

## Optimal Slit Length Limit of Tight Skirts in Movement and Physiological Response

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### 동작에 따른 타이트 스커트의 최소 적정 트임량과 생리적인 반응

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#### Abstract

본 연구는 타이트 스커트의 트임의 개수가 왼쪽 옆선에 1개 있을 때와 왼쪽 옆선, 오른쪽 옆선에 각각 1개씩 모두 2개 있을 때 평지 보행, 계단 승강, 버스 승강 등과 같은 일상동작에 잘 적용할 수 있는 타이트 스커트의 적정 트임 길이를 설정하는 것을 목표로 하였다. 아울러 각 동작시의 트임 길이에 따른 생리적인 반응을 의복압, 산소 섭취량을 통해 알아보고자 하였다. 평균보폭은 4m 구간을 평상시대로 걸을 때의 발자국간 평균거리를 이용하였으며 국민표준체위조사보고서(1997)에 의한 평균체형을 가진 9명의 피험자를 정하였다. 스커트의 형태는 무릎길이인 타이트 스커트로 정하였다. 스커트의 트임은 왼쪽 옆선에 1개 있는 경우와 왼쪽 옆선, 오른쪽 옆선에 각각 1개씩 있는 경우의 2종류이다. 트임이 1개인 스커트는 2cm 간격으로, 트임이 2개인 스커트는 1cm 간격으로 트임 위치를 표시하여 길이를 조정하였다. 적정 트임 길이는 Likert 척도에 의한 만족도 평가로 측정하였으며 의복압은 air-bag system으로, 산소 섭취량은 Quark B<sup>2</sup> 으로 측정하였다.

본 연구의 결과는 다음과 같다.

1. 스커트의 최소 적정 트임 길이는 트임 1개일 때 평지 보행시 4cm, 계단 승강시 12cm, 버스 승강시 18cm이며, 트임 2개일 때 평지 보행시 2cm, 계단 승강시 8cm, 버스 승강시 15cm로 나타났다.
2. 의복압의 경우, 동일 트임 길이에서 트임 1개의 의복압이 트임 2개의 의복압보다 높았지만 트임 개수에 따른 전체 트임 길이로 보면 트임 1개의 의복압이 트임 2개의 의복압 보다 낮게 나타났다. 동작별로는 버스 승강의 의복압이 가장 높고 계단 승강, 평지 보행 순으로 낮아졌다.
3. 산소 섭취량의 경우, 동일 트임 길이에서 트임 1개와 트임 2개의 산소 섭취량은 거의 비슷하였다. 트임 개수에 따른 전체 트임 길이로 보면 트임 1개의 산소 섭취량이 트임 2개의 산소 섭취량보다 낮게 나타났다. 동작별로는 버스 승강의 산소 섭취량이 가장 높고 계단 승강, 평지 보행 순으로 낮아졌다.

**Key words:** slit, tight skirt, movement, clothing pressure, oxygen uptake; 트임, 타이트 스커트, 동작, 의복압, 산소섭취량

#### I. Introduction

As modern society becomes more industrialized and puts the emphasizes on function and the area of body movement becomes wide, it is necessary to design

clothing with function (Jang, 1989). Skirts have a simple shape than upper garments. However, skirts must be designed taking into consideration function and beauty, because skirts surround the waist, abdomen, hip, and lower limbs. In designing a skirt, changes of the

outer block of the knee must be considered for movements such as 'walking on the flat' and 'going up the stairways'. Especially, the movement of 'riding on a bus stair' restricts movement of person dressed in skirts, thus it makes them uncomfortable (Inomata et al., 1990, Inomata et al., 1992).

If the mobility of clothing is insufficient, clothing will create the pressure on specified parts of the body. These kinds of clothing pressure create problems with frame transformation, such as a decline of lung and heart function, difficulty in blood circulation, and displacement of internal organs (Nakahashi & Yoshida, 1998).

As the pressure part, pressure area, and pressure strength are changed, physiological responses like oxygen uptake become different (Morooka et al., 2001). Oxygen uptake, which is regarded as an important index of sustaining power, increases with exercise intensity increase rather than increase in exercise time and distance (Kim & Jung, 1995).

