

PROCEEDINGS OF THE 32ND ANNUAL CONFERENCE OF THE HUMAN ERGOLOGY SOCIETY

Nagoya, June 7 - 8, 1997

Secretary: Toru Itani

Laboratory of Health Sciences of Life, Work and Environment
Nagoya City University Graduate School of Medical Sciences
Nagoya, Japan

Control engineering analyses on the EMG patterns of lower limb muscles in human normal gait

Fujio Hashimoto¹, Tomohiko Fujikawa², Toru Oshima², and Minayori Kumamoto³

¹*Osaka Electro-Communication University*

²*Toyama Prefectural University*

³*Kyoto University*

We have reported that characteristic discharge patterns were observed in the antagonistic bi-articular muscles in lower limbs during the early stance phase of normal gait; the medial hamstrings (Mh) ceased and the rectus femoris (Rf) increased electrical activities about 30msec prior to the heel contact, whereas the mono-articular gluteus maximum (Gm) and vastus medialis (Vm) showed sustained activities in the same period.

Recently, we have demonstrated that the tightly coordinating activity patterns among the antagonistic bi-articular as well as the mono-articular muscles contributed to the output force and direction control, the force/position control and the stiffness control of the endpoint of the two joint link model, and have proposed the coordination control model. In the present experiments, we attempted to analyze the electrical activity patterns of the antagonistic bi-articular Mh and Rf and the mono-articular Gm and Vm during normal gait cycles. Subject employed were 35 healthy young adults.

Results obtained here strongly suggested that the crisscross EMG patterns of the bi-articular Rf and Mh and sustained activities of the mono-articular Gm and Vm during the early stance phase in the human normal gait were caused by the changes in the output force direction.

Handrails for entrance lobby level differences in dwellings: A study of handrails for use by the elderly during negotiation of level differences in dwellings, part 1

Satoshi Kose¹, Yoshiaki Goto², Shinji Tanaka², and Takeshi Kimura²

¹*Building Research Institute*

²*Sekisui House Corporation*

Level difference at the entrance is allowed with the maximum height of 18 cm. It necessitates installation of handrails for use by the elderly. The present study examined acceptable handrails layout under the condition of 18 cm height difference. Sixteen elderly subjects (4 males and 12 females) participated, and their motor behavior along with preferred handrails layout was analyzed. Five vertical handrails were prepared at a horizontal interval of 5 cm. The subjects negotiated the level difference at the entrance under four conditions, i.e. with no shoes, while taking on/off shoes, and two arrangements for sandals.

The results showed some differences for preferred handrails placement according to the posture during negotiation. The subjects basically grabbed the central handrails or handrails further to the direction of movement. The height they grabbed was determined by the original floor level, not the level of the destination. Some of the subjects grabbed the handrail when they were to turn themselves in order to put on the shoes facing backward. The movement to walk down the level difference included multiple and simultaneous activities, i.e., horizontal/vertical movement, twisting of the body, in addition to the movement of putting the footwear on. Some of the subjects could not handle the activities simultaneously, and stepped on to the footwear or on the floor barefoot.

It is perhaps worthwhile to consider the introduction of intermediate steps between two levels, which will allow two kinds of movement to be done separately, and will make it easier to negotiate 18 cm level difference.

Estimation of energy consumption with upper limb movement

Kunio Tsurumi, Hatsuko Suzumura, Norihide Tachi, and Toru Itani
Nagoya City University

This study aims to evaluate the utility of both surface-electrode EMG and acceleration of the upper limb to predict energy consumption in daily life. The following variables were measured in 12 female students; oxygen consumption (VO_2), heart rate, EMG from the deltoid muscle, and acceleration of the wrist. The subjects were requested to perform four different tasks. In the tasks 1, 2, and 3, subjects repetitively touched two points on a table, the height of which was adjusted at the elbow of the subjects. The distance between the two points was 50 cm in tasks 1, 3, and 100 cm in task 2, respectively. The frequency of the movement was 100 touches per minute in tasks 1 and 2, and 152 touches in task 3. In the task 4, the points were located vertically on a wall. The height of the points was 10 cm below and 40 cm above the acromion, and task frequency was 100 touches a minute.

