Clean Room 문제점의 인간공학적 연구
(Ergonomic Consideration of Clean Room Workers)

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1. INTRODUCTION

Clean rooms are widely used in high technology industries. Currently within the microelectronics industry there is an explosive growth in the number of clean rooms. Therefore, special consideration of clean room workers is needed to the work induced stresses from contamination avoidance, clothing requirements, and confinements [1].

2. DESIGN

After completion of a survey to determine potential ergonomic problems in the clean room, dominant problems appeared to be garment heat retention, garment vision or breathing interference, and garment design [2]. An experiment was designed to focus on these problems and to use the Texas Tech environment chamber to simulate a clean room environment. The temperature of the environmental chamber was set at 72°F with relative humidity maintained at 60%.

Several different sizes of clean room garments were borrowed from a microelectronics manufacturing firm. In order to familiarize the subjects with the experimental tasks and procedures, they first performed the simulated tasks in their street clothing. Three sizes of garments were assigned to each subject; under, over, and exact size. The sizes were based on each subjects's height and weight which were measured before the experiment. The garment sequence and task sequence were randomly selected for each subject. Subjects did not know the garment sequence or the task sequence. On the fifth trial, a randomly repeated size which was not same as that of the fourth trial was used.

A series of three tasks required the subjects to use a wide range of body movements which are typically encountered in a clean room. These tasks were:

1. SEATED TASK
The subject played a blackjack computer game for 2 minutes. The task simulated seated work such as writing or data entry and

was expected to reveal garment restriction associated with seated tasks.

2. ARM (UPPER ACTIVITY) TASK

The subject placed a cassette box on a shelf located at the subject's shoulder height. The subject was instructed to push the box two feet along the shelf with his or her right hand and then push it back to its original position with the left hand. The subject then removed the cassette box from the shelf using both hands and lowered it to the table. The subject then instructed to open the cassette box and run over five cassettes, close the box and place it back on the shelf using both hands. This series of activities was repeated five times. The task simulated reaching and twisting tasks such as the loading and unloading of wafer trays.

3. WHOLE BODY TASK

The subject took the cassette box from the previous work station, walked approximately ten feet to another work station where he or she bent over a table and with both hands released the cassette box, allowing it to go down a slide to approximately two inches above the floor level. The subject then bent down to a squatting position, reached under the table with both hands, and retrieved the cassette box. The subject stood up and walked ten feet back to the original station, placed the cassette box on the table, opened it, turned over five cassettes, closed the box and repeated the entire sequence two more times. This task simulated walking, bending, and squatting tasks similar to those found in clean room processing.

3. RESULTS

Main independent variables were task, garment size, body region, and sex. The dependent variable frequency of restriction represented a numerical count of the places where restriction was reported. The variable intensity of restriction represented a summation of the degree of restriction values indicated by the three point scale system previously described. Paired t-tests showed no statistical difference between the repeated size data and the original data. This indicated that a learning effect from repeating that task was not significant.

Figure 1 shows the summary chart of task effect. Garment restrictions were significantly different for each task. Task 3 showed the greatest garment restriction and Task 1 the last. The garment restriction data appeared to be a function of the level and range of the active movement (see Table 1).

Analysis of data with respect to the size variable (n=240) is summarized in Figure 2. For the frequency of restriction for

