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A study on the Improvement of Electromyography of Agricultural Work Chairs for the Prevention of Musculoskeletal Disorders

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Abstract

Squatting of agricultural work can cause musculoskeletal disorders due to excessive pressure and rotational force on the knee joint In order to improve the assistive chair used in squatting agricultural work so that it can be used in a narrow groove, it is intended to improve the musculoskeletal harm of squatting work by attaching a spring on the assistive chair. Therefore, in the presenty study, 3D drawing was done using Pro-Engineer (3D), and a mock-up was produced and tested. Using pro-Engineer, it was judged that it was rare for plastic to be broken by a spring, so the analysis was conducted with a focus on springs. It was found that the structure that can absorb the shock according to the rigidity of the tape spring and balance the body is that the power to withstand the load of the weight is distributed as a whole when five springs are used. Electromyography was measured using ME600 (Mega Electronics, Finland) Measuring equipment attached to the waist, thighs, calves, and shins. EMG values were measured and compared with the prototype in two ways, when the worker did not wear the product and when he wore an existing product on the market. As a result of the experiment when using the prototype, the maximum EMG value for each part is considered to be helpful in preventing musculoskeletal diseases as the amount of muscle used is reduced in the waist, thighs, calves, and shins. .

Keywords: *Agricultural Work Chairs, Musculoskeletal disorders, Pro-Engineer, EMG*

1. Introduction

Agricultural work has a higher proportion of manual work than other than the works, espoeically squatting or bending the waist Therefore, most farmers are exposed to risk factors for work-related musculoskeletal disorders, and in fact, about 58% of farmers diagnosed with musculoskeletal disorders require treatment for preventing and managing musculoskeletal disorders [1]. Musculoskeletal disorders are diseases that appear due to accumulated fatigue in the musculoskeletal and skeletal system. And are one of the work-related

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diseases because they are caused by long-term continuous repetitive work [2]. As for work improvement measures to prevent musculoskeletal disorders, facility growers should implement hydroponic cultivation that allows the height of the work table(bed) to be adjusted or use a movable auxiliary chair, etc. Disease incidence can be minimized. Fruit farmhouses that grow apples, pears, and persimmons, work in a team of two of more people as much as possible, and the weight of the object should be less than 40% of the weight for men and 24% for women. It is most important to make stretching a habit before work and to exercise frequently during work. In order to prevent rotator cuff tears that cause shoulder pain, musculoskeletal disorders can be prevented by refraining from excessive work and resting in between. It is known that musculoskeletal disorders are a major risk factor for health in agricultural workers, and have a negative impact on the health and economic aspects of farmers by causing limitations in agricultural work [3]. These risk factors for musculoskeletal disorders include repetitive work movements, work posture, work intensity, work hours, mental stress, and fatigue [4]. Agricultural work by its nature, has a risk factor of causing musculoskeletal disorders due to long-time repetitive work, and these difficult tasks have recently been reduced with advanced agricultural technology and scientific farming. However, musculoskeletal disorders of agricultural workers due to manpower-oriented agricultural work performance in difficult mechanization work, decrease in rural population, and aging still remain high [5]. This study aims to improve improper working postures in various tasks by devising an auxiliary work chair for agricultural work using springs according to the height of cultivated crops when squatting. Auxiliary work chairs for agricultural work are aimed at improving the convenience and health of workers by reducing labor intensity improving work efficiency, and reducing physical stress such as back pain and musculoskeletal disorders.

