EMG Activity of Arms Muscles and Body Movement During Chucking in Lathebetween Expert and Non-expert

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Abstract. The subjects were three men differential experience of lathe processing such as 87,500 h, 6,300 h and 384 h on 87, 32 and 40 years old respectively. The attendees were affixed fourteen reflective markers for motion analysis and ten surface electrodes on the muscles of arms. The chucking movement did not leaned the body and used the center of the body to be a center of movement characterized the muscle contraction of expert on bilateral muscle of Flexor carpi radialis and Triceps bracii and then they still used the right Extensor carpi radialis longus, right Biceps brachii and left Deltoid. The abnormal twisting movement by bending the body to the left side and leaned the left knee down indicated the experts still contracted the muscle as like the first movement. The muscle energy usages of the experts had higher than the non-expert whom took a muscle continuously contraction along time.

Keywords: Arms muscles contraction · Center of gravity movement · Body twisting movement · Chucking movement

1 Introduction

Lathe is one of the machine tools most well used. It is a machine tool used principally for shaping pieces of metal, wood, or other materials by causing the work piece to be held and rotated by the lathe while a tool bit is advanced into the work causing the cutting action. A lathe chuck is a special kind of clamp used on a lathe. These chucks hold objects that are cylindrical, radial, or irregularly shaped, gripped by what are called lathe chuck jaws. They hold steady the objects to be worked on. The Fig. 1 showed the lathe chuck jaws which have been usually tightened into place on the work-piece using a chuck key, a t-shaped wrench.

The chuck has either three or four jaws and mounts on the end of the main spindle. The universal scroll chuck usually has three jaws, which move in unison as an adjusting pinion rotated. The advantage of the universal scroll chuck is its ease of operation in centering the work for concentric turning. This chuck is not as accurate as the independent chuck but,

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Fig. 1. Chuck jaw and chuck key

when in good condition, it will centre the work automatically to within 0.003 of an inch. In addition, the universal scroll chuck is capable of holding and automatically centering round or hexagonal work-pieces. However, this chuck is unable to effectively to hold square, octagonal, or irregular shapes. The independent chuck includes four jaws that are adjusted individually on the chuck face by means of adjusting screws. The jaws of the independent chuck may reverse so that the steps face in the opposite direction; thus, work-pieces capable grip either externally or internally. The independent chuck can uses to hold square, round, octagonal, or irregular shape work-pieces in either a concentric or an eccentric position due to the independent operation of each jaw. Because of its versatility and capacity for fine adjustment, the independent chuck is commonly to use for mounting work-pieces that require extreme accuracy. The jaws of the universal scroll chuck and the independent chuck have a series of teeth that mesh with spiral grooves on a circular plate within the chuck. This plate is rotated by the chuck-key inserted in the square socket [1]. The objective of this study would like to observation the effect only the three jaw chuck gripping.

Even if the chucking performance of the lathe worker include two characteristics as loose and tighten the jaws tooth of chuck with the work-piece but the mistake of force gripping on the work-piece surface indentations have occurred by chuck jaws gripping as like Fig. 2 that always have found on the chucking movement of the non-expert.

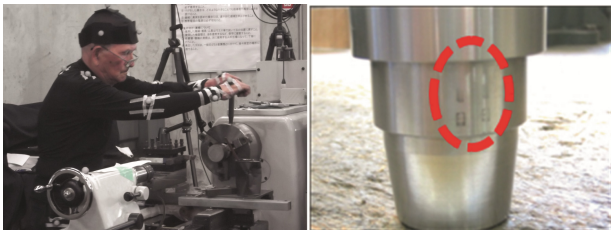

Fig. 2. The work-piece indentation by jaws gripping

The research of the differences of chucking behavior on the expert and the non-expert in lathe processing showed there were two characteristic of chucking behavior of them within the two standing posture and two hand holding position on chuck key. The characteristic of standing posture and the hand holding position on chuck key of the expert worker have not influenced on movement pattern of body along the vertical movement.