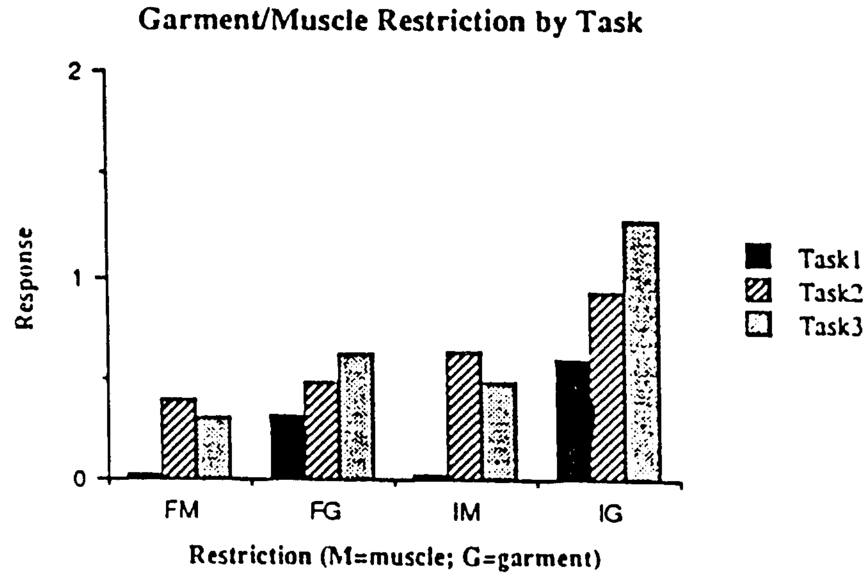

Figure 1. Task effects on garment and muscle restriction.

FREQUENCY OF RESTRICTION						
GARMENT (FM)			MUSCLE (FM)			
MEAN	TASK	GROUP	MEAN	TASK	GROUP	N
.062	3	A	0.40	2	A	320
0.49	2	B	0.31	3	A	320
0.32	1	C	0.03	1	B	320
INTENSITY OF RESTRICTION						
GARMENT (IG)			MUSCLE (IM)			
MEAN	TASK	GROUP	MEAN	TASK	GROUP	N
1.27	3	A	0.64	2	A	320
.093	2	B	0.49	3	A	320
0.60	1	C	0.03	1	B	320

Table 1. Task effects on frequency and intensity of restriction.

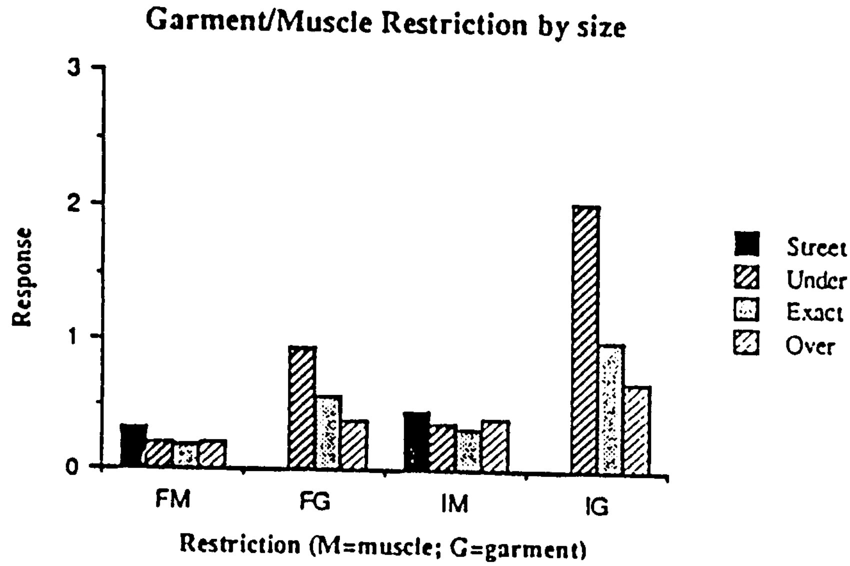

Figure 2. Clothing size effects on garment and muscle restriction.

FREQUENCY OF RESTRICTION						
GARMENT (FG)			MUSCLE (FM)			
MEAN	SIZE	GROUP	MEAN	SIZE	GROUP	N
0.93	Under	A	0.33	Street	A	240
0.58	Exact	B	0.24	Over	AB	240
0.38	Over	C	0.21	Under	AB	240
0.00	Street	D	0.20	Exact	B	240
INTENSITY OF RESTRICTION						
GARMENT (IG)			MUSCLE (IM)			
MEAN	SIZE	GROUP	MEAN	SIZE	GROUP	N
2.04	Under	A	0.45	Street	A	240
0.99	Exact	B	0.41	Over	A	240
0.69	Over	B	0.37	Under	A	240
0.00	Street	C	0.33	Exact	A	240

Table 2. Clothing size effects on frequency and intensity of restriction.

garment, all sizes were statistically different; the undersized garment being most restrictive, followed by the exact-size and the oversize the least restrictive. Since there was no "garment" for the street clothes trial, those means were zero. The intensity of the restriction for garment showed a similar pattern to the frequency of the restriction for garment. However, exact size and over size were not statistically different. This might be due to the non-uniformness of the human body and the wide range of the categorized sizes (see Table 2).

