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A Study on the Work Environment and VDT Syndrome in Radiation Technologists Working in the Area of 3D Processing

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Abstract

As the frequency of use of VDT has increased in the hospitals, related diseases have been found to occur. Especially among the radiologists who perform 3D operations, there has been a gradual increase in the number of reported cases of VDT diseases. Hence, this study performed surveys among radiologists working in the area of 3D processing operations in MRI rooms, CT rooms, PACS rooms, and radiation oncology treatment planning offices to determine the symptoms and work conditions of radiologists suffering from VDT syndrome. It was also found that work environment related characteristics had an effect on VDT syndrome ($p<0.05$). In the correlation analysis between general characteristics and work environment related characteristics of radiologists suffering from VDT syndrome, it was found that both showed a positive correlation. A positive correlation was only observed in the questions on how 3D operation affected health ($p<0.05$). In this study, the following result was obtained: There is a need for promotion and education to prevent VDT syndrome symptoms in order to improve the problems related to the work environment of 3D processing workspace.

Keywords: 3D Processing, MRI Rooms, Radiation Treatment Planning, Radiologists, VDT Syndrome

1. Introduction

The current era is an information era in which computer technology has developed rapidly. The fields of application of computers have increased rapidly to areas such as personal, scholastic, offices, factories, and hospitals and this technology is being used to a great extent[1]. Especially in radiology, with the introduction of the PACS (Picture Achieving Communication System) system in the 2000s, it led to many environmental changes.

Previous analog methods of acquiring and storing images changed to acquiring and storing images digitally so that clinicians could use digital images instead of x-ray films to provide medical consultation. Also, the state of the art equipment in radiology including that used in CT (Computer Tomography) scanning, MRI (Magnetic Resonance Imaging) and RTP (Radiation Treatment Planning) reconfigures two dimensional images into three dimensional images to provide images that are similar to the organs of the body, to enable differentiation between organs in proximity, and to allow for a more accurate diagnosis[2]. However, with the development of this equipment, there has been an increase in the frequency and the time of usage of computers, and therefore, VDT syndrome, which was found only in office automation operators, is being detected in radiologists.

Especially in radiation treatment planning, a small error results in increased radiation exposure for the patient and radiologists perform more intricate and precise techniques.

VDT Syndrome includes all health problems that occur in a person who performs repetitive tasks with a display terminal in front of a computer screen[3] and diseases reported by VDT operators include eye disease, musculoskeletal

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disorders, skin diseases, mental disorders. The reported symptoms include various complicated symptoms such as itching and redness of eyes, pressure feeling in the eyes, sore and painful shoulders, shaking in fingers, anxiety and fatigue, decreased digestive function, and foggy vision[2,4].

The causes of these VDT syndrome symptoms include sociodemographic factors such as gender and age, work environment related factors such as working period, daily working hours, daily computer usage time, and psychological factors. VDT syndrome does not occur due to a single factor but it occurs as a result of various factors[5,6]. Hence, this study attempted to determine the work environment of 3D operating rooms where the radiologists perform 3D processing and to identify the factors that contribute to VDT syndrome in order to provide basic data for achieving improvement in the work environment of 3D operations and prevention of VDT syndrome.

2. Research Subject and Method

2.1 Research Subjects

For 3 months from 2014–05–13 the period is unclear, through direct visits and mail, 400 structured surveys were sent to radiologists working in the area of 3D processing. In the previous studies by Kim Mi-Jung[2] and Yang Se-Yi[7] it was shown that when the response rate was above 95 percent (more than 250 people), the statistical significance was 0.001, all showing significant values. In this study, the number of research subjects was selected as 400, expecting a response rate of more than 90% (360 people). The standard exception was when the response rate to the survey was below 60% and surveys that were received after the collection date. Data from 368 (92%) surveys, after excluding five surveys with less than 6% response rate and 27 surveys received late, were collected and analyzed.

