

The Association of Subjective Stress, Urinary Catecholamine Concentrations and PC Game Room Use and Musculoskeletal Disorders of the Upper Limbs in Young Male Koreans

The use of PCs can cause health problems, including musculoskeletal disorders (MSDs) of the upper limbs. This study was performed to investigate whether using PCs in PC game rooms may induce MSDs of the upper limbs. 284 young male Koreans were included. A self-administered, structured questionnaire was used to gather information about game room use, perceived subjective stress, and the symptoms related to MSDs. Urinary concentrations of epinephrine, norepinephrine, and dopamine were measured in spot urine. The symptom prevalence of MSDs of the upper limbs increased according to the increase of the duration of game room use. The intensity of perceived subjective stress showed a significant dose-response relationship with the frequency of MSDs symptoms in neck and shoulder areas. However, the urinary level of catecholamines was not significantly correlated with the symptom prevalence of MSDs in the upper limbs. These findings suggest that using PCs in game rooms produce physical stress on the upper limbs, strong enough to induce MSDs.

Key Words : Subjective Stress; Urinary Epinephrine; Urinary Norepinephrine; Urinary Dopamine; PC Game Room; Musculoskeletal Disorder

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INTRODUCTION

Personal computer (PC) game rooms are commercial facilities equipped with high performance PCs connected to the Internet. Since people in Korea can use PCs at reasonable prices in PC game rooms and while PC games are very popular so that there are many professional leagues of PC games in Korea, PC game rooms are spreading explosively. The use of PCs can cause health problems, such as musculoskeletal disorders (MSDs) of upper limb (1). MSDs is a rapidly increasing health problem in many developed countries (2, 3) and there is a growing body of evidence suggesting that excessive computer use can cause MSDs of the upper limb (4). As possible risk factors of MSDs, physical stresses such as unstable posture, repeating movements, and work strength have been investigated (5, 6). However, other authors have insisted that psychosocial factors play important and dominant roles in the development of MSDs (7, 8).

Most users of PC game rooms are young males, and many of them spend considerable amounts of time in PC game rooms. In addition, the time-based charging system of PC game rooms ensures that the users keep playing PC games without a break. Consequently, it is probable that a range of health effects, including MSDs, would be expected to appear more frequently in habitual PC game room users than in the

general population. As almost all visitors to PC game rooms are there voluntarily for enjoyment, operation of PCs in game rooms may be related with physical stress, but not with job-related psychological stress.

This study was performed to investigate whether playing PC games in PC game rooms could induce MSDs, and, if this is the case, to define the roles of physical and psychological stresses in the development of MSDs.

MATERIALS AND METHODS

Study Subjects

Two hundred and eighty-four young male Koreans from 17 to 29 yr of age were included in this study. 184 subjects were recruited among the visitors of two PC game rooms, and 100 participants were volunteers from a nearby university. All of the subjects were paid volunteers and took part in this study of their own free will and gave informed consent.

Questionnaire

Information about demographic factors, game room use, and perceived subjective stress was collected using a self-ad-

ministered and structured questionnaire. After finishing questionnaire, each questionnaire were reviewed on the spot by study assistants and revised if there is any incomplete or inappropriate accurate answer.

Questions on the presence, duration and severity of MSDs related symptoms including pain, aching, burning, tingling and numbness of the upper limbs, were also included in the questionnaire. The answers to the questions about the duration of game room use and perceived subjective psychological stress were trichotomized: 'less than one hour per day', 'from one hour to two hours per day', and 'more than two hours per day' for the duration of game room use, and 'minimally stressed', 'moderately stressed', and 'severely stressed' for perceived subjective psychological stress.

Symptom prevalence of MSDs of the upper limbs was made according to the MSDs-screening criteria of National Institute for Occupational Safety and Health (NIOSH) (8-10) based on musculoskeletal symptoms in the neck, shoulder, elbow, wrist, and fingers. These criteria define MSDs as 'pain, aching, stiffness, burning, tingling or numbness of specific anatomical areas persisting for at least seven consecutive calendar days, or one or more of these symptoms persisting for at least 24 hr, and occurring more than once per month for the last year.'