The correlation coefficient was 0.411, 0.568, and 0.570, between VO_2 and heart rate, VO_2 and acceleration, and VO_2 and EMG from the deltoid, respectively. The coefficients of the determination reached around 0.6, when employing multiple regression analysis, using acceleration and EMG as independent variables. These results suggest that energy consumption can be accurately estimated by using the data from acceleration of the wrist and EMG from the deltoid.

A study on shift and night work in a steel wire factory in Malaysia

Tsuyoshi Kawakami, Kazuhiro Sakai, and Kazutaka Kogi
Institute for Science of Labour

As the rapid industrialization progresses, night and shift work systems are spreading in Malaysia. The purpose of the present study was to know working conditions of night and shift workers in Malaysia and to investigate the appropriate approach for their improvement. A steel wire factory was selected as a research site where a weekly-rotated 3-shift system in 3 teams was adopted. The research methods included: (1) direct observation of working conditions of 2 workers in each shift by a 30-second snap reading method and (2) subjective fatigue feeling monitoring of 15 workers in each shift by using the 30-item fatigue questionnaire developed by the Fatigue Research Committee of the Japan Association of Industrial Health. All the workers surveyed were male. The workers' main job contents were to provide raw materials for wire developing machines and to maintain them.

The direct observation showed that standing and walking were dominant in their work while sitting and squatting were more frequently observed during the night shift (3.4% in morning shift, 2.3% in afternoon shift and 9.6% in night shift). The fatigue feeling monitoring revealed that complaints

relating to the drowsiness and dullness category were highest among workers in this factory. It was noted that the complaints rate of night shift workers in the drowsiness and dullness category was particularly higher even before starting their shift (28.0% before work and 26.0% after work among morning shift workers; 30.7% before work and 46.4% after work among afternoon shift workers; 50.7% before work and 52.7% after work among night shift workers). This high fatigue complaint rate before the night shift indicated that the night shift workers in this factory could not recover from fatigue of the previous night shift.

It was concluded that support is required for managers and workers in this factory to reduce the workload and facilitate fatigue recovery after the night work.

Dichotic recognition, handedness, and hemispheric cerebral asymmetry

Shigeru Takatsuji and Haruhiko Sato
Kyushu Institute of Design

The present study attempted to determine by dichotic listening test whether handedness was related to hemispheric cerebral asymmetry with respect to language processing. The subjects were 8 male college students (20-24 years of age). All subjects reported normal hearing. The subjects were divided into two groups by handedness questionnaires, i.e. 4 right-handed and 4 non-right-handed. The subject heard a pair of dichotic stimuli, which consisted of different two words. The subject had to click a mouse quickly if one of the words belonged to animal (animals were included 20/40 times). Then the subject reported orally all words that he could recognize. Two tests were performed for click by the right hand and for click by the left hand, respectively (one test consisted of 40 trials). Reaction time and correct clicks were compared for each ear for each click-hand between right-handed and non-right-handed subjects.

On the reaction time, words presented to the right ear were reported faster than those to the left ear in both right-handed and non-right-handed group. For the right-handed, click by the right hand were faster than left-hand-clicks, while there was no significant difference due to click-hand for the non-right-handed. On the correctness, words presented to the right ear were reported more accurately than those to the left ear for the right-handed group, but there was no significant difference due to the ear for the non-right-handed group.

As a result, it has been found that spoken words are processed primarily by the left hemisphere in the right-handed subjects, whereas the non-right-handed ones don't show a consistent tendency.

