Living Status and Cardiopulmonary Function of Persons with Severe Cerebral Palsy

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Abstract Most of persons with severe cerebral palsy are caused pain due to osteoarthritis or hypertone as their age advances to 20 or more. As a result, ADL is restricted and living ability drops. On the other hand, those who actively participate in social activity despite the inability of ADL seem to maintain a high livelihood ability and have less pain due to hypertone. A study was carried out in search for the relationship between actual status of living of the persons with severe cerebral palsy and their cardiopulmonary and physical functions. The subjects consisted of 14 persons staying at facilities for the handicapped and 9 staying at home, totaling 23 ; 13 males and 10 females, age ranging from 22 to 42 mean being 31. The cardiopulmonary function was assessed at rest and at physical load. The items of measurement were TV, VE, RR, VO_2, VCO_2, METS, VO_2/W, SaO_2, and ALL OUT TIME. A comparison was made respectively between 1. facility and home groups, 2. athetotic type and spastic type groups, 3. deformative thorax and nondeformative groups, 4. ADL self-managing and non managing groups, and 5. socially independent and dependent groups. (Results) 1. The respiratory function, especially VO_2/W was lower in the facility group compared to home group. 2. Superior in athetotic type to spastic type. 3. Lower in deformative thorax group compared to non-deformative group. 4. The ADL self-managing group tended to show a better respiratory function (especially ventilation) than the non-self managing group. 5. The socially independent group compared to dependent group was definitely superior in respiratory function (especially ventilation, VO_2/W).

Most of those whose social independency was high were superior in cardiopulmonary and physical functions even though their mobility was poor. It is

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very difficult for the severely handicapped to attain social independency but their mind of independency and will power they acquired through their struggles with handicap are more than normal pesons. Their continued activities to participate in social life should be encouraged.

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Key words : Cerebral palsy, cardiopulmonary function, home group, facility group, ADL

Introduction

Persons with severe cerebral palsy are apt to be governed by a typical total pattern and pathologic postural hypertone, since selective dynamic function of joints is restricted due to spasticity and tonic postural reflex. They show inclined motility of joints toward a specific direction and their physical activity is poor, resulting in deformative arthropathy, dislocation, deformation and contracture at an early age. The pain caused by these factors intensifies systemic hypertone. As a result, their livelihood ability drops and their physical activity is further reduced. Persons with severe cerebral palsy usually tend to stay in a facility for the handicapped or at home maintaining a certain posture. This in return seems to enhance the occurrence of the above abnormal conditions.

On the other hand, those who actively participate in social activity despite the inability of ADL seem to maintain a high livelihood ability and have less pain due to hypertone.

A study was carried out by analysing the respiratory function of persons with severe cerebral palsy from the aspects of their physical function and social activity in search for the relationship with the actual state of their living.

Subjects and Methods

The controls were 10 students and staff members of the School of Allied Medical Sciences, Nagasaki University, with normal cardiopulmonary function, conisting of 3 males and 7 females, age ranging from 19 to 39 with mean of 22 years. The cerebral palsy group consisted of 13 males and 10 females, totalling 23 persons at mean age of 31 years ranging from 22 to 42 years.

The cerebral palsy group was further divided into, 1) facility and home groups, 2) athetotic type and spastic type groups, 3) deformative thorax and

non-deformative groups, 4) ADL self-managing and non-managing groups, 5) socially independent and dependent groups, and 6) standing position available by the use of standing aids and unavialable groups.

The cardiopulmonary function was assessed at rest and at physical load. The normal group was given multistage load by Sheffild and Reeves using a treadmill. The cerebral palsy group was asked to move on a 10-meter line with the help of a stick, by crawling and on knees at respective maximum speed until they became unable to cotinue the movement.

Respiratory function was measured breath by breath using Minato Ikagaku respiromonitor RM200 in terms of maximal tidal volume (TV), maximal minute volume (VE), maximal O_2 consumption (VO_2) and maximal CO_2 production. The respiromonitor was connected to a PC-9801 VM computer and the measured values were recorded into computer every 10 seconds.

