

# Effectual Points of View in Occupational Health Management for Persons with Cerebral Palsy—Interventional Case Approach in VDT Work—

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**Abstract:** In our previous study, we elicited effectual points of view (POV) in occupational health management for visual display terminals (VDT) operators with disabilities. In order to validate the POV, two VDT operators with cerebral palsy newly-participated in our case study. Problems were ascertained, and in order to attempt to reduce the workload and improve operability, we performed intervention using ergonomic measures. Evaluations were conducted through observations of the equipment used and posture, as well as measurements of sitting pressure distribution and surface electromyogram. For Case 1 (a 33 yr-old male), a trunk support was introduced inside the armrest of his chair to maintain the trunk in a comfortable position. For Case 2 (a 21 yr-old female), in order to improve her unstable sitting position, we changed her chair and adjusted it to an appropriate desk height. For both cases, we confirmed improvements in posture, sitting pressure distribution, myoelectric potential or operability. We were able to confirm that “maintaining of a comfortable trunk” and “alleviation of excessive bending, extension, and curvature of the spinal column and joints” obtained from the previous study as POV in health management are also effective in the present interventional cases.

**Key words:** Persons with disabilities, Secondary disorders, VDT work, Health management, Limb impairments, Cerebral palsy, Working environment control

## Introduction

Due to recent development and popularization of information technology, it has become possible to exchange information with people around the world without leaving the home, thus resulting in the reduction of social participation barriers for persons with physical disabilities accompanied by difficulty in moving. In terms of work, job descriptions and working modes have significantly changed, and leading to an expansion in work opportunities for challenged persons who had previously been considered unable to work in general occupations, and allowing them to enter the workforce<sup>1</sup>. On the other hand, as opportunities and time for per-

sons with disabilities to operate personal computers (PCs) has increased, their physical and psychological loads have also increased<sup>2</sup>. In fact, cases of secondary problems to their health (Secondary Disorders) that cause deterioration due to underlying diseases and a decline in physical ability along with employment<sup>2</sup> was reported in Japan; additionally, in America<sup>3</sup> and Australia<sup>4</sup>, where work conditions and the environment for employed persons with disabilities are different, Secondary Disorders cases have also been reported. Particularly in Japan, many persons with disabilities are limited to employment provided through public welfare, and the dysfunctioning of safety and health management for workers, which is implemented based on the law at general companies, is believed to be a major reason for the onset of Secondary Disorders.

In the US, the Americans with Disabilities Act (ADA)<sup>5</sup>

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was issued in 1990, and in the UK, the Disability Discrimination Act (DDA)<sup>6)</sup> was issued in 1995. As described in the ADA, “It required that employers make reasonable accommodation to the known physical or mental limitations of otherwise qualified individuals with disabilities, unless it results in undue hardship”, discrimination against people with disabilities is prohibited, particularly discrimination in regard to employment, and sufficient consideration is requested. Other reports exist, including one which investigated workplace accommodation in relation to the health of persons with disabilities<sup>7)</sup> and another in Russia, requesting employers to understand and consider disability issues for employment of persons with disabilities, for example, the mismatching of physical environment and difficulties in acquiring skills and education<sup>8)</sup>. Regarding visual display terminals (VDT) work, in Japan, the Ministry of Health, Labor and Welfare has released the guidelines for industrial health controls of VDT operations<sup>9)</sup> in 2002, and it is already being implemented by companies. The guidelines describe equipment-related measures, for example, “Countermeasures must be taken as required to ensure that operators with disabilities who find it difficult to use a keyboard or mouse, VDT operation input equipment are offered voice input devices etc.”

However, no studies exist clarifying a method for preventing Secondary Disorders regarding VDT work, which can be effectively utilized in workplaces where persons with disabilities are employed. It is inferred that the reasons for this include that points of view (POV) in health management vary in each case due to differences in remaining physical functions depending on the type and degree of disabilities, and that when planning measures for preventing Secondary Disorders, essential accumulation of findings based on actual work conditions is insufficient. For example, regarding the study reports on work environment and work methods of persons with disabilities in the field of occupational health, a report exists which examines the relationship between work environment/work method for workers in wheelchairs along with their physical symptoms using a posture analysis technique by video filming<sup>10)</sup> and a study on recommendations for workplace accommodations for persons with multiple limitations<sup>11)</sup>, etc.; however, examination of these measures has not yet been achieved. In a study by SP Wu<sup>12, 13)</sup>, by only focusing on the height and angle of the screen for wheelchair users, the results were evaluated according to the claimed degree of discomfort of the musculoskeletal series; however, seating has not been sufficiently examined, which is an important point for wheelchair users.

The remaining functions of persons with disabilities

vary respectively, having strong individuality; therefore, it is first necessary to attempt to reduce physical and psychological loads corresponding to individuals with disabilities. Then, by accumulating cases of improvement and organizing the relevance among disability characteristics of individuals with disabilities, problems that make maintenance of health and execution of tasks difficult, and causes of the problems derived from the work method and environment, and then finding effectual POV in occupational health management in groups of persons with disabilities that are classified by the type of disability, remaining functions, etc., we believe that it may lead to the prevention of Secondary Disorders in many persons with disabilities.

According to such aspect, we conducted interventions aiming to reduce load and improve PC operability for VDT operators with limb impairments, elicited POV in health management that were effective for creating ideas for improvement of work environment, and are reporting on it herein<sup>14)</sup>. The POVs in VDT work performed in a sitting position on a chair were summarized as follows: i) attempt to “maintain a comfortable position of the trunk” by utilizing supporting tools, etc. created with cushions, because it is required for persons with disabilities having lower hemi-paralysis or equinus foot to maintain trunk position by minimally using the lower extremities; ii) “support the paralyzed part” to reduce the load on the circumference implied by the weight of the paralyzed body parts; and iii) prevent “excessive bending, extension, curvature of the spinal column and joints” by altering inappropriate and unsuitable work environments. In the present study, for the purpose of validating efficacy of the previously elicited POV in health management, we attempted to reduce physical and psychological loads on VDT operators with limb impairments.

