

강우환경 하에서의 스포츠웨어 착용시 인체생리반응 및 쾌적감

권오경¹⁾ · 김진아²⁾

- 1) 경일대학교 패션디자인산업학과
- 2) 청우섬유

The study on the physiological response and comfort in wearing sportswear in Rainy environments

Oh Kyung Kwon¹⁾ · Jin-A Kim²⁾

- 1) Dept. of Fashion Design & Fashion Industry, Kyungil University, Kyungsan Korea
- 2) CHUNG WOO Textile. Co., Ltd

요 약

쾌적한 스포츠웨어는 기능성에 있어서 자연환경의 변화조건과 인체의 운동 및 활동에 맞추어 열 전달 및 수분전달 등을 적절히 조절할 수 있어야 한다. 이에 본 연구에서는 일반환경조건 및 강우환경조건하에서의 형상기억 투습방수직물 소재의 스포츠웨어 착용에 따른 인체생리반응 및 쾌적감을 규명하기 위하여 스포츠웨어를 제작하여, 인공기후실에서 환경조건변화에 따른 온열생리학적 특성 및 주관적 감각을 측정, 그 특성을 비교, 고찰하였다. 평균피부온은 강우환경조건에서 온도가 낮게, 변동폭이 크게 나타났다. 변화경향은 운동부하를 기점으로 온도의 상승이 나타났고, 운동 2단계에 가장 높은 온도를 나타냈으며, 이후 감소하였다. 직장온은 일반환경조건에 비해 강우환경조건에서 온도의 미세한 상승을 보였다. 의복내 기후는 두 조건 모두에서 가슴부위보다 등부위의 온·습도의 변동폭이 크게 나타났고, 강우환경조건에서의 의복내 온도를 제외하고는 모두 등부위의 온·습도가 높게 나타났다. 최고 혈압은 운동의 강도에 따라 비례하여 상승하고, 최저 혈압에는 큰 영향없이 나타났으며, 변화경향은 의복내 온도의 경향과 역으로 나타났다. 평균혈압은 일반환경조건에서 6.9mmHg 높게 나타났다. 심박수는 일반환경조건에서 4.4beats/min 높게 나타났다. 강우환경조건의 주관적 감각의 평가에서, 신체에 직접 가해지는 빗물 등으로 인해 불쾌감이 증가하였고, 운동 후에는 일반환경조건과 달리 냉감이 증가하였으며, 습윤감은 최고치에 달하였다

Keyword : comfortable sports wears, general environmental conditons, rainy environmental conditions, mean skin temperature, rectal temperature, clothing micro climate.

1. Introduction

Owing to the rapid progress of science in civilization and the change in quality of lifestyle, people have become more and more interested in leisure and sports to improve their health. As a consequence, the conditions for the proper sports environment have varied and people have become more concerned about the functions of sports wear.

There are physical, physiological psychological conditions for comfortable sports wear. Among those conditions, the movement of heat, moisture and air to maintain body heat balance under the changing weather and during the sports activity is considered to be the main condition.

In other words, comfortable sports wears should control the transmission of heat and moisture according to changeable weather conditions and the motion of the body.

The transmission of heat and moisture, two physiological variables of clothing, should be properly applied according to the weather and environmental conditions and should be able to adopt according to changing weather conditions and the decrease of motion during a break when it is worn for a long time.

As for the condition of the sports wear during a change of weather, under the summer heat condition or during severe exercise low conduct effect, fast transportation of moisture and low absorption of moisture have to be achieved, environment because body weight loss is high. However, under the cold environment, when body weight loss is low, high conduction effect and good absorption of moisture is needed.

In this study, to find out the physiological

reaction of the human body and the sensation of comfort when people are wearing sports wear which is made of waterproof breathable material under general environmental conditions (temperature : 20 ± 1°C, humidity : 60 ± 5%RH, air current : 0.1m/sec) and rainy environmental conditions (temperature : 20 ± 1°C, humidity : 60 ± 5%RH, air current : 0.1m/sec, rainfall : 250 l/hr), I have made sportswear experimented in an artificial weather room and studied the thermal physiological features and subjective sense by comparison.

2. Experiment

2.1 Subject

Subjects were 4 healthy men and the physical features are in Table 1.

Table 1. Physical characteristics of subjects

Subject	Age (year)	Height (cm)	Weight (kg)	Rohrer ^{a)} index	Body surface ^{b)} area (m ²)
A	26	179	68.1	1.184	1.804
B	26	182	72.9	1.210	1.880
C	26	183	63.6	1.038	1.775
D	26	178	67.2	1.192	1.786

Note) a) Rohrer Index = $(W \cdot 1000 / H^3) \times 100$

b) Body surface area(m²) = $W^{0.442} \times H^{0.725} \times 88.83$

W : Weight (kg), H : Height (cm)

2.2 Environmental Conditions

This experiment had been conducted in an artificial weather room for 2 months from July 1999 to August 1999.