2.2 Research Tool

The items in the survey included structured questionnaires, 9 general questions, and 15 questions about the work environment, which were designed based on the study performed by a previous researcher Lee Seung-Hwan[1]. The survey on VDT subjective symptoms was based on the survey performed by Lee Min-Cheol[8] and it used the survey that included system related symptoms such as eye related symptoms, musculoskeletal symptoms, psychological symptoms, systemic symptoms, and skin related symptoms as a measurement tool. The survey included a total of 33 questions and 10 questions on eye related symptoms, 5 questions on musculoskeletal symptoms, 7 questions on systemic symptoms, and 2 questions on skin related symptoms. According to the level of subjective symptoms, the answers were categorized on a 5 point Likert scale. The Likert scale score ranged from 'No symptom'– 0 to 'Severe symptoms – 4'. Therefore, a higher score represented a more severe symptom of VDT syndrome.

The study was conducted after receiving approval from the common clinical research ethics committee (IRB: Institutional Review Board, No: P01–201402–SB–02) governed by the Ministry of Health and Welfare.

2.3 Statistical Method

For the analysis of the survey data, SPSS (Statistical Package for the Social Science) VER. 18.0 program was used. To verify the validity of the survey, reliability analysis was conducted, and to determine the general characteristics and work environment of the research subjects, frequency analysis was conducted. Also, to identify the relationship between work environment and VDT syndrome, difference analysis (t-test and F-test) was conducted. Correlation analysis was conducted to determine the correlation between variables. Also, to identify the factors that affect VDT syndrome, hierarchical regression analysis was conducted. Statistical significance was set at a significance level of 95% ($p<0.05$).

3. Results

3.1 Reliability Analysis

To measure the reliability of survey questions, factor analysis and reliability analysis were conducted. The result of factor analysis was divided into three groups, and these were eye related diseases (8 questions), musculoskeletal diseases (8 questions), and systemic diseases (13 questions). In the result of reliability analysis of each group, survey questions on eye related diseases showed Cronbach's $\alpha=0.920$, on musculoskeletal diseases showed Cronbach's $\alpha=0.899$, and on system diseases showed Cronbach's $\alpha= 0.938$, indicating high reliability.

3.2 VDT Syndrome Symptoms according to the General Status

To identify the relationship between general status and VDT syndrome symptoms, t-verification and one way

layout Analysis of Variance (ANOVA) were conducted. For post verification, Duncan's test was conducted. In the result, it was found that in terms of gender, women showed a more statistically significant difference in the prevalence of musculoskeletal diseases (F=0.22, p<0.05), than men. It was found that hospital experience affected eye-related diseases (F=7.04), musculoskeletal diseases (F=6.14), and systemic diseases (F=3.06) (p<0.001). Eye related diseases and systemic diseases showed high average points in the above 5 and below 7 years group, and musculoskeletal diseases showed high average points in the above 3 and below 5 years group. In the post analysis, eye related diseases and systemic diseases showed differences between the below 1 year group and the above 5 and below 7 years group, and with respect to the musculoskeletal diseases, there were differences between the below 1 year and the above 7 years groups. It was also found that lab experience affected eye-related diseases (F=3.18), musculoskeletal diseases (F=3.14), and systemic diseases (F=2.55) (p<0.01). Eye related diseases, systemic diseases, and musculoskeletal diseases showed high average points in the above 3 and below 5 years group. In the post analysis, eye related diseases and systemic diseases showed differences between the below 1 year group and the above 3 and below 5 year group, and musculoskeletal diseases were categorized into the same group. Computer usage time and VDT syndrome symptoms were found to affect eye related diseases (F=4.67), musculoskeletal diseases (F=3.76), and systemic diseases (F=2.45, p<0.01) (p<0.001). Eye related diseases and musculoskeletal diseases showed five points in the 6~8 hour group, and systemic diseases showed high points in the 8 hour group. In the post analysis, eye related diseases and musculoskeletal diseases showed differences between the 2 hour and 6~8 hour groups. Systemic diseases showed differences in the 2~8 hour group [Table 1].