He has not bent his knee down and leaned down the body to the left side. Anyway, the hand holding positions: right and left hand hold on the handle, only left hand hold on the shank of chuck key but right hand hold on the handle: have not influenced on the activities pattern of horizontal movement. On the standing posture around in front of a chuck that slightly stood at the left, the expert always used the center of body as like the axial rotation movement (Fig. 3-Group 1). On the contrary, the standing posture at the right side of the chuck indicated he always fixed the waist as like the center for twisting the body (Fig. 3-Group 2 and 3). In the case of the uncommon movement of the non-expert who has stood slightly at the left side of chuck and both left and right hand have held on the handle always showed he have swung the body together with bent the knee down by using the left hand as the center rotation (Fig. 3-Group 4).

In addition, the experiment of effect of chucking movement with the indentation on the work-piece surface in chuck jaws gripping of a lathe between an expert and a non-expert that had imitation the both activity on first experiment by three novice students

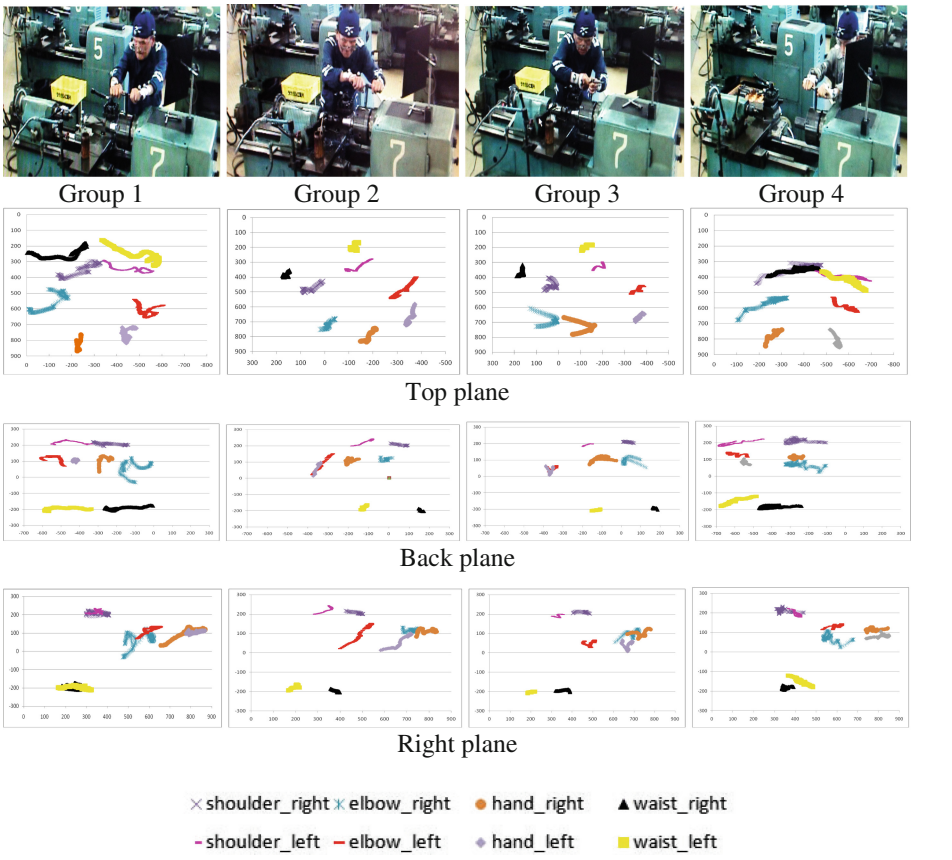

Fig. 3. Chucking activity on an expert (Group 1, 2 and 3) and a non-expert (Group 4) depended on standing posture and hand holding position. An expert has worked on the lathe processing more than 70 years but a non-expert has worked only 1 years experience on lathe.

of lathe experience on Niihama National College of Technology explained the strain value on chuck jaws gripping varied amongst four movement. There were the tendency of strain sequence similarly pattern although the subjects have been a variously personality. It was clearly confirmed that the chucking imitation mobility of the attendees on the non-expert movement pattern (Fig. 3-Group 4) have been the highest in terms of apparent strain average value on chuck jaws gripping. This power grip strength was higher than any event of the expert movement pattern (Fig. 3-Group 1, 2 and 3) second half, double and four times respectively. All resultants analysis have confirmed that the chucking behavior of the non-expert worker whom could not keep the balance movement, always leaned the body to the left side and bent the left knee while he was beginning twisted the chuck key cause of the indentation on work-piece surface [2]. The torque on the chucking behavior of the non-expert was excessive and affect to the compression of jaw teeth.