In order to exclude physiological changes of subjects, the experiments had been conducted at the same time.

Considering the feature of material of the sports wear, the generally pleasant

conditions of spring and fall and slightly rainy conditions were chosen as environmental conditions and those are described in Table 2.

Table 2. Two environmental conditions established in a climate chamber

	Temperature (°C)	Humidity (% R.H.)	Air current (m/sec)	Rainfall (ℓ/hr)
General Condition	20±1	60±5	0.1	-
Rainy Condition	20±1	60±5	0.1	250

2.3 Experimental Garment

The material for the experimental Garment was new breathable waterproof fabric invented by the company K and its features are shown in Table 3.

With this material, the experimental garment was made in with the same design as Fig. 1.

I added an detachable hood to General forms of sports wear such as casual jackets hiking, fishing, jogging gear have mash paper inside to make it a double layer.

2.4 Methods of measuring

Two hours after lunch subjects sit for

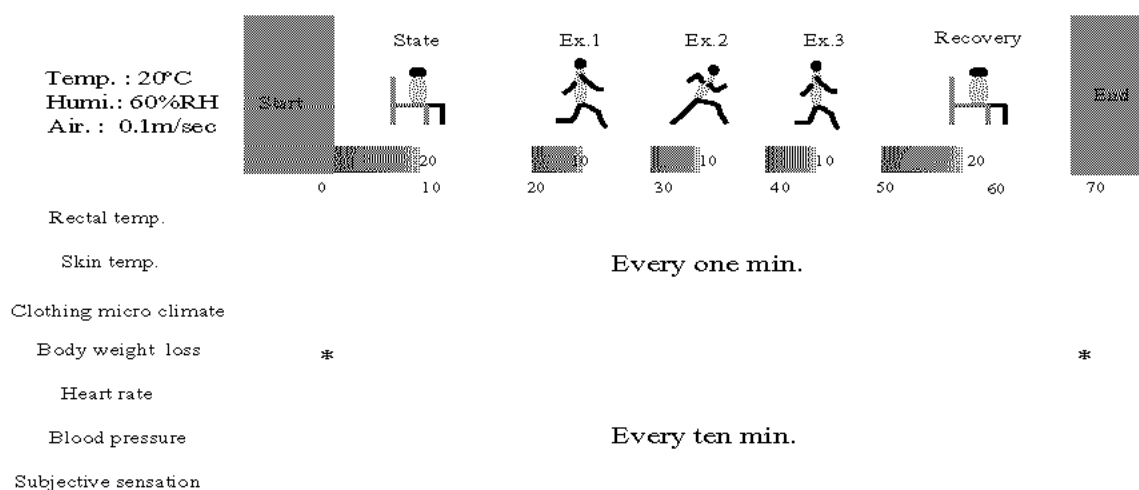


Fig. 2. The experimental protocol.

Table 3. Specification of the samples used for the experiment

Coating method	Ground fabric		Thick-ness (mm)	Weight (g/m)
	Fiber	Yarn number (Wp×Wf)		
shape memory polyurethane	N100%	70/24×160/96 (12/4)	120×68	0.18 109.6

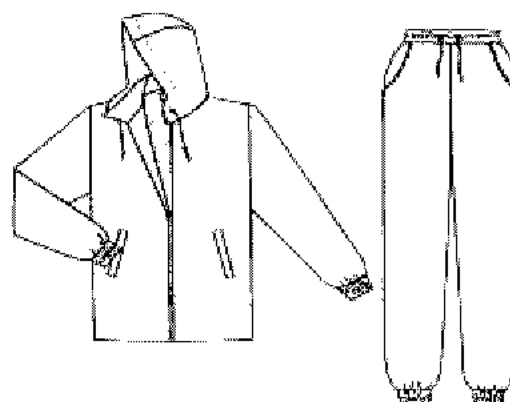


Fig. 1. Design of the sportswear used for the experiment

60minutes in the preparing room (20°C, 60% RH) to calm down then their weight is tacker and they are put on a sensor for measuring the experimental garments before they enter the artificial weather chamber

which is adjusted to experimental conditions.

The experiment is to minutes long and the interval and the process are stated in Fig. 2. After they enter the artificial weather chamber, they spend 20 minutes relaxing and then the next 30 minutes exercising and 20 minutes recovering.

Taking R.M.R. into consideration was established ; normal and strong.