Table 1. VDT syndrome symptoms according to the general status

Question	Frequency	E.D			M.D			B.D		
		AR	F/t	D.C	AR	F/t	D.C	AR	F/t	D.C
Sex	368									
Male	301	1.21	2.21		1.77	0.22 *		0.85	1.40	
Female	67	1.44			1.99			0.97		
W	368									
1Y	36	0.95		A	1.60		A	0.63		A
1Y~3Y	46	0.77	7.04	A	1.41	6.14	A	0.64	3.06	A
3Y~5Y	40	1.09	***	AB	1.56	***	A	0.78	***	AB
5Y~7Y	47	1.46		C	1.02		B	1.02		B
7Y	199	0.25		BC	0.95		B	0.95		AB
W.R	368									
1Y	119	1.06		A	1.68		A	0.76		A
1Y~3Y	88	1.22	3.18	AB	1.74	2.55	A	0.79	3.14	A
3Y~5Y	59	1.49	**	B	1.97	**	A	1.13	**	B
5Y~7Y	31	1.21		AB	1.72		A	0.75		A
7Y	71	1.42		B	2.01		A	0.98		AB
C.T	368									
2H	15	0.60		A	1.61		A	0.59		A
2H~4H	38	1.05	4.67	B	1.55	3.76	A	0.75	2.45	AB
4H~6H	74	1.06	***	B	1.58	***	A	0.70	*	AB
6H~8H	161	1.39		B	1.94		B	0.94		AB
8H	80	1.35		B	1.81		B	0.98		B

*p<0.05, **p<0.01, ***p<0.001

1Y: 1 Year Below 1Y~3Y:1 and Below 3 Years Group.

3Y~5Y: 3 and Below 5 Years Group. 5Y~7Y: 5 and Below

7 Years Group. 7Y: 7 Years Group. C.T: Computer Usage Time. 2H: 2 Hour Below. 2H~4H: 2 and Below 4 Hour Group. 4H~6H: 4 and Below 6 Hour Group. 6H~8H : 6 and Below

8Hour Group. 8H: 8 Hour Group. D.C: Duncan. W.R: Lab Experience. **A.R:** Average. W: clinical experience.

E.D: Eye Related Diseases. M.D: Musculoskeletal Diseases. B.D: Systemic Diseases

3.3 VDT Syndrome Symptoms according to the Work Environment related Characteristics

To identify the relationship between work environment and VDT syndrome symptoms, verification and one way layout Analysis of Variance (ANOVA) were conducted. For post verification, Duncan's test was conducted. The distance between the operator and the monitor showed an association with eye related diseases (F= –2.47, p<0.01), musculoskeletal diseases (F= –1.68, p<0.01), and systemic diseases (F= –2.39, p<0.01). Exercises performed to relax the muscles showed an association with eye related diseases (F= 4.25, p<0.001), musculoskeletal diseases (F= 3.39, p<0.01), and systemic diseases (F=3.31, p<0.01). Eye related diseases and musculoskeletal diseases showed high average points in the more than 10 times a day group. Systemic diseases showed high average points in the 6~10 times a day group. In the post analysis, eye related diseases and musculoskeletal diseases showed differences between the 3~5 times a day group and more than 10

times a day group. Systemic diseases showed differences between the 3~5 times a day group and 6~10 times a day group. Exercises to alleviate eye fatigue showed an association with eye related diseases (F=2.92, p<0.001), and systemic diseases (F=3.53, p<0.01), and there was no statistically significant difference for musculoskeletal diseases (F=1.42).

In the post analysis, in the eye related diseases, there were differences between the groups which reported that they did not perform eye exercises and the groups which reported that they often performed eye exercises. With respect to questions on VDT syndrome symptoms and lab temperature humidity, the eye related diseases (F=5.36), musculoskeletal diseases (F=6.32), and systemic diseases (F=6.33), showed statistically significant differences (p<0.001).

In the post analysis, eye related diseases showed differences between the two groups; 'other' and 'very were categorized into the same group severe.' Musculoskeletal and systemic diseases With respect to the question on 3D operations and risk of exposure in VDT syndrome, eye related diseases (F= 4.68), musculoskeletal diseases (F= 4.09), and systemic diseases (F=2.62), showed statistically significant results (p<0.001), and the most frequent response was that 3D operations were associated with the risk of VDT syndrome (Table 2).

