

## Influence of menstrual cycle on preferred clothing and preferred ambient temperature

### 생리주기가 쾌적착의량과 쾌적온도에 미치는 영향

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(2001. 10. 9 접수)

#### Abstract

여성의 생리주기가 행동성 체온조절에 미치는 영향을 관찰하고자, 본 연구에서는 6명의 건강한 여자대학생을 대상으로 하여 22.5°C와 55%RH의 환경에서 피험자 스스로가 의복을 선택하는 쾌적의복선택 실험과 피험자 스스로가 온도를 선택하는 쾌적온도선택 실험을 각각 수행하였다. 평균피부온은 생리주기에 관계없이 쾌적온도선택 실험보다 쾌적의복선택 실험에서 높게 유지되었고, 생리주기에 따른 쾌적착의량과 쾌적온도의 차이는 보이지 않았다. 그러나, 6명의 피험자 중 4명의 피험자가 선택하여 착용한 착의량은 황체기보다 여포기에 더 많았고 ( $p<0.05$ ), 5명의 피험자가 선택한 쾌적온도 역시 황체기보다 여포기에 평균 1.4°C 더 높은 것으로 나타났다 ( $p<0.01$ ). 이러한 결과는, 피부의 온도를 조절함으로써 여포기보다 황체기에 심부체온을 높게 유지하기 위한 행동성 체온조절반응을 나타낸 것으로 보이나, 보다 명확한 결론을 내리기 위해서는 다양한 환경조건에서 다수의 피험자를 대상으로 하는 후속연구가 지속적으로 수행되어야 할 것이다.

**Key words:** Menstrual cycle, Follicular phase, Luteal phase, Preferred clothing, Preferred ambient temperature; 생리주기, 여포기, 황체기, 쾌적착의량, 쾌적온도

### I. Introduction

Deep body temperature of women is closely related to their menstrual cycle and it is maintained higher in luteal phase than in follicular phase of the menstrual cycle. Most of the studies related to the menstrual cycle have been conducted in terms of autonomic thermoregulation(Bartelink et al., 1990; Cunningham and Cabanac, 1971; Frascarolo et al., 1990; Gonzalez and Blanchard, 1998; Hessemer and Brück, 1985; Horvath and Drinkwater, 1982; Kolka

and Stephenson, 1997a, 1997b; Nakayama et al., 1997; Stephenson et al., 1982; Stephenson and Kolka, 1985).

Only a few studies(Kim and Tokura, 1995; Shoemaker and Refinetti, 1996; Jeong, 2001) have been conducted on menstrual cycle in terms of behavioral thermoregulation. In the Kim and Tokura's research(1995), female subjects felt cooler and wore thicker clothing in luteal phase than in follicular phase of the menstrual cycle during air temperature decreasing. However, a further dispute remains because Bartelink et al.(1990)

reported that peripheral skin temperature was maintained lower in luteal phase than follicular phase and Frascarolo et al.(1990) also reported that skin thermal conductance was maintained lower in luteal phase than follicular phase of the menstrual cycle. On the other hand, Shoemaker and Refinetti(1996) showed no correlation between phase of the menstrual cycle and threshold of discomfort in the cold. Whether or not those studies were conducted in different experimental conditions, studies on behavioral thermoregulation related to the menstrual cycle remains to be carried on.

In daily life, additionally, people generally heat up or cool down their body using air conditioner as well as clothing. In this respect, human behaviors, such as selecting clothing or ambient air temperature must be taken into account for thermal comfort of the human body. Although self-selection behaviors of clothing(Jeong, 1999; Kim and Tokura, 2000) and of ambient air temperature (Natsume et al., 1992; Taylor et al., 1995) have been studied, those studies were mainly focused on the elder people. Therefore, self-selection behaviors of both clothing and ambient air temperature were investigated in this study to compare follicular phase and luteal phase of the menstrual cycle in young women exposed to a cool environment.

## II. Materials and Methods

### 1. Subjects

Six college-aged female students volunteered and consented to participate in this study after they were explained the purpose and the experimental protocol of the study. They participated in the experiments conducted on the same time of two separate days in follicular phase(FP) and luteal phase(LP) of their menstrual

cycle. Their age, height, weight, and body surface area were  $22 \pm 0$  yr(mean $\pm$ SE),  $159.9 \pm 3.1$  cm,  $50.0 \pm 2.8$  kg, and  $1.50 \pm 0.05$  m<sup>2</sup>, respectively.