Tight skirts are usually used as a full dress uniform or office uniform in various age groups, and research about skirts is being conducted (Kim & Choi, 1993). Kim (1992) investigated the size of the back slit for tight skirts. Park (1992) studied moving fitness of tight skirts. Shimizu et al. (1990) studied the dynamic behavior of clothing pressure on the body in slacks. Makabe et al. (1991) investigated clothing pressure developed by girdles. There are many studies about other physiological elements such as oxygen uptake related to clothing. Morooka et al. (2001) studied the effects of clothing pressure exerted on the trunk on heart rate, blood pressure, skin blood flow, and respiratory function. They showed decreased oxygen uptake during exercise when a swimsuit was worn. Kim and Park (1999) investigated the effect of uniform style and temperature change on physiological responses during submaximal exercise, but they did not find any effect by uniform style.

Up to now, studies on tight skirts were focused on slit length related to skirt length, slit position, and number of slits. However, there has been little research on physiological responses about the various usual movements. The purpose of this study was to investigate the

optimal slit length of tight skirts having one or two slits, and the physiological responses like clothing pressure and oxygen uptake. Two types of skirts slit, one-slit skirts (only in one left placket) and two-slit skirts (one is in left placket and the other is in right placket), three types of movement such as 'walking on the flat', 'going up the stairways', and 'riding on the bus stair', were used for the evaluation of optimal slit length and physiological response.

## II. Methods

### 1. Subjects

Nine healthy young women who have standard body size on the basis of 'National Anthropometric Survey of Korea 1997'(KRIS, 1997) were recruited for this study. All subjects were informed of the contents and purpose of this study. The subjects completed a standardized health questionnaire for medical history medication, lifestyle, diet, smoking habits, alcohol consumption, and physical activity. All subjects were non-smokers in good health and had no evidence of hypertension, cardiovascular disease, or endocrine diseases. The body measurement tools were balance, line tape, sticker, and a Martin instrument consisting of a standimeter, a large sliding caliper, and a measuring tape. Measurement items were 15 items, which were based on KS K 7004. Measurement items were height, weight, waist circumference, hip circumference, hip length, thigh circumference, knee circumference, waist breadth, hip breadth, hip depth, waist depth, waist height, trochanter height, gluteal furrow height, and knee height. Subject posture in measurement was straight standing, both arms hung down naturally, and eyes and ears maintained on a horizontal line.

The standard step length of subjects was 55.10cm, which was measured by foot prints after walking a distance of 4m.

### 2. Optimal slit length

Optimal slit length was measured by the subjects'

sensory evaluations such as pleasantness. Two different types of basic tight skirts were used in the present investigation. One had one slit on left side. The other had two slits on left and right side. The skirts length was adjusted to knee length. The material of skirts was muslin and the basic pattern of skirt was Rim Won-ja's(Rim & Choi, 1988). Slit length was controlled by a fastener. In the case of one-slit skirts, slit interval was marked every 2cm. For two-slit skirts, slit interval was marked every 1cm. The subjects were asked to do three kinds of movements such as 'walking on the flat', 'going up the stair ways', and 'riding on the bus stair'. The stair model for the movement of 'going up the stairways' was designed with breadth of 26cm, and height of 17cm based on conventional building regulations. The bus stair model for the movement of 'riding on the bus stair' was designed with breadth of 30cm, and height of 36cm based on the automobile code of laws. Pleasantness was recorded by a Likert 5scale (5 very good, 4 good, 3 usual, 2 inconvenient, and 1 very inconvenient) in every slit length and all kinds of movements. When the subjects recorded Likert scale 3(usual), we regarded it as the optimal slit length limit. The order of experiments was randomized, and the subjects wore the same T-shirts, socks, and experimental tight skirts. Fig. 1 shows three kinds of movement types.