Results

The results of tests for controls and persons with severe cerebral palsy are shown in Table 1-a, b. The respiratory function of persons with severe

Table 1a,b. Physiological values of CP and normal subjects during exercise

NAME	TVmax. mℓ	VEmax. ℓ/min	RRmax. f/min	$\dot{V}O_2$max. mℓ	$\dot{V}CO_2$max. mℓ	METS	$\dot{V}O_2$/Wmax. mℓ/kg·min
K. K	872	21.9	26	912	677	5.66	19.8
K. N	632	43.1	70	1012	937	6.48	22.2
K. N	957	26.1	28	855	813	6.43	22.5
M. T	359	16.8	45	441	350	4.5	15.8
T. K	695	19.5	28	683	563	4.65	16.6
M. M	945	33.8	38	1221	914	7.75	27.1
Y. N	894	33.7	38	960	980	7.62	26.7
M. T	992	46.3	48	1225	1018	7.78	26
Y. M	715	21.4	30	680	566	4.52	15.8
N. N	895	50.5	57	1077	924	6.84	28.3
S. K	603	18.8	32	506	442	4.98	17.4
K. O	667	37	57	915	778	5.81	25.4
S. T	794	27.4	34	696	641	4.78	16.9
K. K	1053	51.6	49	1480	1338	7.69	26.9
S. H	537	30.7	56	631	631	6.44	22.5
N. Y	831	28.2	34	904	662	6.8	23.8
N. T	520	17.4	33	431	362	3.63	12.6
K. K	1152	52.7	46	1220	1123	6.34	22.2
K. G	925	23.3	25	845	725	4.47	15.6
M. K	719	15.7	22	444	373	3.34	11.7
Y. E	604	19.9	33	558	464	3.99	14
F. F	1016	45.6	45	1050	892	7.5	26.3
K. K	870	37.4	45	1302	968	9.3	31
M	793	31.3	40	872	745	5.97	21.2
SD	192	11.9	11.8	294	256	1.55	5.58

a : CP

NAME	TVmax. mℓ	VEmax. ℓ/min	RRmax. f/min	$\dot{V}O_2$max. mℓ	$\dot{V}CO_2$max. mℓ	METS	$\dot{V}O_2$/Wmax. mℓ/kg·min	HRmax. beats/min	$\dot{V}O_2$/HRmax. mℓ/beats
U. M	1820	86	47	2180	2560	12.5	43.6	189	11.8
U. Y	1690	110	69	2550	2870	14.6	51.0	191	13.4
E. M	1070	88	75	1890	1900	11.1	39.0	197	9.6
S. N	1080	55	51	1840	1790	13.1	46.0	195	9.4
O. T	1360	76	56	2080	2200	12.4	43.3	184	11.3
H. M	1940	82	43	2100	2260	11.8	41.1	189	11.1
M. T	2200	138	63	3600	4070	14.5	50.7	196	18.2
I. I	2030	86	42	2540	2770	10.3	45.0	188	13.6
Y. Y	2780	128	46	4010	4600	17.6	61.7	190	21.1
T. T	1590	84	53	2250	2510	12.1	42.5	194	11.6
K. K	2370	141	60	3550	4100	18.4	64.5	174	20.3
M	1812	97.6	55	2599	2875	13.5	48.0	190	13.8
SD	581	27.7	11	761	954	2.6	8.3	6.4	4.2

b : Normal

Table 2. A comparison between cerebral palsy and control groups

	Cerebral palsy N=23		Normal N=11		
	M (%)*	SD	M (%)*	SD	P<
TVmax. mℓ	793 (44)	192	1812 (100)	851	0.05
VEmax. ℓ/min	31.3 (33)	11.9	95.6 (100)	27.7	0.05
RRmax. f/min	40.0 (73)	11.8	55 (100)	11	0.1
$\dot{V}O_2$max. mℓ	872 (34)	294	2599 (100)	761	0.05
$\dot{V}CO_2$max. mℓ	965 (26)	256	2875 (100)	954	0.05
METS	5.97 (44)	1.55	13.5 (100)	2.6	
$\dot{V}O_2$/Wmax. mℓ/kg·min	21.2 (44)	5.59	48 (100)	8.35	