3.4 Correlation between VDT Syndrome Symptoms and Work Environment General Status

To identify the relationship between VDT syndrome symptoms and work environment and general status, correlation analysis was conducted. Eye related diseases showed a statistically significant correlation with distance between the display and operator's eyes (r=0.12, p<0.05), lab temperature humidity (r=0.20, p<0.01), clinical experience (r=0.24, p<0.01), lab experience (r=1.4, p<0.01), and computer usage time (r=0.19, p<0.01). Experience (r=0.24, p<0.01), lab experience (r=1.4, p<0.01), and computer usage time (r=0.19, p<0.01). Health status (r=-0.25, p<0.01) showed a negative correlation. Also, eye related diseases, exercises performed to relax the muscles (r=0.79), exercise performed to relax the eyes (r=0.10) did not show a statistically significant correlation. Systemic diseases showed a statistically significant correlation with distance between the display and operator's eyes (r=0.12, p<0.01), lab temperature humidity (r=0.21,

Table 2. VDT Syndrome Symptoms According to the Work Environment Related Characteristics

Question	Frequency	E.D			M.D			B.D		
		AR	F/t	D.C	AR	F/t	D.C	AR	F/t	D.C
M.D	368									
O.L	302	1.2	-2.47 **		1.77	-1.68 **		0.82	-2.39 **	
O.L.N	66	1.5			1.97			1.07		
M.S	368									
1D 1~2	171	1.25		A	1.81		AB	0.83		A
1D 3~5	56	1.0	4.52 ***	A	1.75	3.39 **	A	0.75	3.31 **	A
1D6~10	8	1.93		B	2.32		BC	1.55		B
1D 10	10	2.11		B	2.61		C	1.38		B
D.N	123	1.25		A	.73		A			A
E.S	368									
D.N	129	1.20		A	1.76		A	0.85		A
S.D	195	1.23	2.92 ***	A	1.79	1.42	A	0.84	3.53 **	A
O.D	37	1.36		A	1.91		A	0.95		A
V.O.D	7	2.19		B	2.78		B	1.41		B
T.H	368									
O.L	168	1.08		AB	1.66		A	0.74		A
M.O.L	136	1.28	5.36 ***	AB	1.79	6.32 ***	A	0.84	6.33 ***	A
O.L.N	44	1.63		B	2.28		A	1.31		A
V.O.L	18	1.76		B	2.25		A	1.21		A
Other	2	0.62		A	1.62		A	0.61		A
V.E	368									
Yes	274	1.37	4.68 ***		1.91	4.09 ***		0.93	2.62 ***	
No	89	0.87			1.49			0.68		

*p<0.05, **p<0.01, ***p<0.001

M.D: Musculoskeletal Diseases. M.S: Exercises Performed to Relax the Muscles. E.S: Exercise Performed to Relax the Eyes. T.H: Lab Tempe Rapture Humidity. V.E: VDT Syndrome Exposure Risk. O.L: Adequate. O.L.N: Not Adequate. M.O.L: Satisfactory. V.O.L: Very Unsatisfactory. 1D: Day. D.N: Not Done. S.D: Occasionally Done. O.D: Frequently Done. V.O.D: Very Frequently Done. E.D: Eye Related Diseases. M.D: Musculoskeletal Diseases B.D: Systemic Diseases. **A.R:** Average.

p<0.01), clinical experience (r=0.16, p<0.01), lab experience (r=0.10, p<0.05), and computer usage time (r=0.14, p<0.01). Health status (r=-0.20, p<0.01) showed a negative correlation, and exercises performed to relax the muscles (r=0.06), exercise performed to relax the eyes (r=0.06) did not show a statistically significant correlation. Musculoskeletal diseases showed a statistically significant correlation with exercises performed to relax the muscles (r=0.13, p<0.05), exercise performed to relax the eyes (r=0.11, p<0.01), lab temperature humidity

(r=0.22, p<0.01), clinical experience (r=0.21, p<0.01), lab experience (r=0.13, p<0.01), and computer usage time (r=0.16, p<0.01). Health status (r=-0.20, p<0.01) showed a negative correlation. Also, distance between the display and operators eyes did not show a statistically significant correlation [Table 3].