### 2. Procedure

Experiment consisted of two sessions: self-selection of clothing(Session 1) and self-selection of ambient air temperature(Session 2). The subjects entered a climatic chamber controlled at 22.5 °C, 50%RH. After weighing their body weight, they put on basic garments(100% cotton sleeveless shirt, 100% cotton short sleeved T-shirt, polyester/cotton knee-high pants; total weight of 400g) over their own brassiere and shorts. A rectal probe of a thermistor(Hybrid Recorder K370, Technol Seven Co., Japan) was inserted about 10 cm beyond the anus. Probes were also taped down on seven skin sites of the subjects(head, hand, forearm, chest, thigh, leg, foot) to measure skin temperature. After the subjects stayed 40 minutes on a couch for equilibrium, they immersed their legs at 17 °C water in a refrigerating bath circulator(RBC-30, JEIO Tech Co., Korea) for 30 minutes in order to get the cooling effect of whole body. After toweling the legs, the subjects continued to stay again on the couch for 30 minutes(Session 1). During Session 1, they were instructed to select and wear additional clothing whenever they needed for the thermal comfort of their body. In this session, several kinds of clothing, such as muffler, hat, gloves, socks, sweater, trousers, etc., were displayed in front of the subjects in order to be chosen easily by the subjects. Weight of additional clothing worn after selected by the subjects was measured in Session 1.

On a different day, the subjects experienced another session of the experiment for 30 minutes(Session 2) after the same equilibrium and leg immersion as in Session 1. During Session 2, the subjects were instructed to select ambient air

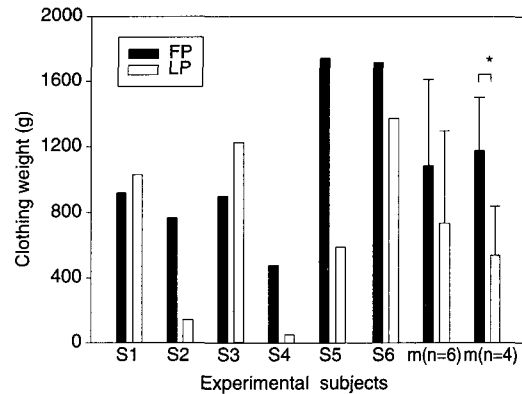
temperature( $T_a$ ) that they felt thermally comfortable at least for 20 minutes. The subjects were allowed to sign the experimenter through the window of the chamber to increase or decrease  $T_a$ . Air temperature was controlled according to the subject's sign by the experimenter who stayed outside the chamber. Thus, preferred ambient temperature was determined.

Rectal temperature and skin temperatures were recorded every 10 minutes, and mean skin temperature( $T_{sk}$ ) was calculated using Hardy and DuBois, equation(1938). Thermal sensation felt in the whole body of the subjects was voted every 10 minutes. Nine graded voting scale, such as very hot(1) · hot(2) · warm(3) · slightly warm(4) · neutral(5) · slightly cool(6) · cool(7) · cold(8) · very cold(9), was used for evaluating thermal sensation. Results were analyzed using paired t-test and repeated measures of ANOVA with the data obtained during the last 10 minutes of each experiment.

### III. Results and Discussion

Figure 1 shows amount of additional clothing worn after selected by the subjects in Session 1. There was no significant difference of clothing weight between follicular phase(FP) and luteal phase(LP) of the menstrual cycle in six subjects. However, four of the six subjects(S2, S4, S5, S6) wore heavier in FP than in LP( $p<0.05$ ) while, conversely, two subjects(S1, S3) wore more heavily in LP than FP.

Table 1 shows comfortable air temperature selected by each subject during Session 2. Five subjects except for S4 preferred  $T_a$  as higher as  $1.4 \pm 0.2$  °C in FP compared to LP( $p<0.01$ ) although there was no significant difference between FP and LP in six subjects.