2 Methods

2.1 Participants

The subjects were three males differential experience of lathe processing such as 87,500 h, 6,300 h and 384 h on aged 87, 32 and 40 years and 155, 180 and 170 cm height respectively. Furthermore, Table 1 still showed the differential data of hand griping strength. The first one has worked at Takayoshi Company Limited in Ehime prefecture and the others have been a technical staff at Mechanical Engineering in Niihama National College of Technology, Japan.

Table 1. Three male Subjects characteristics and lathe experience

Subject	Age	Weight (Kg)	Height (cm.)	Hand grip strength (Kg) (Average)		Experience (Hours)
				Left	Right	
1	85	52.7	155	26.75	28.35	87,500
2	32	62.2	180	48.25	54.2	6,300
3	40	64.8	170	44.4	48.6	384

2.2 Apparatus

This study focused the relationship between the direction patterns of body movement by using the Motion analysis measurement with the muscles activity investigated by EMG. The participants were concentrated on fourteen reflective markers position for motion analysis such as a bilateral body part of shoulder, elbow, wrist, hip, knee, ankle and foot (Fig. 4). In addition, ten muscles responsible for arm motion were studied namely a bilateral muscle of Deltoid, Biceps brachii, Triceps bracii, Flexor carpi radialis and Extensor carpi radialis longus (Fig. 5).

