Analysis of movement in sit-to-stand motion using parallel bars-one side support

Keio Ishiguro*[1)], Yoshihiro Ehara[1)], Yukio Kurukawa[1)], Kazuyoshi Sakamoto[2)]

Key words : Sit-to-Stand, Parallel bars, One side support

Movement of body in sit-to-stand(STS) is an important study subject because it is necessary to stand up from a chair, a bed and toilet and to walk in everyday activity, throughout one's life. Movement in STS depends on various functions. For example, strength of the quadriceps femoris muscle and improved range of dorsiflexion in a foot joint. These and many more are indispensable functions focused on in kinesitherapy for cerebrovascular accident (CVA) patients. When they pull on parallel bars in a sit-to stand motion, their trunk is extended, based on their strength, everything considerable burden.

Some studies have been carried out on movement in STS using parallel bars on both sides, however, few studies have been done on the STS motion with one side support which is often observed in the case of single paralysis (CVA) patients. We have analyzed the motion in STS with one side support from parallel bars applicable to support such patients. This is to report the influence of the angle of the body in relation to femur in STS, relative to joint moment using electromyogram (EMG). A previous study of STS was done in which both sides of parallel bars were held and the movement of upper and lower limb joints were analyzed while subjects changed the holding position both forward and backward. The extension moment of hip and knee joints increased as grip position moves backward away from the trunk relative to held near trunk. In the case of upper limb joints, the moment increases when the parallel bar was held near the trunk.

Material and methods 1

Seven healthy male students participated in this study. The means of their age, height and weight were 20.5 years, 172.7 centimeters and 61.1 kilograms, respectively. Prior to the start of the study, the purpose and procedures of this study were explained to every subject in detail and informed written consent was obtained.

There were two methods employed in this study. Method 1: How to stand up from a chair using a parallel bar. Each subject stood up from a chair set between parallel bars. The starting position involved a angle of knee joint angle of 90 degrees to flexion and an ankle joint angle of 0 degrees to dorsiflexion. The subject stood up from the chair using one side of the parallel bars held in his left hand (normal side for right hemiplasia). Then, he stood up again without flexing his hip joint as shown in Fig.1. The angle between body and femur was controlled at 70, 90, 110 and 130 degrees. The subjects were directed to maintain each angle until their gravity line of body moved onto the bottom of supporting foot. Three repeated measurements were taken. Before the actual measurements, they practiced this movement several times until they could move as directed.

1) Department of Physical Therapy, Niigata University of Health and Welfare, Shimami-cho, Niigata-shi, 950-3198, Japan
2) Department of Systems Engineering, University of Electro-Communications,
1-5-1 Chofugaoka, Chofu-City, Tokyo, 182-8585, Japan

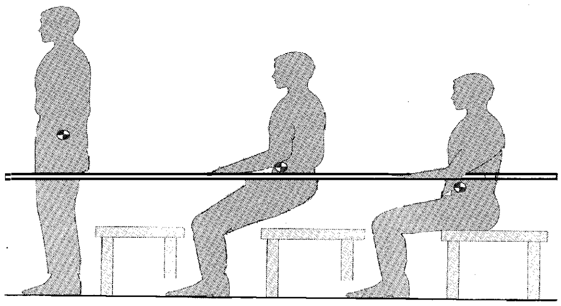

Fig.1 How to stand up from a chair using parallel bars

Method 2: The VICON system was used for analysis of three dimensional movements. The sampling frequency used was 60 Hz. It was equipped with 6 infrared cameras and 6 force plates. Fifteen markers were set for each subject. The position of the markers are set at bilateral accordion, tip of elbow, styliod process of radius, at a line of one third of the distance from the bottom anterior superior iliac spine to the greater trochanter, lateral epicondyle of femur, lateral malleolus, head of the 5th metatarsal and one point on the right side of the posterior iliac spine. Disposable bipolar electrodes were attached to the skin over each muscle, using adhesive gel. The distance between the center of electrode was placed on the midline of muscle belly along the longitudinal muscle fibers. The surface electro myographic (EMG) signals from the muscles were recorded while the subject was moving from the chair to steady a standing position on his feet. The disposable electrodes were attached on the right side of the elector spine, rectus of abdominis, biceps femoris, rectus femoris, lateral gastrocnemius and anterior tibial muscle. EMG frequency used was 1080Hz and recorded as Rectified Filtered Electromyography (RFEMG)[4]. In this method, the potential obtained was converted to 60 Hz for compatability with the VICON system. The measurement of RFEMG was carried out by means of a Low pass filter at 2.6 Hz. and the data was saved in personal computer (Fig.2). The data of RFEMG was taken as the average at the maximum isometric contraction within one second. Each muscle was measured to obtain the average of maximum isometric contraction on RFEMG and the value thus obtained was taken as 100% and used for normalization.

