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Evaluation of Power Assistance Chair by Motion and Myoelectric Analysis

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***Abstract*— Recently, rehabilitation, training method, motion support equipment and likes are developed and diversified along with advances in technology. An assist function chair has been developed to support rehabilitation and training method, but the performance is still not sufficient now. It is necessary to evaluate the performance of the chair for further improvement. In this study, we evaluated the performance of assist function chair by simultaneous measurement of motion capture system and myoelectric signal.**

***Index Terms*— Aged person, motion analysis, myoelectric signal, power assistance.**

I. INTRODUCTION

Recently, rehabilitation and training method are diversified along with advances in technology. There are many kinds of equipment and instruments for these requirements. Motion capture system is equipment that can record motion of a human body and of object as numerical data, not just image. A chair with the power assistance function was developed by a Japanese company for training and rehabilitation of aged person. Developers aimed to help muscle training without other person's support. The situation using this chair is for training of leg muscle by a motion of sitting down and standing up. However, its effect of the function is not yet sufficiently evaluated. In order to evaluate power assistance function of the chair, it is effective to measure the motion and change of muscle power of user.

II. EXPERIMENTAL METHODS

A. Power Assistance Chair

An assist function chair evaluated here and its basic dimension of this chair is shown in Fig. 1. This chair is used as a rehabilitation device that supports muscular training as well as support for a motion of sitting down and standing up of aged person. The basic structure and mechanism of this chair is shown in Fig. 2. The chair has double seat structure with a moving seat surface and a base seat. The moving seat is connected to a spring set under the seat through a rod. Since certain preload is set to the spring, the spring is expanded not from the natural length but from a state of certain force. The user of the chair can adjust strength of the preload by an adjustment mechanism which is located in the back of the chair to control the supporting force. Also, angle of the seat of chair and the seat height can be adjusted to several steps. In addition, it can be used as an ordinary chair by a seat fixing function.

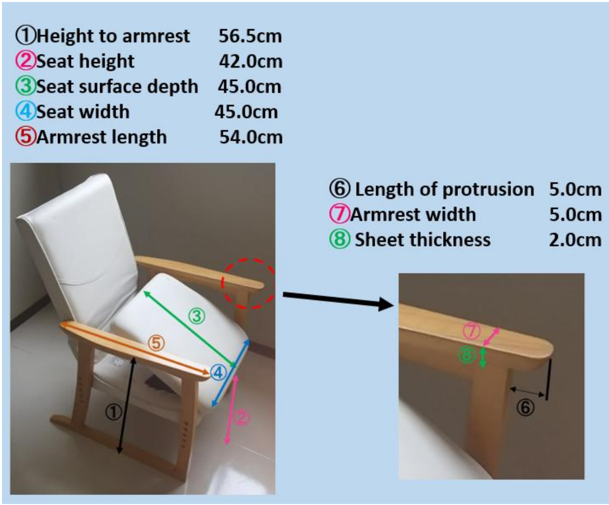

Fig. 1: Basic dimensions of assist chair

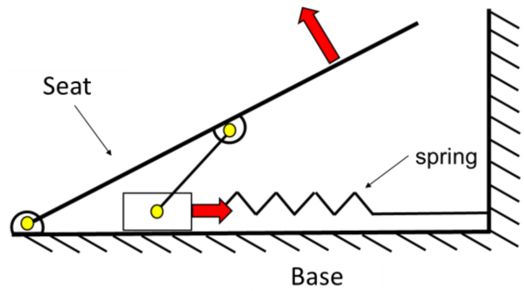

Fig. 2: Basic structure of assist chair

B. Measurement system

As evaluation of function of the chair, we measured user's motion and myoelectric signal simultaneously. Motion capturing is a technique that records position information of body parts or objects as digital data. There are several types of motion capture system, optical, video, magnetic, mechanical, etc. In this study, optical motion capture system is used. Fig. 3 shows the layout of the optical type motion capture system. The outline of using the system is described below. First, many markers that reflects light is attached to subject person or object body to be measured. Then, the light emitted from the light source (infrared ray) is reflected by each marker, and the positions of each marker are recognized by the system

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through IR camera. In this system, motion can be recorded if there are at least two cameras. However, depending on the position and angle of camera, several markers to be captured are hidden, and the accuracy of motion decreases. Therefore, in many cases, 6 to 10 or more cameras are used. Also, in order to reflect the light to the marker reliably, it is necessary to prepare the same number of light sources as cameras, and set as close to the camera as possible. The camera used in the system has IR-light in its body.