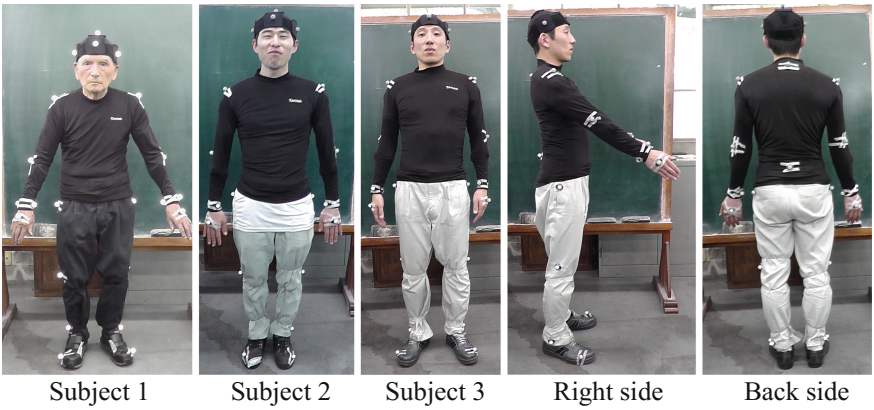

Fig. 4. Reflective markers placement of each subject

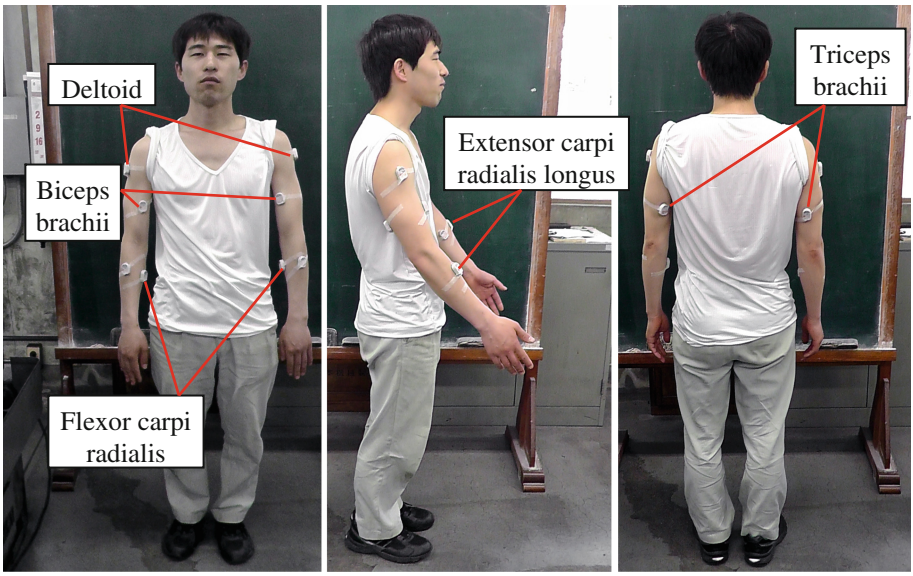

Fig. 5. Ten EMG surface electrodes on bilateral muscle of Deltoid, Biceps brachii, Triceps bracii, Flexor carpi radialis and Extensor carpi radialis longus.

As equipment of Motion analysis is three dimensional motion capture system (Mac3D Motion analysis) consisted of 7 infrared cameras and 2 video cameras captured the reflective markers of each subject. The machine telemeter system WEB-1000(NIHON KOHDEN Co.) and the sampling frequency rate of 1,000 Hz are the electromyography devices of EMG system which are used as the record condition (Fig. 6).

Fig. 6. The experiment setup for recording the motion of chucking movement and muscular activity.

3 Results and Discussions

3.1 Participants Characteristics of Chucking Motion Analysis

This experimental measurement of chucking motion captured on the actually working behavior without movement control. It illustrated the chucking movement only two groups in Figs. 7 and 8. Figure 7 showed the movement characteristic on slightly standing at the right side moreover left and right hand holding position on the handle of chuck key. The pattern movement of all subject on Fig. 7 showed they did not lean the body to the left side and not bend the left knee. They used the center of vertical axial as like the center of body twisting. It has caused of distance movement similarly occurrence between left and right side. For reliability and validity data, there were six time of chucking capture on subject 1 but only one time of this one showed the chucking activity which moved the body to the left side as like the non-expert movement on the first experiment. The other chucking performance of subject 1 still had similarly pattern movement with the expert. Three time of chucking movement observation on subject 2 disappeared the leaning the body to the left side and bending the left knee. However, four time of subject 3 indicated that he often moved the body to the left side by bending the left knee. This resultant analysis identified that the subject 1 and 2 who have worked many year of lathe experience always kept the controllable balance of the body movement. The observation on the left elbow movement showed the subject 1 and 2 always jerked this part down meanwhile this activity was invisible on subject 3.

Figure 8 showed only subject 1 and subject 3 have not the capability to control the body balanced of twisting. However, as above-mentioned described that only one time of six times on subject 1 had uncommon pattern movement. This Figure demonstrated they used their hands as like the center of rotation and bent the left knee while they began