### 3. Physiological responses

#### 1) Clothing pressure

Garment restraint is an important factor influencing clothing comfort, and clothing pressure is often used to evaluate garment restraint. Therefore in this study,

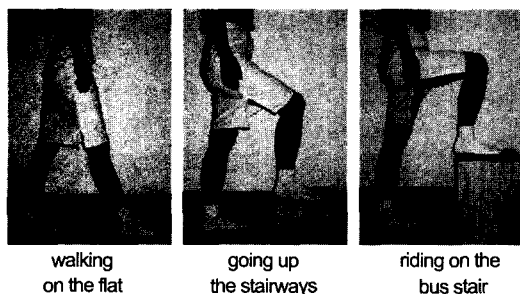


Fig. 1. Three kinds of movement types.

clothing pressure was measured by an air bag system (AMI 3037, AMI company, Japan). The equipment utilized consisted of an air bag sensor with diameter of 20mm, thickness of 1mm and the sensor contained 1ml air. The clothing pressure was determined by the voltage which varied with movement change, and the unit of clothing pressure was mV(100mV=1kPa, 0.98kPa=7.36 mm Hg=10gf/cm<sup>2</sup>). The air bag sensor was adhered to 9cm on the upper part of the knee. As the clothing pressure value depended on breath inhalation or exhalation, we measured clothing pressure on inhalation with 3 second breath suppress. Fig. 2 shows the measurement posture of clothing pressure in the 'going up the stairways' movement.

#### 2) Oxygen uptake

Activity level of body was measured by oxygen uptake considering many factors. Oxygen uptake is

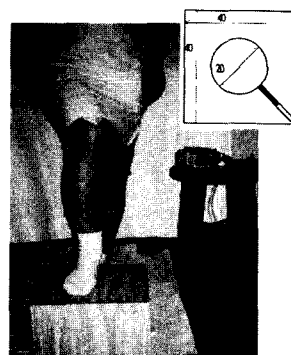


Fig. 2. Clothing pressure (sensor type and measurement posture in going up the stairways).



Fig. 3. Oxygen uptake (walking on the flat).

different according to the kind of exercise. Oxygen uptake can be measured by many kinds of methods.

In this study, oxygen uptake was measured by a Breath-by-Breath method using Quark B<sup>2</sup> (Cosmed Srl, Italy). After calibration of Quark B<sup>2</sup>, the subjects wore a mask and took a rest until their breath had been stable. And they began to do three kinds of experimental movements such as 'walking on the flat', 'going up the stair ways', and 'riding on the bus stair'. We obtained oxygen uptake values for two minutes in every kinds of movement and every slit condition. Fig. 3 shows the measurement posture of oxygen uptake in 'walking on the flat' movement.

#### 4. Statistical analysis

The significance of the difference between one slit and two slits was tested using students t-test. All dependent variables about movement types were analyzed by analysis of variance. Evaluation of significant differences between means was achieved using 95% confidence intervals. Significance was reported at  $p < 0.05$ .

### III. Results and Discussion

#### 1. Optimal slit length

After walking 4m with three kinds of movement in

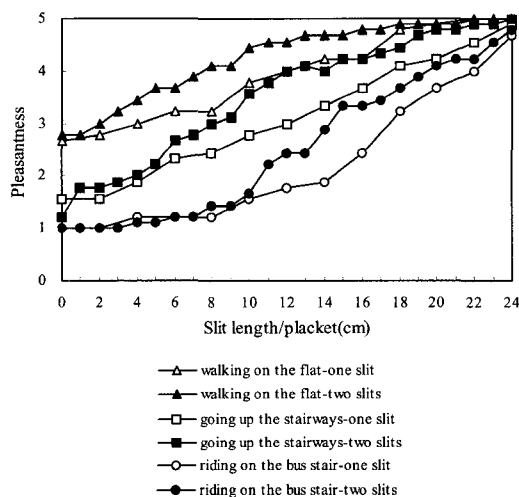


Fig. 4. Pleasantness in three kinds of movement types.

every slit length and slit numbers, the subjects voted on the perception of restraint. When the subjects recorded Likert scale 3 (usual), we regarded it as an optimal slit length limit. Fig. 4 shows pleasantness of three kinds of movement types. As shown in Fig. 4, the longer the slit length was, the higher the pleasantness was. Pleasantness was the highest in 'walking on the flat' and lowest in 'riding on the bus stair'. Pleasantness of three kinds of movement types showed significant difference ( $p < 0.05$ ). Pleasantness in the two-slit skirts was higher than the one-slit skirts in the case of the same length. However, when it comes to total slit length, the subjects felt better in the one-slit skirts than the two-slit skirts. When the slit length was longer than 6cm, pleasantness of one slit and two slits showed difference ( $p < 0.1$ ).