2. Experiment materials and methods

In the spring chair, the cushion dons not move when sitting, and 5 taper springs with a width of 25 cm and a length of 25 cm that can sufficiently support the hips of subjects who mainly work in agriculture are fixed to the lower plate. A farm chair is shown in Fig. As shown in Figure. 1, 2D work and 3D drawing work were performed to produce and test the restoration, Using AutoCad (2D) and Pro-Engineer (3D), the structural analysis was conducted using Mechanica, a module of Pro-Engineer., The purpose of this was to determine the electromyography (EMG) value for each part and the degree of load generated in each muscle of the upper and lower extremities when moving forward in a squatting posture. Among the muscles that act as agonists used in the squatting posture, the back, thighs, calves, and shins were selected as the muscles to be tested, and the analysis was conducted with electromyography (EMG) data collected form this experiment. In order to find out the characteristics of the spring, an analysis was conducted on the deformation and stress that occur when a load is applied to the spring. For spring analysis, it is assumed that the pitch interval of the spring is constant, and when a distributed load is applied to the of the spring to see the stress in one of the five springs, the part where the maximum stress and deformation occurs is in the spring, It was judged that it was rare for plastic to be broken by a spring, so the subsequent analysis was conducted with a spring-oriented structural as follows.

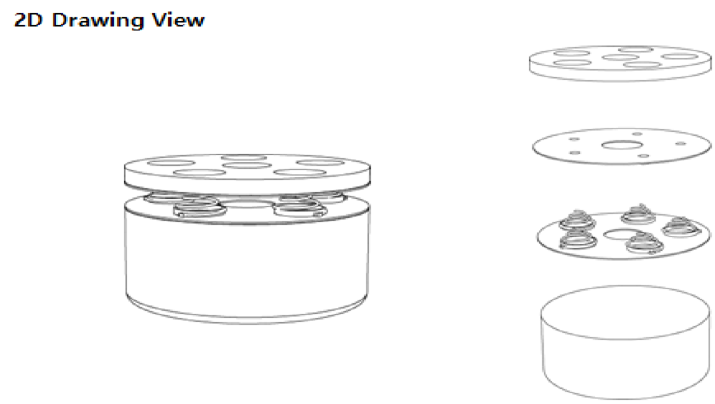


Figure 1. 2D Modeling of agricultural work chair design

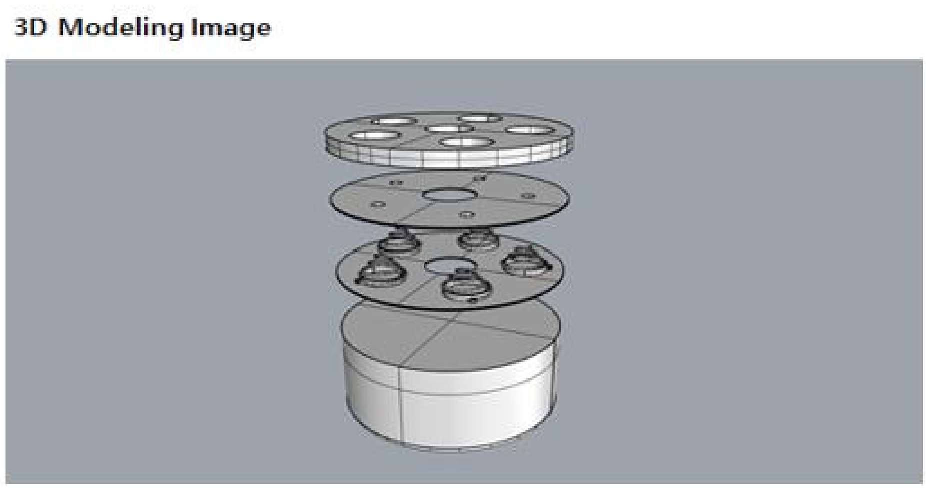
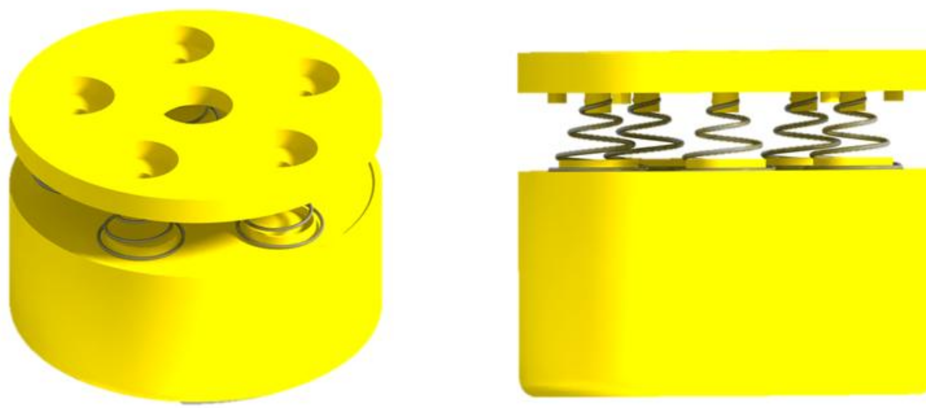


