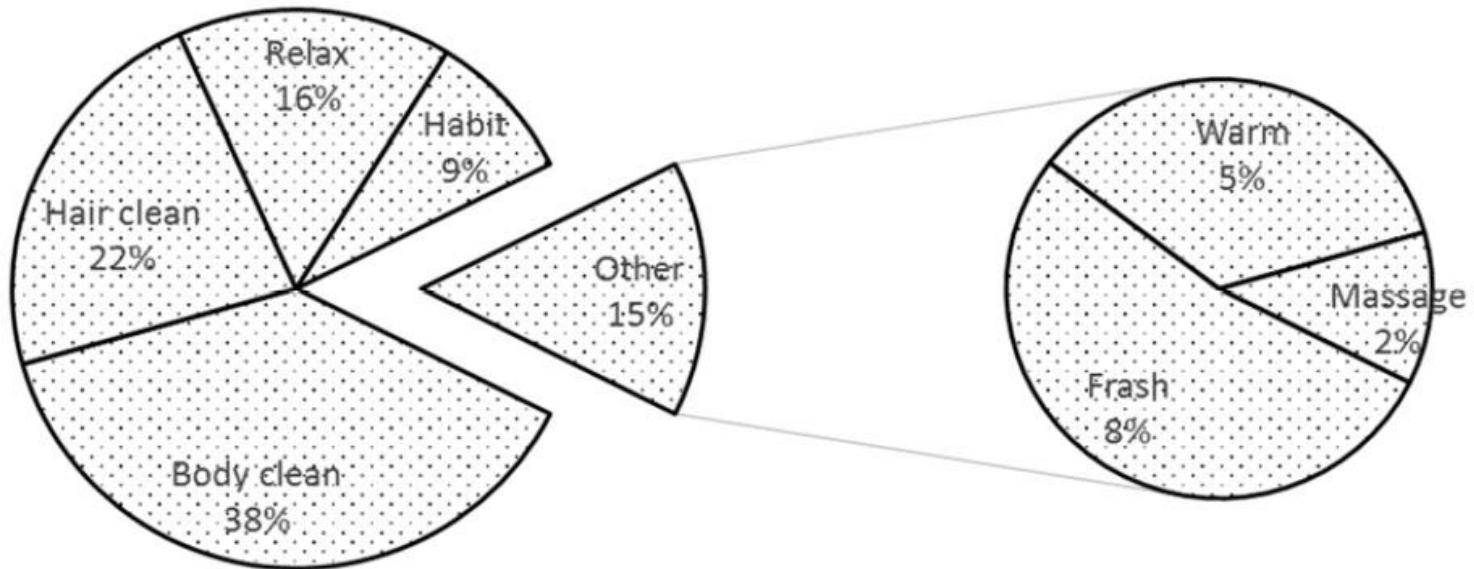
1.Introduction



In Taiwan, the largest amount of water usage is toilet flushing, then bathing, clothes washing, faucet (wash basin, kitchen sink) and others. The hot water requirements in bathrooms are majority, so saving water efficiently, keeping water cleaning, and using water comfortably become important issues gradually.

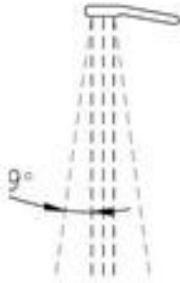
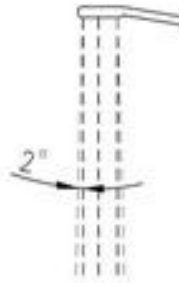
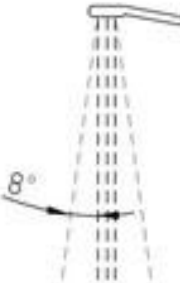


According to previous experiments, more than 850 people were invited to do a bathing experiment to measure their water requirements and asked about shower behavior. The results show most people in body shower cleaning and hair cleansing (about 60%) .Cleaning requires more water than the other activities. The cleaning performance is affected by the showerhead ejection type.

