

A Study on Functional Movement Screen and Automobile Worker's Musculoskeletal Disorders

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Objective: The aim of this study is to figure out the level of Functional Movement Screen (FMS) of 122 automobile manufacturing workers and to set the FMS score for predicting risk of musculoskeletal disorders.

Background: Although today's industrial sites have been becoming automated rapidly, the risks of work-related musculoskeletal disorders (WMSDs) have been on the rise. In the case of WMSDs, it is important to control WMSDs at the early stage. Early detection of WMSDs is very important for the successful treatment. However, the medical examination puts a great financial burden on most workers. To reduce their burden, there is one test to check the musculoskeletal functional condition and to predict the risk of injury, which is called FMS.

Method: This research tested the FMS score of 122 workers at a motor company, and also conducted a questionnaire survey of individual characteristics and job characteristics.

Results: For the 122 subjects, the average score of FMS is 14.63 ± 2.27 . There is a negative correlation between FMS and their ages and BMI ($p < 0.05$). FMS is higher when exercising regularly ($p < 0.05$). The FMS scores of musculoskeletal disorder patients are lower than those of normal workers ($p < 0.05$). While it is more likely to become a musculoskeletal disorder patient when FMS score is less than 14, it is more likely to become a normal worker when FMS score is more than or equal to 14.

Conclusion: According to the result of FMS test, there is a score difference between individuals with musculoskeletal disorders and normal ones. FMS scores can also predict and identify workers with risk of the musculoskeletal disorders.

Application: According to this study, FMS can be expected to have a positive effect on the prevention of WMSDs in worksites.

Keywords: Functional movement screen, FMS, WMSDs

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1. Introduction

Modern industrial sites have been rapidly automated according to production technology development. Nonetheless, the prevalence rates and the seriousness of musculoskeletal disorders in the process of carrying out work are on the rise (Yoon and Song, 2006). Work-related musculoskeletal disorders (WMSDs) are defined as chronic health disorders occurring to human's body due to delicate microtrauma inside of human body due to the overuse of specific body parts and muscles in

relation with work (Kim and Bae, 2006). The occurrence of musculoskeletal disorders affect worker's activities, and thus cause many social and economic problems such as the quality of life decline, loss of labor, decline of work quality and increase of industrial accident compensation. Korean manufacturing worksites implement various preventive actions including risk factors survey, working environment improvement, medical actions and the execution of musculoskeletal disorders prevention and control programs for the prevention and control of musculoskeletal disorders (Kim, 2012; Kim and Jang, 2010).

For the control of musculoskeletal disorders, the work evaluation needs to be carried out. Researches so far have mainly been on work postures and on measurement of muscle loads according to improper postures using electromyogram (EMG) (Kim and Kim, 2012; Kim and Woo, 2011). Many studies on developing checklist and using it to workplaces in view of the characteristics of industrial health evaluating risk factors targeting many people have been conducted (Kim and Hong, 2009; Oh and Jeong, 2005).

It is important to control musculoskeletal disorders at the early stage. For such an early stage control, early stage detection is important; however, medical examination becomes an economic burden in reality. Although a tool to check the functional conditions of worker's musculoskeletal system is in place in a workplace, most tools can just measure one ability such as muscle strength or flexibility, and therefore there is a difficulty to link with musculoskeletal disorders. Actually, tools and researches that can check musculoskeletal disorder conditions of the workers whose musculoskeletal disorders are worried, and that can predict the risk of injuries lack in reality (Kim and Woo, 2011).

The Functional Movement Screen (FMS) is a new tool to predict musculoskeletal system conditions and the risk of injuries, and is a tool that is quick to use, cheap and easily applicable, while it does not damage human body (Teyhen et al., 2012; Cook et al., 2006). The efficiency of FMS as a basic preventive tool of injuries has been proved in the researches targeting athletes and firefighters. By using FMS, Kiesel et al. (2007) found out that the injury rate of the American football players with less than 14 in FMS score is 11 times higher among the American football players. As a result of a study on firefighters' WMSDs, lower FMS scores were revealed from the firefighters with injuries in the past (Peate et al., 2007). His study revealed that the number of injuries fell 42% for the 12 months after the 12-month training program was executed in relation with work-related injuries between a group of firefighters that exercised to increase FMS score, and a control group.

FMS has been proved as a valid indicator of the risk of injuries among elite athletes abroad. However, a study on FMS targeting workers have yet to be conducted in Korea and abroad. The studies using FMS in Korea as follows: study on reliability and validity on the Korean version FMS, and a study on the effects of pain and performance ability of fencing players on FMS (An and Lee, 2010; Kim et al., 2011).

