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Special Topic
Ergonomics in Seating

Ergonomics of Office Seating and Postures

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Objective: This research focuses on the working environment of office workers and aims to propose an ideal seating posture and chair design.

Background: Generally, office workers having to seat in a fixed posture for long periods of time tend to suffer from an increased rate of musculoskeletal disorders.

Method: The measurement and survey of 123 office workers on their working conditions and literature survey will lead to a suggestion of an ideal seating posture and workstation design theory.

Results: Work environment satisfaction appeared low for chair and desks. Work-related pain over the last year was experienced among 47.2% of the respondents in shoulder (34.2%), neck (30.9%). Observation of working posture revealed that only 27.6% of workers utilize backrest during work.

Conclusion: Office work embodies many situations where risks of musculoskeletal disorders may be high. Thus, the seated workplace must be set up to allow proper seating posture for workers.

Application: The results of this study can be applied as baseline data for preventing musculoskeletal disorders of office workers.

Keywords: Seated workplace, Chair design, Seating and posture

1. Introduction

According to Statistics Korea (2013), 4,288,000 out of 24,962,000 employees (17.2%) were office workers in 2013, and the number has increased in the last 5 years. Along with the incremental trend, interest in office setting has also risen. In the era of information, an office is where a worker spends most of the day and interacts with colleagues for conduction of business (Mandal, 1981). Thus, an office should be built considering physical properties of the worker for them to work effectively.

Office workers tend to seat down for long periods of time with little variation, taking physically demanding postures. Workers who have developed a bad posture can experience muscle or ligament imbalances. This can also alter cortex alignment and lead to cases of low back pain or intervertebral disc problems. For this matter, guidelines and evaluation techniques for office workers with constant use of computers are being discussed to prevent musculoskeletal disorders (OSHA, 1997; NIOSH, 1999; HSE, 2003; ANSI/HFES, 2007). Poor office settings can induce not only

musculoskeletal disorders but also job-related-stress and disrupt concentration leading up to less work efficiency. Preventing musculoskeletal disorders in offices involves several factors; workstation (computer, table, chair, surrounding objects), work conditions (working hour, intensity, break time), systematic factors (work design, schedule, disposition of men), office setting (light, noise, temperature, air quality), worker (working posture, physical property, gender).. Ergonomic furniture design according to personal physical properties enhances worker satisfaction of the workplace and reduces musculoskeletal disorders. Among these, chair comfort is known to have the biggest influence on workplace.

This research studies office worker's workplace conditions and provides guidelines for seated office tasks and postures. Physical measurements of workplaces were taken while subjective worker satisfaction of office settings and task related physical pains were also surveyed. This study aims to provide guidelines for optimal working posture.

2. Method

Workplaces of 13 different institutions in 38 offices of 123 office workers were measured and surveyed. 82 men and 41 women participated. Survey included general characteristics (age, gender, length of service (years), office hours per day, computer-work hours per day), satisfaction for work environment, work-related musculoskeletal pain and measurements of office environment. Survey on conformance levels for office environment included noise, light, monitor layout, desk and chair, and total feeling. Each factor was evaluated in 5 scales of 'Very discomfort (1), discomfort (2), moderate (3), comfort (4) and very comfort (5)'.

Work-related physical pain was surveyed considering workplace musculoskeletal harmful factors survey guidelines (KOSHA CODE H-30-2008) and asked yes/no question, 'Have you experienced physical pain due to computer tasks over the last 1 year'. Specific questions about pain region, intensity, frequency were asked for those that answered 'yes'. Pain region were classified into neck, shoulders, arms, wrists, back and legs. Pain intensity was evaluated among 'Negligible pain (does not feel pain), minor pain (little discomfort but cannot be felt during intensive work), moderate pain (pain during tasks but better with relaxation after work), severe pain (pain during tasks and continues after work), very severe pain (pain hinders work and daily activities)'.

Light, noise, chair (height, width, depth, back height), chair functions (neck rest, arm rest, seat pan, wheel) and chair monitoring and adjustability were surveyed about work environment. Distance between the table and light was measured straight from the center of the worktable to the closest light source. Light intensity was measured at the center of the worktable using an illuminometer (National BN-2000LTE) for 3 seconds and recorded the average value. Noise meter (Intell Safe JTS-1357) was used to measure noise level from 30cm from the worker's ear. Similarly, noise levels were measured for 3 seconds and the average value was recorded.