* ( ) : Percentage versus healthy subjects

cerebral palsy was markedly reduced in all measurement items with a significant difference compared to the control group (Table 2). In comparison between home group and facility group among persons with severe cerebral palsy, all measurement items were significantly lower in the facility group than in the home group. The values of TV, VE, RR, VO_2, VCO_2, O_2 consumption /weight (VO_2/W) and metabolic equivalents (METS) in the home group were 52%, 44%, 84%, 44%, 32%, 53% and 54% of those in the control group, respectively. In the facility group, the equivalent rates compared to the control group were 39%, 25%, 64%, 27%, 22%, 37% and 38% (Table 3, Fig. 1).

In comparison between the athetotic type group and spastic type group, the former showed a significantly higher respiratory function ($p<0.05$) except for TV and RR. The percentage of TV, VE, RR, VO_2, VCO_2 and VO_2/W in the athetotic group compared to the control group was 50%, 39%, 79%, 42%, 32%, and 52%, respectively, and that in the spastic group was 40%, 27%, 71%, 28%, 22% and 39%,respectively (Table 4).

In comparison between the socially independent group and dependent group, the former showed a significantly higher respiratory function except

Table 3. A comparison between facility and home groups

	Facility N=14		Home N=9		
	M (%)*	SD	M (%)*	SD	P<
TVmax. mℓ	702 (39)	173	934 (52)	141	0.05
VEmax. ℓ/min	24.0 (25)	7.6	42.6 (44)	8.7	0.05
RRmax. f/min	35 (64)	13	46 (84)	7.6	0.05
$\dot{V}O_2$max. mℓ	689 (27)	201	1154 (44)	168	0.05
$\dot{V}CO_2$max. mℓ	639 (22)	227	920 (32)	223	0.05
METS	5.11 (38)	1.24	7.31 (54)	1.01	0.05
$\dot{V}O_2$/Wmax. mℓ/kg•min	17.9 (37)	4.34	25.6 (53)	3.57	0.05