## Subjects and Methods

We explained the purpose and method of this case study and employed two VDT operators with cerebral palsy (CP) as subjects, and obtained consent from both the individuals themselves and the employers in their workplaces.

For each case, the procedure for conducting the study included: 1) survey for ascertaining problems that were considered relevant to Secondary Disorders, 2) development of measures for solving problems and preparation for implementation, 3) implementation of the measures (intervention), and 4) evaluation.

### *Survey for ascertaining problems*

It should be pointed out that in persons with CP,

hypertonia of the muscles develop into contracture of the joints and dislocation and bone malformations, resulting in declined functions<sup>15, 16</sup>, and thus, (i) we asked about their health condition mainly focusing on subjective musculoskeletal symptoms, physical abilities and lifestyle, and their courses, etc. Then, referring to the work environment, equipment to be used, and postures recommended in the Japanese guidelines of VDT operations, etc.<sup>9, 17, 18</sup>, (ii) we observed VDT tasks and measured the size of equipment, etc. Furthermore, (iii) we asked regarding seating comfort and operability of the PC input equipment. From the information obtained in these surveys, problems of claimed symptoms, etc. and their inferred causes were ascertained.

#### *Development of measures for solving problems and preparation for implementation*

For the intervention measures, under the conditions of (a) removing or alleviating loads derived from the extracted problems and (b) not decreasing the operability significantly, and if possible, further aiming for improved operability of the VDT equipment, several measures were developed. In addition, practical measures using existing equipment (desks and chairs, etc.) have also been suggested, while taking into consideration both appropriate technical standards and economic efficiency in order to reduce operational expenses in the workplace.

#### *Intervention*

We explained the interventional measures to the individuals and the employers in their workplaces and implemented the measures for solving problems starting with the highest order of priority.

#### *Evaluation*

In the pre-interventional condition, VDT work was performed for approximately 10 min and, thereafter, the interventional measures were implemented. After sufficient rest, similar VDT work was performed for the same period of time as that before intervention and immediately following the respective work, a subjective evaluation was given and an objective evaluation was performed. For the objective evaluation, we observed postures by photography, measured the sitting pressure distribution, and measured the surface electromyogram at each part of the body. For the subjective evaluation, questions were posed regarding feelings of physical load, stability of posture, operability of PC input equipment, etc. Furthermore, when possible, the subjective evaluation was given again after a few months.

The sitting pressure distribution was measured using a body pressure measurement device called BIG-MAT

(spatial resolution: 44 × 48 cells; detected cell dimension: 0.4 inch square; NITTA Co., Ltd.).

For measurement of the surface electromyogram, firstly, we specified parts on which significant muscle load was implied according to the subjective symptoms and posture observation. On the skin surface of the parts, a bipolar electrode (NEUROLINE 72-501-K, Medicotest, Denmark) was attached, and the elicited electromyogram was amplified by an amplifier (RMS Preamplifier Unit; range of effective frequency 10–1,200 Hz; TEAC Co., Ltd.) and converted to root mean squares (RMS, with 50 ms time constant); thereafter, a PC card-using digital recorder (DR-C2; TEAC Co., Ltd.) was used to record at 16 bit resolution for 50 sample/s. We carried out an evaluating time before and after an intervention under selected conditions by ourselves. We calculated the mean value and 95 percentile of the measured myoelectric potential for the evaluating time, and we also obtained the Load Reduction Ratio defined in the following formula, and evaluated the reduction in muscle load.

Load Reduction Ratio (%) =  $100 \times (\text{pre-intervention value} - \text{post-intervention value}) / \text{pre-intervention value}$

Our study protocol was approved (approval number: 19-43) by the human research ethics committee of Shiga University of Medical Science (Otsu, Japan).

## **Results**

### *Case 1*

The subject was a 33-yr-old man who was working at a welfare work activity center. This individual had a disability due to athetoid-type cerebral palsy and had been identified as having a second grade physical disability certificate (due to athetosis, ataxic, etc., usage of the upper extremities is extremely limited in daily life activities and walking<sup>19</sup>).

#### *Case 1-1. Survey results and ascertaining of problems 1-1a. Course of activity of daily life and health condition*

Although performance was limited as set out by the second grade physical disability certificate, walking was possible without aid. This individual was able to perform keyboard operations with both upper extremities, requiring no assistance in daily performance.

From a few years before the survey, his walking distance had shortened, and frequency of falling during walking had increased. From around 27-yr-old, this individual became aware of back pain and stiffness in the neck and shoulder regions during work and after work, enhanced muscle tension from around 28-yr-old, and declined muscle power from around 30-yr-old. He



**Fig. 1-1. The chair used by the subject 1.**

(Left: His lower extremities were not satisfactorily supported by the soles. Right: His lateral back region was not supported.)

claimed stiffness in the shoulder/back region, and back pain, and in the right paraspinal muscles near the vertebrae thoracicae 10th level, induration was observed.

#### *1-1b. VDT work*

Using spreadsheet software for laptop word processors, this individual performed accounting transactions. Pointing equipment had not been used.

He worked 7 h a day, 4 d a week at a welfare work activity center. Due to his physical condition, he was allowed to have short breaks whenever he felt fatigued.

#### *1-1c. Work environment, equipment used, and posture*

The chair that the subject was using had armrests and 4 legs with casters (Fig. 1-1). The height of the seating surface of the chair, which was the lowest setting in the adjustable range, was slightly high for his build, and also, due to his equine foot, the lower extremities were not satisfactorily supported by the soles. Furthermore, the lateral back region was not supported and the pelvis inclined to the left. Moreover, curvature of the left convex side of the trunk along with inclination of the head to the right were observed. During keyboard operation, the upper extremities were suspended in the air. Although the chair had armrests, they were low and narrow, and were not actually utilized.

No parts of the desk used by the subject were adjustable.

#### Case 1-2. Intervention Measure

For the purpose of ameliorating excessive muscle

tension of the neck/shoulder region and the lower back region that are causes of stiffness and pain in the shoulder and lower back regions, the following interventional measures were implemented.