On illumination producing appetite-tempting food appearance

Ayano Kawaguchi and Haruhiko Sato
Kyushu Institute of Design

There are a number of studies on lighting in which food looks delicious. Many of them, however, compare one lighting condition with other ones. In this study, subjects by oneself determined the brightness of illumination with fluorescent lamp to produce appetite-tempting food appearance. It was examined whether three factors, i.e. color temperature of fluorescent lamp, kind of food, and sex of subjects, affect the brightness of food lighting or not. The experiment conditions were 3 color temperatures of lamp, i.e. 3,000K of warm white, 5,000K of neutral white and 6,700K of daylight, and 5 kinds of food on white plate, i.e. cooked hijiki (spindle-shaped bladder-leaves), sliced raw tuna. Japanese plain omelet, boiled spinach mixed with sesame, and rice. Subjects were 10 male and 10 female students.

Women preferred less brightness than men. Subsequent analyses were made separately for each

sex. It was clear that women preferred different brightness for each food as compared with men. Sliced raw tuna needed the highest lighting-level irrespective of sex (Is this related to be raw food?). Women's preference was also affected by color temperature of lamp. Lighting-level was the highest with warm white lamp and lowest with neutral white lamp in women. The highest lighting-level with warm white lamp may be explained by that generally we feel darker when color temperature lowers at a constant brightness. The lowest brightness with neutral white lamp may be accounted for by that neutral white light is close to natural daylight, and used in home frequently.

In this study, brightness preference for foods was much influenced by sex. Anyone has an interest in foods regardless of sex, but the experiments were performed with young people (19-24 years old). It is suggested that young men think about "quantity rather than quality", while women think of the reverse.

The workload in the bread delivery service

Yoshio Oguro
Kanagawa University

The workload in the bread delivery service was investigated. The items examined were details of bread delivery working hours, distances between shops to be delivered, moving hours, heart rate, flicker value (CFF), 2 points contact identification threshold value, subjective symptoms, etc. In addition, the measurements of the temperature and noise level inside and outside of the delivery car were carried out.

Judging from the data obtained, special features of driving car conditions need to be taken into consideration in the bread delivery service, in addition to the typical transportation labors such as loading, unloading, and carrying of goods. In other words, it is indispensable to take into consideration, in addition to the traffic conditions, the environmental conditions inside of the car such as noise, vibration, temperature, humidity etc, as well as the human factors engineering with the driving seat. The following facts were found in the diagnosis test for the subjective symptomatic fatigue. The descending order of complaints was $> >$. The top of order is $-$ dominant group as usually seen. Top ranking in each group were "eye strain", "sleepy", "yawn" in the group $$, "become irritated" in group $$, and "stiffness in shoulder" and "pain at waist" in group $$.

In general, there is a special feature of delivery work with driving labor. In other words, it is conjectured that the factors which prevent the progress of delivery due to the traffic conditions make drivers irritate.

The relationship between flights and sleep patterns of cockpit crews on international flights as shown by time budget studies

Kazuhiro Sakai and Tsukasa Sasaki
Institute for Science of Labour

Time budget studies were conducted for 24 cockpit crews including co-pilots and flight engineers engaged in international flights. The time budget data were collected for a period of one month. The subjects were asked to check each of the following items every 15 minutes; (1) boarding time, (2) transport, (3) sleep time, (4) presence of sleepiness, (5) mealtime, and (6) alcohol consumption.

The sleep patterns of the crews were notably irregular due to frequent night or daytime sleeps and time zone differences arising from flight schedules of the international flights. Because the crews could not sleep for a period of about 24 hours after the previous sleep in Japan, they usually took a short nap after arriving at a hotel in their destination. They tended to wake up in the middle of a

sleep. On the other hand, crews engaged in domestic flights slept for an average of 450 minutes. In the case of crews on overseas flights, the sleep patterns were disrupted depending on whether the sleep was taken during daytime or at night at the destination and during corresponding daytime or night in Japan. If the sleep was taken during nighttime both at the destination and in Japan, the average sleep length was 421 minutes. If it was taken in daytime at the destination and at night in Japan, the sleep length was 217 minutes. Sleep taken during daytime in both locations lasted for 170 minutes.

The results show that sleep patterns among crews flying east to U.S. were more irregular and more disrupted than those among crews flying within Asia or to Australia.