Table 1 shows the optimal slit-length limit in three kinds of movement types. According to Table 1, in the case of the one-slit skirts, the optimal slit-length limit was 4cm in 'walking on the flat', 12cm in 'going up the stairways', and 18cm in 'riding on the bus stair'. Jang's research (1995) suggested an optimal slit-length limit of the 2cm in 'walking on the flat', 8cm in 'going up the stairways', and 20cm 'riding on the bus stair'. We found a longer optimal slit-length limit in 'walking on the flat' and 'going up the stairways' but a shorter limit in 'riding on the bus stair'. We think that this difference occurs because of walking speed such as 90 step/min in Jang's research (1995) and normal speed in this study. In the case of two-slit skirts, the optimal slit-length limit was 2cm in 'walking on the flat', 8cm in 'going up the stairways', and 15cm in 'riding on bus stair'. 15cm in 'riding on the bus stair' was shorter than 21.5cm in Hirasawa and Nagai's study (1990). We suppose this is caused by the higher stairways in their study compared with our study.

Table 1. Optimal slit length limit in three kinds of movement types

|                         | One Slit | Two Slits |
|-------------------------|----------|-----------|
| walking on the flat     | 4cm      | 2cm       |
| going up the stairways  | 12cm     | 8cm       |
| riding on the bus stair | 18cm     | 15cm      |

## 2. Physiological responses

### 1) Clothing pressure

Fig. 5 shows clothing pressure in three kinds of movement types. As seen in the figure, the longer the slit length, the lower the clothing pressure. Clothing pressure of one slit and two slits in 'walking on the flat' and 'riding on bus stair' showed significant difference ( $p < 0.05$ ). Clothing pressure of one-slit skirts was higher than two-slit skirts in case of the same slit length. However, clothing pressure in the one-slit skirts was not double clothing pressure in the two-slit skirts of the same length. For example, in the case of the one-slit skirts, clothing pressure was 124.80mV, equal to 12.73 gf/cm<sup>2</sup>, in 12cm of the movement 'going up the stairways'. This value is smaller than 100gf/cm<sup>2</sup> of Kawabata et al. (1993). This difference is perhaps attributable to clothing type such as slacks or skirts. However, this value is larger than 9.7gf/cm<sup>2</sup> of Park et al. (2000). We think that this difference results from different kind of material. However, in the case of two-slit skirts, the clothing pressure was 95.20mV in slit length of 12cm. In comparison of total slit length, slit length of 12cm in one-slit skirts equals to slit length of 6cm in two-slit skirts. In slit length 6cm of two-slit skirts, clothing pressure showed 165.38mV.

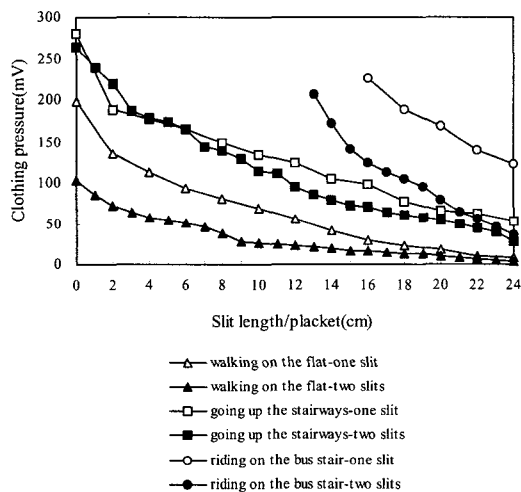


Fig. 5. Clothing pressure in three kinds of movement types.

The clothing pressure in 'riding on bus stair' was higher than in 'going up the stairways'. Clothing pressure in 'walking on the flat' was the lowest among the three types of movements. Clothing pressure of three kinds of movements showed significant difference ( $p < 0.05$ ). The results of this study agree to the research of Jo(1995). As the stairway height was increased, the clothing pressure increased. This shows that clothing restriction of the thigh is the largest in 'riding on bus stair'. The clothing pressure of a slit length under 16 cm with one slit, and under 13cm with two slits is not plotted, because the subjects could not step up the bus stairs in skirts having the slit length mentioned above. In every slit length described by the subjects in three movement types, the clothing pressure was lower in two-slit skirts than in one-slit skirts. This showed more slit numbers gave less clothing pressure.