Figure 2. 3D Modeling of agricultural work chair design

3. Results and discussion

The 3D modeling of the working chair for agricultural work is shown in Fig. It was configured as in 3. In order to find out the characteristics of the spring, an analysis was conducted on the deformation and stress that occur when a load is applied to the spring. For spring analysis, it is assumed that the pitch interval of the spring is constant, and when a distributed load is applied to the top of the spring to see the stress in one of the five springs, the part where the maximum stress and deformation occurs is in the spring, It was judged that it was rare for plastic to be broken by a spring, so the subsequent analysis was conducted with a focus on the spring as follows.



(a) (b)

Figure 3. Structural Analysis 3D Modeling (a) aspect (b) Front side

The conical compression spring in the middle of the working cushion is also called a taper spring and has higher stability when bent or bent than a general coil spring. The diameter of the spring is 2.7 mm, and the large and small radius is 58 mm and, 15 mm, respectively, and the number of winding the coil is 4.5 times, and the length is 41.3 mm in the initial state. When a load is applied to the conical spring, the stress can be obtained by the following equation (1).

$$\tau = \frac{8wDK_{\omega}}{\pi d^3} \tag{1}$$

Here, is the size of the load, is the average coil diameter, is the diameter of the coil, and is the Wahl factor, which is the spring correction constant for the fatigue load, and can be obtained by the following equation (2).

$$K_{\omega} = \frac{4C-1}{4C-4} + \frac{0.615}{C} \tag{2}$$

Here, C is the spring index ratio and is the value obtained by dividing the diameter of the spring by the diameter of the spring by the diameter of the coil.

In order to find out the characteristics of the spring, an analysis was conducted on the deformation and stress that occur when a load is applied to the spring, and it was assumed that the pitch interval of the spring was constant for spring analysis.

3.1 Stress Distribution

In the case of a working cushion using 5 springs, the maximum stress and deformation occur in the spring. Fig. 4 shows the stress distributed load is applied to the top of the spring to see the stress in one the five springs. 4.

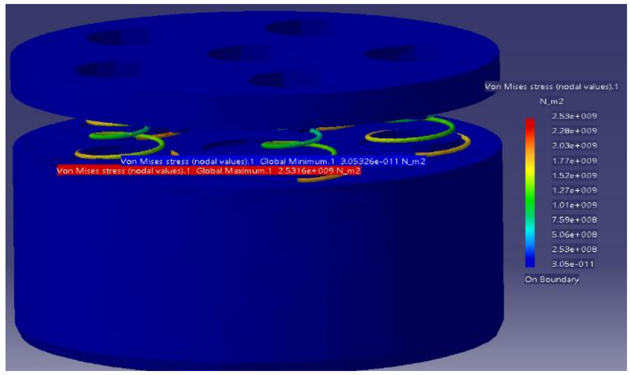


Figure 4. Overall Von-Mises stress distribution

3.2 Deformation distribution

Table 1 is a table of the stress and deformation according to the material of the five springs and the applied load. In addition, the cases where the diameter of the coil was 2.7 mm and 3 mm were compared. Based on the weight of an adult male (80 kg, 784.8 N), the load applied to one spring when five springs are used is 157 N, and the comparison results for values greater than or less than 157 N are shown for comparison.

