The Adaptation to Seasonal Environmental Variations Seen in Patients with Spinal Cord Injury

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Abstract: For the purpose of investigating the adaptation to the environmental variation by seasons on patients with spinal cord injury, the basal metabolism was consecutively measured throughout the year. The patients with spinal cord injury indicated a lower rate in general. Those with cervical lesion indicated a significantly lower rate than those with thoraco-lumbar lesion. Furthermore, it is said that a healthy Japanese demonstrates the highest rate in winter and lowest in summer throughout the year, but on the contrary, the patients with cervical lesion indicated the lowest in winter in many cases. On the other hand, patients with thoraco-lumbar lesion, having duration more than one year after injury indicated the highest rate in winter in many cases. These results show that patients with cervical lesion have the problem of adaptation ability in winter even at their chronic stage. As for the results of reaction under exposure to low temperatures, there was no significant increase of metabolism in the patients. The declining degree of temperature of skin and body was greater than in the case of a healthy person. This suggested that adaptation ability as to the metabolism was weak in patients with cord injury. Furthermore, the seasonal variation in plasma free fatty acid which has a significant correlation with basal metabolism and is used as direct fuel against the cold was hardly observed. This is assumed to be somewhat related to the amount of catecholamine release. Also, it should be noted that according to our investigation these spinal patients had worn more clothes in winter for insulation, and those with higher level of lesion had a tendency of wearing heavier clothing.

Key words: spinal cord injury, seasonal adaptation, basal metabolism.

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The authors have continued their studies on adaptation to environmental variation by seasons in patients with chronic spinal cord injury.

The items examined mainly included heat congestion in summer (Ogata, 1973), effects of air-conditioning upon heat accumulation (Ogata & Asayama, 1974), as well as studies related to basal metabolism (Ogata et al., 1979).

The adaptation disorders in summer in regard to dyshidrosis caused by injury of the spinal cord (Guttman, 1973) have been the major studies in this field.

However, the results of the present investigation for the basal metabolism carried out
throughout a year raised another question i.e. the examination of adaptation in winter, which had not been especially discussed so far. Thus, the results of adaptation attitude to the cold environment are reported below with some considerations.

Inpatients of Kyushu Rosai Hospital who had complete, traumatic spinal cord injury and were in a chronic stage were used. They were mainly undergoing medical rehabilitation therapy. Those with severe urinary infection, decubitus and other complications were excluded.

Results

1. Seasonal variations of basal metabolism

The measurement of basal metabolism was made seasonally with each subject in order to obtain results to determine adaptation to all four seasons.

Seventeen cervical and eleven thoraco-lumbar of 28 patients with spinal cord injury, all males, ages 17 to 60 years, were used. Of these patients, 9 cases had a duration of up to one year, 6 cases 1–3 years and 13 cases longer than 3 years after injury respectively.

The basal metabolism was measured at least 3 times under the basal conditions such as early in the morning before breakfast in the patient's rooms. The basal metabolic rate (BMR) was employed for measurement and area of the body surface was obtained in accordance with Du Bois' formula. The patient's rooms were air-conditioned in summer.

The BMR was revealed to be significantly lower in the patients with spinal cord injury than healthy persons throughout the year, and the patients with cervical lesion apparently indicated lower rate than those with thoraco-lumbar lesion.

It is generally indicated that the basal metabolism with healthy Japanese is highest in winter and lowest in summer (Ogata et al., 1966), though it is said to be less variable by seasons nowadays (Yurugi & Yoshimura, 1975). However, the patients with thoraco-lumbar lesion had a tendency of showing the highest degree in winter, while the patients with cervical lesion tended to show the lowest. Neither of them indicated the lowest degree in summer. The patients with cervical lesion showed a declining trend from autumn to winter at a rate of 42.9% (P<0.01) and an increasing trend from spring to summer at a rate of 27.9% (P<0.01). On the other hand, a 50.3% (P<0.01) declining rate was revealed in winter when compared with summer which was completely reversed with healthy persons (Fig. 1).

On dividing the duration between a group of less than one year and more than one year after injury for comparison, no difference was noted in patients with cervical cord injury, however, those with thoraco-lumbar injury who had more than one year duration showed the same pattern seen in healthy ones. The others who had less than one year indicated the same pattern observed in patients with cervical lesion (Fig. 2).
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2. Situation of illness throughout the year

The basal metabolism is not only one of the very important factors for body temperature regulation, but also indicates the integrated vitality of the living body. Thus, by checking illness of the patients with whom basal metabolism was examined throughout the year, the reasons of absentees from the rehabilitation therapy were studied.

The patients with cervical lesion frequently did not attend the rehabilitation work in summer complaining of fatigue, headache, etc. However, in winter, a higher of absentees suffering from the common cold was determined. Thus, in the coldest season, the highest number of absentees were found (Fig. 3).

On the other hand, a number of patients with thoraco-lumbar lesion who had caught a common cold in winter increased, however, the frequency was rather low compared with the patients with cervical lesion and the result suggested they had no special problem of adaptation in winter (Fig. 4).