Intensity and time length are like this : 5.5mile/hr for 10 minutes, 9.5mile/hr for 10 minutes, 5.5mile/hr for 10 minutes on a tread-mill.

Measurement takes were skin temperature, rectal temperature, body weight loss, micro climate, blood pressure, heart rate, sensation of comfort, thermal sensation, humidity sensation and fatigue sensation.

3. Results and Discussion

3.1 Mean skin temperature.

Mean skin temperature in the general environmental condition was 31.71~32.27°C with the range of fluctuation of 0.56°C and Mean Skin temperature in the rainy environmental condition is 31.60~32.32°C with a gap of 0.72°C.

Skin temperature went up till the second level of exercise and declined from the 3rd level of exercise through the recovering period. The hike in skin temperature in the 2nd level of exercise was because the increase in quantity of motion created a lot of heat in the human body as time went on.

The decline in skin temperature of the 3rd level of exercise appears to be due to the evaporation of sweat resulting in cooling down and decline in the body temperature as the intensity of the exercise slowed down.

This decline occurs more clearly in the

rainy condition.

3.2 Rectal temperature.

Mean rectal temperatures according to the conditions are shown in Fig. 3.

Rectal temperature in the general environmental condition was 36.32~36.46°C with fluctuation range of 0.14°C. The rectal temperature in rainy conditions was 36.34~36.50°C with the fluctuation range of 0.16°C.

The difference between the two conditions was 0.034°C and smaller increase was shown in rainy condition.

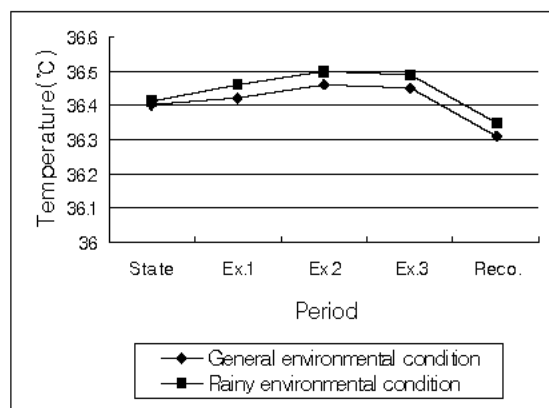


Fig. 3. Rectal temperature.

3.3 Clothing Micro climate

Temperature inside the garment : Fig. 4 shows temperatures inside the garment according to the parts and the level of the experiment.

Compared to the environmental conditions, inner temperature in rainy conditions was 30.94°C, which is 1.25°C higher than that of general conditions and the range of fluctuation in rainy conditions was larger than that of environmental conditions.

In general conditions the inner temperature of the chest area was higher than that of the back area by 1.54°C and the fluctuation range of the chest area was bigger than that of the back area.

Fig. 5. shows inner humidities according

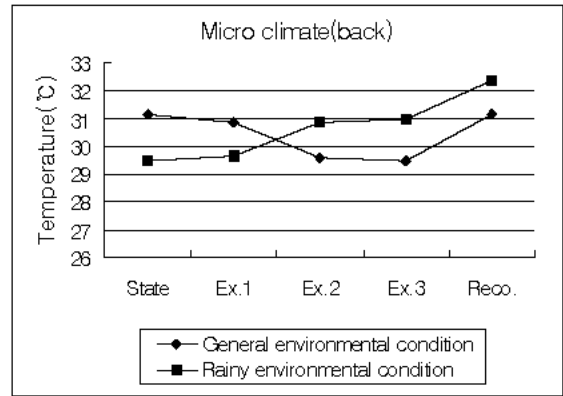
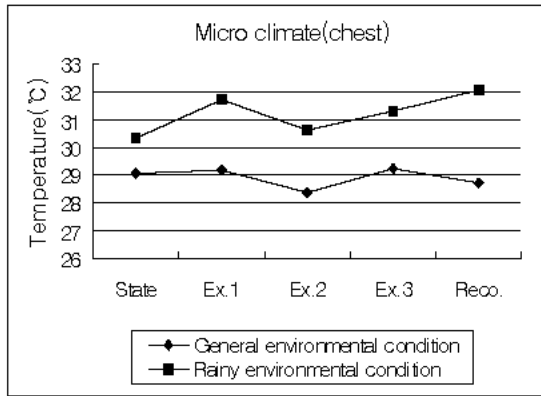


Fig. 4. Temperature within clothing at chest(upper) and back(lower)

to the level of experiment. inner humidity around the chest in general conditions went down at the 1st level of exercise, which I believed to be because of the non-moving air layer during the relaxation period started to move as the exercise started and caused convection current phenomena.