Measurement of Urinary Catecholamine Concentrations

Spot urine was collected from each study subject, and urinary concentrations of epinephrine (E), norepinephrine (NE) and dopamine (DA) were measured using a high performance liquid chromatography (HPLC) system (11). To 100 μ L of urine sample, 1 μ L of 1 M trichloroacetic acid and 100 μ L of 1 μ M isoproterenol were added and mixed well. The mixture was centrifuged at 1,500 rpm for one minute. The supernatant was applied to a cartridge (Toyopak SP, Toyo Soda, Tokyo, Japan) and then eluted with 1 mL of CH₃CN/0.6 M KCl 1:1 solution. One hundred microliters of 0.1 M diphenylethylenediamine and 100 μ L of 15 mM K₃Fe(CN)₆ solutions were added to the eluent and incubated for 80 min at 37 °C. Fifty microliters of the eluted sample was injected into an HPLC system consisting of a pump (Waters 600E, Millipore, Milford, Mass., U.S.A.), a variable fluorescence detector (RF-10AxL, Shimadzu, Kyoto, Japan), an automatic injector (L-7200, Hitachi, Tokyo, Japan), and an integrator (Chromatopac C-R3A, Shimadzu, Kyoto, Japan). A 150 mm long reverse-phase column (TSK gel ODS-80™, Tosoh, Tokyo, Japan) was used. The mobile phase was a mixture of acetonitrile/0.1 M sodium acetate buffer/ methanol (60:40:5), and the flow rate was 1.0 mL/min. Excitation/emission wavelength used in the detection of catecholamine was 350/470 nm. Urinary concentrations of epinephrine, norepinephrine, and dopamine were corrected by urinary creatinine level.

Statistical Analysis

The Statistical Analysis System (SAS) for Windows version 6.12 was used for data analysis. The means of age, height, weight, and urinary catecholamine concentrations were compared using ANOVA with Duncan's multiple comparison method. Chi-square tests and chi-square tests for trend were applied to test the relationships between categorical variables.

The PC game room use, not the site of recruitment, was adopted as the independent variable because the associations of subjective stress, urinary catecholamine concentration and PC game room use and MSDs of upper limbs in each group were similar.

RESULTS

Two hundred and sixty nine (94.7%) of study subject were high school or university students. The distributions of age, height, and weight of study subjects are shown in Table 1. The mean age, height, and weight were not significantly different among the subject groups with different duration of game room use per day.

Table 2 shows the distributions of urinary concentrations of epinephrine, norepinephrine, and dopamine in study subjects. The urinary concentrations of epinephrine, norepinephrine, and dopamine did not show any significant correlation with the duration of game room use or with perceived subjective stress.

The distribution of study subjects according to the inten-

Table 1. Means and standard deviations of age, height, and weight of study subjects

Duration of PC game room use (hr/day)	No.	Age (yr)	Height (cm)	Weight (kg)
<1	113	22.9 ±2.7	173.7 ±5.0	66.8 ±8.4
1-2	102	21.9 ±2.5	173.4 ±5.4	64.9 ±8.7
2<	69	22.3 ±2.8	173.9 ±4.1	64.2 ±8.6

Table 2. Means and standard deviations of urinary catecholamine levels in study subjects

Game room use	No.	Urinary catecholamine level (μ mol/mol creatinine)		
		Epinephrine	Norepinephrine	Dopamine
Duration of game room use (hr/day)				
<1	113	3.5 ±2.6	11.6 ±4.4	81.2 ±21.3
1-2	102	4.0 ±2.6	12.9 ±5.1	78.6 ±32.8
2<	69	3.5 ±2.3	12.5 ±5.1	81.8 ±23.7
Perceived subjective stress				
Minimal	80	4.0 ±2.9	13.2 ±5.9	83.6 ±27.4
Moderate	170	3.7 ±2.5	12.0 ±4.3	77.8 ±26.8
Severe	34	3.1 ±1.5	11.8 ±4.5	85.5 ±20.8

sity of perceived subjective stress by the average duration of the game room use per day is shown in Table 3. We could find no significant association between the intensity of perceived subjective stress and the duration of game room use per day.