Table 1. Coil diameter = 2.7 mm: Stress and strain

Spring Material	Yield Strength [MPa]	Tensile Stress [MPa]	Load [N]	Maximum Deformation [mm]	Maximum Von-Mises Stress [MPa]
SUS 302	275	590	261.6	113.2	3830
			196.2	84.8	2880
			157	66.3	2330

Fig. 5, when a force of 157 N is applied to spring steel with a coil diameter of 2.7 mm, it is deformed by about the length of the spring in the initial state and becomes a state in which it is no longer compressed. At this time, when looking at the stress for the load, it is 2300 MPa, which is greater than the minimum tensile strength of 1970 N, so it can be seen that fracture will occur.

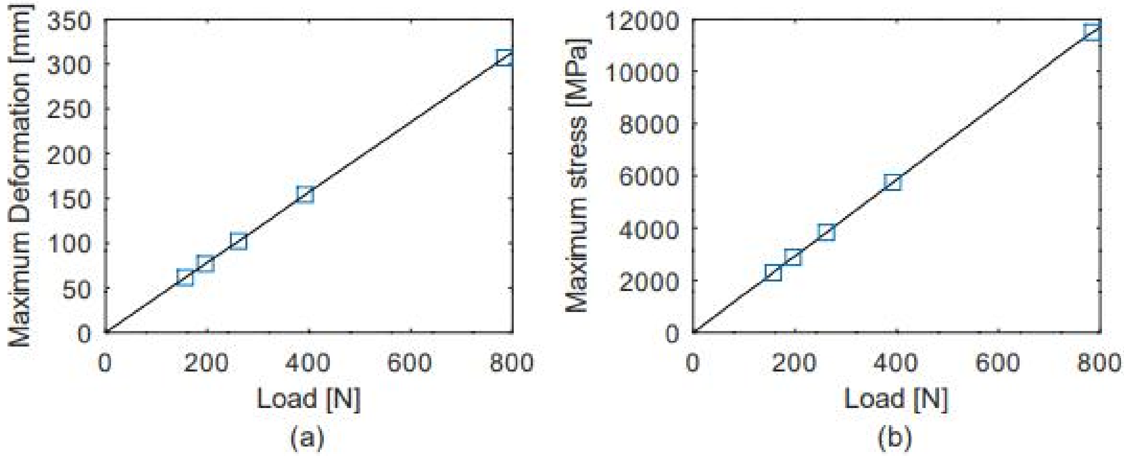


Figure 5. 5 Coil diameter = 2.7 mm: Stress and strain (a) Deformation of SUS 302 (dia meter 2.7 mm) (b) Stress of SUS302 (diameter 2.7 mm)

Table 2 is table showing the stress and deformation amount of coil diameter = 3.0 mm when 5 springs are used

Table 2. Coil diameter = 2.7 mm: Stress and strain

Spring Material	Yield Strength [MPa]	Tensile Stress [MPa]	Load [N]	Maximum Deformation [mm]	Maximum Von-Mises Stress [MPa]
SUS 302	275	590	261.6	67.22	3191
			196.2	50.4	2392
			157	41.4	1920

Fig. 6, when a force of 157 N is applied to 3 mm spring steel (SUS 302), it is deformed by about the length of the spring in the initial state and becomes a state in which it is no longer compressed. At this time, when looking at the stress for the load, it is 1920 MPa, which is less than the minimum tensile strength of 1970 N, so it can be seen that no fracture occurs.

