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Correlation Between the Height and the Subjective Discomfort Ratings and Muscle Performance at performing the Lower Arm's Pronation and Supination according to the Changes in Height of Working Table

The purpose of this study is to analyze the correlation between the stature and the muscle performance ratings and the subjective discomfort rations at performing lower arm's pronation and supination according to change sin the height of working table for more efficient performance at designing a working table and performing a work. For the purpose, this study conducted an experiment targeting 40 people in their 20s, who were classified into 4 groups each group composing 10 people at intervals of 5cm from the standard stature of 166.5cm. The experiment measured the maximum isometric pronation and the supination muscular power, and at measuring the factors, the heights of working tables were set as 800mm, 850mm, and 900mm. From the measurement results, it was found that the stature and the maximum muscular power was correlated. That is, as the experiment groups's average stature is higher, the maximum muscular power was higher. For the correlation between the motion patterns(pronation and supination) and the maximum muscular power, it was seen that the maximum muscular power was higher at performing the pronation than the supination. In the correlation between motion patterns and the subjective discomfort ratings, it was seen that the subjective discomfort rating was higher at performing the supination than the pronation. For the correlation between height adjustment and the subjective discomfort ratings, as the height of working table was lower, the subject discomfort rating was lower. Therefore there was no difference in the maximum muscular power according to the height changes of working table, but it was found that as the working table was higher, the user felt more comfortable.

Key words: *Muscle Performance; Subjective Discomfort Ratings; Pronation; Supination*

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INTRODUCTION

Work related Musculoskeletal Disorders represent chronic health hazards which are usually appeared in hands, wrists, shoulders, neck, shoulder blade, and back by minutely injuring muscles, joints, blood vessels and nerves caused from excessive use of a specific physical part or muscle(1). The work kinds with especially higher potential of musculoskeletal disorders were simply repeating works, heavy material dealing works, hand tool and various machines operating works, VDT work, various assembling works, wrapping works, and poultry and meat processing work(2). Most musculoskeletal disorders are cumulative trauma disorders, meaning the functional injuries in soft physical tissues like muscular tissues.

Production workers in industrial or production sites are much exposed to repetitive motions by performing simple repetitive works, and such work environments may become potential factors to insure body parts. Such discomfort working factors are long term influenced on body parts, especially on upper parts like neck, shoulder, arms. In the physical part long term influenced, the musculoskeletal disorders (MSDs) or the cumulative trauma disorders(CTDs) are created with showing ill symptoms like pain, declined muscular power, decreased flexibility. As far as such bad work environments are replaced with suitable work environment, the MSDs and CTDs will happen more frequently and will be more serious(3).

It is known that the work related MSDs is happened by various causes including the work types, the work environment, psychological factors, or demographic factors, and the increase of these disorders is recently emerged as a social problem. In Korea, the government is aware of the seriousness of MSDs and legislated the MSD relevant laws forcing the companies to do preventive actions from happening this disorder(4).

For workers in production sites, the height of work table can enormously influence on their fatigue as an outcome of performing works. But in most work environments, the workers perform their duties on the existing work tables whose height doesn't consider its influence on the worker's fatigue, the worker's gender. Even though the variables influencing on the worker's body like the load amount vary according to the companies or products, many companies don't consider such variables and conventionally use the working tables with similar height(5). There are factors causing physical injuries or discomfort while performing the works. Among them, the height is an important factor. Most workers who have experienced some pain in their back, neck or shoulder pointed out the cause of discomfort as the unsuitable height of work plan for their statures. So low height of working plane makes the workers bend over so much. Opposingly so high height of working plane makes the workers lift their shoulder higher than its position in convenient state, so makes the shoulder and the neck more discomfortable(6). A work space should be designed in basically considering the characteristics of the object to be designed or user's aspects. It means that a work space should be ergonomically designed, and a working table ergonomically designed improves the concentrativeness on working and reduce the worker's fatigue, leading to reduce the accident rate(6).

According to korean industrial standard(KS), the standard heights for kitchen working table are 800mm, 850mm, and 900mm(7). The working table range used in the department of clothes in 5 universities located in Seoul in 2004 were 73~81cm(6), and Jeon reported average height of kitchen working table in korea was 851.7mm(±23.3)(8).