In the present study, symptom prevalence of MSDs of the upper limbs was 26.8% (76 subjects). Symptom prevalence of MSDs was most frequent in neck (16.2%), followed by MSDs in the shoulders (14.4%), wrists (8.8%), fingers (5.3%) and elbows (4.2%), in decreasing order. The symptom prevalence of MSDs in neck, wrists and fingers increased according to the increase in the duration of game room use (Table 4).

Table 3. Distribution of subjects according to perceived subjective stress by duration of game room use per day

Perceived subjective stress	Duration of game room use per day (hr/day)			Total
	<1	1-2	2<	
Minimal	31 (38.8%)	27 (33.8%)	22 (27.5%)	80 (100%)
Moderate	67 (39.4%)	65 (38.2%)	38 (22.4%)	170 (100%)
Severe	15 (41.1%)	10 (29.4%)	9 (26.5%)	34 (100%)
Total	113 (39.8%)	102 (35.9%)	69 (24.3%)	284 (100%)

Peason's chi-square=1.616 ($p=0.806$).

For the subjects who use game rooms from one to two hours per day, the odds ratios of MSDs in the neck, wrist and finger were 1.68, 1.52, and 1.89, respectively, and the corresponding values for those who use game rooms more than two hours per day were 2.75, 3.38, and 4.14, respectively. The symptom of MSDs in the upper limbs was found in 25 (22.1%) of 113 subjects who use game rooms for less than one hour per day, in 27 (26.4%) of 102 subjects who use game rooms for one to two hours per day, and in 24 (34.8%) of the remaining 69 subjects who use the rooms for more than two hours per day. The symptom prevalence of MSDs of the upper limbs increased with the increase in the duration of game room use per day with marginal significance (chi-square for trend=3.369, p value=0.066).

The intensity of perceived subjective stress showed a significant dose-response relationship with the frequency of MSDs in the upper limbs (Table 5). The odds ratio was 1.60 for subjects feeling moderate stress, and 5.97 for subjects perceiving severe stress. Perceived subjective stress showed significant positive correlation with the symptom prevalence of MSDs in the neck and shoulder, but not with the symptom prevalence of MSDs in the elbows, wrists and fingers.

A multiple logistic analysis including age, hours of game room use, and perceived subjective stress was performed. The

Table 4. Distribution of MSDs in the upper limbs according to the mean duration of game room use per day

Anatomical area	MSDs		Duration of game room use per day (hr/day)						p -value for trend test			
			<1		1-2		2<					
	Yes (%)	No (%)	MSDs		OR	MSDs		OR		MSDs		OR
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)		Yes (%)	No (%)	
Neck	46 (16.2)	238 (83.8)	12	101	1.00	17	85	1.68	17	52	2.75*	0.013
Shoulder	41 (14.4)	243 (85.6)	17	96	1.00	12	90	0.75	12	57	1.19	0.772
Elbow	12 (4.2)	272 (95.8)	3	110	1.00	3	99	1.11	6	63	3.49	0.106
Wrist	25 (8.8)	259 (91.2)	6	107	1.00	8	94	1.52	11	58	3.38*	0.018
Finger	15 (5.3)	269 (94.7)	3	110	1.00	5	97	1.89	7	62	4.14*	0.033
Whole upper limbs	76 (26.8)	208 (73.2)	25	88	1.00	27	75	1.27	24	45	1.88	0.066

* p -value <0.05.