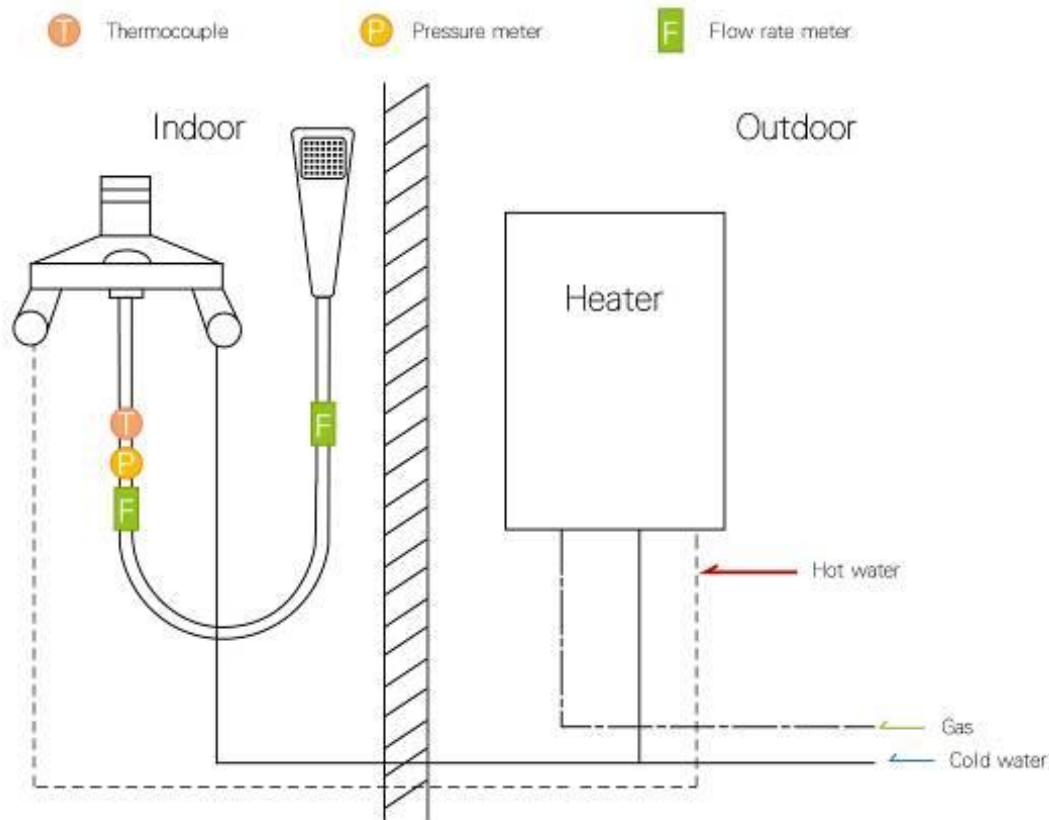


2.Methodology

This study is to discuss the flow characteristics of comfort and water conservation, so we chose four types of shower nozzles, which represented different water supplements, and invited 31 subjects (1 predictor and 30 subjects) to get the relationship between washing behavior and time.

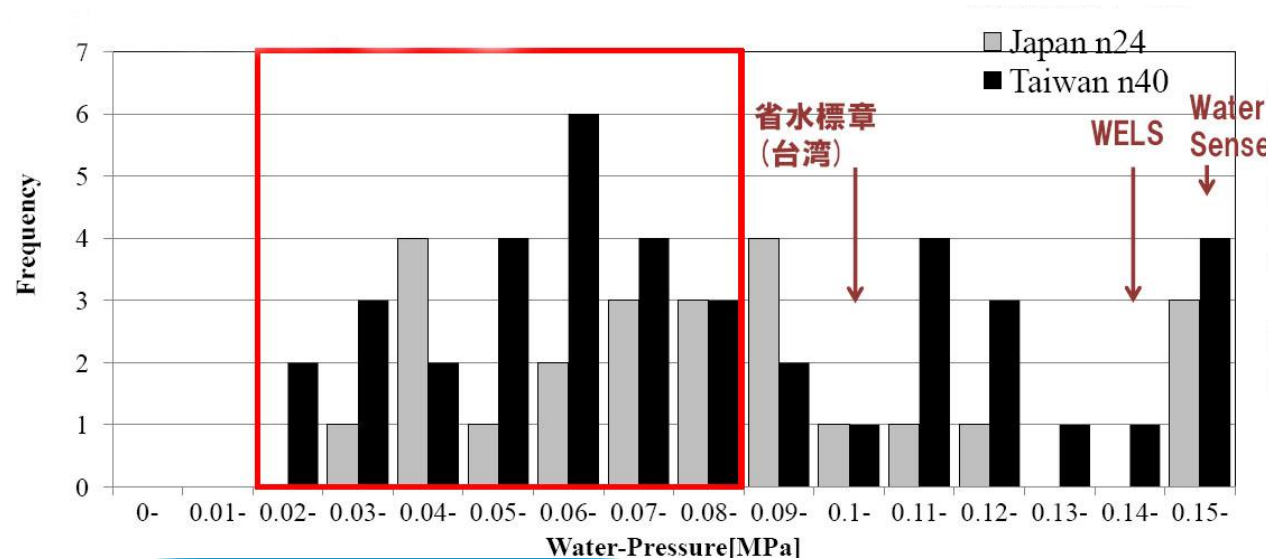
ShowerID	A	B	C	D
Showerhead				
Spray angle(°)				
Water ejection type				
	Straight line	Swirl type	Hollow water	Spread ⁴
Holes	40	64	60	48 ⁴
Water Pressure at 6.5L/min [MPa]	0.037	0.023	0.026	0.020 ⁴

Besides using the instruments such as fluid flow meter, fluid pressure gauge, fluid thermometer and alcohol thermometer, we used the data logger to record the flow, pressure and comfortable temperature.

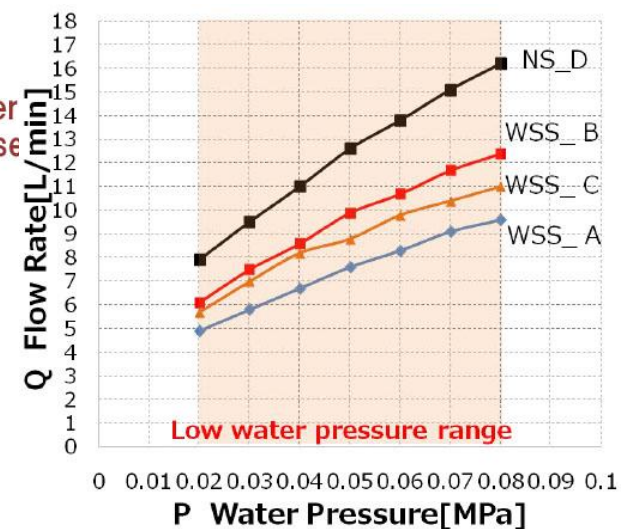




The water pressure in Taiwan was usually designed for low-pressure water supplement. In light of water conservation and safety, manufactures usually regulate the pressure range of water supplement. In order to meet the requirements of water pressure, the the Variable frequency pump was installed at the entrance of water supplement , the flow meter was installed at the exit of the shower nozzle, and we proved that we can get data we set under the same water pressure.