#### *1-2a. Installation of supporting tools to the left side of the trunk*

In order to prevent the pelvis from inclining to the left and the trunk from curving at the left convex side and to assist with the maintaining of a comfortable trunk position, we installed a supporting tool, created using a board and cushion, at the left side region of the lower trunk and inside the left armrest of the chair (Fig. 1-2).

We attempted to use a footrest to solve the slightly-high seating surface for his build. However, this attempt was not successful due to interference with the chair legs (see Figs. 1-1 or 1-2). We did not install a seating surface mat to obtain a stable sitting position and favorable seating because the height of the seating surface would have been higher if such a mat had been installed.

#### *1-2b. Installation of useful armrest*

In order to prevent the upper extremities from being suspended in the air, we created armrests of sufficient width and height adjusted to the table surface such that the subject could easily place his elbows, and installed them on the original armrests of the chair (Fig. 1-2).



Fig. 1-2. The supporting item.

Case 1-3. Evaluation

1-3a. Posture

Figure 1-3 shows photographs looking from the rear of the subject before and after the intervention. By installing a supporting tool at the left side region of the trunk, displacement of the mid-trunk to the left decreased. Along with this decrease, the degree of left

inclination of the pelvis and left convex side curvature of the trunk also decreased. Furthermore, bending of the cervical spine to the right was reduced from 21 degrees in the head deflection angle of the vertical line to 8 degrees. In addition, by installing the new armrests, it became possible to support the upper extremities using the armrests.

1-3b. Surface electromyogram

Measurements were taken at 8 regions including the right and left biceps brachii muscles (Arms), upper trapezius muscles (Shoulders), erector spinae muscles at the lumbar 3–4th level (Lumbar), right paraspinal muscle at the thoracicae 11–12th level (Right back), and right obliquus externus abdomenis. 4 min and 45 s of actual key typing during VDT work was carried out both before and after the intervention (Fig. 1-4), and the mean, SD, and 95%ile values of the myoelectric potential RMS value and the Load Reduction Ratio were calculated (Table 1-1).

In the lower back region, the Load Reduction Ratio (mean) of 4% to 28% was obtained. In addition, at the left side where the armrests were installed, the Load Reduction Ratio (mean) of 17% was obtained from the upper arms; however, there was very little difference in the myoelectric potential in the shoulder. On the other hand, on the right side, the Load Reduction Ratio for the upper arms resulted in a negative value; however,

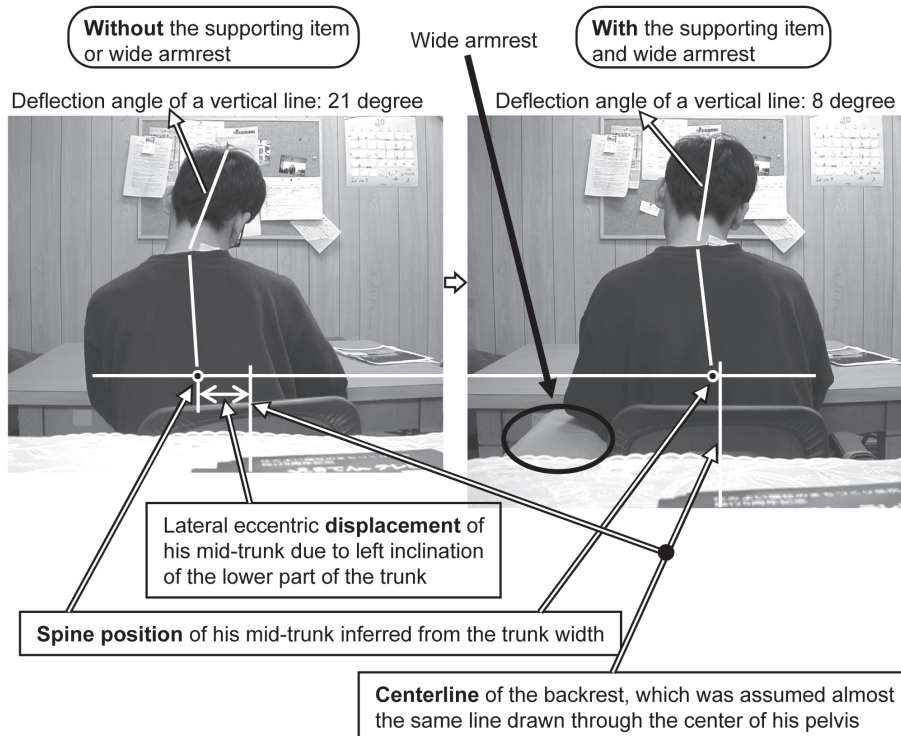


Fig. 1-3. Seated posture of the subject 1 as seen from the rear.

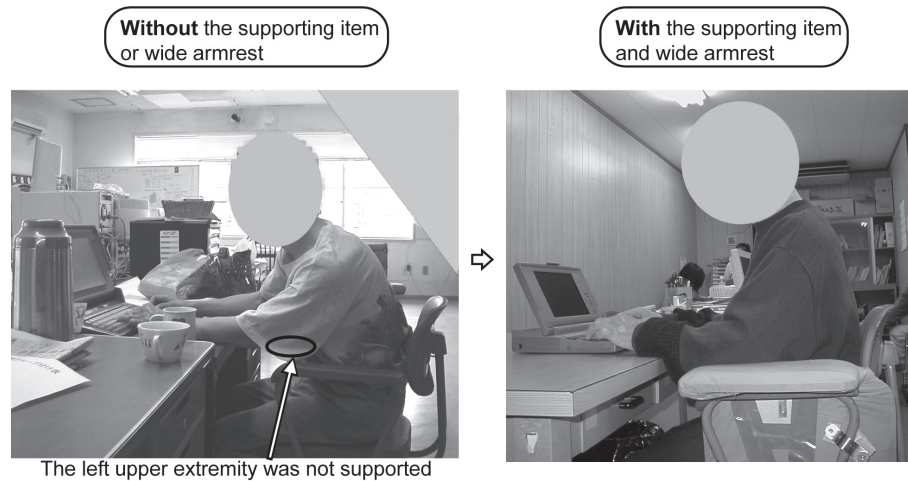


Fig. 1-4. Seated posture of the subject 1 as seen from the left during keyboard operation.