Table 5. Distribution of MSDs in the upper limbs according to the degree of perceived subjective stress

Anatomical area	MSDs		Perceived subjective stress						p -value for trend test			
			Minimal		Moderate		Severe					
	Yes (%)	No (%)	MSDs		OR	MSDs		OR		MSDs		OR
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)		Yes (%)	No (%)	
Neck	46 (16.2)	238 (83.8)	7	73	1.00	25	145	1.80	14	20	7.30*	0.001
Shoulder	41 (14.4)	243 (85.6)	9	71	1.00	19	151	0.99	13	21	4.88	0.003
Elbow	12 (4.2)	272 (95.8)	3	77	1.00	6	164	0.94	3	31	2.48	0.350
Wrist	25 (8.8)	259 (91.2)	5	75	1.00	14	156	1.35	6	28	3.21*	0.085
Finger	15 (5.3)	269 (94.7)	3	77	1.00	9	161	1.44	3	31	2.48	0.293
Whole upper limbs	76 (26.8)	208 (73.2)	14	66	1.00	43	127	1.60	19	15	5.97*	0.001

* p -value <0.05.

Table 6. Odds ratios (95% confidence intervals) of variables for MSDs in the upper extremity areas estimated by multiple logistic analyses

	Neck	Shoulder	Elbow	Wrist	Finger	Whole upper limbs
Age	1.33 (0.81-2.18)	1.18 (0.71-1.96)	2.78* (1.07-7.20)	1.18 (0.64-2.20)	2.71* (1.15-6.39)	1.28 (0.85-1.92)
Duration of game room use	1.83 [†] (1.19-2.80)	1.13 (0.72-1.72)	2.22* (1.05-4.68)	1.95* (1.14-3.33)	2.31* (1.17-4.56)	1.47* (1.04-2.09)
Perceived subjective stress	2.90 [†] (1.65-5.01)	2.24 [†] (1.23-3.94)	1.59 (0.63-4.04)	1.84 (0.93-3.64)	1.61 (0.69-3.74)	2.38 [†] (1.50-3.80)

Age was trichotomized to '19', '20-24', and '25-29' yr. Duration of game room use per day was trichotomized to '>1 hr', '1-2 hr', and '2 hr or more'. Perceived subjective stress was trichotomized to 'stressed', 'moderately stressed', and 'severely stressed'. **p*-value <0.05, [†]*p*-value <0.01 *p*-value <0.001.

duration of the game room use was a significant determinant of MSDs in neck, elbow, wrist and finger areas. Perceived subjective stress, however, was a significant risk factor for MSDs in neck and shoulder areas. Age of subjects was statistically significant for MSDs in the elbows and fingers (Table 6).

DISCUSSION

Urinary catecholamine level is increased by experimental mental stress (12) and physical exercise (13). In the subjects of this study, the concentrations of urinary catecholamines were not affected by the duration of the PC game room use. Moreover, urinary catecholamine level did not differ in accordance with the degree of perceived subjective stress. These findings are compatible with the previous study that video display terminal (VDT) work did not increase urinary adrenaline (14). It could be suggested that the level of sympathetic nervous activity of individuals engaged in VDT work would not significantly be influenced by the use of the VDT itself, but by the intensity of VDT work (14).

Among many MSDs related studies, some authors used comparable screening method for MSDs and comparable anatomical area. Rhen *et al.*, whose study subjects were male drivers of all-terrain vehicles, reported that musculoskeletal symptom prevalence were from 48% to 61% for neck, and 44% to 56% for shoulder area (15). Blatter *et al.*, whose study subjects were both male and female office workers, reported that symptom prevalence of MSDs were from 10.3% for neck and shoulder, and 2.6% for elbow, arm or wrist/hand (16). Baker *et al.*, whose study subjects were both male and female telecommunication workers, reported that symptom prevalence of MSDs were 57% for neck, 41% for shoulder, 19% for elbow, and 52% for wrist (17). Ha *et al.*, who studies MSDs symptom prevalence among male foundry workers, reported that symptom prevalence of MSDs were 11.8% for neck, 13.7% for shoulder, and 23.5% for hand/wrist (18). Sung *et al.*, whose study subjects were both male and female symphony orchestra players, reported that 43.6% for neck, 59.6% for shoulder, 23.1% for elbow, 24.4% for wrist, and 30.1% for finger (19). Yoon *et al.*, whose study subjects were male automobile related job workers, reported that 47.1% for neck,