Increasing the motivation of crane operators

Y. Ideura¹, T. Kayahara², T. Kitagawa², and E. Masuyama³

¹*Komatsu Ltd.*

²*Tokyo Metropolitan University*

³*Takushoku University*

In making the construction equipment, we have been focusing on the automatization and the reduction of operator's workload. On the other hand, it is doubtful that an easy work satisfies operators because they may feel bored or they cannot show their very professional technique. In this paper, the satisfaction of the crane operator was investigated with respect to the three fields: crane, work, and life. Subjects were 77 professional operators who daily drive rough terrain cranes in Kanagawa Prefecture. The subjects were asked 10 questions for each of the three fields. They were requested to choose one answer from five steps, "satisfaction-large" to "dissatisfaction very much". The last question in each field was about the satisfaction for the entire field, and the final question was about the whole satisfaction in the total life.

The result was that the overall satisfaction feeling correlated with the work satisfaction and the life satisfaction, both of which also correlated with the crane satisfaction.

We also analyzed the relation between operators' technical level and their motivation. Operators who drive a large-sized crane had high technique, and tended to be satisfied with "originality" during the work, because the degree of operator's discretion increased in large and complex site of construction. Moreover, these operators valued "handling quality of the crane" by which they could demonstrate their own technique. By contrast, the support of the machine by "convenient auto-function" was valued by small-sized crane operators, because their ability had not developed enough.

Our study has suggested that the satisfaction with the work and life is improved by providing the crane with high quality. It has been also understood that the factor structure of the operator's satisfaction to the crane and the work are different according to the scale of crane or lifting weight the operator handles.

Vocational abilities necessary for workers of the tertiary industry

Kazuo Mori

Polytechnic University

Vocational abilities different from those of the secondary industry are necessary for the workers of the tertiary industry. This basic difference influences the job qualification system, ability evaluation, and method of education/training. However, little progress has been made in its systematic and consistent understanding. In this research, we tried to examine and compare the vocational abilities of the workers in the tertiary industry with those in the secondary industry in the three areas of DPT (D

area: information; P area: person; T area: things). The following items were investigated: a) content of vocational abilities required for each worker; b) characteristics viewed from the three areas of vocational abilities; c) difference in service works between the secondary and tertiary industries. Results were as follows.

First, four characteristics appeared in the vocational abilities in the tertiary industry: 1) “understanding and treatment of a person” is underlying; 2) attitude and character are regarded important in addition to ability; 3) considerable value is set on team vocational ability; 4) services using hardware are involved. Second, vocational abilities of the vocational training instructor and hotel employees were found to be similar in the three areas of DPT. Third, the main vocational abilities of the workers in the secondary industry are related with “things”, and those of the tertiary industry workers with “person”. “Information” is likely to be common to both. Fourth, a characteristic difference was identified in “action and judgment by the tertiary industry workers” and “transfer and analysis of information”.

Control properties of the limbs with various muscular arrangements. Part 1: Differences in muscular arrangements among animals

Y. Noguchi¹, T. Fujikawa¹, T. Oshima¹, M. Kumamoto², and N. Yokoi¹

¹*Toyama Prefectural University*

²*Kyoto University*

Living in the gravitational environments, animals have muscular arrangements reflecting differences in their locomotive life styles. We have reported that coordinating the activities among three pairs of antagonistic muscles, i.e. two pairs of the mono-articular shoulder and elbow muscles and a pair of bi-articular muscles in the upper arm, contribute to the force /direction control, the force/position control, and the stiffness control at the endpoint of the extremities. In the present paper, the relations between the muscular arrangements in animals and their characteristic locomotive styles were analyzed in terms of functional anatomy.

In plantigrade humans, three pairs of antagonistic muscles exist in the thigh as well as in the upper arm, but a bi-articular muscle which is antagonistic to the gastrocnemius does not exist on the front side of the shank. Gorilla and chimpanzee, which are also plantigrade but move freely in the tree using the four limbs, also do not have a bi-articular muscle antagonistic to the gastrocnemius on the front side of the shank.