On the other hand, myoelectric signals are minute potential changes that can be measured during muscle contraction. The myoelectric signal contains abundant information such as the amount of muscle activity, balance, timing, state of muscle fatigue, and so on. If this information can be accurately extracted, it will be useful in various fields as medical care, welfare and sports etc.

In the experiment, motion of user and moving seat are measured by using motion capture system, and muscle force is evaluated by acquisition of myoelectric signal at the same time. Motions of standing up and sitting down were repeated under the conditions with and without assistance function of the chair. Simultaneous measurement of motion capture and myoelectric signal was performed. Its results are useful for understanding of the effect of the power assistance function by comparing motion of assistance chair and normal chair.

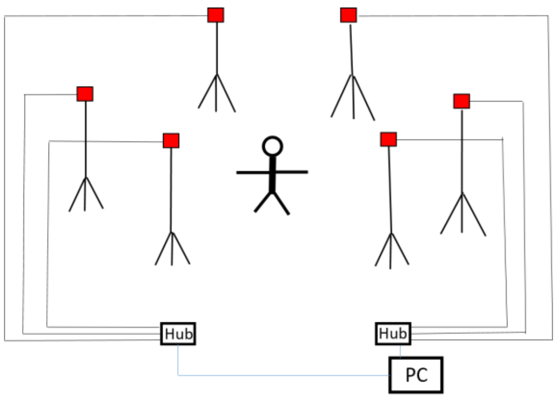

Fig. 3: Setup of motion capture system

III. RESULTS

A. Forces of seat surface of the assist function chair

First, we evaluated forces on the moving seat surface from the structure of the assist function chair. Fig. 4 shows these three forces and its directions with the mechanism of chair. Fig. 5 shows change of the three forces depending on angle of moving seat, under assumption that the spring constant is 1 N/mm and the preload is 0 N. In the graph, normal force of the seat is shown, and vertical and horizontal components of force are also shown. These are assumed value for convenience of calculation, so we can only see the features of change of forces on the seat surface. The graph curves start from 0 deg. of seat angle, since the spring and connecting rod are set into inside of the base seat in the actual device structure. This graph shows that the assistance force of seat surface is strong when the angle of moving seat surface is large, but the forces decrease extremely when the angle becomes small. Therefore, the assistance force is not sufficient when user starts standing and it is too much at the finish of standing. It is thought that some improvement is needed for the characteristics of force.