Pronation and supination are the motions happened in an elbow joint which forces the palm to go downward or upward when the lower arm is kept horizontally by bending the elbow joint(9).

Previous studies mainly focused on the subjective fatigue, the work efficiency, or concentrativeness(5) according to the changes in height of working table, the relation between the height of working table and chair pattern and the Cumulative Trauma Disorder(10) depending on working postures(11), the relation between the work related MSD and the work characteristics(4). Such studies mainly used the questionnaire method to collect necessary data, and there were. rare experimental studies.

Concerning the studies about the lower arm's pronation and supination, there were studies investigating the muscular power changes at doing the pronation and supination depending on different bending angles of elbow joint(12), or the muscular power changes at doing the pronation and the supination and the electromyogram(EMG) activity ratings according to different bending angles of elbow joint(13). Besides, there were studies on the thickness of grip's influence on the lower arm's pronation and supination(14), the symmetry between lower arm's pronation and supination(15). But there has not been any study researching the differences of muscular power according to changes in height of working table. The purpose of study is to analyze the correlation between stature and the muscle performance ratings & the subjective discomfort rations at performing lower arm's pronation and supination according to changes in height of working table for more efficient performance at designing a working table and performing a work.

METHODS

Subjects

This study was conducted targeting 40 people in their 20s attending on N university located in Chungnam. The people with past histories of any neurological disorder, muscular disorder, or skeletal disorder or with current external injuries or pain are excluded from the subjects. Before the participation in the experiment, the subjects heard and enough understood the explanation about experiment contents and methods and voluntarily agreed the content form. The investigator classified the subjects into 4 groups each group composing 10 people at intervals of 5cm from the standard stature of 166.5cm, the average height of Korean 20s according to KATS(Korean agency for technology and standards) and conducted the experiment.

Table 1. Subject groups classification

Group	Height(cm)
A	156.5 ~ 161.5
B	161.5 ~ 166.5
C	166.5 ~ 171.5
D	171.5 ~ 176.5

Table 2. Subjects' general characteristics (Mean±SD)

Group	N	Age(yrs)	Height(cm)	Weight(kg)
A	10	22±1.83	157.52±1.25	51.67±4.97
B	10	23±1.66	164.08±1.82	55.00±5.70
C	10	21.20±1.69	168.86±1.71	62.81±6.50
D	10	22.70±1.82	174.08±1.94	71.35±7.70

A: 156.5~161.5cm, B: 161.5~166.5cm, C: 166.5~171.5cm, D: 171.5~176.5cm

Measurement

At classifying into 4 groups based on the subjects' height, the investigator used the automatic height meter(BSM330, Biospace, Korean) to measure subjects' statures. A tape line was used to measure the heights of working tables. And in measuring the maximum muscular power at doing lower arm's pronation and supination, the PRIMUS RS(BTE, USA), an instrument for functional exercise therapy and evaluation, was used. At measuring the maximum muscular power, a pedal was put between the upper arm and the torso of each subject in order to maximumly prevent from happening the reaction in his/her shoulder joint.

Procedure

Before the experiment, the investigator recorded the subject's general characteristics including gender, age, dominant hand, medical histories through the basic survey, and got the participation content form from them after making them enough being aware of the experiment. After then, the investigator conducted the experiment targeting the 40 subjects. With the automatic height meter, the subjects' heights and weights were measured. The selection standard of subjects was based on the Korean 20s average stature, 166.5cm(16), and the subjects were randomly arranged into 4 groups each group composing 10 people at intervals of 5cm.

The maximum isometric, muscular power at doing the pronation and the supination were measured by allowing each subject to grasp the grip of PRIMUS RS, the measurement instrument. At measuring the muscular power, each subject had to take a pedal under his/her arm. At measuring the muscular power, the heights of working tables were set 800mm, 850mm and 900mm based on KS(7). The measurement process was as follows. First, the head height of measurement instrument was set at 800mm, and the grip was attached on the instrument. After each subject's muscular power was measured at the height. The measurement process was same applied at other heights of 850mm and 900mm. The experiment was conducted in row of 800, 850mm and 900mm. All subjects had to stand and put their legs apart at the shoulder width. At measuring the isometric maximum muscular power at doing the pronation and the supination, the subject's lower arm position was set at the zero degree, the neutral angle. Before measuring the muscular power, the subjects were familiar with the way to measure the muscular power. They exercised the maximum muscular power for 5 seconds after the investigator's oral order. After exercising the muscular power 3 times at each measured height(800, 850, 900mm) and the maximum values were recorded. When the subjects contracted the lower arm's muscular power to the maximum, the investigator helped them with encouraging by word, and gave 3 minute break time between each measurement time in order to minimize the transference effect(17). After completing the muscular power's measurement process by height, each subject had to fill in the Borg's scale numerically quantifying the subjective discomfort ratings(18).