By contrast, the hoofed as well as digitigrade animals have the three pairs of the antagonistic muscles in the shank as well as in the thigh. It is interesting to note that a part of the tendon of the bi-articular muscles on the backside of the thigh branches off, runs downward, and attaches to the calcaneus. This part becomes a tri-articular muscle.

Both the upper and lower segments of the forelimbs of plantigrade as well as digitigrade animals have the full arrangements of the three pairs of the antagonistic muscles including a pair of bi-articular muscles. The frog, in which the predominant locomotive movement is jumping, shows a characteristic muscular arrangement where the mono-articular hip extensor and the mono-articular knee flexor disappear and the antagonistic bi-articular muscles are well developed.

Control properties of the limbs with various muscular arrangements. Part 2: Mechanical link model analyses

T. Fujikawa¹, Y. Noguchi¹, T. Oshima¹, M. Kumamoto², and N. Yokoi¹

¹*Toyama Prefectural University*

²*Kyoto University*

Theoretical and experimental analyses were made for differences in the output force distributions and in the control properties exerted at the endpoint of the extremities between the fully arranged musculo-skeletal model and the model in which one or a few muscles lacked. Theoretical analyses were conducted by using a musculo-skeletal two joints link model equipped with two pairs of antagonistic mono-articular muscles acting at each of the joints and a pair of antagonistic bi-articular muscles acting at both joints. Experimental analyses were carried out with a robotics arm model installed with pneumatically controlled artificial rubber actuators having the same muscular arrangements as in the link model.

Results obtained here have suggested that the particular muscular arrangements in the extremity reflect the particular locomotive style in each animal. In the plantigrade animals including humans and gorillas, in which the force/position as well as stiffness control would be very important at the foot, but not be so important at the toe, for their postural and locomotive control, the full arrangements of the three pairs of antagonistic muscles exist in the thigh, but a bi-articular muscle antagonistic to the gastrocnemius does not exist on the front side of the shank. The gastrocnemius generates propulsive forces by plantar flexion of the ankle, and as a bi-articular muscle, effectively transfers the muscular forces produced in the proximal segments to the foot.

By contrast, in the hoofed and digitigrade animals which stand and walk with the toes with elongated metatarsus, the full arrangement of antagonistic bi-articular muscles would be necessary in the shank as well as in the thigh, to get sufficient force/position and stiffness control at the toe. Parts of the bi-articular muscles on the back of the thigh, which became tri-articular with the branched-off tendon, could very effectively transfer the muscular force generated in the trunk to the extreme end of the extremity.

The muscular arrangement in lower extremities of the frog showed the strained force distribution curve where the forces toward the distal and lateral were larger than those to the other directions, and might be suitable for swimming as well as for jumping.

How to attain enjoyable vaulting

Hideo Oka¹ and Minayori Kumanoto²

¹*Hyogo University of Teacher Education*

²*Kyoto University*

A well-performed vault win gives a person a great satisfaction and a perfect accomplishment feeling. We have reported that an important point to accomplish the vaulting is to get a vertical force component sufficient to push up the center of body mass at the hand contacts, and that the vertical component can be produced by the shoulder joint flexion and elbow joint extension at the contacts, a spring like mechanism. In the present paper, we attempted to improve the vaulting motions of beginners, and the process of improvement was analyzed in terms of EMG kinesiology.

First, in the straddle vaulting, the most fundamental vaulting, the subjects were requested to swing their upper limbs in front of their upper body during approach running, to make hand contacts with extended elbow joints, and to spread their upper limbs lateralward immediately after the contacts, so called "front swing, bird-like vaulting". After the several trials, most of the subjects showed marked activities, prior to the hand contacts, in the anterior deltoid, acting on the shoulder flexion, an

increase in the shoulder joint angle at the contacts, and a marked upward shift of the center of body mass, resulting in an almost perfect achievement of the straddle vaulting.

Second, in the long horse vaulting, where the long horse was leaned forward about 6 degrees and the croup was lifted up, the subjects were requested to perform the “front swing, bird-like vaulting”. After the trials, most of the subjects showed marked activities, prior to the hand contacts, in the biceps brachii long head simultaneously with those in the anterior deltoid, and a remarkable upward shift of the center of body mass without any change in the shoulder joint angles at the contacts.