The data of joint moments was recorded while the subject was moving from chair to steady standing position as mentioned earlier. The maximum value from the data of percent RFEMG and joint moments are presented in Table1. Statistic values were obtained from repeated measurements and analysis of valiance (ANOVA).

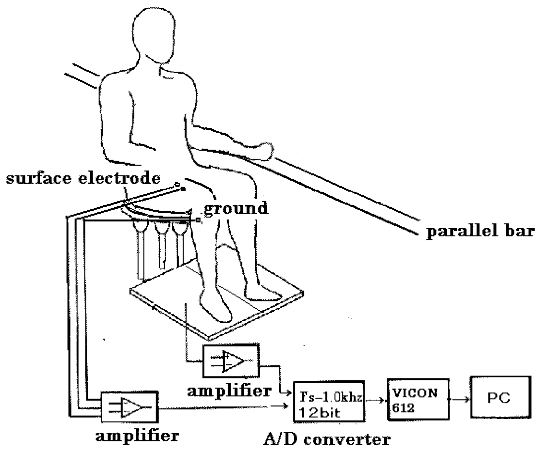

Fig.2 Recording and data analysis using EMG.

Results

An average of percent RFEMG for each angle rectus of abdominis muscle is shown in Fig.3. As the body angle relative to the femur increases, percent RFEMG rectus abdominis muscle also increases. Fig.4 shows the data of percent RFEMG and force plate obtained from one subject. Vertical lines represent the values from the beginning of movement till steady standing position. Action potential of rectus of abdominal muscle appears prior to the actual standing up motion.

As the body angle relative to the femur

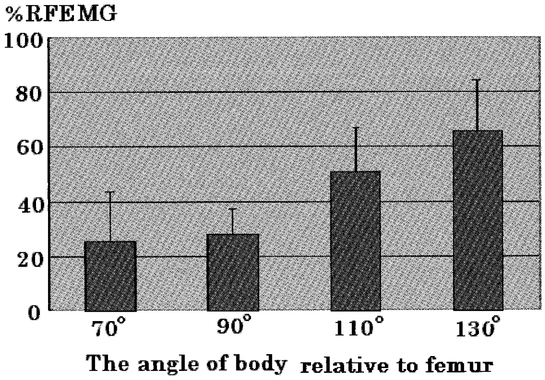

Fig3. Average of %RFEMG of each angle of the rectus abdominis muscle.

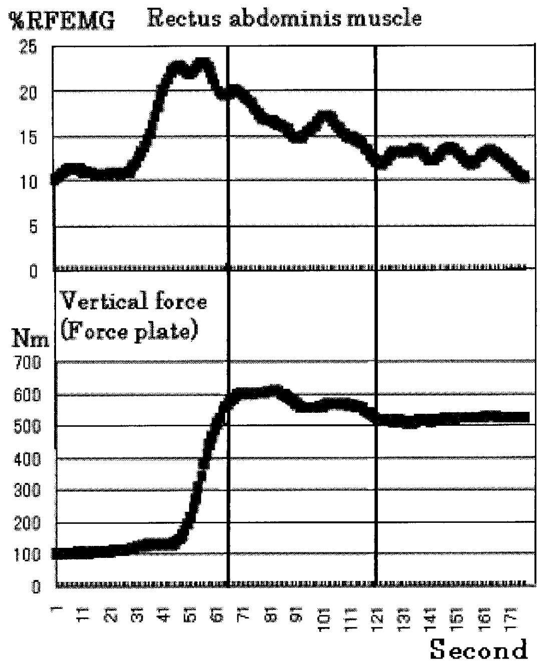

Fig4. %RFEMG and force plate data from one person at 110 degrees

increases, percent RFEMG of reectus abdominis muscle also increases (Table 1). The other muscles tested did not present any significant value. The results from joint moment are shown in Table 2 but failed to present significant value with different angles.