3.5 VDT Syndrome related Factor Analysis

To identify the effects of general characteristics and 3D lab environment on VDT syndrome, hierarchical regression analysis was conducted. First in the primary stage, relationship between general characteristics such as hospital size, clinical experience, lab experience, computer usage time, and work environment and VDT syndrome was assessed. As a result, VDT syndrome symptoms showed explanatory power of general characteristics in eye related diseases 12% (F=5.80), systemic diseases 12% (F=2.65), and musculoskeletal diseases 10% (F=4.59). In eye related diseases, it was found that there was a relation between computer usage time, work environment, and VDT syndrome, and in systemic diseases, hospital size was shown to have an effect (p<0.001).

Table 3. Correlation between VDT Syndrome Symptoms and Work Environment General Status

	E.D	B.D	M.D	M.S	M.D	E.S	T.H	G.E	W	W.B	C.T
E.D	1										
B.D	.75**	1									
M.D	.73**	.64**	1								
M.S	.79	.06	.13*	1							
M.E	.12*	.12*	.08	-.19**	1						
E.S	.10	.06	.11*	.47**	-.61	1					
T.H	.20**	.21**	.22**	.00	.19**	-0.3	1				
G.E	-.25**	-.20**	-.31**	-.05	-.06	-.03	-.11*	1			
W	.24**	.16**	.21**	-.04	.05	.03	-.04	-.31**	1		
W.B	1.4**	.10*	.13**	.007	-.007	.009	-0.3	-.18**	.55**	1	
C.T	.19**	.14**	.16**	.10	-.003	-.03	-.09	-.13**	.21**	.12**	1

*p<0.05, **p<0.01, ***p<0.001

E.D: Eye related Diseases. M.D: Musculoskeletal Diseases. B.D: Systemic Diseases. M.S: Exercises Performed to Relax the Muscles.
M.E: Distance Between the Display and the Operators' Eyes. E.S: Exercise performed to relax the Eyes. T.H: Lab Temperature Humidity
W.R: Lab Experience. W: Clinical Experience. C.T: Computer Usage Time.
G.E: Presence of Health Effects.

Table 4. VDT Syndrome Related Factor Analysis

	E.D		B.D		M.D	
	B(ß)	B(ß)	B(ß)	B(ß)	B(ß)	B(ß)
1 stage: C						
A	.146(.145)	.164(.162)	.040(0.47)	055(.065)	.040(.042)	.061(.065)
S	-.102(-.056)	-.109(-.060)	-.157(-.102)*	-.159(-.103)*	-.164(-.096)	-.175(-.103)
W	.069(.110)	.051(0.80).	.059(.110)	.046(0.85)	.086(.145)	.066(.110)
WR	.003(.006)	.001(.002)	.015(.030)	.014(.028)	.020(.035)	.015(.027)
C.T	.098(.114)*	.115(.134)	.067(.093)	.085(.118)**	.065(0.81)	.079(.098)
W.V	-.251(-.132)*	-.114(-.060)	-.096(-.060)	-.013(-.008)	-.163(-.091)	-.004(-.002)
2 stage: F.W						
M.E		-.141(-.060)		-.131(-.066)		-.056(-.026)
V.D		.224(.122)*		.111(.066)		.331(.117)**
E.S		.150(.116)**		.096(.088)		.147(.121)**
T.H		.203(.198)***		.176(.207)***		.205(.213)***
R2	.127	.199	.127	.199	.104	.191
F	5.80***	6.754***	2.65**	3.85***	4.59***	6.39***
R2	.127	.071	0.62	0.62	.104	.087

*p<0.05, **p<0.01, ***p<0.001

C: General Characteristics. A: Age S: Hospital Size. W: Clinical Experience. W.R: Lab Experience. C.T: Computer Usage Time.
W.V: Work Environment and VDT Syndrome Relation. 3D F.W: 3D Work Environment Characteristics. V.D: VDT Exposure Risk.
E.S: Exercise Performed to Relax the Eyes. T.H: Lab Temperature Humidity. M.E: Distance Between the Display and the Operators' Eyes. E.D: Eye Related Diseases. M.D: Musculoskeletal Diseases. B.D: Systemic Diseases.

In the secondary stage, screen and operator eye level, exercise performed to relax the eyes, lab temperature humidity, and VDT exposure risks were assessed. As a result, the explanatory power was 19% in eye related diseases (F=6.75), 19% in systemic diseases (F=3.85), and 19% in musculoskeletal diseases (6.39). For eye related diseases and musculoskeletal diseases, VDT exposure risk, exercise performed to relax the eyes, and lab temperature had a significant effect, and for systemic diseases, lab temperature humidity was found to have an effect ($p<0.001$) [Table 4].