EMG kinesiology analyses were also conducted on primary school children during the “front swing, bird-like vaulting” with the forward-leaned long horse, and the results obtained were the same as those described above. A free questionnaire survey for the school children revealed that the advises on the motion could lead them to the enjoyable vaulting.

How people rest on the grass in a park: A study on sitting and lying posture

Hiroko Iwata

Nagoya Women's University

In order to clarify the characteristics of resting posture, a total of 429 people were photographed in two parks in Nagoya City. Among 319 people who were sitting, 35 patterns of resting posture were observed. More than half of the people (N=198, 62.1%) placed their right and left legs asymmetricaly. A small number of the people (N=4, 1.3%) straightened one leg and bent the other. Most of them sat stretching both of their legs (N=163, 51.1%) or bending both of their knees (N=152, 47.6%). While the difference in the leg posture was not statistically significant among four age groups (children, young people, middle aged, and senior people), sex difference was significant (χ^2 test; symmetry of the legs: $p<0.01$, bending of the knees: $p<0.01$). Even in the open air, men showed a tendency to sit with their legs crossed. On the other hand, women had preference for sitting with their legs stretched when they were relaxed.

Among 110 people who rest lying on the lawn, 62 patterns of lying posture were observed. More than two-thirds of the lying people (N=75, 68.2%) put the head directly on the ground or supported it with their arms or something else. The rest of the people (N=35, 31.8%) lifted up their head without support. The frequency of the younger people who lay lifting up the head without support was higher than that of the older people. With respect to the head support, a significant difference was seen among three age groups (children, young, and middle aged people) ($p<0.01$).

More than half of the lying people (N=60, 54.5%) shifted their body weight on either side of the trunk, and about one-thirds of them (N=39, 35.5%) lay on the back. The number of the people who lay on the stomach was small (N=11, 10.0%). As for the frequency of lying on the side, on the back and on the stomach, a significant difference was seen among the age groups ($p<0.01$), while sex difference was not significant. Among the people who lay on the back or on their stomach, more than a half (N=28, 56.0%) assumed asymmetric posture. The difference in the frequency of the symmetric posture was significant among the age groups ($p<0.05$), while sex difference was not significant. As age advanced, asymmetric postures increased. In the case of the people who lay on the side, those who lay on the right side were 28 (46.7%) and those on the left side were 32 (53.3%). The lateral preference for lying on the side was approximately the same for both sexes across all the age groups.

Ergological implications revealed by participant observation of Japanese Antarctic year-round team

Tatsuro Matsuda

National Institute of Polar Research

The author conducted a research on behaviors and works of small groups in the Japanese Antarctic year-round team for twenty years. The meaning of the group ergology in this research was considered here. After leaving Tokyo Port, it took one and half months for an icebreaker to arrive at the Antarctic Continent. The icebreaker left the year-round team behind at the Showa Station after her stay there for two months. At that time, the year-round team became an isolated and closed group at the Station; they had to live in the Antarctic without any support from other civilized society throughout one year. The life of Antarctic year-round team appeared to be analogous with those in the primitive age, since they made their own living environments in the Antarctic and had to adjust their lives to them.

The author referred to the transportation and exchange of information in the team. In the modern society, people use ships, vehicles and airplanes to move, while the Showa Station team members walk on foot or use a snow vehicle. The fastest speed of airplane is over 1,000 km per hour whereas walking speed was only 4 km per hour and the speed of the snow vehicle was only 3 km per hour on the snow field in those days. The wireless was the only medium to connect the Station and outside world, and it was obvious that only a very small amount of information came to Antarctica. Then there was a chronic information famine in Showa Station. However, the author found in the year-round team its own language world in which a lot of slang was used, and also could know that a supply and demand of the information in the team was self-sufficient. The author also noticed that the age structure of the team came to be indicated by nicknames. The relationship among the members of a small group was made clear from the above-mentioned topics.