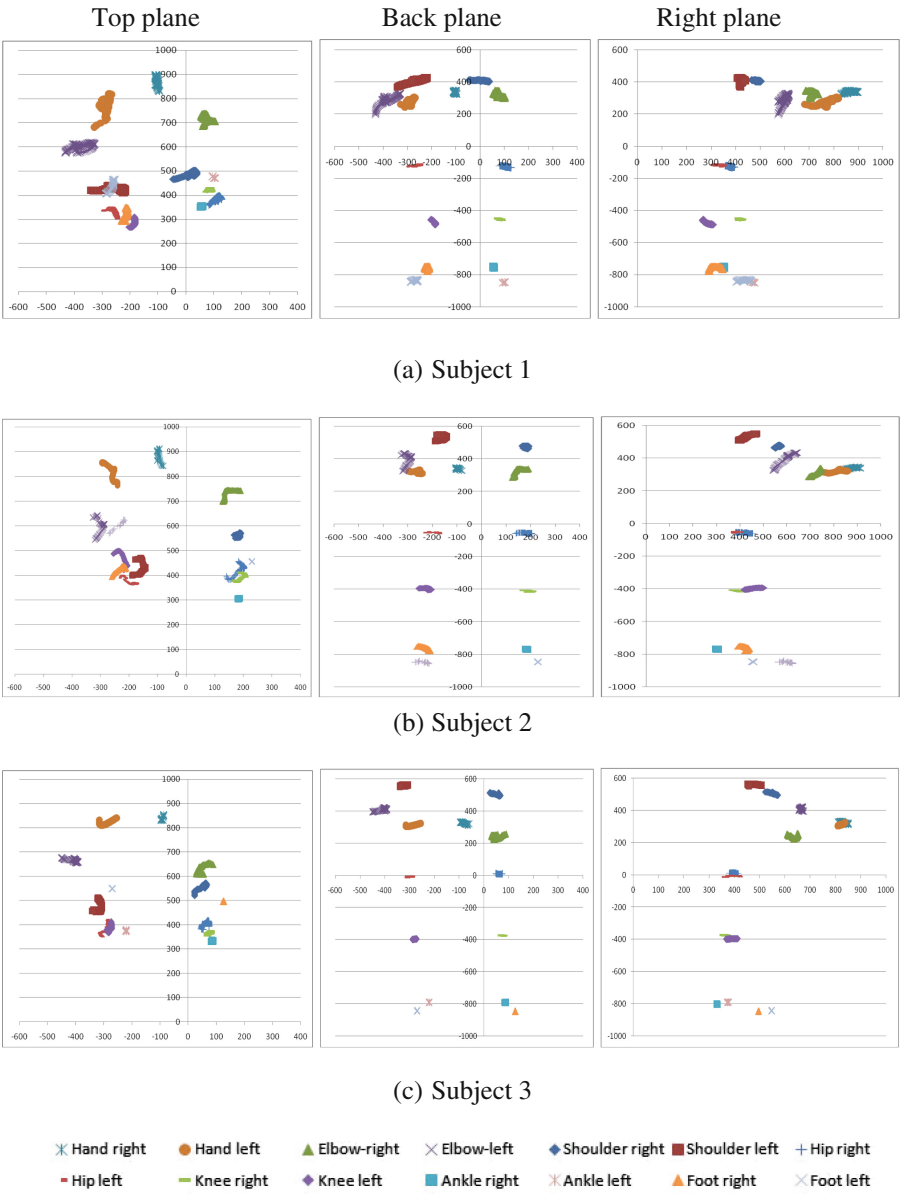

Fig. 7. The pattern of chucking movement which the subjects capable of being controlled the balance of body.

twisting the chuck key. The body trajectory movements were a curve line and had a lot of distance movement that were invisible on the controllable chucking performance on Fig. 7.