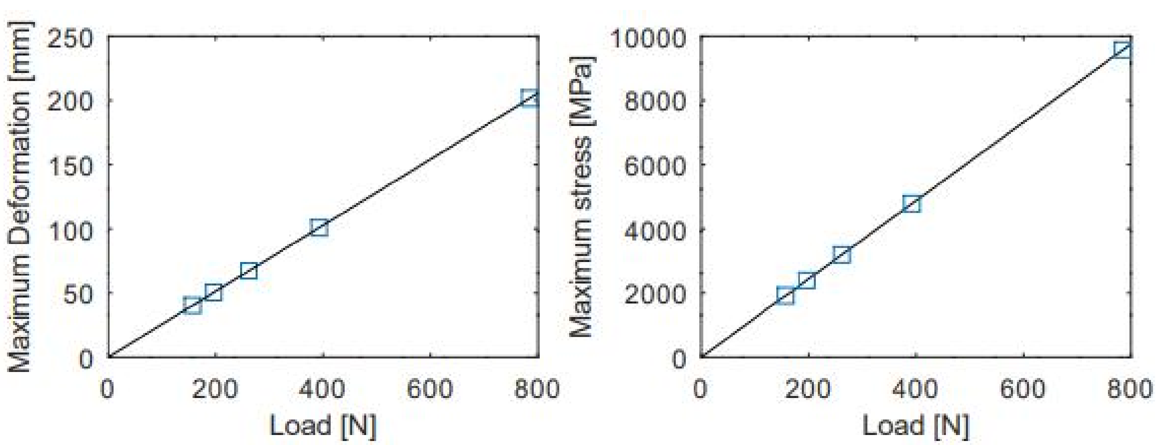


Figure 6. Coil diameter = 3 mm: Stress and strain (a) Deformation of SUS 302 (diamet er 3 mm) (b) Stress of SUS302 (diameter 3 mm)

3.3 EMG analysis

In order to test the EMG of the work chair, maximum EMG measurement equipment was introduced and ECG machines were attached to the parts to be measured in various postures to measure values in the waist, thighs, calves and shins. Values and current conduction values for each forward movement part were classified into Tables 3 and 4, and comparative analysis was performed with existing products. As a result of the electromyogram tester when sitting and working, it was confirmed that the electromyogram values of the waist, thigh, calf and shin parts were the lowest in the prototype production, and the maximum electromyogram value for each part when moving forward also confirmed that the prototype product had less muscle usage.

Table 3. Maximum EMG value by site during sedentary operation

	Waist	Thigh	Calf	Shin
Not Used	8	3	3.6	17.5
Current Product	6.25	3	3.5	6.5
Prototype	6	2.75	2	4.75

Table 4. Maximum EMG value by site on forward movement

	Waist	Thigh	Calf	Shin
Not Used	68.75	173.75	167.5	154.75
Current Product	51.75	157.5	148.75	138.0
Prototype	44.75	138.5	126.25	120.75

4. Conclusion

Assistive chairs for agricultural work are related to musculoskeletal disorders as a squatting posture, and improve this, finite element analysis was performed by inserting were obtained after conducting electromyography experiments.

1. A spring was inserted in the hip seat of the auxiliary chair to disperse the leaning phenomenon and force, and it was found that the muscle usage in the hip, waist, knee, and shin areas was low when seated.
2. If a spring with a diameter of 3 mm is used, the stress generated in the spring is 1920 MPa when the maximum compression amount of 41.4 mm is generated, There-fore, since the spring is smaller than the yield strength of 1970 N, it can be seen that it can be used safely without breaking.
3. Considering the aspect of comfort, the number of springs used inside the working cushion is 4 or less, and when used, it causes excessive deformation relative to the standard weight (80 kg), so it is judged that the user may find it somewhat inconvenient. So 5 may be appropriate.

4. Through the electromyogram experiment, it was confirmed that the EMG values of the waist, thighs, calf and shin parts were lower than those of the existing products, and the maximum EMG values for each part when moving forward also confirmed that the prototype product had less muscle usage

Acknowledgement

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