Data Analysis

For analyzing the data of this study, the investigator used SPSS version 15.0 program for WINDOW to statistically analyze subjects' raw scores. To find out the correlations between the stature and the height of working table, the motion pattern and the isometric maximum muscular power, the subjective discomfort ratings, the scores was analyzed in using Pearson's correlation coefficients.

RESULTS

Correlation Between the Stature in experiment groups and the Maximum Muscular Power and the Subjective Discomfort Ratings

It was found that the correlation between the stature in experimental group and the maximum, muscular power and the subjective discomfort ratings was statistically positive, showing the significantly positive coefficient($r=.417$, $p<.01$). The result means that as the average stature of experimental group is higher, the maximum muscular power is higher. But there is no significant correlation between the experiment groups and the subjective discomfort ratings($r=.030$, $p>.01$).

Table 3. Correlation between the experiment and the maximum muscular power and the subjective discomfort ratings

	Maximum muscular power	Subjective discomfort ratings
Experiment groups	.417*	.030
Motion type	−.542*	.192*
Working table height	.048	.463*

Correlation between the Motion patterns and the Maximum Muscular Power and the Subjective Discomfort Ratings

It was found that the correlation between the motion patterns and the maximum, muscular power and the subjective discomfort ratings was statistically negative, showing the significantly negative coefficient($r=-.542$, $p<.01$). This result means that the maximum muscular power was more increased at performing the pronation than the supination. And it was found that the correlation between motion patterns and the subjective discomfort ratings was statistically positive, showing the significant positive coefficients($r=.192$, $p<.01$). This result means that the subjective discomfort ratings was higher at performing the supination than the pronation.

Correlation between the Height of Working Table and the Maximum Muscular Power and the Subjective Discomfort Ratings

There was no significant correlation between the height of working table and the maximum muscular power($r=.048$, $p>.01$). It was found that the correlation between the height adjustment of working table and the subjective discomfort ratings was statically positive, showing the significantly positive coefficient($r=.463$, $p<.01$). The height of working table was higher, the subjective discomfort ratings was higher, but the height was lower, the subjective discomfort ratings was lower.

DISCUSSION

The purpose of this study is to find out the height of working table suitable for users by analyzing the correlation between the isometric maximum muscular power at performing the lower arm's pronation and supination and the subjective ratings and the subjective discomfort ratings and by confirming whether the maximum muscular power was exercised at the height of working table felt most comfortably by the subjects.

In the correlation of maximum muscular power and the average stature of experiment groups, it was appeared that as the average stature was higher, the maximum muscular power was larger. The result corresponds with the results of researches that the isomatric maximum muscular power at performing the pronation and the supination was larger in the male(12), and was influenced by the factors like subject's gender and age, his/her muscle length, the firing rate of motor nerve, the active motor unit number in muscle, the motor unit size and type in muscle, and neurological, endocrine, psychological factors(19, 20). And as the average stature of experiment groups was higher, the rate of male was higher in each experiment group. Richards reported that the male's power of grasp was found to be higher than that of female(21). Therefore it is guessed that the physical factors like genders and body patterns of male and female might influence on the measured muscular power.

Correlation between the subjective discomfort ratings and the changes in stature and height of working table was not significant. Because this experiment controlled only the height of working table, so the subjects might comfortably posed with an comfort elbow angle at measuring their maximum muscular power at a discomfort height of working table for them. Therefore an experiment is needed to know about the differences of subjective discomfort ratings by measuring the muscular power in the wider range of other factors as well as the changes in height of working table.