Table 1-1. sEMG value and the Load Reduction Ratio in Case 1 during 4 min and 45 s of actual key typing

Measurement site	sEMG value ( $\mu$ Vrms) before the intervention			sEMG value ( $\mu$ Vrms) after the intervention			Load reduction ratio (%)	
	Mean (SD)	95%ile		Mean (SD)	95%ile		Mean	95%ile
Rt. biceps brachii	27 (22)	66		28 (23)	70		-3	-6
Lt. biceps brachii	9 (4)	19		8 (4)	12		17	37
Rt. upper trapezius	19 (9)	34		16 (8)	30		15	12
Lt. upper trapezius	9 (5)	19		9 (6)	18		-2	2
Rt. Th.11-12 paraspinal	24 (11)	44		22 (12)	43		8	2
Rt. L.3-4 paraspinal	21 (9)	34		15 (7)	27		28	22
Lt. L.3-4 paraspinal	8 (4)	17		7 (3)	14		4	19
Rt. obliquus externus adbominis	20 (7)	30		18 (7)	30		12	-1

Rt.: Right, Lt.: Left, Th.: Thoracicae, L.: Lumbales.

the Load Reduction Ratio (mean) of 15% was obtained from the shoulder.

### 1-3c. Subjective evaluation (feeling of load, operational feeling)

We obtained the evaluation, "I feel more comfortable". Furthermore, when asking about the condition of using the modified chair after approximately one month, there were no claims of any particular trouble, and the subject commented, "I am not sure what to do because the other challenged person in my same workplace sometimes uses the chair, saying that it is comfortable and stable to sit in, which is great".

### Case 2

The subject is a 21-yr-old woman who has been working at the welfare work activity center for the past 2 yr. This individual has a disability due to cerebral palsy, and is identified as having the second grade physical disability certificate<sup>19</sup>). In addition, she had been undergoing training for walking and other physical functions from infancy, and at the time of this study,

she went swimming at a pool on holidays.

### Case 2-1. Survey results and ascertaining of problems

**2-1a. Transition of physical ability and health condition**  
Although her performance is limited equivalent to the second grade physical disability certificate, she was able to walk using a clutch cane. This individual had weak eyesight. She did not require assistance with her daily performance.

Since starting to work 2 yr ago, the frequency of falling when walking has increased. In addition, she more easily becomes tired. She also complained of stiffness in the shoulders and back as well as a feeling of weariness in her lower back region.

### 2-1b. VDT work

This individual was involved in creating documents and web pages, etc. She was using a laptop PC and a mouse for pointing.

She worked 8 h a day, 4 d a week at a welfare work activity center. Due to her condition, she was allowed to take short breaks when feeling fatigued.