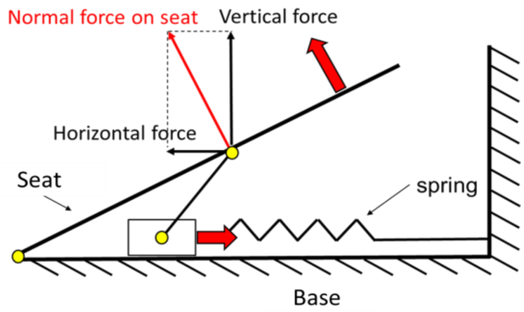

Fig. 4: Components of force

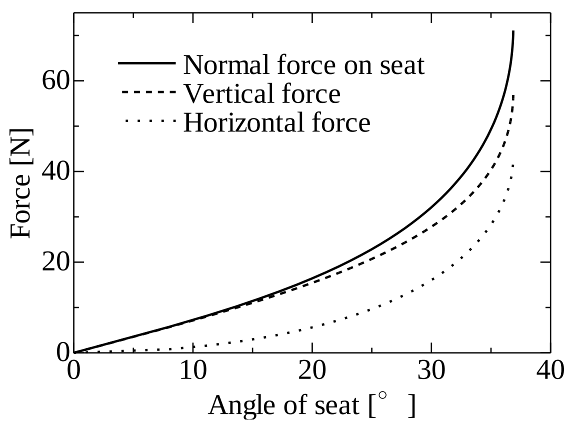

Fig. 5: Forces against seat angle

B. Measurement of motion

For basic measurement of motion to evaluate the assistance chair, we recorded motion of sitting down and standing up by using assistance chair as shown in Fig.6. Subject person put on suit of optical motion capture system and set markers on the suit to record human motion. In addition, markers are set on side of moving seat, to record motion of moving seat. Fig.6 shows several moments in a series of motion. In these shots, the position of moving seat is shown as a rectangle. In this experiment, different preloads are applied to the spring and motions under conditions of maximum preload and minimum preload were recorded.

From this experiment, coordinate values of the markers set on body suit and on the side of moving seat were measured [1]. The angle changes of moving seat vs. number of frame were derived as shown in Fig.7. Here, the frame rate is 100fps.

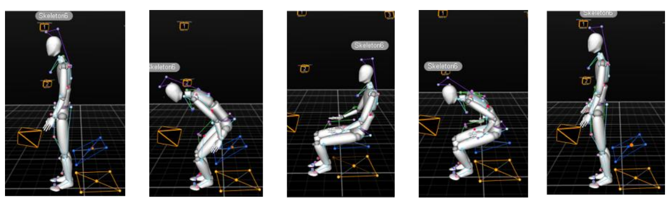

Fig. 6: Arbitrary moments in a series of motion

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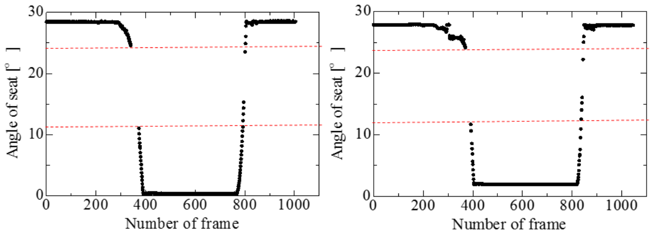


(a) Minimum preload (b) Maximum preload

Fig. 7: Changes of seat angle

These two graphs show the result under the conditions of minimum preload and maximum preload. First change of angle is when the subject person sat down and second change is when the subject person stood up, in both graphs. Here, the frame interval is equal to 0.01 second. A section of about 11 to 24 degrees is not correct. The reason is that the cameras could not capture the position of markers which are put on the moving seat, because marker is behind armrests of the chair. Comparing these two graphs, we cannot point out clear difference between (a) and (b) in Fig.7. Therefore, it is thought that there is no difference of effect between minimum and maximum preload in this chair mechanism. In addition, there is a problem of marker setting which is hidden behind the armrests. Settings of more markers on moving seat and of cameras on better position are required. Also, we will record motion by means of same chair without power assistance function as additional work. Because it is useful for understanding the efficiency of power assistance functions to compare motion of assistance chair and normal chair.

C. Simultaneous measurement of motion and myoelectric signal

In order to evaluate the effect of assistance chair on muscular power, simultaneous measurement of motion and myoelectric signal were performed. The measured motion started from the state of sitting on the chair. The motion of sitting down and standing up was defined as one set, and repeated five or more times. Between each set, an interval of about one second was put. This interval prevented influence of muscle activity of preceding motion, due to the continuous muscle activity. Muscle activity with respect to the timing of exercise can be understood well, by simultaneous measurement. The photo diode was used to take the synchronization of the myoelectric signal and the motion data [2]. An impulse signal from photo diode by flash light is measured by same recorder which measures myoelectric signal. Also that flash light can be caught by camera of motion capture system at the same time. Therefore these data can be synchronized by using impulse signal and flash light. The experimental conditions were without assist and with assist of maximum preload. In this time, only leg muscles were used because the subject person did not touch armrest in the motion. Fig. 8 shows the measured signals of four muscles of legs. Here, RMS (root mean square) processing was applied to measured original myoelectric signal. Fig. 9 shows captured motions, when femoral biceps muscles indicated peak value under the condition without assist force. Fig. 10 shows same motions under the condition of maximum preload. From the results of sitting down motion, it is found that the muscle activity level of femoral biceps muscle indicates peak value just before to after contact between the subject person's bottom and seat surface, with and without force assistance.