4. Discussion

In modern societies, many offices use VDTs. These applications are used not only in the offices but also in hospitals. The introduction of VDT has provided many benefits such as convenience in patient treatment and in accuracy, but at the same time it is causing VDT related health problems[9].

Symptoms that can occur due to the use of VDT include eye related diseases that cause eye fatigue and eyestrain, musculoskeletal diseases that affect the muscles such as those of the shoulder, neck, and back, and systemic diseases. Also, there are reports of psychological diseases and skin diseases[11] and the results reported by Goldhader MK and others suggest that VDT syndrome affects pregnancy[10]. The factors that affect VDT syndrome are sociodemographic factors such as gender, work experience, work period, and daily computer usage time, lab environment characteristics such as lab temperature, humidity, lighting, and operator posture[12].

In this study, it was found that the general characteristics affecting VDT syndrome were gender, hospital experience, lab experience, and computer usage time during work. It was found that in terms of gender, women showed a higher prevalence of musculoskeletal diseases than men. This finding differs from the results of the study by Kim Mi-Jung[2] which shows that gender is not related to VDT syndrome, and it is deemed that women are more susceptible to VDT syndrome.

Also in the results of converting points of VDT syndrome symptom questions, musculoskeletal diseases showed the highest points, followed by eye related diseases and systemic diseases. These results are similar to those obtained in the studies by Lee Seung-Hwan[1] and Kim Mi-Jung[2]. Also, in terms of work environment, there was more responses that the distance between the display and the operator's eyes was adequate than otherwise, but in terms of the level of symptoms, the most prevalent response was that the distance between the display and the operator's eyes was not adequate. In the study by Lee Ji-Woo[13] it was reported that as the distance between the display and the operator's eyes reduces, the eye control ability increases causing more eyestrain leading to eye diseases and even musculoskeletal diseases. However, it also reported that with rest the ability can recover to a state before VDT operation. In this study, it was found that most operators did not perform exercise to relax the eyes and it was seen to affect eye related diseases and systemic diseases. In terms of lab temperature and humidity, there were more people who replied that it was so-so or not good at all rather than those who replied that it was adequate. It was found that people who replied that it was not good at all had a high degree of VDT subjective symptoms.

It was found that the recommendation of the Korean Labor Welfare Corporation, which states that the lab temperature should be maintained between 18 to 24 degrees and humidity should be maintained between 40 to 70 percent, was not being followed[3].

5. Conclusion

This study used structured surveys among radiologists working in the area of 3D processing operations in MRI rooms, CT rooms, PACS rooms, and radiation oncology treatment planning offices to determine the symptoms and working conditions and to identify the factors that affect VDT symptoms in order to improve the working environments and to prevent VDT syndrome symptom occurrence, and the following conclusions were derived.

- General characteristics and VDT syndrome symptoms showed statistical significance in hospital experience, lab experience, computer usage time during work ($p<0.05$).
- Three-dimensional lab characteristics and VDT syndrome showed statistical significance in distance between the display and operator's eyes, exercises performed to relax the muscles, lab temperature humidity, VDT syndrome exposure risk awareness ($p<0.05$).
- The VDT work environment related factors and VDT syndrome symptoms showed a positive correlation and only the health effect hazard showed a negative correlation ($p<0.05$).

- VDT syndrome related to fiscal analysis showed that eye related diseases were significantly affected by computer usage time, VDT exposure risk, exercise performed to relax the eyes, and lab temperature humidity, systemic diseases were significantly affected by hospital size, computer usage time, and lab temperature humidity, and musculoskeletal diseases were significantly affected by VDT exposure risk, exercise performed to relax the eyes, and lab temperature humidity ($p<0.05$).

According to the results of this study, 3D processing operators in radiology should be designated as personnel exposed to risk of VDT syndrome and improvement in lab environment and prevention education, and measures for VDT syndrome and promotion are needed. The limitation of this study was that because the research subjects relied only on surveys, measurement of the actual 3D lab environment was not possible.

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