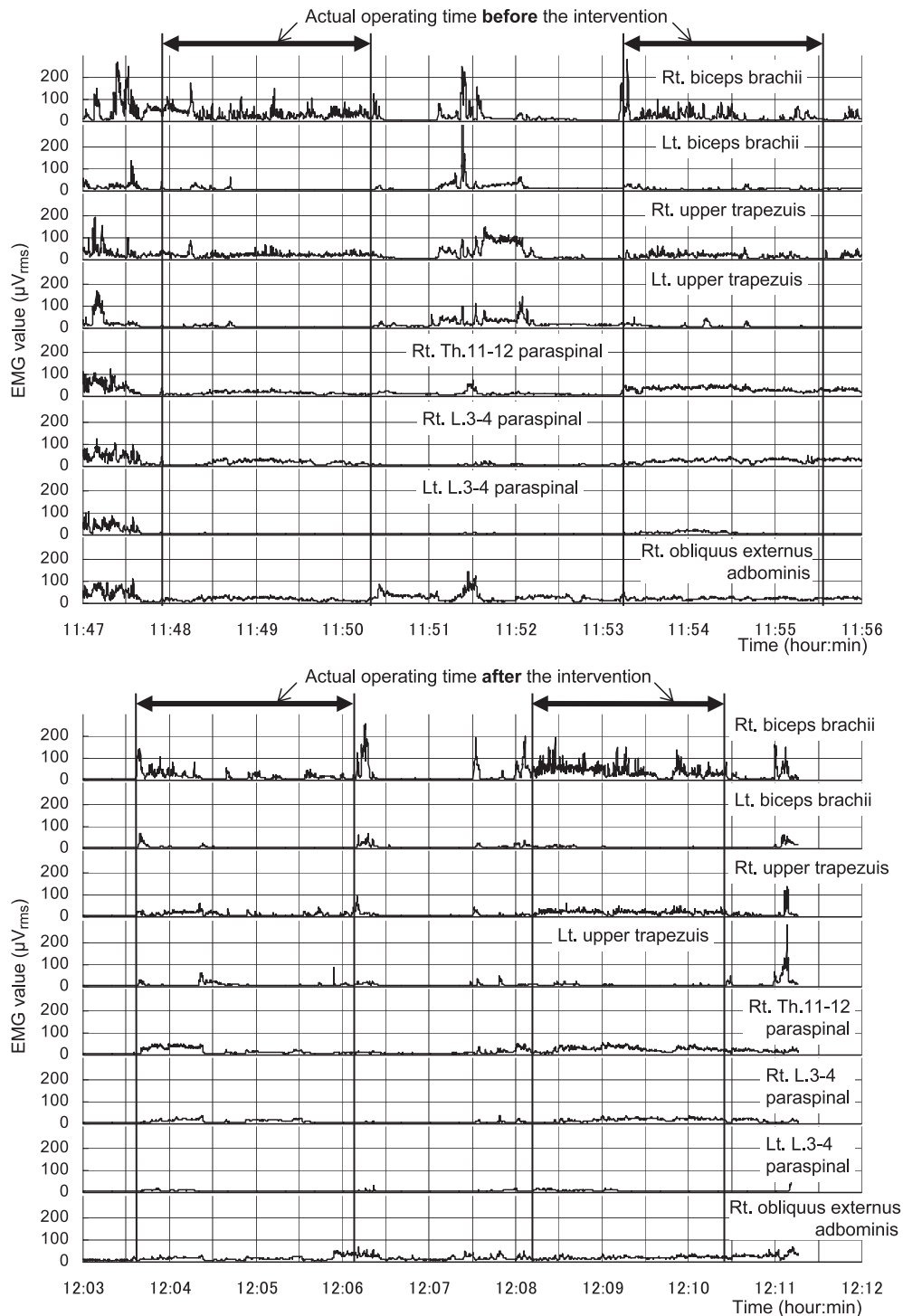


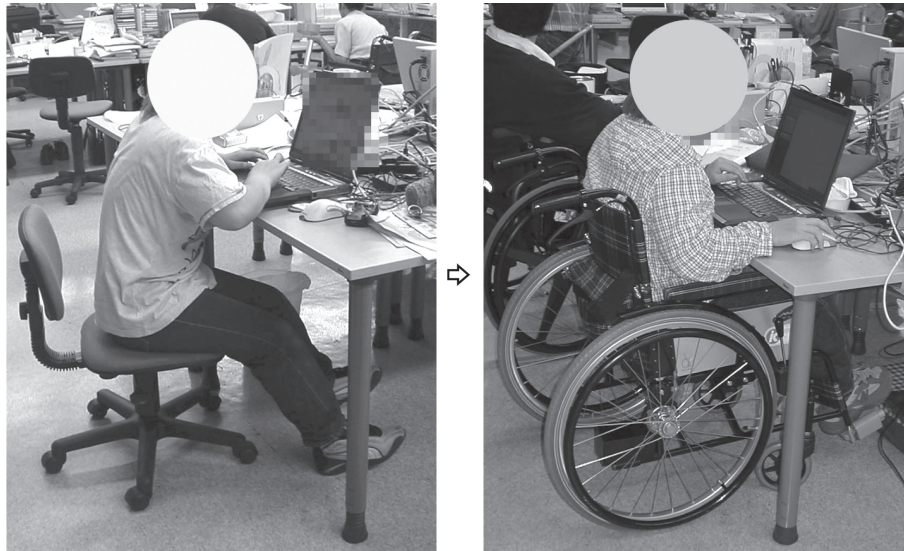
Fig. 1-5. Root mean square sEMG before (upper chart group) and after (lower chart group) the intervention in the Case 1.

### 2-1c. Work environment, equipment used, and posture

The office chair that the subject was using had no armrests and 5 legs with favorably rotating casters. The desktop surface was 73 cm high but could be lowered by around 10 cm, and had no drawers (Fig. 2-1).

This individual was sitting in a position on the edge

of the chair to bring her face to a closer position, approximately 20 cm from the PC screen, and leaning on the desk. The reason for taking such a posture was to prevent accidental movement of the chair due to the excessively light rotation of the chair casters by lowering the seat height to the lowest level such that she



**Fig. 2-1. Seated posture of the subject 2.**

(Left: the chair & desk used by the subject 2 before the intervention, Right: the wheelchair after the intervention).

could easily put stress on her lower extremities, staying seated by using the friction of her soles. Furthermore, due to her weak eyesight, it was necessary to shorten the visual distance and, therefore, she leaned on the higher desktop surface rather than the height of the sitting surface (and thus her scapular arch was lifted up). We believed that the load on the upper and lower extremities in retaining such a sitting position was the cause of her claims of pain in the shoulder and lower back regions.

#### Case 2-2. Intervention Measure

With the aim of alleviating this unstable sitting position and excessive muscle load on the shoulder and lower back regions, we employed the following interventional measures.

##### 2-2a. Change from an office chair to a wheelchair

To enable a stable sitting position, her office chair was changed to a wheelchair owned by the subject (left at home because it had not been used).

##### 2-2b. Install a mat with a three-dimensional structure on the wheelchair seat

In order to achieve favorable seating, a mat with a three-dimensional structure (CU2-3; 5 cm thickness; DELTA TOOLING Co., Ltd.) was placed on the wheelchair seat.

##### 2-2c. Optimization of the height of the desktop surface

By changing to a wheelchair, even without the support of the desk and the upper extremities, maintaining of a stable sitting position became possible; therefore, to solve the lifting up of the scapular arch, the height of the desktop surface was lowered by 5 cm.

#### Case 2-3. Evaluation

After changing to a wheelchair and adjusting the height of the desktop surface, an evaluation was conducted after approximately one month. The subject performed VDT work under the same conditions before changing and, thereafter, after changing to the wheelchair and adjusting the height of the desktop surface, the subject performed the same work. From before starting work, the sitting pressure distribution and the surface electromyogram were measured throughout.

##### 2-3a. Posture

By using a wheelchair, i) accidental movement no longer occurred due to the wheel lock, which eliminated the need to use the lower extremities to prevent the chair from moving. In addition, the subject no longer leaned on the desk because ii) the wheelchair was equipped with foot rests, reducing the distance from the seat surface to the sole by 14 cm and making the knee joint angle approximately 90 degrees, thus providing iii) support for the dorsal and lateral pelvic regions. The forward inclination of the upper body was also resolved, resulting in a substantially upright state, and iv) due to decreased height of the desktop surface and resolution of the forward inclination of the upper body, lifting up of the scapular arch was alleviated (see Fig. 2-1).

##### 2-3b. Interface pressure distribution between the human body and the seat face

Figure 2-2 shows the temporal change in the sitting pressure distribution indicated by a colored scale before and after changing the chair, with Table 2-1 showing the interventional measures and change in the sitting pres-



sure distribution.

According to the difference in the total load on the seat surface and posture observation, after changing to the wheelchair, it was possible to retain a sitting position with the seat surface and the back rest. Furthermore, regarding the sitting pressure distribution, before changing, the local maximum point was posi-

tioned in the lower part of the thigh but the position of the local maximum point significantly moved over time; however, with the wheelchair, a bimodal distribution pattern at the time of normal sitting posture was shown and the local maximum point no longer moved considerably over time.