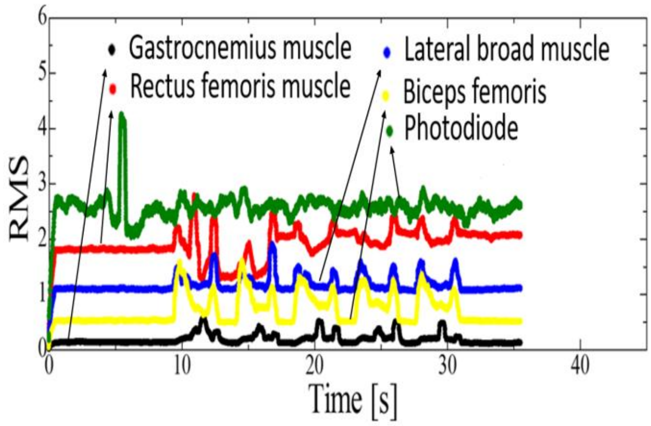
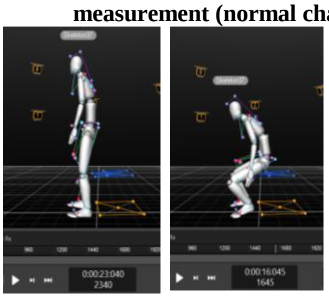


Fig.8: Myoelectric data obtained by simultaneous measurement (normal chair, without using armrest)



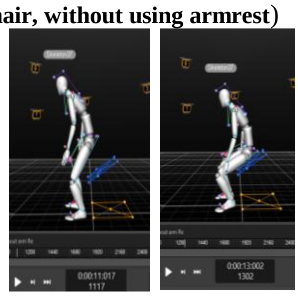


Fig.9: Normal chair (standing, sitting) **Fig.10: maximum preload (standing, sitting)**

This might prevent the shock of person’s bottom when it contacts the seat. In the case of assistance, person's bottom reaches the seat surface early, so that less amount of muscle activity is required than ordinary sitting down motion.

Fig. 11 shows reaction forces from moving seat and myoelectric signal in standing up motion under condition with maximum preload and without using armrest. The reaction forces are evaluated from the relationship between forces and angle of moving seat as shown in Fig. 5. Here, we focus on the change of forces since absolute value of forces in Fig. 5 is not accurate because it has several assumptions. In this figure, the force values after increasing are not true. It was evaluated by position of moving seat, but the force after releasing of user's bottom is applied to the seat stopper. Seeing the myoelectric signal, the peaks of four muscles appear after releasing the bottom from the seat surface, that is, after the assist was finished. Therefore, it is thought that support function is effective before bottom releasing. It is expected that more detail of efficiency of support function and forces can be investigated by using this measurement method..

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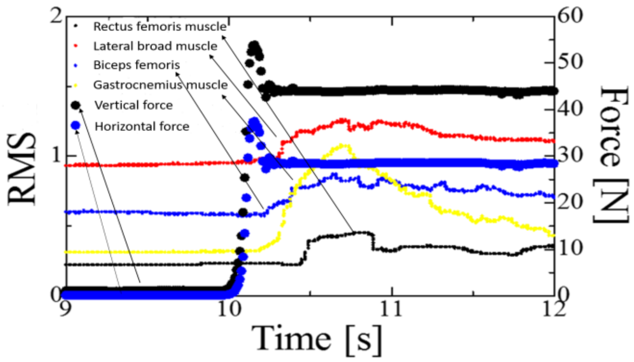