3. Survey Results for Office Worker and Workstation

3.1 General characteristics

Table 1 displays 123 worker characteristics with average age of 42.8 (7.67), 15.0 (8.38) years of service, and 10.7 (2.08) office hours with 8.2 (2.56) hours of computer-work per day.

3.2 Feelings of comfort for office environment

Table 2 shows conformance levels for office environment. 38.2% answered 'comfort' or 'very comfort' compared to 17.1% that replied 'discomfort' or 'very discomfort' for chair and desk function satisfaction. Monitor layouts were answered as 49.6% 'comfort' of 'very comfort' while 73.3% thought it was 'discomfort' or 'very discomfort'. 43.9% evaluated noise levels as 'comfort' or 'very

comfort', higher than 17.9% that replied 'discomfort' or 'very discomfort'. Lighting also had positive results of 52.9% 'comfort' or 'very comfort' compared to 17.0% 'discomfort' or 'very discomfort' evaluations.

Table 1. Subject characteristics (n=123)

Variable	Mean (Standard deviation)
Age (yrs)	42.8 (7.67)
Length of service (yrs)	15.0 (8.38)
Office hours/day	10.7 (2.08)
Computer-work hours/day	8.2 (2.56)

Table 2. Subjective conformance levels (5 scales) for office environment

Variable	Response ratio (%) of 'Is the variable adequate/comfortable?'					Mean (Standard deviation)
	1=very discomfort	2=discomfort	3=moderate	4=comfort	5=very comfort	
Chair and desk	3.3	13.8	44.7	33.3	4.9	3.23 (0.87)
Monitor layout	1.6	5.7	43.1	46.3	3.3	3.44 (0.73)
Noise	4.1	13.8	38.2	39.8	4.1	3.26 (0.89)
Lighting	2.4	14.6	30.1	47.2	5.7	3.39 (0.89)
The total feelings	1.6	16.3	51.2	30.1	0.8	3.12 (0.74)

Overall satisfaction for the office environment show only 30.9% 'comfort' or 'very comfort' and 17.9% 'discomfort' or 'very discomfort'. The satisfaction for each component is lower for chair and desks, and increases in order from noise, lighting, monitor layout.

3.3 Complaining rate of musculoskeletal pain

Table 3 displays the results of survey on work related musculoskeletal pain in the last 1 year. 47.2% replied to have experience of musculoskeletal pain in the past year. Allowing multiple choices, the region of were surveyed to be shoulder (34.2%), neck (30.9%), back (22.0%), wrist (14.6%), arm (11.4%), leg (11.4%), showing common occurrence of shoulder and neck pain. Meanwhile, severe pain (pain during tasks and continues after work) was experienced in shoulder (5.7%), back (3.3%) and leg (3.3%), when daily pain included shoulder (8.1%), back (4.9%) and neck (4.1%).

3.4 Measurements of office environment

Table 4 shows measurements of lighting, noise, light distance, chair properties (height, width, depth, back height) in office environments. Lighting was an average of 542.5 lux (156.9), noise levels 51.7 dBA (4.4), light distance 2.0m (0.2) in these environments. Chairs had an average height of 39.7cm (4.2), width 49.0cm (2.00), depth 48.2cm (2.29) and back height 58.0cm (6.13).

Table 5 illustrates the rate of possession of function for chair. Various functions were equipped differently in the seat pan; height adjustment functions 97.1%, angle adjustment 98.2%, wheels 99.2%, spin structure 98.4%. Only neck rests were present in only

35.0% of the chairs and only 11.4% among the total number held height adjustment functions. Arm rests existed in 99.2% of the chairs but height adjustment was only available for 38.2% of the total.

Table 3. Complaining rate of musculoskeletal pain

Variable	Example	Body part					
		Neck	Shoulder	Arm	Wrist	Back	Leg
Pain experience during last year		30.9	34.2	11.4	14.6	22.0	11.4
Severity of pain	Negligible pain	2.4	1.6	3.3	1.6	1.6	
	Minor pain	17.9	17.1	7.3	8.9	13.0	
	Moderate pain	8.9	9.8	0.0	3.3	4.1	8.1
	Severe pain	1.6	4.9	0.8	0.8	3.3	3.3
	Very severe pain		0.8				
Frequency of pain	Every six months	4.9	3.3	4.1	4.9	2.4	2.4
	Once per 2~3 months	7.3	7.3	1.6	3.3	3.3	0.8
	Once a month	2.4	2.4	1.6	2.4	5.7	4.9
	Once a week	12.2	13.0	2.4	3.3	5.7	1.6
	Every day	4.1	8.1	1.6	0.8	4.9	1.6