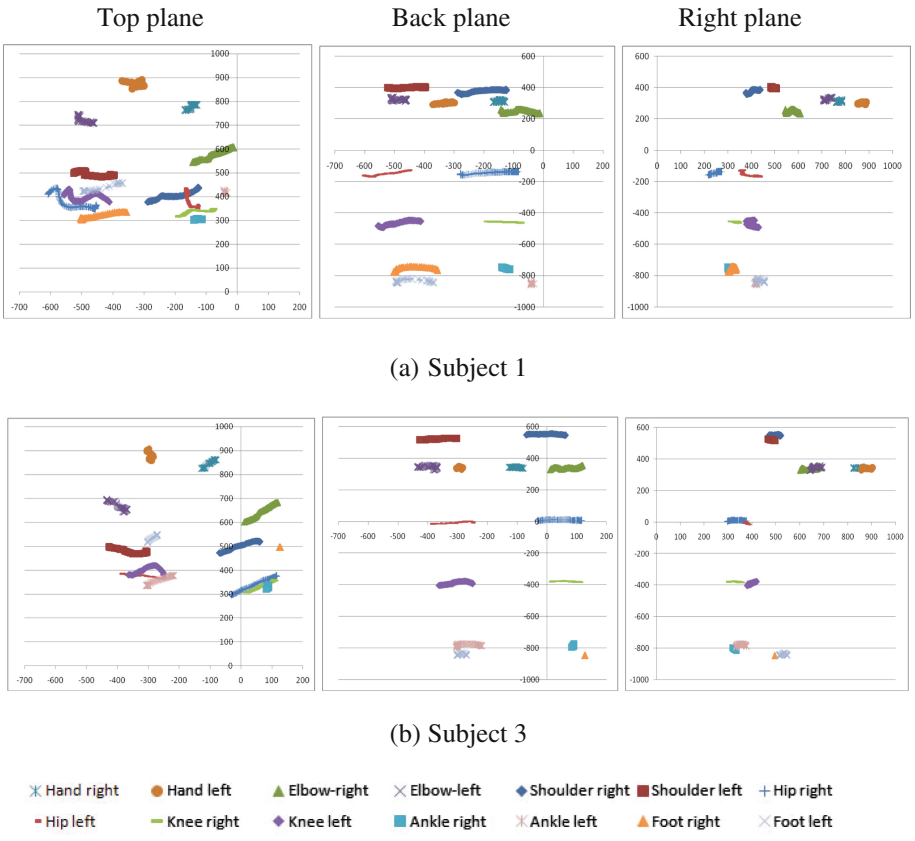

Fig. 8. The uncommon chucking activity by bending the left knee and moving the body down to the left side while twisting the chuck key.

3.2 EMG Processing Analysis

The comparison of EMG activity during the muscle of arms contractions among subject 1, 2 and 3 who had differential experience of lathe processing on Figs. 9 and 10 indicated although there were the similarly pattern movement in chucking process on these subject but the arms muscles activity of them have differed. On the muscle activity of the tighten gripping in chucking process that the subjects stand slightly on the right side of the chuck which left and right hand holding on the handle which disappeared the bending of body down to the left side explained the muscle activity using between subject 1 and 2 on Fig. 9 were quite similarly pattern. They always used the bilateral muscle of Flexor carpi radialis(L and R-FCR) and Triceps bracii(L and R-TB) and then they still used the right Extensor carpi radialis longus(R-ECRL), right Biceps brachii(R-BB) and left Deltoid(L-D). There were just a little using a muscle of left Extensor carpi radialis longus(L-ECRL), Biceps brachii(L-BB) and right Deltoid(R-D). Although the chucking performance of subject 1 had more like a muscle jerk of subject 2 but the period term muscle using of subject 2 were shorter than the subject 1. The duration of arms muscle contraction while