In the correlation between the motion patterns and the maximum muscular power, the maximum muscular power was larger at performing the pronation than the supination. According to Matsuoka, when the isometric maximum torque was measured, it was found that the maximum muscular power was significantly higher at performing the pronation regardless of the forearm's rotation angles(15). The result from this experiment was similar with the previous research. That is, it was appeared that the isometric maximum muscular power was larger at performing the pronation than the supination.

In the correlation between the motion patterns and the subjective discomfort ratings, the subjective discomfort ratings was larger at performing the supination than the pronation. This experiment result showing the pornation produced larger maximum muscular power than the supination can be explained in the association with the result of Karen reporting that the isomaximum muscular power was exercised at performing the pronation(22).

As larger muscular power can be exercised at performing the pronation than the supination, so it is assumed that the subjects might felt less subjective discomfort ratings at performing the muscular motion to exercise larger power.

In the correlation between the height adjustment and the maximum muscular power, there was not any statiscially significant difference. In the studies dealing the maximum muscular power difference at performing the pronation and the subpination according to the changes in elbow joint's bending angle, Mathiowetz and Rennells reported that the 90 degree of elbow joint's bending angle generated the largest muscular power(23), but other researchers insisted that at the elbow joint's unfolding state, that is zero degree of elbow joint's bending angle produced the largest muscular power(12). This study only controlled the height of working table and allowed the subjects to be measured their muscular power in their most comfortable posture concerning the elbow joint's bending degree. So the subjects' postures at measuring their muscular power were not consistent, and not controlled. Due to such reason, it is considered that each subject determined his/her elbow joint's bending angle by him/herself, and such inconsistent bending angles among subjects might generate such a result.

In the correlation between the height adjustment and the subjective discomfort ratings, it was found that as the height of working table was higher, the subjective discomfort ratings felt by subjects was higher. In previous studies, it was appeared that as the elbow join's angle was closer to zero degree, the isometric maximum muscular power became higher(24). Similarly to such result, this study identified that as the height of working table became lower, the elbow joint's bending was closer to zero degree in spite of not controlling the elbow joint's angle degree, therefore it is considered that subjects might felt more comfortable at exercising the maximum muscular power. In the above correlation between the height of working table and the maximum muscular power, the elbow joint's bending degree was not controlled, so this study could not get a statistically signigicant values, but as the height of working table became lower, then the elbow joint's bending angle became naturally closer to zero degree. So it is considered that such result might be appeared.

From the analysis on the experiment results, the investigator could find out some limits in this experiment. First, because the experiment group could not balance the gender ratio equally, so this study could not exactly compare 4 experiment groups. Second, in real work environments, most workers use their dominant hand and non-dominant hand in many cases, but this study didn't compare the muscular power of dominant hand and non dominant hand by measuring the dominant hand's muscular power. Third, this study was conducted targeting male and female college students in their 20s, so lacked the research about more various ages. So future researches should complement the above limits. This study conducted the experiment about the lower arm's muscular power and the subjective discomfort ratings based on the height of standard kitchen working table set by KS, but future researches should deal the differences in muscular power and subjective discomfort ratings depending on various heights of working tables which are seen in real work sites.

CONCLUSION

This study was purposed to find out the correlation between the stature and the subjective discomfort ratings at performing the lower arm's pronation and supination and the muscle performance according to changes in height of working table targeting 40 students in their 20s attending on N university located in Chungnam.

In the correlation between the stature and the-maximum muscular power, it was found that as the average stature of experiment groups was higher, the maximum muscular power was higher. But in the correlation between the stature and the subjective discomfort ratings, there was no statistically significant difference. In the correlation between the motion patterns and the maximum muscular power, the maximum muscular power was higher at performing the pronation than the supination. In the correlation between the motion patterns and the subjective discomfort ratings, the subjective discomfort ratings was higher at performing the supination than the pronation. However in the correlation between the height adjustment and the maximum muscular power, there was not statistically significant difference. In the correlation between the height and the subjective discomfort ratings, it was found that as the height of working table was lower, the subjective discomfort ratings was lower.

From the above results, this study could know that there was no difference in the maximum muscular power depending on different heights of working table, but the subjective discomfort ratings was influenced by the height of working table. It was found that as the height of working table was lower, the user felt more comfortable. But this study has a few limits, and even got a result not corresponding the previous similar researches. It is considered that future researches should deal such limits.

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