2-3c. Surface electromyogram

The measurement regions were determined to be at 8 regions including the right extensor digitorum muscle (Forearm), biceps brachii muscle (Arm), paraspinal muscle at the thoracicae 10th level (Middle back), paraspinal muscle at the thoracicae 11–12th level (Middle back) and the right and left upper trapezius muscles (Shoulders), and erector spinae muscles at the lumbar 2–3th level (Lumbar). Evaluating the time of the myoelectric potential was selected to avoid her actual PC operation because we did not provide any detailed directions regarding the task. The evaluating time before intervention was selected when the myoelectric potential values were relatively low and stable, and this was in order to not overevaluate the Load Reduction Ratio. The subjects were allowed to sit comfortably for 1 min and 22 s under the selected conditions before and after the intervention (Fig. 2-3), and the mean, SD, and 95%ile values of the myoelectric potential RMS values and the Load Reduction Ratio were calculated (Table 2-2).

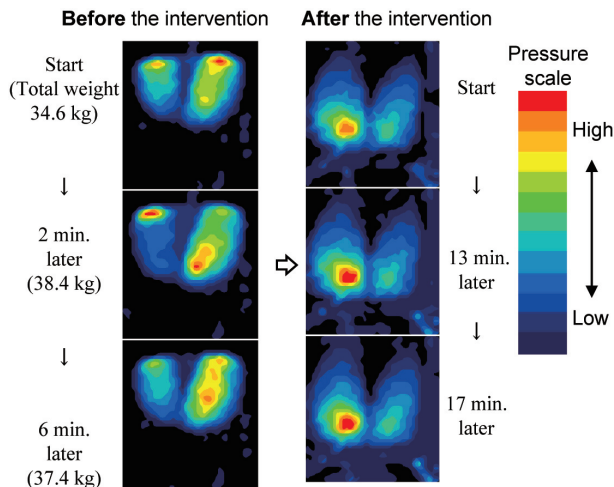


Fig. 2-2. The time series of interface pressure distribution between the human body and the seat face.

Table 2-1. Item dimension, subjective opinion and the change of pressure distribution

	Before (office chair)	After (wheelchair)
Vertical distance between the seat surface and bottom of her feet	41 cm	27 cm
Backrest	Not use	Use
Both sides of the pelvis	Not support (No armrest)	With supporting
Desk surface height	73 cm	68 cm
Stability of chair movement	Unstable (casters without a lock)	Stable (wheels with a lock)
Subjective opinion	Fear moving the chair happening at any time	Security feeling by steady seated posture
	Mean total weight	37 kg (weigh rather less than her weight)
	Mean peak pressure	87 mmHg
Pressure distribution measured three times every several minutes (1) → (2) → (3)	Position of the peak pressure	(1) front edge of the seat under the left thigh (2) front edge of the seat under the right thigh (3) under the bottom left bulge of the ischial tuberosity
	Distribution pattern	Trimodality with the front edges of the seat under the both thigh and the bottom left bulge of the ischial tuberosity in the peak
		Almost the same weigh as her weight
		128 mmHg
		Under the bottom left bulge of the ischial tuberosity; (1), (2) and (3) are the same.
		Bimodality with the both bottom bulge of the ischial tuberosity in the peak