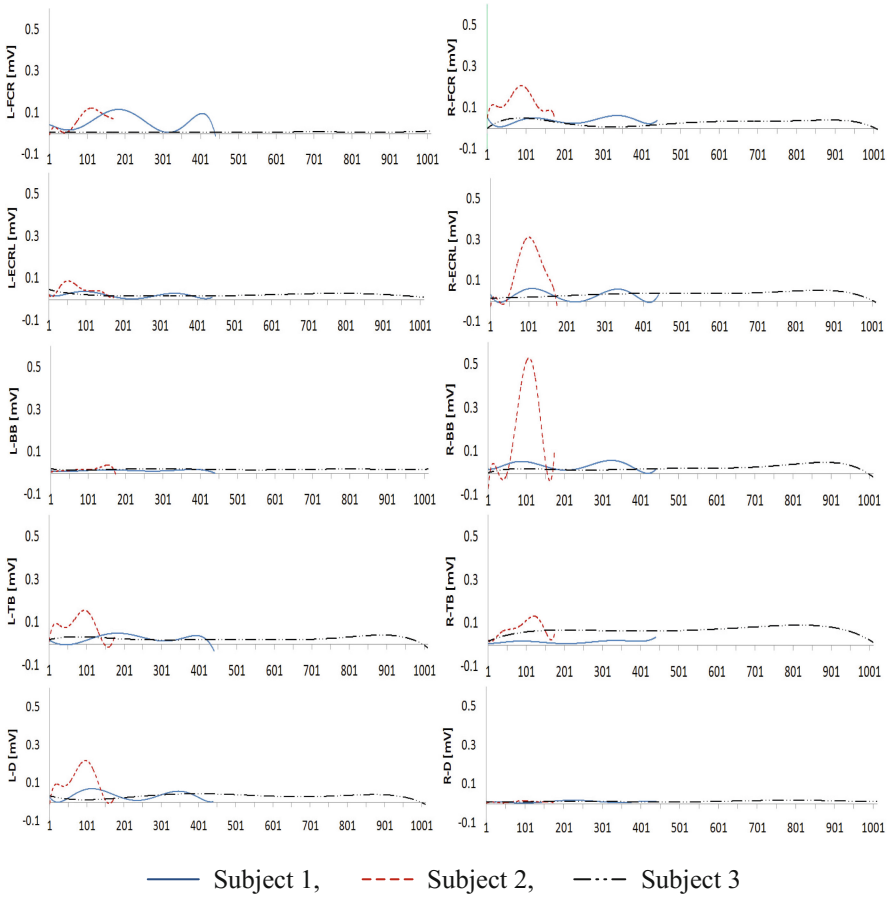

Fig. 9. The differential muscle activity on the subjects who capable controlled the body balance which did not bend the knee down and lean the body to the left side.

chucking on subject 1, 2 and 3 were 0.44 s, 0.2 s and 1.01 s respectively. In addition, subject 2 had a lot of the power exertion of arms muscle than the others and he had a high force of arms jerk only 1 time for chucking. The arms jerk on subject 1 was visible on 2 times. However, the subject 3 has continued to use the muscle of arms but it had not more muscle activity and did not obtain the arms jerk. All of arms muscle performances of subject 3 were on approximately 0 mV.

The EMG muscle of arms contraction of Fig. 10 which included the muscle performance not only the subject 1 who had a 1 time for bending the left knee down and leaned the body to the left side but also the subject 3 who very often bent the left knee down together with leaned the body to the left side. Even if these 2 subjects changed the pattern of chucking movement from the body balanced controlling to uncommon body movement but the arms muscle contraction of later movement were still similarly performance with the former. The subjects still contracted the bilat-