* ( ) : Percentage versus healthy subjects

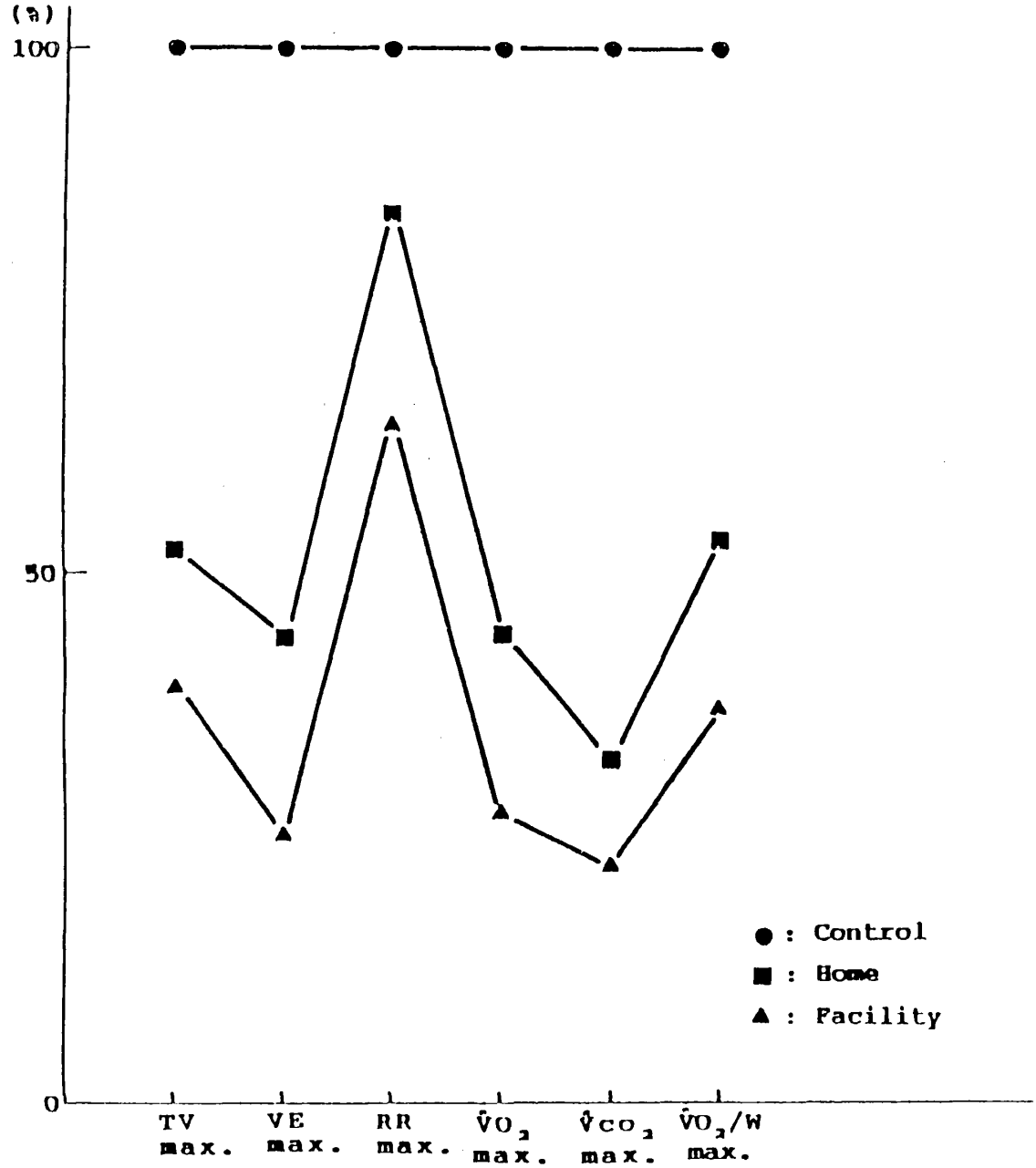

Fig. 1. Respiratory function : control, home and facility groups

Table 4. A comparison between athetotic type and spastic type groups

	Athetotic type N=10		Spastic type N=11		
	M (%)*	SD	M (%)*	SD	P<
TVmax. m ℓ	902 (50)	169	728 (40)	185	0.1
VEmax. ℓ/min	38.6 (39)	10.5	269 (27)	109	0.05
RRmax. f/min	43.3 (79)	7.48	39 (71)	16	
$\dot{V}O_2$max. m ℓ	1084 (42)	262	736 (28)	223	0.05
$\dot{V}CO_2$max. m ℓ	914 (32)	242	644 (22)	192	0.05
METS	7.06 (52)	1.43	5.31 (39)	1.07	0.05
$\frac{\dot{V}O_2/W\text{max.}}{m\ell/kg\cdot min}$	24.7 (52)	5.02	18.6 (39)	39	0.05

* ( ) : Percentage versus healthy subjects

Table 5. A comparison between socially independent and dependent groups

	Independent N=7		Dependent N=17		
	M (%)*	SD	M (%)*	SD	P<
TVmax. m ℓ	983 (54)	106	711 (39)	167	0.05
VEmax. ℓ/min	44.1 (45)	9.46	256 (26)	84	0.05
RRmax. f/min	45.3 (82)	7.52	38 (69)	1.4	
$\dot{V}O_2$max. m ℓ	1168 (45)	182	725 (28)	239	0.05
$\dot{V}CO_2$max. m ℓ	982 (34)	211	599 (21)	274	0.05
METS	7.24 (54)	0.58	5.41 (40)	1.51	0.05
$\frac{\dot{V}O_2/W\text{max.}}{m\ell/kg\cdot min}$	25.3 (54)	2.01	19.0 (40)	5.5	0.05

* ( ) : Percentage versus healthy subjects

RR. The values of TV, VE, RR, VO_2, VCO_2 and VO_2/W in the independent group were 54%, 45%, 82%, 45%, 34%, and 54% of those in the control group, respectively. In the dependent group, respective percentage was 39%, 26%, 69%, 28%, 21% and 40% (Table 5, Fig. 2).