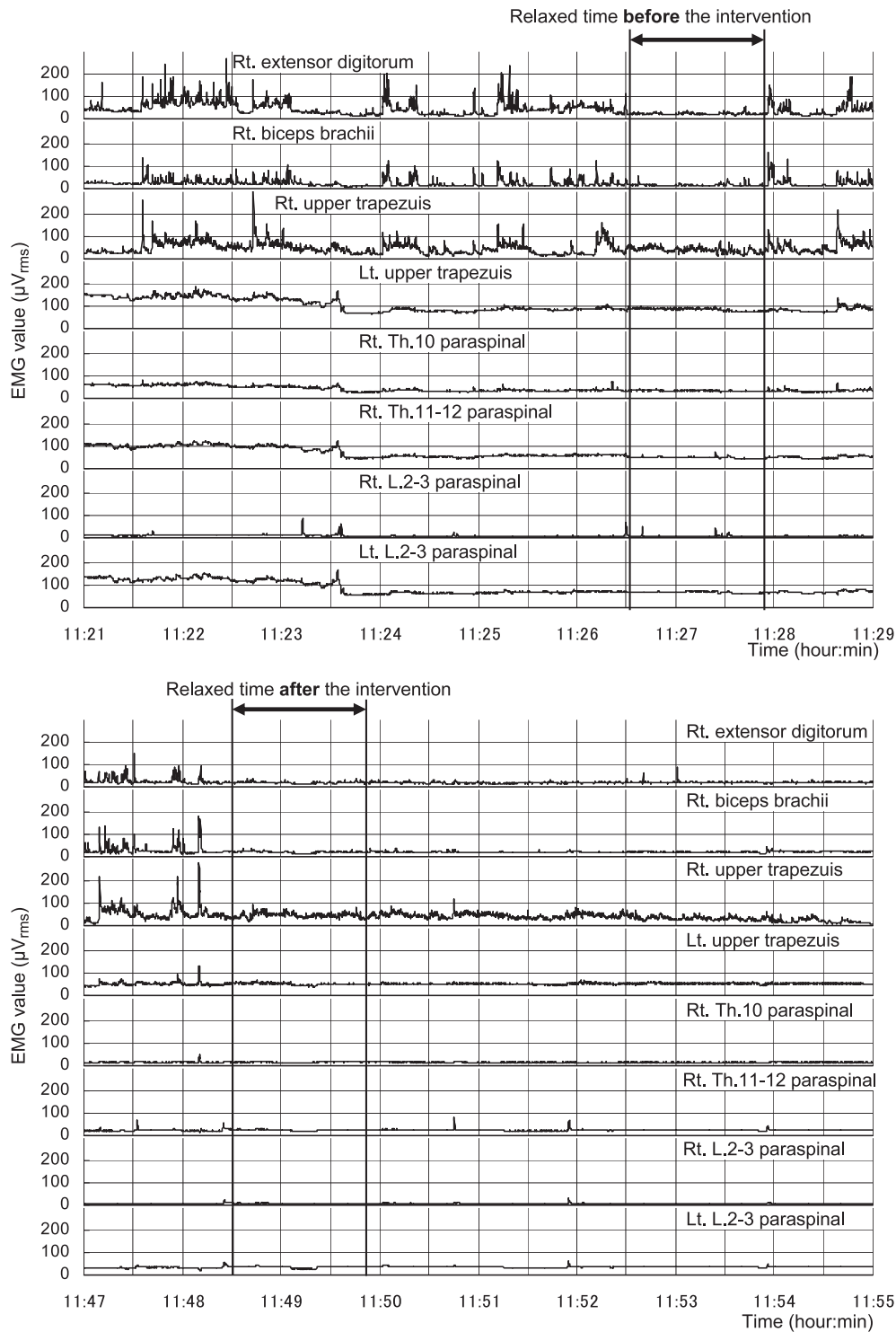


Fig. 2-3. Root mean square sEMG before (upper chart group) and after (lower chart group) the intervention in the Case 2.

After changing to the wheelchair, the Load Reduction Ratio of 37% to 52% (95%ile value) was obtained from the left shoulder region, the right middle back region, and the left lumbar region. The Load Reduction Ratio of the right biceps and the right shoulder region became

negative, while the mean myoelectric potential RMS value after the change was less than (mean + SD) the value before the change, respectively.

#### 2-3d. Subjective evaluation (feeling of load)

Due to a stable sitting position, concerns about acci-

**Table 2-2. sEMG value and the Load Reduction Ratio in Case 2 during 1 min and 22 s in a comfortable sitting position**

Measurement site	sEMG value ( $\mu$ Vrms) before the intervention		sEMG value ( $\mu$ Vrms) after the intervention		Load reduction ratio (%)	
	Mean (SD)	95%ile	Mean (SD)	95%ile	Mean	95%ile
Rt. extensor digitorum	22 ( 4)	29	18 ( 4)	25	17	14
Rt. biceps brachii	16 ( 5)	24	21 ( 4)	26	-29	-11
Rt. upper trapezuis	38 (11)	57	44 (10)	62	-17	-9
Lt. upper trapezuis	84 ( 6)	91	51 ( 5)	57	40	37
Rt. Th.10 paraspinal	33 ( 2)	37	15 ( 2)	18	54	52
Rt. Th.11-12 paraspinal	49 ( 3)	53	24 ( 3)	28	51	48
Rt. L.2-3 paraspinal	7 ( 3)	10	8 ( 1)	9	-11	7
Lt. L.2-3 paraspinal	68 ( 3)	72	35 ( 4)	39	48	45

Rt.: Right, Lt.: Left, Th.: Thoracicae, L.: Lumbales.

dental movement of the chair and falling from the chair were eliminated.

## Discussion

### *Discussion about each case*

#### Case 1

During PC operation at the welfare work activity center, the lateral curvature of the trunk was alleviated by installing a supporting part to the lower part of the trunk inside the chair, and the suspension of upper extremities in the air during operation was prevented by installing useful armrests.

Before intervention, the lateral part of the lower trunk was not satisfactorily supported by the chair, and thus, maintaining of a sitting position was not sufficient, resulting in left inclination of the pelvis caused by the original disability to be facilitated and the lower part of the trunk also inclining to the left. In order to prevent falling to the left, the upper part of the trunk and the head are displaced to the right by bending the central trunk and the cervical spine, thereby moving the center of gravity to the right. Accordingly, muscle tension is maintained at the right paraspinal part of the dorsal region, as proven by stiffness and induration of the right paraspinal muscles near the vertebrae thoracicae 10th level. By installing a supporting tool at the left side of the trunk to prevent left inclination of the lower part of the trunk, anti-clockwise moment centering on the lumbar part looking from the dorsal side decreases, making it no longer necessary to move the upper part of the trunk and the head to maintain balance. Accordingly, we believe that right bending of the central trunk and the cervical spine decreased and the muscle tension in the lower back region was alleviated. This result conformed to the result that the myoelectric potential in the lower back region decreased due to intervention.

One of the reasons for the Load Reduction Ratio of the right arm turning to a negative value was considered to be due to the fact that no armrest was installed on the right and that the positional relationship between the shoulder, the arm and the desktop surface changed. In addition, it is also possible that inaccurate work descriptions before and after the intervention may have had an effect. For the myoelectric potential of the shoulder, the left arm was no longer suspended in the air; however, we believe that supporting the trunk by placing the left arm on the armrest may compensate any increase and decrease in the myoelectric potential.

By having the left side of the trunk lean on the supporting tool, muscle tension in the lower back part was alleviated; however, when maintaining the same posture for a long period of time, excessive tension may appear in other regions. In addition, it cannot be denied that the left and right asymmetry of the body may be facilitated. We believe that frequent changing of posture and appropriate rest are necessary, and it is necessary for not only the individual but also the staff members at the welfare work activity center and the family to conduct long-term observation and be aware of health management.

#### Case 2

In order to improve the unstable sitting position and in order for the subject to be able to sit comfortably, the chair was changed, a mat with a three-dimensional structure was placed on the wheelchair seat and the height of the desktop surface was optimized. The muscle load on the shoulder region and the lower back region was reduced, which allowed for a comfortable trunk to be maintained.