Table 1 %RFEMG

	70 degrees(%)	90 degrees	110 degrees	130 degrees	p
Erector spinae	38.4±18.1	40.5±9.3	42.3±16.3	42.8±18.4	ns
Rectus abdominis	25.4±26.5	27.7±20.1	50.7±29.6	66.0±30.4	*
Biceps femoris	20.1±14.3	16.7±13.0	18.8±15.4	24.9±15.9	ns
Rectus femoris	27.0±20.0	32.5±26.2	39.5±32.9	35.2±26.0	ns
Gastrocnemius	13.8±13.2	14.0±14.0	12.9±8.8	17.3±11.2	ns
Anterior tibial	11.7±5.4	15.0±6.1	19.0±14.4	25.9±27.4	ns

mean±SD ns: non significant (n=7)*p<0.05

Table 2 Joint-moment

	70 degrees(Nm)	90 degrees	110 degrees	130 degrees	p
Hip joint					
Moment for extension	60.6±23.1	56.0±25.1	45.9±18.0	42.5±9.3	ns
Moment for flexion	4.8±6.0	- 1.6±	6.5±11.6	4.3±4.9	ns
Knee joint					
Moment for extension	12.9±11.7	9.3±22.3	6.0±12.0	5.8±15.0	ns
Moment for flexion	13.7±7.3	19.5±23.0	15.9±10.2	17.6±12.7	ns
Ankle joint					
Moment for extension	21.5±7.0	17.9±11.7	11.9±9.1	21.3±10.4	ns
Moment for flexion	7.7±12.0	6.2±3.9	2.9±2.9	1.8±2.2	ns

mean±SD ns: non significant (n=7)*p<0.05

Discussion

STS movement is unstable when the body weight moves from a large basal surface of chair to rather limited surface base of feet. In general, STS starts from flexion of trunk and the weight moves forward as the trunk begins to show maximal flexion on leaving the chair[1)2)3)]. It has been recognized from Katsuhiras' earlier study[2)] that the flexion occurred, in similar fashion in this study, i.e. in a position of holding the parallel bar to lift the trunk and flex, while the subject pull his trunk forward by bending his body. As the position the parallel bar is held moves further away from his trunk, his momentum to extend his hip and knee increase. The joint moment of upper limb increases when the bar is held near the trunk. Our results presented here are different from Katsuhira's findings.

We are concerned about hemiplegic patients who want to stand up from a sitting position on chair, bed or toilet, and it is understood that they stand up using a fixed trunk position (in extended state). Therefore, we asked patients to stand up using of their knee joints, hip joint and upper limb on their healthy side, by increasing the load to the right side of upper limb.

However, we have failed to obtain significant difference in the value between the previous and current study. The reason for this may come from individual differences in rotation of the pelvis.

The other reason may be due to the state of latissimus muscle.

Namely, as trunk angle relative to the seat became larger, the extension of prime shoulder muscle joint required maximum strength[5)6)].

Percent RFEMG of rectus abdominis muscle became larger and thus the activity of latissimus muscle occurring in iliac crest began to increase. As the activity of latissimus muscle increases, due to the increase of rectus abdominis, the percent RFEMG also increases.

The patient extends his shoulder joint, while grasping parallel bars.

The activity of latissimus muscle increases, as the shoulder extension enlarges and accompanies the increased trunk extention. Latissimus muscle which begins with an acantha of waist fascia, sacral vertebrae of the back of waist and the rear of iliac crest connects with lesser tubercle of humerus which can induce an extension of trunk and a rotation of pelvics.

In this case, pelvics and trunk may become unstable, because the latissimus muscle anchors at acantha of waist fascia, as well as at sacral vertebrae of the back of waist and the rear of iliac crest, and it rotates the trunk as the pelvis bends forward. It is considered that latissimus muscle functions as a corrector of extension of trunk and pelvis as they are activated. On extension of the human trunk and pelvis, an activity such as stomach bias rectus abdominis, contracts in order to avoid bending forward and to neutralize the rotation of body.

Conclusion

The current study can be summarized as follows: We have analyzed the movement of presumptive single paralytic patients by using one side of parallel bars. Percent RFEMG of right side rectus abdominis muscle increases as the angle between trunk and longitudinal axis of femur bone increase. The reason for the increase of percent RFEMG of right rectus abdominis muscle is considered as following the moment of arm, produced by the angle of action center and body weight center increases, and latissimus muscle develops to neutralize the forward bending and rotation of pelvis, which is caused by the activity of latissimus muscle, induced such increase of percent RFEMG.

A similar study on single paralytic patients remains to be carried out.

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