When the standing position available group was compared to the non-available group, the former showed a significantly higher value in TV and VO_2 but there was no significant difference in other measurement items (Table 6). The standing position available group being further divided into socially independent and dependent groups, the respiratory function was higher in the former than in the latter (Table 7).

In comparison of the ADL self-managing group and non-managing group, the former showed a higher respiratory function without any significant difference.

The deformative group compared to the non-deformative group showed a significantly lower value of TV ($p<0.05$) which seemed to be covered by RR. There was no significant difference in other items between the two groups.

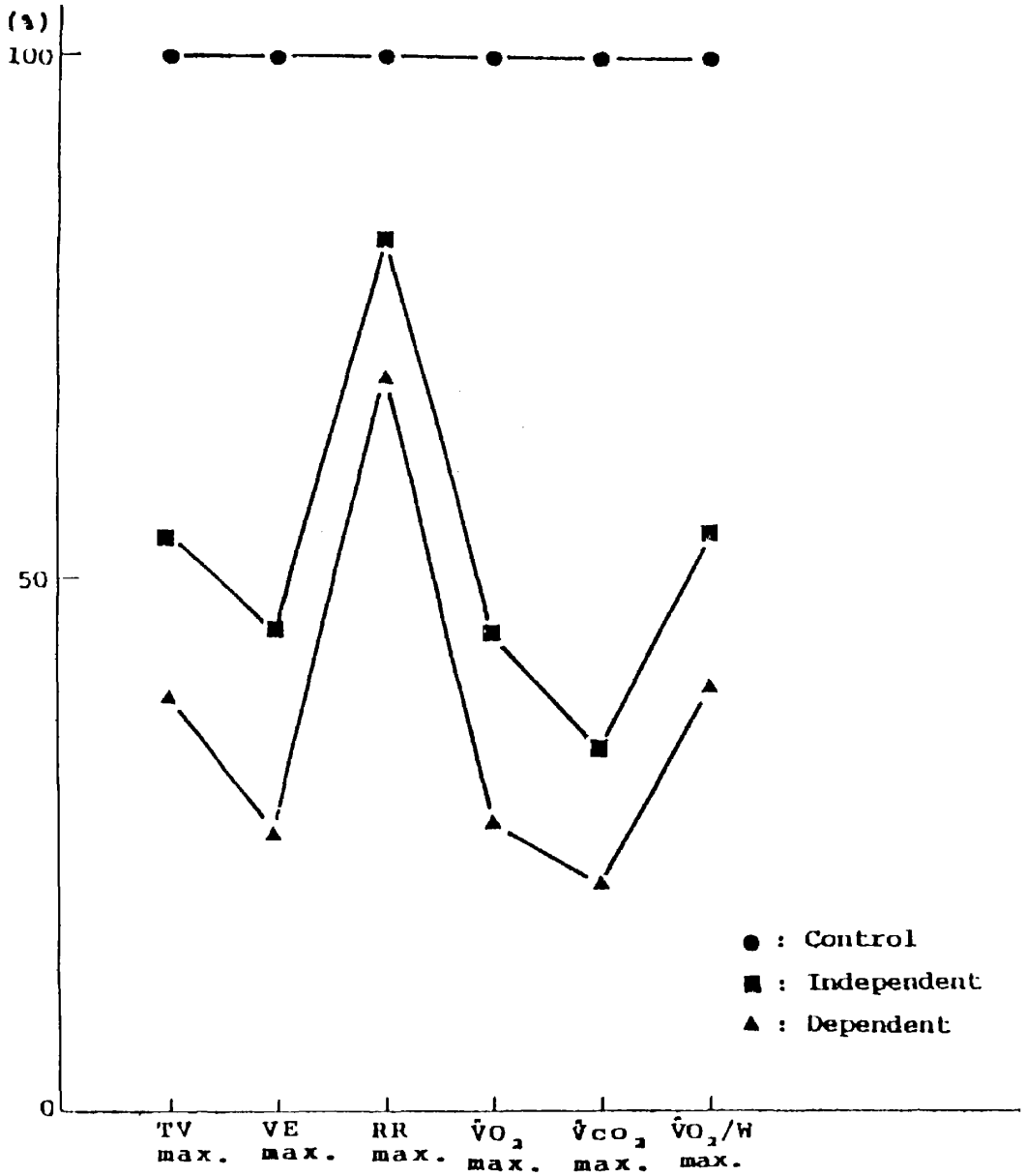

Fig. 2. Respiratory function : control, independent and dependent groups

Table 6. A comparison between standing position available by the use of standing aids and unavailable groups