**Fig. 1. Weight of additional clothing worn by each subject in follicular phase(FP) and luteal phase(LP) of the menstrual cycle. Mean values are represented with standard errors.  $p=0.04$  between FP and LP in four subjects( $n=4$ ).**

Table 2 shows rectal temperature( $T_{re}$ ), mean skin temperature( $T_{sk}$ ), and general thermal sensation compared between FP and LP in Session 1 and Session 2.  $T_{re}$  was maintained a little higher during LP than FP in both sessions.  $T_{sk}$  was maintained higher during Session 1 than Session 2 in both phases of the menstrual cycle( $p<0.01$ ) although it showed no significant difference between FP and

**Table 1. Preferred ambient temperature of each subject in follicular phase(FP) and luteal phase(LP) of the menstrual cycle**

Subject	FP(°C)	LP(°C)
S1	25.5	24.5
S2	24.5	23.5
S3	25.5	24.5
S4	22.5	24.5
S5	27.5	25.5
S6	25.5	23.5
mean $\pm$ SE( $n=6$ )	25.2 $\pm$ 0.7	24.3 $\pm$ 0.3
mean $\pm$ SE( $n=5$ ) <sup>a)</sup>	25.7 $\pm$ 0.5	24.3 $\pm$ 0.4**

<sup>a)</sup> S4 who showed different result is excluded.

\*\*  $p<0.01$  compared to FP.

**Table 2. Rectal temperature( $T_{re}$ ), mean skin temperature( $T_{sk}$ ) and thermal sensation of the subjects in follicular phase (FP) and luteal phase(LP) of the menstrual cycle**

	Experiment	FP	LP
$T_{re}$ (°C)	Session 1	37.2±0.0	37.3±0.0+
	Session 2	37.3±0.1	37.4±0.0*
$T_{sk}$ (°C)	Session 1	31.3±0.2	31.2±0.1
	Session 2	30.9±0.2(**)	30.6±0.1(**)
Thermal sensation	Session 1	4.3±0.6	4.6±0.2
	Session 2	4.7±0.4	5.1±0.2(*)

Values are mean SE and were obtained during the last 10 minutes of Session 1 and Session 2. + $p<0.1$ , \* $p<0.05$  compared to FP. (\*) $p<0.05$ , (\*\*)  $p<0.01$  compared to Session 1.

LP. The subjects felt slightly warm or neutral with no significant difference between FP and LP in both sessions. In LP, however, they felt slightly cooler when they selected ambient air temperature than they selected clothing( $p<0.05$ ).

During Session 2, hand skin temperature was kept at  $27.5\pm 0.5$  °C in FP and at  $25.7\pm 0.2$  °C in LP( $p<0.01$ ). Higher hand skin temperature in FP of this study seems to be closely related to the higher preferred air temperature in FP when compared to LP in spite of no difference of  $T_{sk}$  between FP and LP(Table 1 and Table 2). As far as the relation between peripheral skin temperature and menstrual cycle is concerned, finger skin temperature was maintained lower in LP than in FP(Bartelink et al., 1990) and skin thermal conductance was lower in LP than in FP(Frascarolo et al., 1990). Those peripheral or skin thermal responses are considered to keep the core temperature higher in LP than FP. On the other hand, Cabanac and his colleagues showed that a resting subject preferred glove temperature higher when internal body temperature fell(Cabanac et al., 1971) and that there was an inverse linear

relationship between core temperature and glove temperature(Cabanac et al., 1972). These findings seem to be supported by the fact that lower peripheral skin temperature is required to maintain higher core temperature whether or not those are related to the menstrual cycle or general thermoregulatory behavior.

It must be noted that most of the subjects preferred both heavier clothing(Fig. 1,  $n=4$ ,  $p<0.05$ ) which is partially supported by the findings of Jeong(2001) and higher air temperature(Table 1,  $n=5$ ,  $p<0.01$ ) in FP than LP although there were not significant differences of both preferred clothing and preferred ambient temperature between FP and LP. This suggests that young women would behave to keep their whole body warmer in FP in order to maintain lower rectal temperature than in LP(Table 2).

All the subjects selected and wore additional clothing(Session 1, Fig. 1) and selected higher air temperature than the given environment of 22.5 °C in the experiment(Session 2, Table 1) to keep their body thermally comfortable(Table 2). In LP, in addition, they felt slightly warmer with higher  $T_{sk}$  in Session 1 than Session 2(Table 2), which suggested that subjective response coincided with physiological response only in luteal phase of the menstrual cycle.

#### IV. Conclusion

In terms of behavioral thermoregulation, in conclusion, most of young women in follicular phase of the menstrual cycle preferred higher thermal insulation of clothing and preferred higher air temperature in order to keep core temperature lower than in luteal phase, and vice versa. These results suggest that menstrual cycle must be considered in selecting clothing and/or ambient air

temperature for thermal comfort studies on young females. Nonetheless, further studies are needed to get conclusion more clearly in 1999.

### Acknowledgments

This work was supported by Andong National University Grant in 1999.

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