Table 4. Measurements of office environments

Office component	Function	Mean	Standard deviation
Environment	Lighting (lux)	542.5	156.90
	Noise (dBA)	51.7	4.45
	Light distance (m)	2.0	0.24
Chair	Height (cm)	39.7	4.20
	Width (cm)	49.0	2.00
	Depth (cm)	48.2	2.29
	Back height (cm)	58.0	6.13

Table 5. Rate of possession of function for chair

Chair component	Function	Rate of possession (%)
Seat pan	Height adjustment	97.1
	Angle adjustment	98.2
	Wheels	99.2
	Spin structure	98.4

Table 5. Rate of possession of function for chair (Continued)

Chair component	Function	Rate of possession (%)
Neck rest	Possession of function	35.0
	Height adjustment	11.4
Arm rest	Possession of function	99.2
	Height adjustment	38.2

Through observation of the working position, only 27.6% of office workers took advantage of chair backrests, meaning 62.4% did not use back rests at all during work.

4. Guideline of Office Seating and Posture

4.1 Seating and neutral postures

4.1.1 Neural posture and lumber support

Neutral postures reduce stress and fatigue on body parts. Muscle strength is greatest working in these postures. On the contrary, static postures reduces blood supply to body parts causing waste products to build up forcing muscles to work without proper nutrients.

A neutral posture depends on the natural alignment of the body. The back has three natural curves; cervical, thoractic and lumbar curves. These curves are correctly aligned when the ears, shoulders and hips are in a straight line (Corlett, 1999). Strong muscles in the hips, thighs and abdomen are required for maintaining such posture. Body weight is evenly distributed in this state, placing no stress on one particular area.

The back is made up of small vertebrae which allow the back to bend in various shapes. Between each of the vertebrae are soft discs act as shock absorbers. Abusive movements and static postures can weaken these vital discs.

Sitting for long periods of time can cause pressure increase in intervertebral discs. The normal alignment of the spine is an S-shaped curve; an inward curve at the neck, an outward curve in the middle of the back and an inward curve at the lower back. The lower curve of the back flattens when a chair fails to provide adequate lumbar support. The hip rotates, flattening the curve in the lower part of the back; the spinal discs stretch from the vertebrae causing back pain.

The purpose of well-designed seating is to provide stable support that allows movement, comfort and task accomplishment. Awkward seated postures and lengthy periods of sitting may increase rick of injury. In office works there are certain conditions or risk factors that can contribute to the development of musculoskeletal disorders (Cal/OSHA, 2005).

- Working with awkward neck, shoulder, elbow, wrist or back postures
- Remaining in the same position for a long time with little or no movement
- Using the keyboard for long periods of time without rests
- Continuous pressure on wrists, forearms or elbows from wrist rests or the work surface; or on the back of the legs from the front edge of the chair.

4.1.2 Neck, shoulders, and limbs

Many cases for WMSDs begin with neck or shoulder strain. The neck must not be bent too much during work. Pain can result from shoulder and neck muscle tension. Generally, the head should be balanced while level or bent slightly forward and in-line with the torso.

The shoulders should be relaxed with arms hanging normally at the side of the body. Static exertions in a fixed seated posture dramatically increase the risk of muscle fatigue and are often considered the first threshold to injury. Supporting arm weight reduces the stress on the spine.

Typing with forearms parallel to the floor, wrists straighten and fingers are relaxed. This is known as a neutral position, which puts minimum strain on the muscles, nerves and tendons.

Sitting is a stressful posture for the feet and legs. Gravity tends to pull blood down to the legs and feet, creating a sluggish return of blood to the heart. Changing positions every 20-30 minutes prevents muscle fatigue and increases blood circulation. Hip joints, knees and ankles should form right angles in a preferable sitting position.

It is important to change positions periodically. Sitting in one position for an extended period of time can interfere with circulation. If you type continuously, a good rule of thumb is to do other tasks for ten minutes every hour. Regular stretches can reduce muscle fatigue and reduce stress (Work Safe NB, 2010).