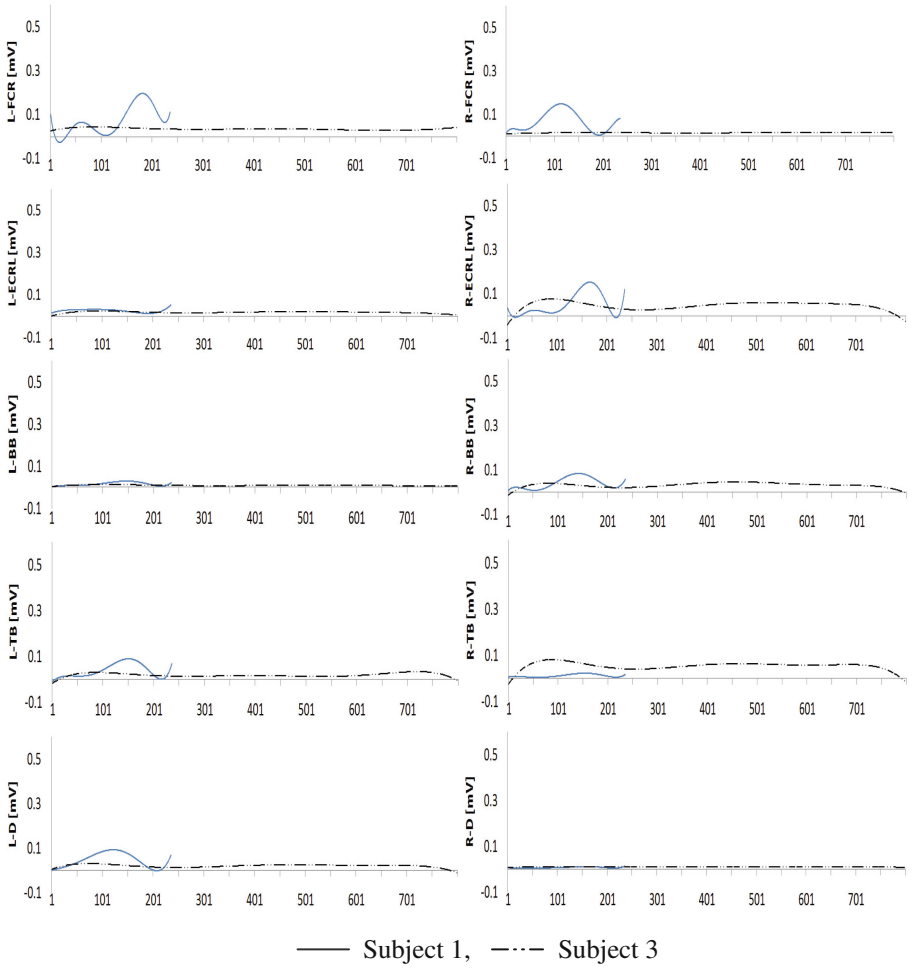

Fig. 10. The differential muscle activity on the subjects who bent the knee down and leaned the body to the left side.

eral muscle of Flexor carpi radialis(L and R-FCR) and Triceps bracii(L and R-TB) and then they still used the right Extensor carpi radialis longus(R-ECRL), right Biceps brachii(R-BB) and left Deltoid(L-D). Nevertheless, there was a differential muscle power using on the subject 1. The comparison between the first characteristic of chucking movement and the second one showed the second pattern activity affected the increasing of arms muscle contracting that it occurred only the subject 1. All of arms muscle performances of subject 3 kept in almost exactly on 0 mV. Conversely, the period of the arms muscle contraction while chucking on the subject 1 and subject 3 have decreased to 0.24 s and 0.8 s respectively.

4 Conclusions of the Relation Among the Subjects Personality, Motion Activity and Arms Muscle Contraction

Because the attendees on this experiment consisted of the 87,500 h, 6,300 h and 384 h therefore, the subjects were categorized in 2 group depended on the hours of experience. The subject 1 and 2 have assumed an expert workers and the subject 3 was supposed to be the non-expert. The result of chucking motion analysis and arms muscle contraction explained as a below;

1. The hands grip strength data of all subjects confirmed that the strength of this parts have not effected of the arms muscle using while twisting the chuck key. Because the data of them on Table 1 have showed the subject 2 got the grip strength of hands approximate to the subject 3; left hand 48.25, 44.4 kg and right hand 54.2, 48.6 kg respectively; but the strength of the first one differed with the subject 1; left hand 26.75 and right hand 28.35 kg; around double times. Conversely, the arms muscle using of the subject 1 was similarly pattern only the subject 2.
2. The age and height have not influenced both chucking movement, arms muscle using characteristic and the jerk direction of left elbow but the hours of experience have more effected of them. The confirmation test indicated on Table 1 the group of the expert that had a lot of age and height differential but the body movement pattern of chucking and the arms muscle activities still were correspondent. However, the age has impact on the arms muscle strength [3, 4]. Beside the group of expert always jerked the left elbow down when they were twisting the chuck key on the body balancing movement pattern.
3. Although the group of the expert and the non-expert had a similarly of the body balance controlling movement pattern even so the arms muscle exertion of both were positively different.
4. The arms muscle performance on the movement characteristic by bending the left body and leaning the left knee down on the subject 1 and 3 who were assumed the expert and the non-expert consecutively proved that only the expert exerted the arms power for twisting the chuck key. As the non-expert exerted to twist the chuck key by swinging the body to the left side together with he has used the arms as like a power transmitter from the body twisting.

References

1. Army Institute for Professional Development: Lathe Operation, Edition 8, pp. 30–33 (1988)
2. Yoshikawa, T., Ito, R., Tsujinaka, T.: Stance of chucking by the Takumi on Lathe Working. In: Proceeding, The Japan Society of Mechanical Engineering, Japan, pp. 517 (2012)
3. Hiroshi, Y., Morihiko, O., Toshiaki, O., Satoko, N., Tomomi, S., Tomohiro, K., Shinya, K., Tadashi, M.: Effects of aging on EMG variables during fatiguing isometric contractions. J. Hum. Ergol. **29**, 7–14 (2000)
4. Laxman U.S., Januaria, M.: Pinch Grip, Power Grip and Wrist Twisting Strengths of Healthy Older Adults 3(2), 77–88 (2004). www.gerontechjournal.net