*Taiwanese and Japanese water pressure scope



*Four showerheads use flow and time diagram

Let the 30 subjects (Table 1) use the equipment (Figure 1), and tested the four types of showerhead ejection.



	Female	Male	total
20~30's	15	5	20
40~50's	5	5	10

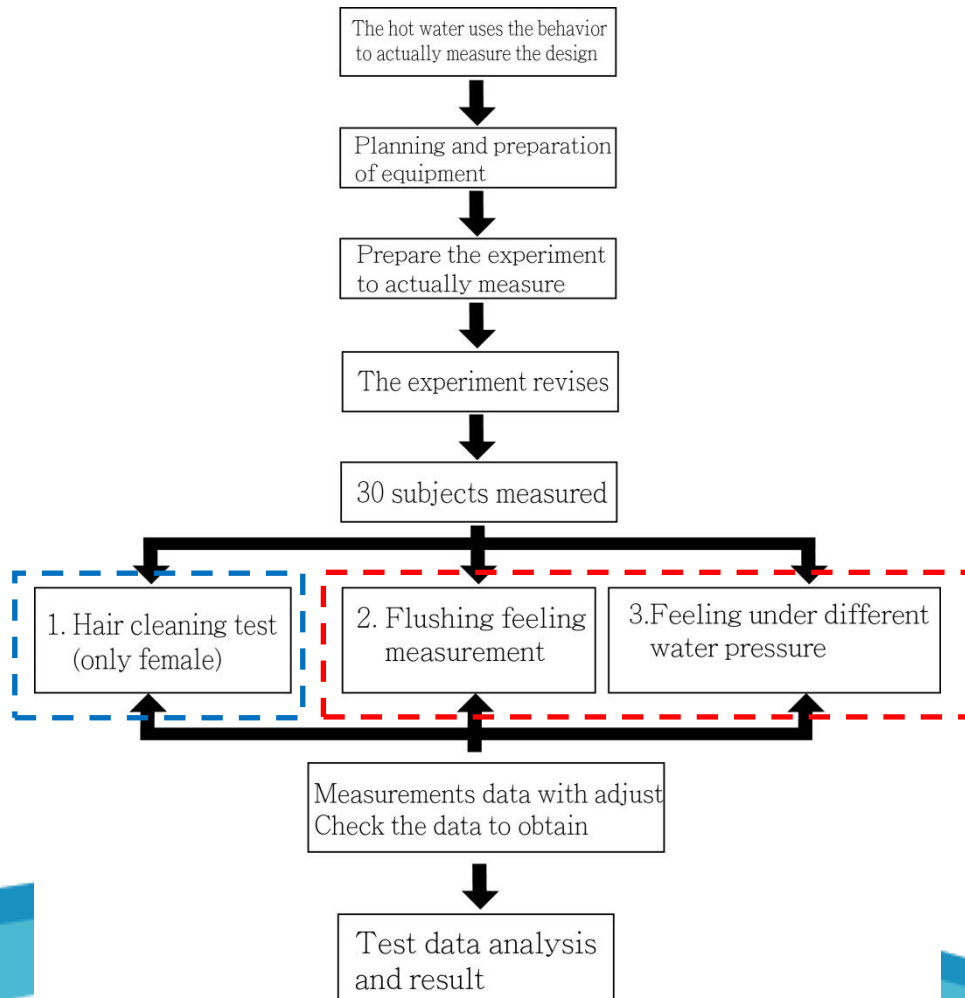
*Table 1. Number of persons surveyed



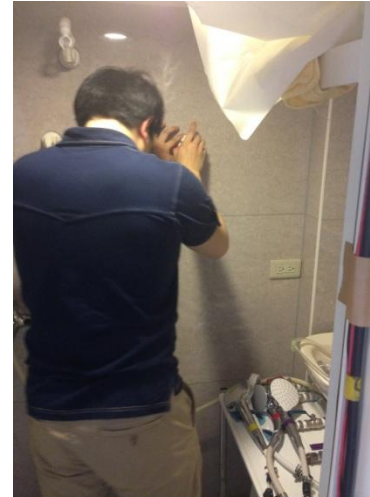
*Figure 1. Experimental shower room in National Taichung University of Science and Technology, iGrEAT Laboratory

3. Investigation

Experiment flow chart blue dotted line frames test for physical level / the red dotted line frame test for the mental level



1. Layout and preparation for equipment



*The instruments are installed before test.



*The discussion of instrument installation.



2. Before experiment

The first subject followed the original procedure (Table 2), but we found that the rest time was too long to make mental and physical influence.

3. The experiment process modify by discussion.

(5min)	(15min)			(5min)	(5min)
Description	Cleaning evaluation			5min (take a rest)	Comfort assessment
	Clean the hair	Cleaning evaluation *2 type	5min (take a rest)	Dry hair	

*Table 2.