Before intervention, the lower extremities were used to prevent the office chair from moving, and according to the measurement results of total load on the seat surface, it can be inferred that the sitting position was

retained by the friction of the soles, implying a load on the soles as well. After changing to a wheelchair, the total load became substantially equal to the body weight, and the maximum sitting pressure at the lower region of the thigh, etc. before intervention became a bimodal distribution pattern after changing to the wheelchair as seen at the time of normal seating posture, and significant temporal displacement of the position of the maximum pressure was no longer present, allowing for stable support of the trunk by the hips. We believe that as a result, the load on the lumbar muscle that was tense from maintaining a sitting position was reduced. With the maintaining of a stable sitting position by the hips and a lowered desktop height, the upper extremities and desk were no longer required to assist in maintaining a sitting position, thereby alleviating lifting up of the scapular arch, and reducing the load on the trapezius due to the reduction in myoelectric potential. We believe that the objective of the intervention of a “stable sitting position” was actualized. In addition, at the posterior side of the lower part of the thigh, the femoral vein runs close to the skin surface, and compression of this part caused by the maintaining of a sitting position inhibits blood flow and induces “coldness” in the lower extremities; therefore, from this point as well, it can be said that more appropriate sitting pressure distribution is achieved.

The Load Reduction Ratio of myoelectric potential in the right biceps became negative; however, the average myoelectric potential itself increased from 16  $\mu\text{V}$  to 21  $\mu\text{V}$ , which is not considered to be a biologically significant increase in load, considering the general muscle power of the biceps. In addition, the Load Reduction Ratio of the right shoulder region also became negative and the mean myoelectric potential RMS value after the change was less than (mean + SD) the value before the change, which does not pose a problem.

In the present case, there was another issue to be addressed, which is improvement in the individual's awareness of load reduction which came to light through implementation of this intervention. For the intervention, we experimentally changed to an office chair with a broad seat surface and casters with appropriate rotation, and a subjectively stable and comfortable sitting position was obtained. Thereafter, this individual recognized that the wheel chair that she possesses has a lock on the wheels, allowing support for the lateral part of the pelvis to be obtained, and so she started using her wheelchair of her own will. Such an improvement of awareness by individuals with disabilities in terms of load reduction is extremely important for preventing Secondary Disorders, and in addition, in the present case, the favorable results obtained were her own idea.

In addition, the importance of educating staff members at the welfare work activity center for improving load reduction can be seen.

#### *POV in the health management for persons with disabilities*

For persons with disabilities who were performing VDT work, we implemented interventions for load reduction. In both cases, the purpose of the intervention was to allow them to maintain a comfortable trunk position during VDT work. Therefore, in Case 1, a supporting tool was installed on the left side of lower part of the trunk, while in Case 2, a chair was changed.

#### *Maintaining of a comfortable trunk position during VDT work*

For VDT work, it is necessary to be able to operate input equipment with the upper extremities, while retaining the head in a position such that the screen is easily visible (VDT work requirement). For healthy individuals, it is possible to actualize stability of the entire body and less load as well as favorable operability with the upper extremities by taking a stable sitting position using the lower body (soles, thighs, hips). However, for disabled persons with lower body paralysis and equinus foot, it is necessary to stabilize the trunk using the lower extremities as little as possible, while satisfying the VDT work requirements. For Case 1, in which the lower extremities could not be used to maintain a sitting position, “maintaining of a comfortable trunk position” was actualized by installing a supporting tool to the lower trunk. For Case 2, due to the use of an unstable chair, the sitting position had to be maintained by using the force of the upper extremities and friction of the soles, thereby causing a significant load; however, by changing to a chair that prevented movement, it was possible to actualize a comfortable and stable sitting position by using the lower back region and hips, without using the force of the upper extremities.

In order to maintain such a comfortable trunk position, in addition to the use of an appropriate chair, it is necessary to assist with maintaining the trunk using supporting tools such as a cushion and bringing the central position of the upper body closer to the midline so as not to cause movement around the lower back region. In addition, according to a comment from the other disabled person at the same workplace in Case 1, “I feel comfortable and stable when sitting, which is good”, we believe that it is an effective method to install the supporting part to the circumference of the lower back region for those who cannot maintain a stable sitting position using their lower body (soles, thighs, hips).

*Alleviation of lateral curvature of the spinal column*

Excessive bending, extension, and lateral curvature of the spinal column is one form of non-physiological physical load, which leads to fixed deformation of the spinal column if continued and has serious effects on the entire body. In Case 1, without maintaining a sitting position by using a chair, a method was used in which the spinal column was laterally bent for maintaining the sitting position on its own, causing muscular symptoms in the lower back region. Many persons with disabilities may have physical deformities, but even without any knowledge of anatomy, biomechanics, or ergonomics, etc., it is not particularly difficult to observe the posture to determine whether the spinal column or joints are excessively bent, and we believe such observations are useful.

*Chair and ergonomics*

Neither case effectively used a chair to maintain a sitting position, which is most essential for performing desk work, thereby causing a significant load. Work environment management, normally conducted in general companies in Japan by industrial physicians with knowledge of ergonomics, was not appropriately performed in the 'welfare work activity center' that is the workplace for our two cases. When implementing health management for persons with disabilities, rather than forcing people to adjust themselves to the environment and tools, the ergonomic point of view is that the load on people should be reduced by improving the environment and the usage of tools<sup>20</sup>, and we believe that it is possible to actualize effectual measures for safety and health management in many cases.

*Limitation in these case studies*

In the present study, for the intervention cases, we were able to validate the usefulness of POV such as "maintaining of a comfortable trunk position" and "alleviating excessive bending, extension, and side curvature of the spinal column and joints"; however, it was a validation of only two cases and in both cases, the subjects were persons with disabilities with CP. In order to validate POV in occupational health management that can be commonly used in a group of persons with disabilities classified by the type of disability and remaining functions by organizing the relevance among characteristics of individual persons with disability, problems, and its causes, in the future, it will be necessary to accumulate as many cases of improvement as possible in persons with disabilities including those other than persons with CP.

Therefore, for intervention and evaluation, the necessity of which was described in Case 1, we believe that

it is important to check deformation of the body, posture, and subjective symptoms, etc. over a long period of time, for a few months for example, and establish a system in order to prevent Secondary Disorders.

**Conclusion**

For persons with disabilities who were performing VDT work, in addition to the cases reported in the previous study, two workload reduction cases were reported. Also in these cases, taking various aspects in health management, such as "maintaining of a comfortable trunk position" and "alleviating excessive bending, extension, and side curvature of the spinal column and joints" into consideration was found to be effective.

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