	Standing N=13		Non-standing N=10		
	M (%)*	SD	M (%)*	SD	P<
TVmax. mℓ	862 (48)	168	612 (34)	246	0.05
VEmax. ℓ/min	34.4 (36)	12.7	27.2 (28)	10.8	
RRmax. f/min	40 (80)	11	39 (31)	14	
$\dot{V}O_2$max. mℓ	993 (28)	294	714 (27)	238	0.05
$\dot{V}CO_2$max. mℓ	819 (28)	262	642 (22)	244	
METS	6.4 (48)	1.64	6.1 (45)	1.55	
$\dot{V}O_2$/Wmax. mℓ/kg·min	22.5 (48)	5.7	21.2 (45)	4	

* ( ) : Percentage versus healthy subjects

Table 7. A comparison between socially independent and dependent subgroups

	Standing(indepemdent)N=7		Standing(dependent)N=6		
	M (%)*	SD	M (%)*	SD	P<
TVmax. m ℓ	933 (51)	154	723 (40)	169	0.05
VEmax. ℓ/min	42.9 (45)	9.8	26 (27)	5.7	0.05
RRmax. f/min	47 (85)	8.7	36.8 (67)	11.6	0.1
$\dot{V}O_2$max. m ℓ	1149 (42)	202	763 (29)	296	0.05
$\dot{V}CO_2$max. m ℓ	965 (34)	223	648 (23)	199	0.05
METS	7.0 (52)	0.77	5.5 (41)	2.1	
$\dot{V}O_2$/Wmax. mℓ/kg·min	24.5 (52)	2.7	19.4 (41)	7.2	

* ( ) : Percentage versus healthy subjects

Dicussion

Persons with severe cerebral palsy complicated with spasticity or athetosis are inclined to take passive livelihood being confined in themselves because of difficulties in physical movement and skillful activity. There is a tendency that mental stress becomes much stronger in the puberty when psychological changes are most vehement, and tonic postural reflex activities (tonic labyrinthine reflex, tonic neck reflex, associated reaction, positive and negative supporting reactions) are still more intensified.

Persons with severe physical handicap have an anxiety that motor dysfunction is intensified as their age advanced. Generally, the severer is the degree of motor dysfunction, the earlier is the arrival of aging phenomena (often in the 20's or 30's). It is anticipated that little opportunity to participate in social activities and lack of physical exercise are factors of such anxiety.

Actually, deformative disease accompanied by pain occurs at an early age and, once pain occurs, muscle imbalance is further aggravated by hypertone in a vicious circle. The drop of physical function induces even cardiopulmonary hypofunction.

There are some studies seeking the effects of longterm life in bed and of space journey,that greatly help in assessing the physical function of persons with severe cerebral palsy.

Ishikawa [1] summarized the results of these studies concerning the effects of bed rest on physical function and cardiopulmonary function, as follows.

" It has been elucidated that bed rest reduces physical strength and also causes such changes to human body that are not favorable for human being. In such cases, major degradation is observed in muscle, bone, heart and adjustment of blood pressure. A decrease of maximal oxygen consumption due to muscular atrophy and cardiac hypofunction may be attri-

buted primarily to inactive living. Consequently, these may possibly be prevented if physical exercise is made regularly for a certain period of time even while aking bed rest. Orthostatic hypotension is aggravated if the gravity fails to act in longitudinal direction of the body, and is prevented by maintaining a standing posture for a certain time. Discharge of calcium into urine can be prevented by oppressing the bone in longitudinal direction."