4. Subject's test (procedure introduction)

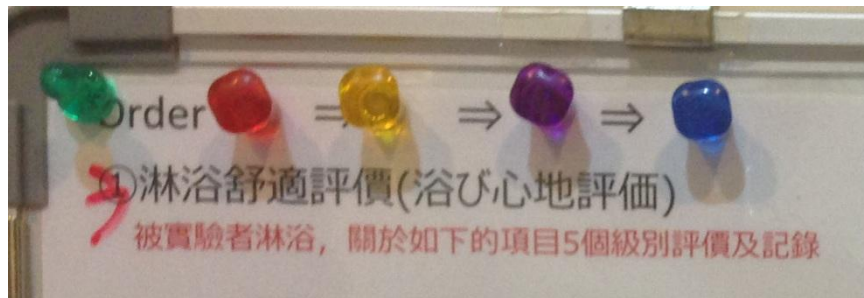
Face to face introduction made the subjects know the procedure details.



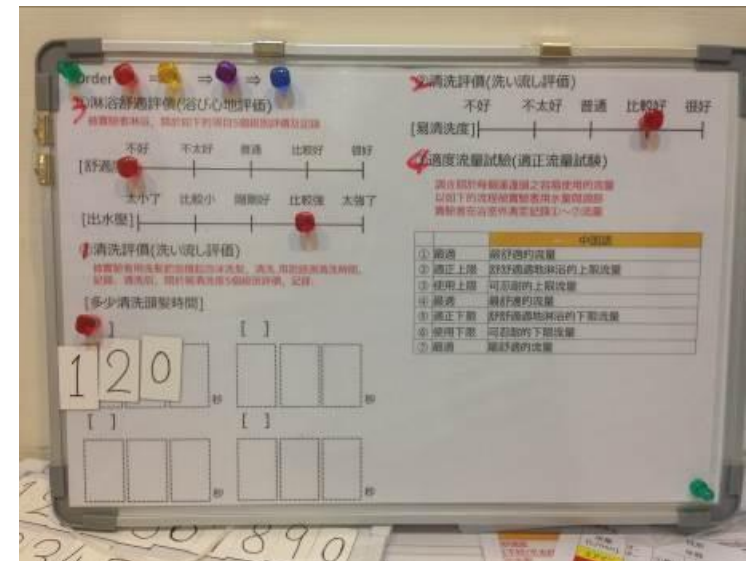
5.The plastic band was circled to Measure the hair volume.



We discussed the comfort and cleaning effect among 4 types of shower nozzles. Each subject should test four types of shower nozzles under the same condition: flow was 65/min. We made the comparison of comfort and cleaning effect, and gave them name such as red, yellow, blue, purple, so that the subjects could easily fill in the questionnaire. Each subject should use four shower nozzles to complete cleaning procedure orderly .



*Performance of showering comfort



*Showering comfort sensation pasted on the whiteboard to keep out the water

6.Flushing feeling measurement

The subjects were tested under the same water pressure, and we would get the relationship between comfort and pressure of shower nozzles. The grades of comfort were divided into very bad, bad, neutral, good, very good. The grades of water pressure were divided into very small, small, fit, large, very large. On the white board, different color magnet represented for different type of shower nozzle.



*The performance of showerhead was pasted by different color magnet

*showering position by handle showerhead



7. Subject's sensation in different water pressure

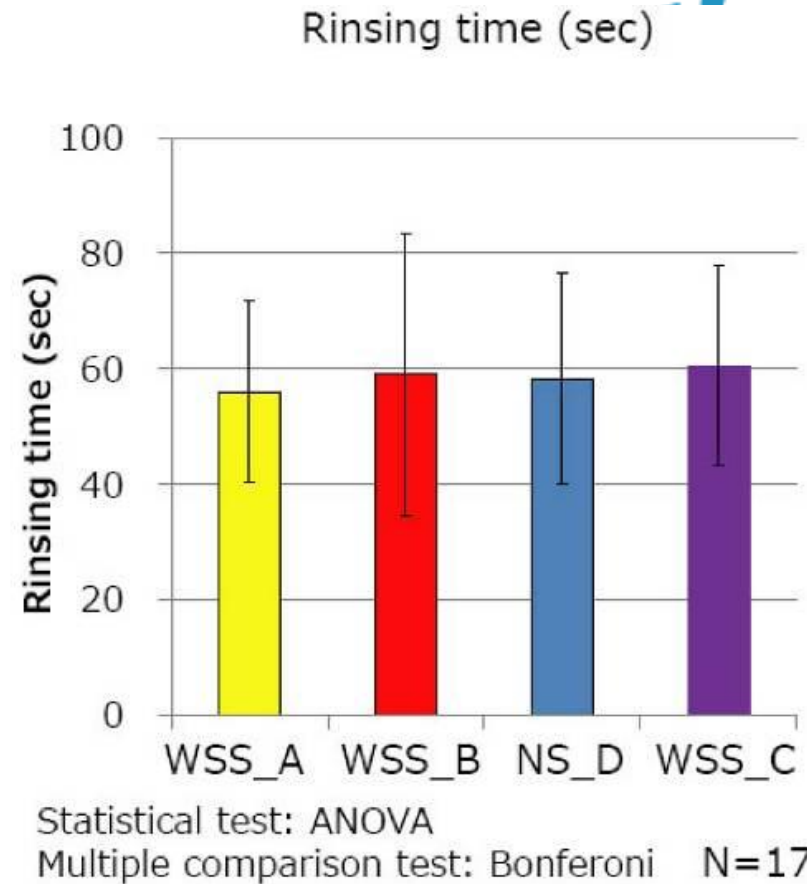
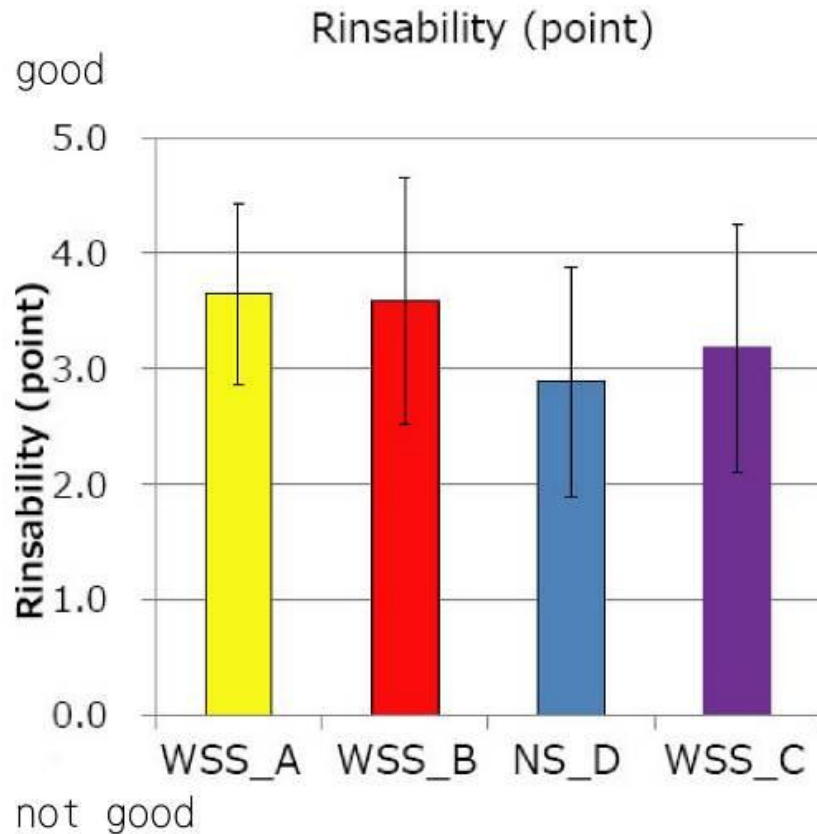
The subjects were tested by different water pressure, then analyzed the relationship between comfort and shower pressure. Based on the analysis, the comfort pressure range was defined.