Although studies on the evaluation of environment and working postures in workplaces as research on the control of musculoskeletal disorders have been actively carried out, the studies on evaluation of workers' musculoskeletal condition lack. If early stage control of workers' musculoskeletal disorders conditions is undertaken through FMS, it will be helpful to the prevention and control of workers' musculoskeletal disorders in the Korean manufacturing industry (Yoon and Kim, 2011).

This study aims to investigate Korean automobile industry workers' FMS scores, identify individual characteristics and work-related factors and association with musculoskeletal disorders, and set the FMS scores, based on which the symptoms of musculoskeletal disorders are predicted.

2. Method

2.1 Subjects

The subjects in this study were the workers in a motor company, and the research survey period was four months. This study targeted 122 workers using the health promotion center located within the company. The average age of the subjects was 37.0, average height was 173cm, average weight was 73.4kg and average period of work was 11.2 years.

2.2 Method

After explaining the background, purpose, method and details of the survey, this study conducted a questionnaire survey to investigate the working environment, individual characteristics, and musculoskeletal disorders symptoms, and also carried out FMS.

The questions on work-related factors included work intensity, job satisfaction, work skillfulness and job group (office work/production work). The questions on individual characteristics included age, body mass index (BMI), drinking and smoking status and usual exercise amount. As for the questions on the symptoms of musculoskeletal disorders, the questionnaire offered by the Korea Occupational Safety & Health Agency (KOSHA) was used. After this study identified whether the subjects felt uncomfortable symptoms such as pain, tingling and numbness on neck, shoulder, arm/elbow, back, leg/foot for the past one year, this study surveyed the duration, frequency and level of pain. Concerning the evaluation criteria of prevalence rate, this study decided the subjects of control (workers to pay attention and workers with WMSDs symptoms) based on the body part evaluation criteria of NIOSH (National Institute of Occupational Safety & Health).

The seven movements of FMS (Figure 1) consist of the following: ① Deep squat ② Hurdle step ③ Inline lunge ④ Shoulder mobility ⑤ Active straight leg raise ⑥ Trunk stability push up ⑦ Rotatory stability (Cook, 2010). Zero~three points are awarded



Figure 1. Seven movement tests and test tools for FMS

to each screen result: three points for performing perfect movement, two points for possible movement with compensation action, one point for impossible movement and zero point for pain during the screen test. The smaller score was recorded in case measuring both left and right sides.

To find out the relations between the characteristics of the subjects and FMS scores, this study conducted a correlation analysis, and one-way ANOVA to find out differences according to exercise amount. To predict musculoskeletal disorders, FMS scores were determined using the ROC (Receiver Operating Characteristics) curve. The SPSS PASW 18 program was used for the statistical analysis of all data.

3. Results

3.1 Distribution of subjects' FMS scores

The subjects' mean FMS score was 14.6, and maximum score was 20, and minimum score was 8. The median value was 15 points, and the mode was 15 points. Figure 2 shows the distribution of FMS scores.

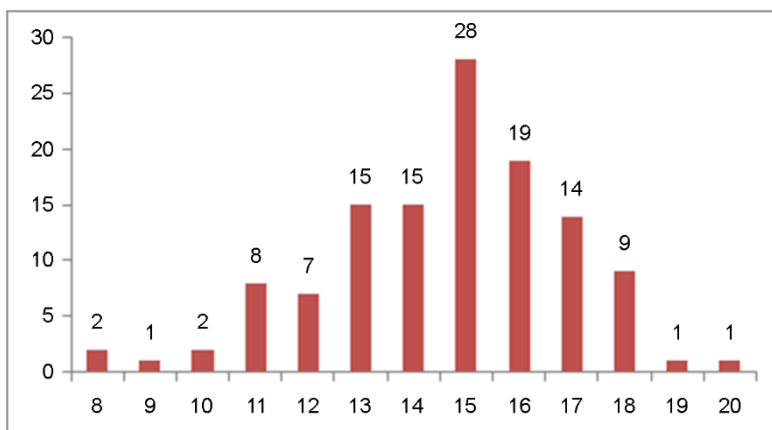


Figure 2. Distribution of FMS scores

3.2 Correlation between FMS and age and BMI

To identify the relations between age, body mass index (BMI), working career and FMS score, this study conducted a Pearson's correlation coefficient analysis. As shown in Table 1, FMS score showed negative and significant correlations with age ($r = -.169$,

Table 1. Correlation between age, BMI, working career and WMSDs

	<i>r</i>	<i>p</i>
Age	-.169	.031*
Body mass index (BMI)	-.167	.033*

* $p < .05$

$p=.031$) and BMI ($r=-.167$, $p=.033$). Therefore FMS score became lower, as age and BMI were higher. However, the job satisfaction, labor intensity, job skillfulness and FMS score by job group did not reveal a statistical difference.