Analysis of data with respect to body region variable (n=240) is summarized in Figure 3. Analysis of the frequency of garment restriction indicated that region 2 (ARMS) had the highest frequency. This was apparently due to the large number of reports of discomfort from the gloves. The region 3 (TRUNK) and region 1 (HEAD) were next highest, but not different from one another. Garment restriction on region 3 (TRUNK) was often related to the crotch and underarms. A similar pattern was reported for the intensity of garment restriction. The mean values were consistently higher (approximately double) and the order was the same except for region 3 (TRUNK). For the intensity of garment restriction the relative restrictions on region 3 (TRUNK) were higher. However, region 3 (TRUNK) was not significantly different from region 2 (ARMS). Region effects are summarized in Table 3.

In Table 3, four body regions were grouped as follows: region 1 (HEAD) included the head and neck; region 2 (ARMS) included the upper arms, lower arms and hands; region 3 (TRUNK) included the shoulder, underarm, trunk, and crotch; and region 4 (LEGS) included hip, upper leg, lower leg, and feet.

Figure 4 shows the summary chart of the sex effect. Analysis of data with respect to the sex is represented in Table 4. There was a strong and consistently observable relationship for both frequency of restriction and intensity of restriction. Reports of both frequency and intensity for muscle and garment restrictions were much higher to the females than for males. Unisex garments, which are typically designed on male anthropometric considerations, likely contribute to this situation.

4. CONCLUSIONS

As expected, the more active tasks resulted in more muscle discomfort and garment restriction as compared to a seated task. However, the seated clean room tasks should not be ignored because sitting for a longer period of time may resulted in more garment and muscle complaints.

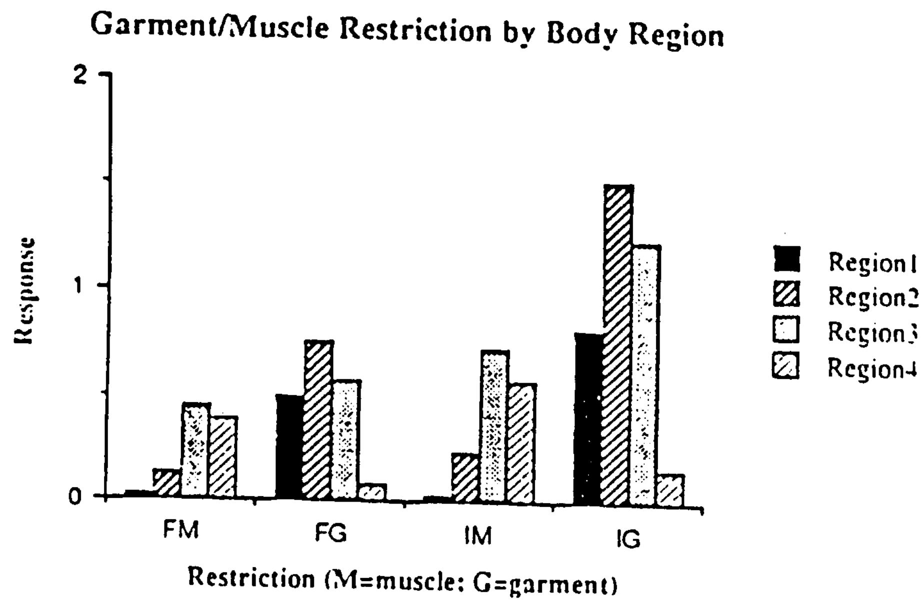

Figure 3. Body region effects on garment and muscle restrictions.