4.2 Guideline of chair design

4.2.1 Chair seat and armrest

The height of a chair should be adjustable in a seated position to allow the feet to rest flat on the floor with the thighs roughly parallel to the floor. If the work surface is too high, then the arms and shoulders are stressed to reach the keyboard. This requires continuous muscular effort and may also hinder blood flow adding discomfort and risk of injury. It also causes wrists to bend forward and place stress on the forearm muscles. If the workstation is too low, arms and back are stressed when bending the body to get closer. Height-adjustable chairs can help place the user at a proper height for typing, writing and viewing the monitor, especially when height-adjustable tables are not available.

Backside of the knees should not come in direct contact with the edge of the seat pan. Seat length should be decided to allow the majority of users to fit comfortably. Typically a taller person will require more seat pan length and a shorter person will require less. A shorter person sitting on a long seat pan will experience pressure behind the knees, or, if they perch on the edge, will not benefit from the seat back support. A taller person sitting on a short seat pan length will have inadequate support resulting in higher contact pressure under the thighs. Good ergonomic seating incorporates several inches of adjustable seat pan depth.

The use of armrests are very effective in reducing the stress onto muscles of the upper back, neck and shoulders, and is a fundamental requirement for proper fit. Armrests are adjusted to be positioned slightly below the elbows when the shoulders are relaxed (ANSI/HFES, 2007). If the armrests are too high, they will elevate the shoulders causing shoulder and neck pain. When the armrests are too low, they promote slumping and leaning postures.

4.2.2 Chair backrest

Lumbar support is a key factor in designing a comfortable and injury preventing seats. The back rest of a chair should be adjustable for each user since it plays a critical role in supporting the spine. A proper backrest successfully supports the entire back of a user, including the lower region, and provides a comfortable posture that permits frequent variation in a seated posture.

The seated position will give least load on the back if there is a slight curve in the lumbar region, just as in the standing position. Back is fully supported with appropriate lumbar support when sitting vertical or leaning back slightly. Lumber comfort is greatly enhanced by allowing users to adjust the height as well as independently adjust support on either side of the spine. Always sit back and move your chair close to the desk to maintain contact between your back and the seat back to help support and maintain the inward curve of the lumbar spine.

4.2.3 Monitor and others

Neck strain is often related to improper monitor height, poor placement of documents, or improper positioning of document holders. The top of the monitor should be slightly below eye level (WCB, 1999). If it is too high the head will be tilted back, throwing the neck out of alignment, possibly causing headaches. Depending on the tasks, users should be able to adjust the monitor to an optimum viewing angle. Monitor distance should be between 60-90cm (Work Safe NB, 2010).

The desktop should be organized so that frequently used objects are stored close to the user to avoid excessive extended reaching and that only those in constant use are on the work surface. The keyboard and mouse should be located at a height that allows the user's forearms, wrists, and hands to be parallel to the floor. Sitting with feet hanging and not resting flat on the floor can reduce leg circulation and cause discomfort on the back. A foot rest adjustable for height and surface angles should be placed if the feet cannot rest comfortably on the floor. Meanwhile, a five-point base is recommended for stability of the chair.

5. Conclusion

Modern life requires people to spend much time seated in offices inside skyscrapers. Thus, interest in office environment and work space of the workers has increased recently. This has led to effort in preventing building syndromes or musculoskeletal disorders and work stress to guarantee the well-being of office workers.

This research conducted a study on work environment, environment satisfaction, occurrence of musculoskeletal pain in seated office settings and provided an optimal seating position and design for the workplace. According to the research, respondents used the computer more than 8 hours a day among the total average of 10 hours at work. Work environment satisfaction appeared low for chair and desks among the factors; noise, lighting, monitor layout, chair and desk. Moreover, work-related pain over the last year was experienced among 47.2% of the respondents in shoulder (34.2%), neck (30.9%), waist (22.0%). Work-related pain had occurred especially in the shoulders and neck of the workers. Meanwhile, chairs lacked neck rests (35.0%) and height adjustment functions of it (11.4%), arm rest height adjustment function (38.2%) despite having other qualities such as chair height, angle adjustments and spin structures. Observation of working positions revealed that only 27.6% of workers utilize backrest during work and 72.4% do not, showing the lack of awareness for correct working postures.

According to this, office workers suffer from significant musculoskeletal pain, especially in shoulders and neck, which is different form the tendencies of manufactory workers. This stresses the need for attention on musculoskeletal disorders by office workers. Education about prevention methods and optimal working postures is also in need. This study also provides guidelines for an ergonomically optimal seating postures and workplace design.

There are limits to the proposed ergonomic guideline in that it focuses on the seated position. Nevertheless, working environment surveys and design guidelines of this research can be used as a base line for seated office design.

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