52.0% for shoulder, and 39.4% for wrist/hand (20). The symptom prevalence of MSDs in the whole upper limbs area was 26.8%, and that of the study subjects whose mean duration of game room use was longer than two hours per day was 34.8% (Table 4). The symptom prevalence of MSDs in wrist or finger areas in the subjects who use PC game rooms for more than two hours per day was 17.4%. These values are relatively higher than those of some reports and relatively lower than those of another reports (15-20). Considering that most of the subjects in this study were high school or university students, and the age of the subjects ranged between 17 and 29 yr, the symptom prevalence of MSDs in this study was much higher than expected. This suggests that playing PC games in game rooms may produce strong physical stress on the upper limbs, enough to induce MSDs of the upper extremity area in a relatively short period of time. The time-based charging system of Korean PC game rooms, as well as PC games that demand rapid and precise PC controls, force the users to stay in front of the PC typing and clicking without a break. Accordingly, PC operation can give more physical stress on the upper extremities in PC gamers than in VDT workers. Since MSDs in youths are likely to have more serious long-term effects, medical and ergonomical measures should be implemented to prevent MSDs of the upper limbs of users of Korean PC game rooms.

The symptom prevalence of MSDs in the wrist and fingers area was much higher than expected considering the young age and occupation-free status of the subjects of the present study. This finding may be due to the difference in job movements between PC game room users and VDT workers. More mouse clicking is needed for PC games, whereas business operators use the keyboard. The fact that 72.9% of the players who use PC game rooms for more than two hours per day held the mouse for more than 80% of the total playing time during some PC games (data not shown) suggests that excessive mouse-clicking may play an important role in the development of MSDs in the wrist and finger areas of PC game room users.

The symptom prevalence of MSDs in neck and shoulder areas was relatively high, compared with that of those of the wrist and fingers, and the occurrence of MSDs symptoms in the elbow was the lowest. This is compatible with previous studies reporting that pain in the neck and shoulder was the

most prevalent musculoskeletal symptom in VDT workers (1, 21, 22). Many studies have addressed the effect of job stress on MSDs in the upper extremities (8, 23-27). In the present study, the symptom prevalence of MSDs of neck and shoulder areas showed a significant correlation with the intensity of perceived subjective stress. As most of the study subjects of the present study were students, it is not likely that the perceived stress of the subjects in this study was job-related. These results suggest that psychological stress, whether job-related or not, can cause MSDs in neck or shoulder areas. This anatomical preference of MSDs induced by psychological stress has been identified in previous studies. Hales et al. reported that psychological stress in American telecommunication employees had a significant association with musculoskeletal disorders in the neck and shoulder areas (8). Although the mechanism is not clear, psychological stress may increase the static load of the neck and shoulder girdle muscles (28-30). On the contrary, the urinary level of catecholamines, an objective biomarker of stress level, was not significantly correlated with the symptom prevalence of MSDs of the upper limbs (data not shown), and nor was there any significant correlation between urinary catecholamine level and perceived subjective psychological stress. This result suggests that perceived stress is a more important determinant of the MSDs in the upper extremities than the level of sympathetic nervous activity. The measurement of perceived subjective stress was performed by using one simple closed question and this method was not validated in other studies yet. This may arouse random measurement error, and tend to decrease the real association. The subjective stresses of the subjects recruited at game room and of university students were similar in spite of the PC game room use patterns were definitely different (data now shown). This result supports that the possibility of systematic bias plays a major role in the measurement of subjective stress was low. There might be more strong association of MSDs and perceived subjective stress than the association observed in the results of the present study.

It is probable that PC game use at home or office also related with the MSDs of upper limbs. But the PC game use duration at other places was not considered in this study and this is one of the limitations of this study. It can be suggested that the total PC game use duration is included in future studies.

The standard quantitative measurement of PC game room use was not established yet. In the present study, the mean game room duration per day was adopted as an exposure index of PC game room use. But the frequency or intensity of PC game room use, if any, must be considered in the evaluation of PC game room use. This topic might be an another study topic and further researches are needed.

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