FREQUENCY OF RESTRICTION						
GARMENT (FG)			MUSCLE (FM)			
MEAN	REGION	GROUP	MEAN	REGION	GROUP	N
0.75	2(ARMS)	A	0.45	3(TRUNK)	A	240
0.57	3(TRUNK)	B	0.38	4(LEGS)	A	240
0.50	1(HEAD)	B	0.13	2(ARMS)	B	240
0.08	4(LEGS)	C	0.02	1(HEAD)	B	240
INTENSITY OF RESTRICTION						
GARMENT (IG)			MUSCLE (IM)			
MEAN	REGION	GROUP	MEAN	REGION	GROUP	N
1.52	2(ARMS)	A	0.73	3(TRUNK)	A	240
1.23	3(TRUNK)	A	0.57	4(ARMS)	A	240
0.82	1(HEAD)	B	0.23	2(ARMS)	B	240
0.15	4(LEGS)	C	0.03	1(HEAD)	B	240

Table 3. Body region effects on frequency and intensity of restriction.

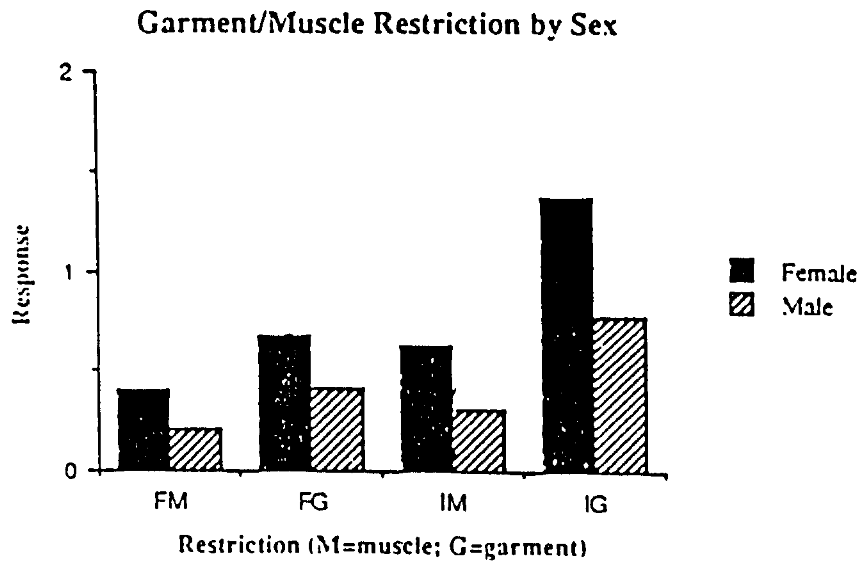

Figure 4. Sex effects on garment and muscle restriction.

FREQUENCY OF THE RESTRICTION						
GARMENT (FG)			MUSCLE (FM)			
MEAN	SEX	GROUP	MEAN	SEX	GROUP	N
0.67	F	A	0.39	F	A	240
0.41	M	B	0.20	M	B	720
INTENSITY OF THE RESTRICTION						
GARMENT (IG)			MUSCLE (IM)			
MEAN	SEX	GROUP	MEAN	SEX	GROUP	N
1.38	F	A	0.63	F	A	240
0.78	M	B	0.31	M	B	720

Table 4. Sex effects on frequency and intensity of restriction.

The mean value associated with body frequency and intensity of garment restriction were twice as high for undersize garment as compared to exact size garments. oversize garments had fewer restriction than exact size garments, which was expected.

Analyzing of the regions of body where garment interferences and discomfort were observed indicated region problems in the trunk or central body region. High responses of discomfort associated with the head and arms were primarily due to the criticisms of the mask and gloves respectively.

REFERENCES

[1] Czaja, S. J., "The Role of Ergonomics on Cleanroom Environments," Panel Discussion of Human Factors in Work Environments, Human Factors Society-27th Annual Meeting, 1983.

[2] Ramsey, J. D., Smith, J. L., and Kwon, Y. G., "Ergonomics in the Clean Room," Proceedings of the 10th Congress of the International Ergonomics Association, Sydney, Australia, 1988