### 2) Oxygen uptake

Fig. 6 shows oxygen uptake in three kinds of movement types. The longer the slit length was, the lower the oxygen uptake was. The results of the current study agree with previous assessments that suggested when the exercise load is greater, energy consumption increases (Kim & Choi, 1997). When the slit length is longer, the load of exercise is lightened, consequently, it

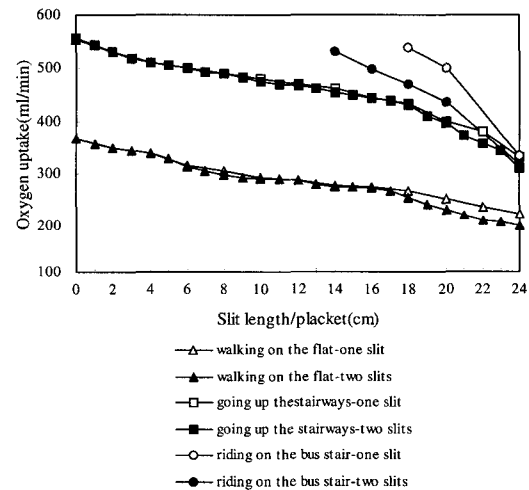


Fig. 6. Oxygen uptake in three kinds of movement types.

demands less oxygen uptake. As shown in Fig. 6, oxygen uptake of the same slit length was almost the same in both one slit and two slits in 'walking on the flat' and 'going up the stairways' but higher with one-slit skirts in 'riding on bus stair'. For example, oxygen uptake in 'going up the stairways' showed 469.68ml/min in slit length of 12cm in the one-slit skirts and showed 464.88ml/min in the two-slit skirts. In comparison of the total slit length, slit length of 12cm with one-slit skirts equals to slit length of 6 with two-slit skirts, which showed 499.25ml/min of oxygen uptake 'going up the stairways'. Oxygen uptake of three kinds of movement type showed significant difference ( $p < 0.05$ ).

Oxygen uptake was higher in 'riding on bus stair' than 'going up the stairways', and was the lowest in 'walking on the flat'. In the case of 'walking on the flat' and 'going up the stairways', slit length had lower sensitivity than the type of movement 'riding on bus stair' in oxygen uptake. From the viewpoint of total slit length, oxygen uptake with one slit was lower than with two slits.

#### IV. Conclusion

The purpose of this study was to investigate the optimal slit length of tight skirts, and physiological responses such as clothing pressure and oxygen uptake. Three types of movement, such as 'walking on the flat', 'going up the stairways' and 'riding on the bus stair', were evaluated for the measurement of physiological changes. Two types of skirt slits, such as one-slit skirts (only in one left placket) and two-slit skirts (one is in left placket and the other is in right placket), were used for the evaluation of optimal slit length.

In the case of 'walking on the flat', the optimal slit-length limit was 4cm in one-slit skirts, and 2cm in two-slit skirts. In case of 'going up the stairways', the optimal slit-length limit was 12cm in the one-slit skirts, and 8cm in the two-slit skirts. In the case of 'riding on bus stair' the optimal slit-length limit was 18cm in one-slit skirts, and 15cm in the two-slit skirts. Pleasantness of the two-slit skirts was higher than in the one-slit skirts in case of the same length. However, when it

comes to total slit length, the subjects felt better in the one-slit skirts than in the two-slit skirts.

Clothing pressure of the one-slit skirts was higher than the two-slit skirts in case of the same slit length. Clothing pressure in 'riding on the bus stair' was higher than in 'going up the stairways', and lowest in 'walking on the flat'. In comparison of total slit length, clothing pressure of the one-slit skirts was lower than the two-slit skirts.

Oxygen uptake of the same slit length was almost the same in both one slit and two slits. Oxygen uptake was higher in 'riding on bus stair' than 'going up the stairway', and was lowest in 'walking on the flat'. Oxygen uptake of the one-slit skirts and two-slit skirts was similar given the same slit length. From the viewpoint of total slit length, oxygen uptake in the one-slit skirts was lower than in the two-slit skirts.

With this result in mind, from the view point of total slit length, it is more effective to have a long slit length with a one-slit skirts than a short slit length with a two-slit skirts in pleasantness and physiological responses.

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