Saltin *et al*[3] reported, based on their experiments of having five young men take bed rest for 20 days, that maximal oxygen consumption measured immediately after bed rest decreased in all five men ; the mean value of 3.39 l/min before bed rest decreased to 2.43 l/min or by 28%.

It is ideal for persons with severe cerebral palsy to have nearly normal respiratory function whereas their cardiopulmonary functionmay decrease according to the respective physical function. However, in comparison between persons with severe cerebral palsy and normal subjects, the maximal $\dot{V}O_2$/W which is considered as an index of physical strength was as low as 44 %, much less than 50%, indicating an unexpected hypofunction in the handicapped. In comparison between the home group and facility group, maximal $\dot{V}O_2$/ W in the former group was 53% of normal value but that in the latter group decreased to 37% or approximately one-third of value in normal subjects. Maximal TV was similar to maximal $\dot{V}O_2$/W. These data suggest much less movement and activity in daily life of the facility group compared to the home group.

Between the standing group with the help of standing aids and non-standing group, a significant difference was noted in 2 items, and respiratory function as a whole was higher in the former. When the standing group was further divided into socially independent and dependent subgroups, 5 items were significantly different between the two subgroups, and maximal $\dot{V}O_2$/ W was definitely different, being 24.5 m ℓ /kg·min in the former and 19.5 m ℓ /kg·min in the latter. It is evident that respiratory function tends to be low in persons with cerebral palsy whose activity is poor even though motor function is relatively high.

In comparison between the ADL self-managing and non-managing groups, none of the measured items showed a statistically significant difference. On the other hand, the socially independent group even if ADL self-managing was not available, showed a significant difference from the socially dependent group in all items except maximal respiration rate. Respiratory function was superior in the former.

From the above results, it is evident that the decreased respiratory function in persons with severe cerebral palsy is strongly affected by social activity in addition to motor ability, and it is desired to provide handicapped

people with comfortable living circumstances in order to increase and maintain their cardiopulmonary function.

In order to prevent a decrease of physical strength and cardiopulmonary function in actual life of persons with severe physical handicap, it seems important to move the body properly by 1) keeping the rhythm of life including dietary life, 2) having a proper degree of physical exercise, and 3) actively participating in social activity.

A case of severe cerebral palsy accompanied by athetosis was a 40-year-old active promotor of independent living of the severely handicapped. When young, he used to lead a steady life enjoying sports and reading daily. However, he became dependent on alcohol six years ago hoping to alleviate muscle hypertone that had been intensified as his age advanced. As a result, he developed hepatic and pancreatic disorders, finally ruining his rhythm of life including dietary life. He died of heart attack and thus such a valuable man was lost. Natural ability can be exercised to a full extent only when proper health control and active social activity work together.

Conclusions

1. Respiratory function of persons with severe cerebral palsy was reduced by half as compared to that of healthy persons.
2. In comparison between the facility group and home group, respiratory function was superior in the latter with a significant difference. The measured value in the former group was approximately one-third of that in healthy persons.
3. The socially independent group compared to the dependent group showed a better respiratory function irrespective of ADL self-managing and motor function.
4. Respiratory function as a whole in the standing group was higher compared to the non-standing group.
5. The athetotic group was higher in respiratory function than the spastic group.

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重度脳性麻痺者の生活能力と心肺機能

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要　旨　重度脳性麻痺者の心肺機能を施設群と在宅群，アセトーゼ型と痙直型，A-DL自立群と非自立群などに分けて，安静時と運動負荷時の両者で評価した。

結論として，

1．重度脳性麻痺者の呼吸機能は健常者のそれと比較して半減していた。
2．施設群の呼吸機能は在宅群のそれに比較して有意の差で後者がすぐれていた。前者は健常者の約⅓の計測値を示した。
3．社会的自立群は非自立群に比して，ADLの自立や運動機能と関係なく，呼吸機能がすぐれていた。
4．standing群と non-standing群との比較では全体として前者が高い呼吸機能を示した。
5．アセトーゼ群は痙直群と比較して，より高い呼吸機能を有していた。

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