Fig.11: Electromyogram and seat reaction force in standing up motion

D. *Evaluation and suggestion of assist function of chair*

From Fig.2, the assistance force of seat is large when the angle of moving seating surface is large, but it rapidly decreases when the angle becomes small. This means that the assistance for the user is small when the angle is small. From the result of simultaneous measurement of motion and myoelectric signal, the peaks of the rectus femoris muscle, biceps femoris, and lateral broad muscle in sitting motion appear near the moment of contact between the seat surface and user's bottom. Also, in standing up motion, a peak appears just after the moment of bottom releasing from seat surface. However, in the actual motion of standing and sitting, it is thought that maximum assistance force is needed when start of standing and end of sitting. In order to confirm the validity of this idea, it is necessary to measure with a different type support function chair that changed the mechanism. In the original mechanism, the force is minimum when the angle of seat is small. So we designed another mechanism that would produce a large force at small angle of seat. A new mechanism proposed is shown in Fig. 12. Fig. 13 shows change of three forces depending on the angle of seat in the new mechanism. Spring constant, magnitude of the preload, etc. are calculated with the same value as the previous mechanism.

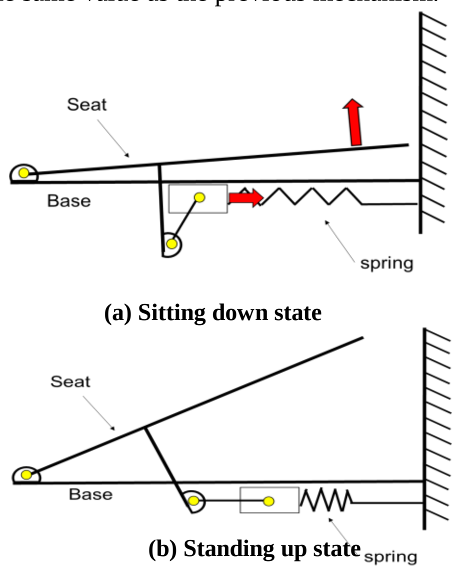

Fig.12: Proposed mechanism

It is confirmed that large assistance force is given from seat surface when the angle is small. On the other hand, the force decreases rapidly when the angle became large. The chair mechanism may need to be improved further in order to realize the constant force regardless of change of angle. It is necessary to measure using the proposed mechanism and compare it with original mechanism to find optimum supporting function.

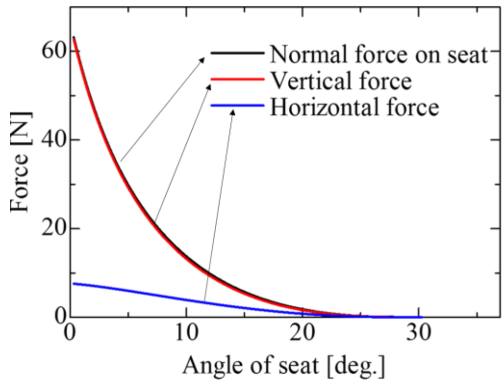

Fig.13: Change of forces vs. angle of seat

IV. CONCLUSIONS

By means of simultaneous measurement of motion and myoelectric signal, muscle activity against timing of motion is well understood. As the result, in the motion of sitting down, the peak appeared in musculus biceps femoris before and after contact of buttocks with seat regardless of power assistance. It is thought to be caused by slowly sitting motion preventing mighty contact of buttocks and seat. From this result, user can sit with a little amount of muscle activity by power assistance because the seat surface comes in contact earlier.

However, as additional work, it is necessary to compare the difference of amount of maximum muscle activity by changing several parameters, to improve the performance of this chair. The more effective assistance is required for aged person, so the chair should be improved by changing of structure, mechanism, assist force, etc.

ACKNOWLEDGMENT

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REFERENCES

[1] S. Itoyama, Y. Ohbuchi, H. Sakamoto and H. Harada, “Evaluation of Power Assistance Instruments by Motion Analysis”. 6th International Joint Symposium on Engineering Education, pp. nnn-nnn, 2016 (in Japanese).

[2] N. Koga, Y. Ohbuchi and H. Sakamoto, “Evaluation of Skilled Technique by Analysis of Tool Motion”, 5th International Joint Symposium on Engineering Education, pp.27-28, 2015.

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