3.3 Difference in FMS score according to drinking, smoking and exercise amount

This study divided drinking and smoking levels and exercise amount into three groups by frequency. To check the FMS score differences among the groups, this study carried out one-way ANOVA.

There was no FMS score difference according to drinking and smoking levels. However, upon looking at the FMS score difference according to exercise amount, the mean FMS score of the regularly exercising group was 15.05 ± 2.20 , that of the irregularly exercising group was 14.72 ± 2.15 , and that of the almost no exercising group was 13.50 ± 2.56 . As shown in Table 2, there were statistical differences at $p < 0.05$ level. As a result of the Scheffe post-hoc test on such a difference, there was a significant difference between the regularly exercising group and the almost no exercising group at $p < .05$ level.

Table 2. Difference of FMS scores in exercise

	SS	DF	MS	F	p
Between group	33.237	2	16.618	3.312	.040*
Within group	597.165	119	5.018		
Total	630.402	121			

* $p < .05$

3.4 Difference of FMS scores by musculoskeletal disorders symptom

According to the judgement result according to musculoskeletal disorders symptom, this study divided the subjects into a group of normal workers, a group of workers to pay attention and a group of workers with WMSDs symptoms. The mean FMS score of the group of normal workers was 15.21 ± 1.87 , that of the group of workers to pay attention was 11.67 ± 2.42 , and the group of workers with WMSDs symptoms was 12.83 ± 2.12 . As shown in Table 3, the F value on the mean difference of the three groups was 23.332, and there was a significant difference at $p < 0.05$ level. As a result of Scheffe post-hoc test on such a difference, there was a significant difference between the group of normal workers and the group of workers to pay attention ($p=.000$) and between the group of normal workers and the group of works with WMSDs symptoms ($p=.001$) at $p < 0.001$ level.

Table 3. Difference of FMS scores in WMSDs

	SS	DF	MS	F	p
Between group	177.568	2	88.784	23.332	.000*
Within group	452.833	119	3.085		
Total	630.402	121			

3.5 Setting up FMS score to predict WMSDs symptoms

To judge the cut-off value of FMS to predict WMSDs symptoms, this study used the ROC (Receiver-Operating Characteristics) curve. The ROC curve is to judge estimated model's performance by sensitivity and specificity. The area under the curve (AUC) was .841, and it was revealed to be a relatively accurate test, and was a useful test for prediction in view of $p=.000$. The general criteria of AUC were as follows: perfect test ($AUC=1$), highly accurate test ($0.9 < AUC < 1$), moderately accurate test ($0.7 < AUC \leq 0.9$), less accurate test ($0.5 < AUC \leq 0.7$) and non-informative test with 0.5 or less (Song, 2009; Greiner et al., 2000). As the sensitivity and specificity are closer to the upper left side of the curve in Figure 3, it is interpreted as a more accurate test method. This study decided 13.5 (higher in sensitivity) as standard score using the data in Table 4. Based on this, the workers whose FMS scores range from zero to 13 points can be classified as a risk group of WMSDs symptoms, and those with 14 or higher FMS scores can be classified as a normal group.

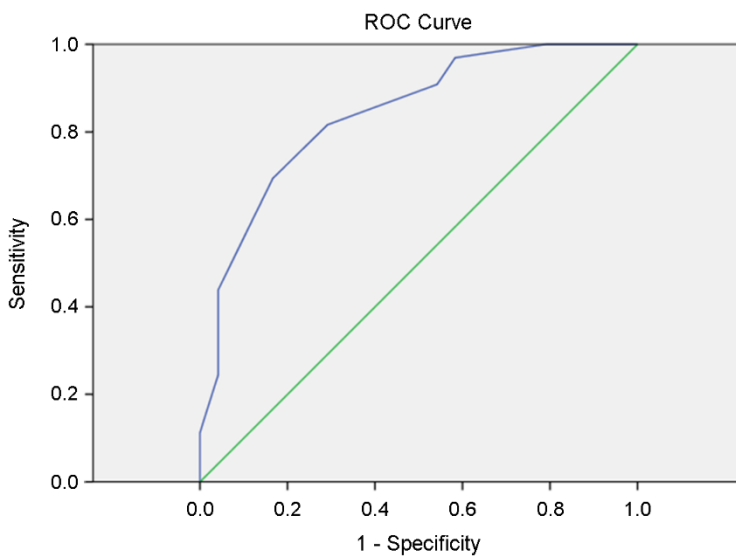


Figure 3. ROC curve for prediction of musculoskeletal disorders

Table 4. Coordinates of the curve

FMS	Sensitivity	1-specificity
10.5000	1.000	.792
11.5000	.969	.583
12.5000	.908	.542
13.5000	.816	.292
14.5000	.694	.167
15.5000	.439	.042
16.5000	.245	.042
17.5000	.112	.000