Compared to the environmental conditions, average inner humidity in general conditions was 51.98%RH and was 9.185%RH higher than that of rainy conditions which was on average 42.795%RH. The range of fluctuation in general conditions was also larger.

The inner humidity around the chest was 4.2%RH higher than that of the back area in general conditions. In rainy conditions that of the back area was higher than that of the chest area by 11.05%RH.

3.4 Blood pressure and Pulse rate

The change of blood pressure in each level of experiment tends to be opposite of the change of the inner temperature. This is identical with the previous result that blood pressure drops when surrounding temperature increases. Average blood pressure in general conditions was 109.33mmHg and was 102.36mmHg in rainy conditions.

The change of pulse rate according to different environmental conditions are shown in Fig. 6. Pulse rate is the measure which evaluate the intensity of the exercise, wearing conditions, different postures and effects of other elements. The increase in pulse rate is in proportion to the intensity of the exercise and the temperature of the environment. This experiment also proved

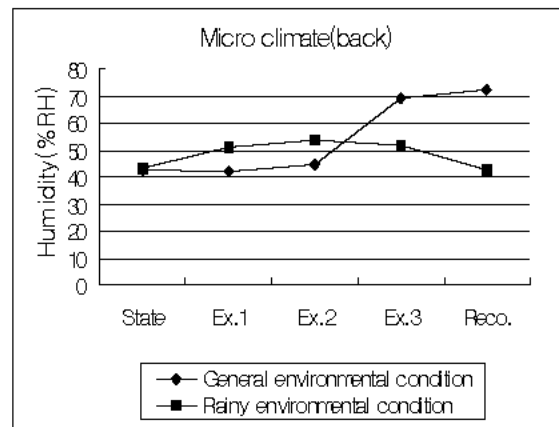
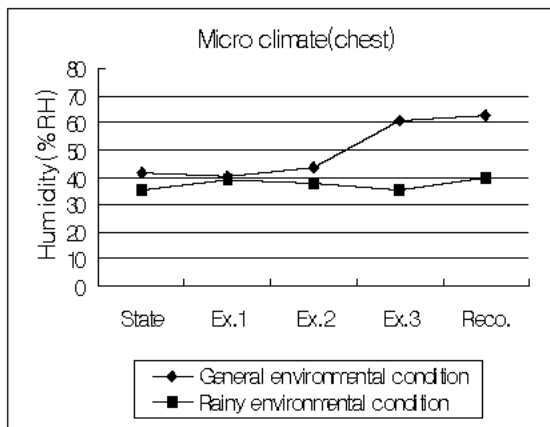


Fig. 5. Humidity within clothing at chest(upper) and back(lower)

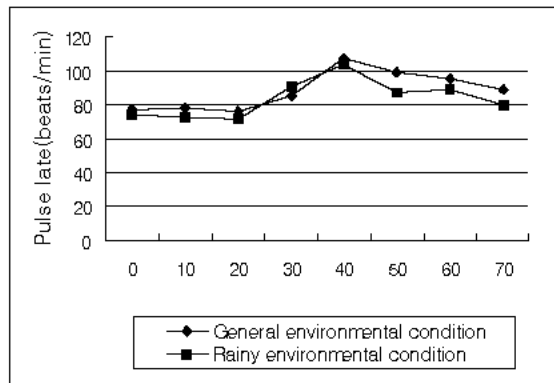


Fig. 6. Pulse rate

that pulse rate increases in proportion to the amount of the exercise. Pulse rate was 88.0beats/min in general conditions and 83.6beats/min in rainy conditions.

4. Conclusion

Mean skin temperature was low and had a big range of fluctuation in rainy environmental conditions. Temperature started to increase at the beginning of the exercise, reached the maximum at the 2nd level of the exercise and then started to decline.

Rectal temperature showed a slighter increase and bigger range of fluctuation in general conditions than in rainy conditions.

As for clothing micro climate, the ranges of fluctuation in temperature and humidity around chest were bigger than those around back in both conditions. Except inner temperature in rainy conditions, temperature and humidity and their range of fluctuation around back were higher than those around chest. Humidity was high and had wide range of fluctuation in general conditions.

Body weight loss in general conditions was higher by 0.11kg.

Maximum blood pressure increased in proportion to the intensity of the exercise,

while minimum blood pressure was not greatly affected. The change in blood pressure was the reverse of the change in inner temperature. Average blood pressure in general conditions was 6.9mmHg higher.

Heart rate in general conditions was 4.4beats/min higher.

In the test of subjective test in rainy conditions, the feeling of discomfort increased due to the raindrops fallen on the skin. Unlike that in general conditions, cold sensation increased and humidity sensation reached the peak after the exercise.

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