No	Question
1	The most comfortable flow
2	Comfortable range of maximum flow
3	Can tolerate the maximum flow
4	The most comfortable flow
5	Comfortable range of minimum flow
6	Tolerable minimum flow
7	The most comfortable flow

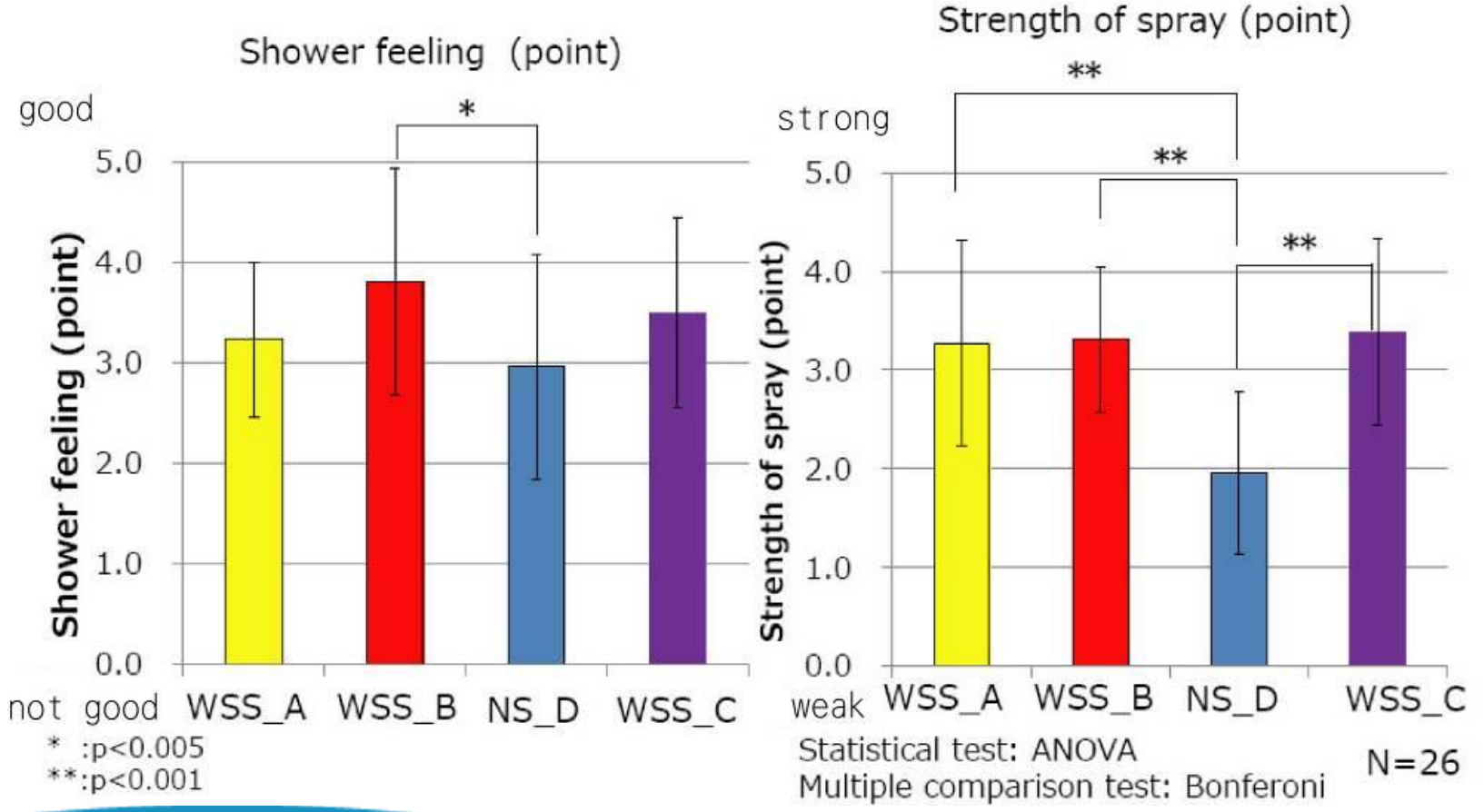
4.Result and Discussion



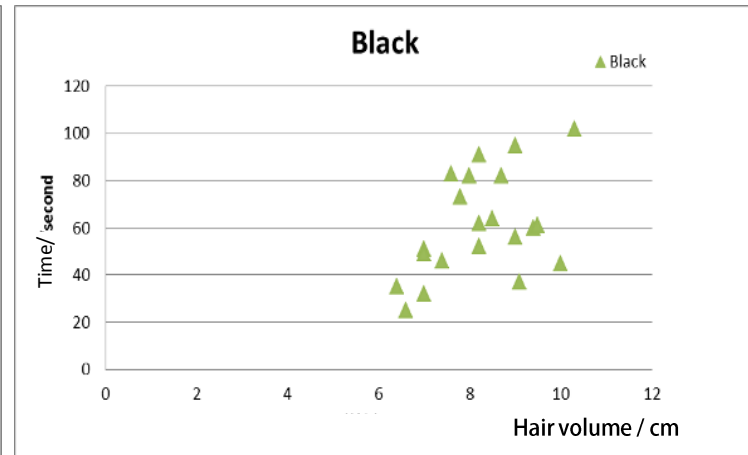
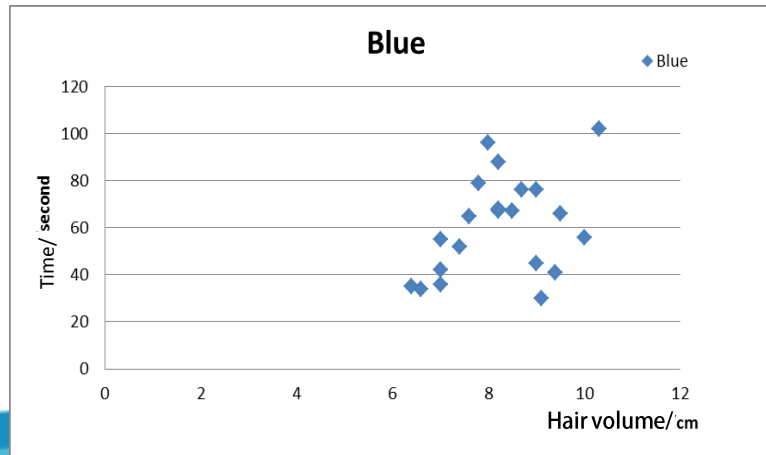
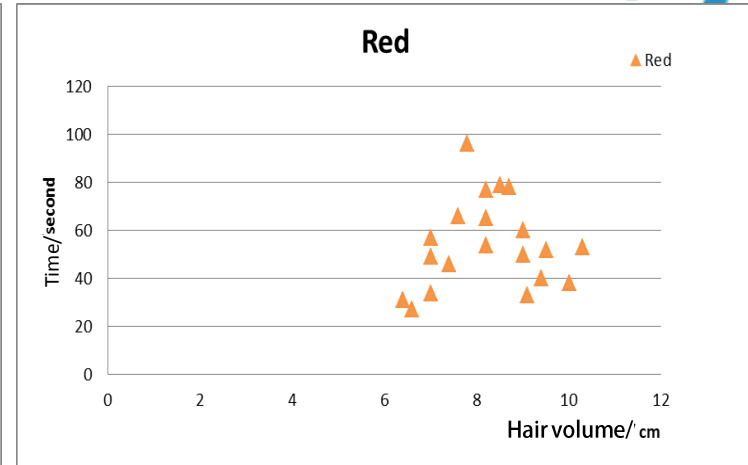
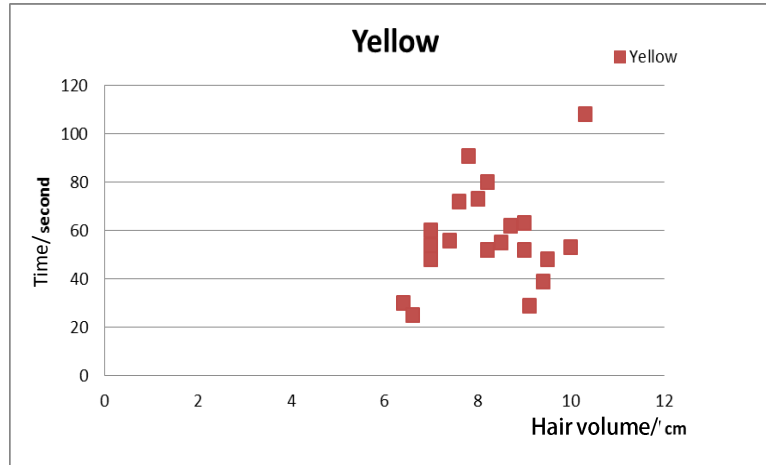
No significant difference