As a result of classifying based on 14 points, the number of the subjects with 14 or higher in FMS score was 87 (71.3%) out of total 122 workers, and the number of the subjects of control (workers to pay attention and those with WMSDs symptoms) was 7, and normal workers were 80. The number of the workers with less than 14 points was 35 (28.75), and the subjects of control (workers to pay attention and workers with WMSDs symptoms) were 17, and the normal workers were 18.

4. Conclusion

This study targeted 122 workers engaged in the automobile manufacturing industry, and identified the correlations of FMS and general characteristics (age, BMI, drinking, smoking and exercise), work-related situation (job group, job satisfaction, labor intensity and work skillfulness), and set up score to predict the risk of WMSDs. The results of this study can be summarized as follows:

- 1) The mean FMS score of 122 subjects was 14.63 ± 2.27 . As the subjects' age and BMI were higher, the FMS score was lower, and the FMS score was higher in the group of regularly exercising workers.
- 2) The mean FMS score of the subjects of control (workers to pay attention and those with WMSDs) were lower than that of normal workers.
- 3) When the FMS score of a subject was less than 14 points, there was a high possibility of the subject to become a subject to control (a worker to pay attention or worker with WMSDs) according to the WMSDs symptoms.

Upon looking at the results of FMS scores, the mean score, 14.63 ± 2.27 , identified in this study, was similar to the research result of Schneiders et al. (2011) targeting 209 general public aged 18 to 40, and the research result of Perry and Koehle (2013) targeting male adults aged 20 to 39. A study of Kiesel et al. (2007) targeting American football players revealed the mean FMS score as 16.9, which is higher than the mean FMS score in this study. But the reason is that Kiesel's study is conjectured to target athletes with excellent physical abilities.

The conclusion of this study that FMS scores were lower, as age and BMI were higher was consistent with a study of Perry and Koehle (2013) that targeted 622 Canadians aged 20s to 60s, and a study of Duncan and Stanley (2012) that targeted 58 British primary school students. The result implies that FMS score will go up, if physical activity increases, and BMI gets lower.

In a study of Peate et al. (2007) targeting firefighters, the standard FMS score was set up as 16 or less, and the study revealed that the probability of the score less than the standard FMS score was higher by 1.68 times, if a subject has an injury. O'connor et al. (2011) reported the injury occurrence rate of the applicants for navy officer with 14 or lower points in FMS score was higher by 1.5 times than those with higher than 14 points in FMS score. The study decided 13.5 points in FMS for prediction of injuries. Kiesel et al. (2007) set up the FMS cut-off score as 14 or lower based on serious injury. This score is higher than the 13.5 points to predict workers to pay attention and workers with WMSDs in this study. It may be a better method to set up lower FMS score, in view of the need for FMS to control WMSDs, so that WMSDs symptoms do not occur by predicting the subjects of control in advance.

As a result of this study, there was difference in FMS scores between the subjects of control in terms of WMSDs and normal workers. Based on this, it is confirmed that the workers to become the subjects of control in terms of WMSDs can be classified beforehand through FMS. By utilizing this well, if mediation for prevention of WMSDs like exercise of correction or stretching is offered or educated to the workers classified as having less than 14 points through a pre-test, WMSDs can be prevented.

The Occupational Safety and Health Law sets forth that an employer shall conduct medical examination for workers to protect and maintain workers' health. Through the first phase examination, the body measurement, blood pressure measurement, chest radiography, urine test, blood test and oral examination are conducted. As a result of the first phase examination, the second

phase health examination is carried out for the suspects of high blood pressure and diabetes. Although medical examination is carried out for workers' health care, there is no examination to prevent WMSDs in the medical examination. If FMS is measured, or examination is conducted by a physiotherapist in a WMSDs prevention room installed within workplace as an examination item for prevention of WMSDs, and the exercise of correction is performed as well, all these will be of great help to the prevention of WMSDs.

There is few research case of FMS in Korea, and only studies on athletes' injuries have been mainly carried out abroad. However, it is conjectured to have limitations in clinical application for WMSDs control. The classification criterion of WMSDs in this study can be difficult to mention it as a standard test criterion to judge WMSDs. More efforts to verify the correlation between FMS and WMSDs based on the results of this study are needed.

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