All showerheads spray at same flow rate (6.5L/min)

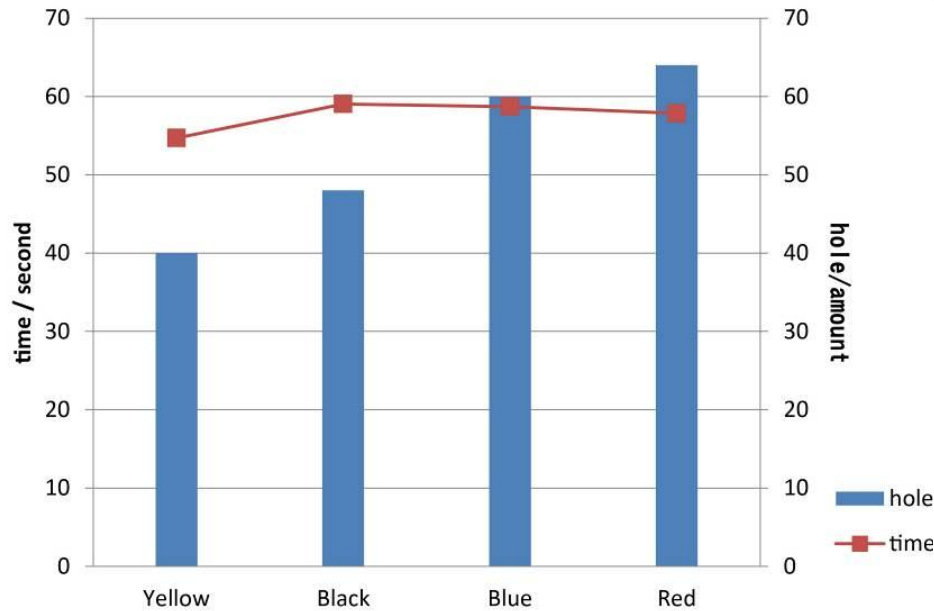


Four shower heads each with the subjects using the time relationship

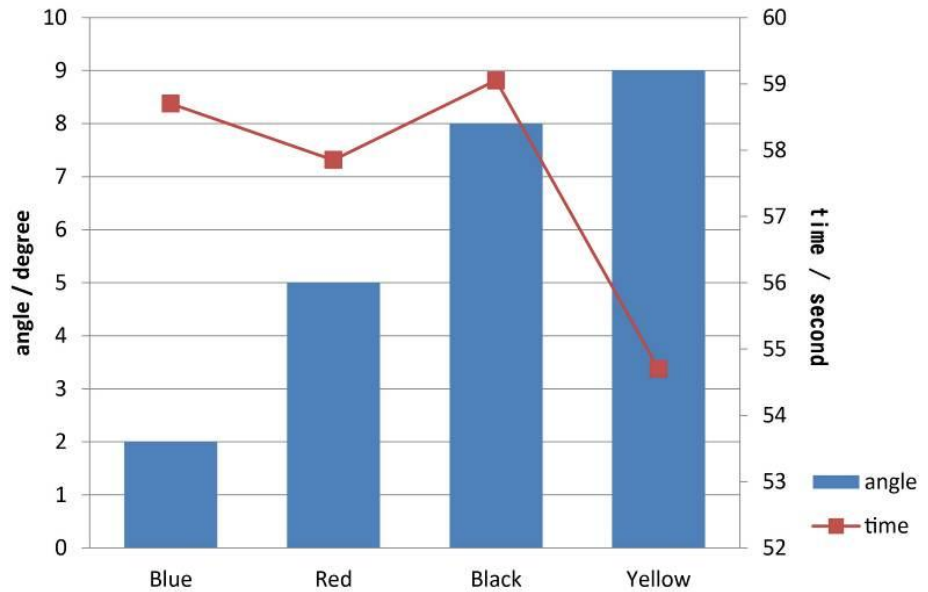


*R<0.1

***Shower head hole number and the measured use of time relationship**

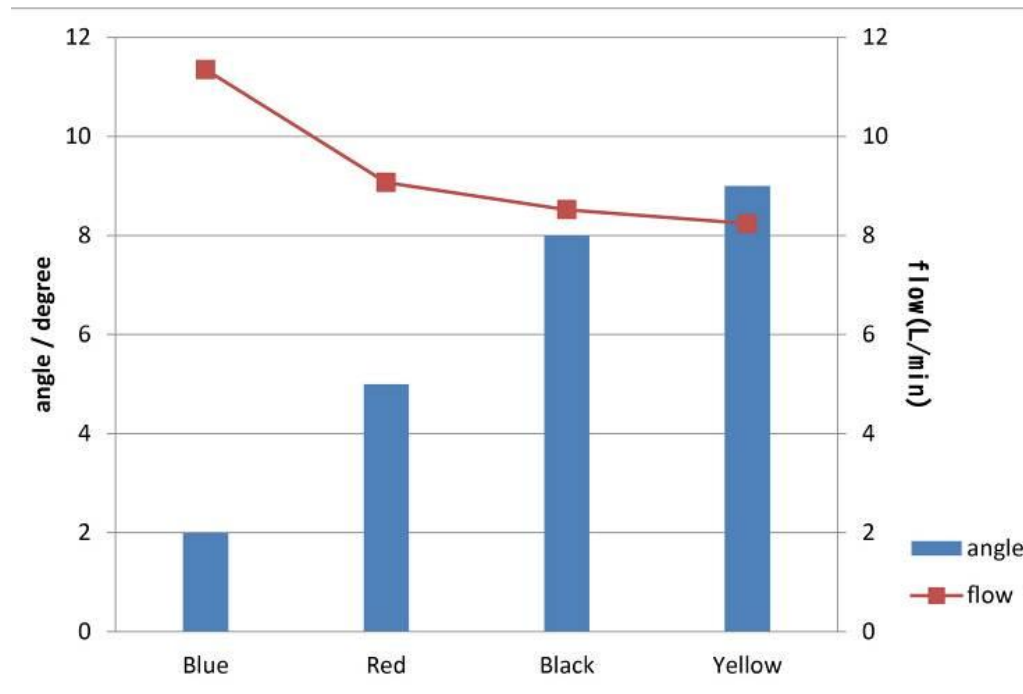


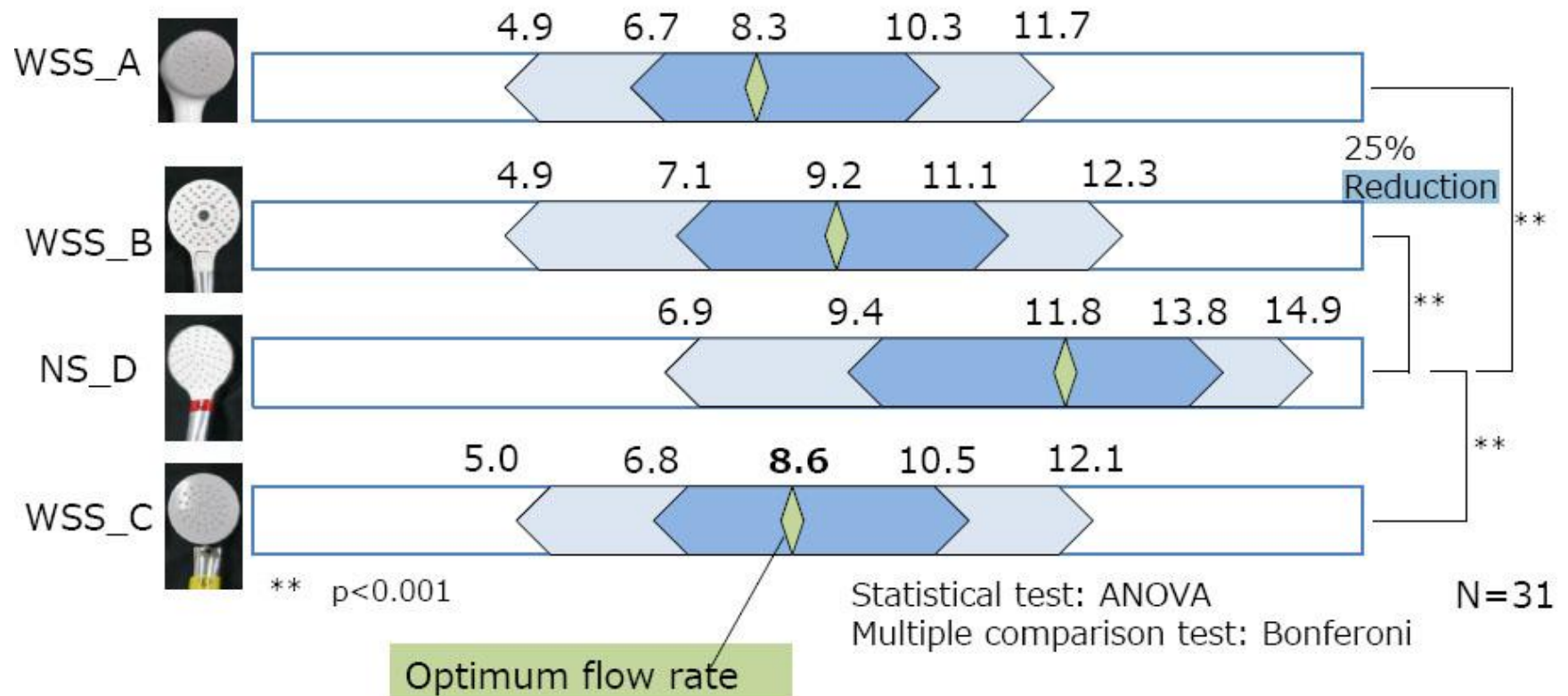
***Showerhead water angle and the measured use of the relationship between the shower period**





***Showerhead in different water angle
and the measured flow rate**





5.Conclusions



According to the results, the hair volume was not directly related to the time and the angles of shower nozzles. The time was approximately 54-57 seconds, and it was unusually related to personal habitation.

The most comfortable flow for the subjects were 8.2- 9(L/min), and the hole quantity of shower nozzle was 40-64. Consequently, the quantity of shower nozzle was not directly related to comfort. Flow and the angles were the opposite relationship ,and the more concentrative flow made more uncomfortable. Thus, the comfort was related to the angles of shower nozzles.

According to the experiment, Shower Nozzle B made the subjects more comfortable than the others. Due to the difference between shower nozzle B and D, helix shower nozzle was more comfortable than spraying shower nozzle. Due to the difference of shower nozzles, Shower Nozzle B was more suitable in low- pressure areas of Taiwan because it could save more water.



Thank you for your attention!