![Fig. 1](image1)

![Fig. 2](image2)

**Fig. 1.** Seasonal variation of BMR.
- **S:** season
- **R.T.:** room temperature
- **TLL:** thoraco-lumbar lesion
- **CL:** cervical lesion

**Fig. 2.** Seasonal variation of BMR as for duration of injury.
- **S:** season
- **R.T.:** room temperature
- **TLL:** thoraco-lumbar lesion
- **CL:** cervical lesion

<table>
<thead>
<tr>
<th>S.</th>
<th>summer</th>
<th>autumn</th>
<th>winter</th>
<th>spring</th>
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<tbody>
<tr>
<td>R.T.</td>
<td>31.6±2.3℃</td>
<td>24.8±2.0</td>
<td>18.9±1.0</td>
<td>21.2±1.4</td>
</tr>
<tr>
<td>CL</td>
<td>-19.5±6.8%</td>
<td>-20.5±8.5</td>
<td>-29.3±3.1</td>
<td>-27.0±8.2</td>
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Data suggest that in the coldest season, the highest number of absentees were found (Fig. 3). On the other hand, a number of patients with thoraco-lumbar lesion who had caught a common cold in winter increased, however, the frequency was rather low compared with the patients with cervical lesion and the result suggested they had no special problem of adaptation in winter (Fig. 4).
3. Reaction to exposure in low temperatures

For the purpose of investigating reactions against the cold, a series of test was carried out with patients who were ordered to wear clothes equivalent to about 1.5–1.8 clo by thermal blocking in a room kept at an environmental temperature of 10°C level for 25 minutes to which patients were transferred from 23°C level (Fig. 5).

The healthy ones indicated a significant increase of metabolism (heat production), while the patients with spinal cord injury, especially those with cervical lesion, hardly indicated any increase. Moreover, as to an average skin temperature, those being healthy showed a small decrease, while patients with spinal cord injury indicated a marked de-
crease. Also, regarding to body temperatures (oral temperature), the patients with spinal cord injury indicated even a slight decline. From these facts a weaker type of metabolic adaptation is found in patients with spinal cord injury, especially those with cervical lesion.

4. Changes of plasma free fatty acid (FFA)

Free fatty acid, utilized in every tissue in the body as direct fuel to withstand the cold and strongly correlated with basal metabolism, is reported to vary by seasons, being high in winter and low in summer with healthy people (Ito, 1975). However, every one of those measured in this series of tests always showed low values, indicating patients

![Bar chart](image-url)

**Fig. 4.** Absence rate for rehabilitation therapy and their reason (thoraco-lumbar lesion—11 cases).
Fig. 5. Changes in physiological response on exposure to cold. (23℃→10℃)

Fig. 6. Seasonal variation in plasma FFA levels. (summer→winter)
Spinal cord level (C: cervical. T: thoracic. L: lumbar.)

had no seasonal variations (Fig. 6).

5. Measurement of total catecholamine (24 hour urine)

It is said that catecholamine released by cold stimulation, acts on adipose tissue to raise free fatty acid level in the blood. Total catecholamine in total urine was, therefore,
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measured. Except for some cases the patients with cervical lesion indicated lower value compared with those thoraco-lumbar lesion, which suggested that catecholamine held an important position in the mechanism of adaptation to the cold (Fig. 7).

6. Condition of clothes worn in winter

As stated above, results were obtained showing that the patients with spinal cord injury had many difficulties in adaptation to the winter season, especially weak adaptation in respect to metabolism. This was especially seen in patients with cervical lesion. Thus, the amount of clothes worn in the ward was investigated.

It was found that the patients were wearing more clothes quantitatively as well as qualitatively in order to have a better insulative effect, furthermore, the higher the injury level, the heavier the clothing became (Fig. 8).

Fig. 7. Relationship between level of spinal cord lesion and total catecholamines (24 hour urine) in autumn. Spinal cord level (C: cervical, T: thoracal, L: lumbar.)

Fig. 8. Relationship between level of spinal cord lesion and weight of clothes in winter. Spinal cord level (C: cervical, T: thoracal, L: lumbar.)
Discussion and Conclusion

It has been pointed out that patients with spinal cord injury have many difficulties in adaptation to summer climate, because less skin remains under normal control for temperature regulation depending upon the injured level. The result of author's investigation revealed an increased or increasing tendency of respiratory rate and skin temperature as a reaction against heat. However, no compensatory increase in perspiration over residual healthy skin areas was noted in patients with cervical spinal cord injury.

The above have become less troublesome due to the widespread use of air conditioning recently. The basal metabolism did not indicate its lowest level in summer, irrespective of the injured level, according to the present serial examination. However, the patients with cervical lesion and those with thoraco-lumbar lesion within one year after injury, showed the lowest level in winter, which was not seen in the healthy persons. It is, therefore, suggested that the type of metabolism seen in these patients had transformed not only in its quality but also in it quantity.

Furthermore, the adaptability of metabolism was poor upon cold load test which was eventually followed by increasing the amount and quality of clothes worn to resist the cold. These condition raised many problems in adaptation to winter. Referring to the morbidity of the common cold throughout the year, significant increase was observed in the coldest season.

It is very important that these problems, as seen in the winter season, are to be solved in the near future. First of all, it is necessary to install complete heating facilities. However, the heating apparatus in Japan, except for some districts, has not developed to a satisfactory level at the present time. Furthermore, due to the low metabolism (less basal heat production) seen in these patients, especially in those with cervical cord lesion, great effort must be made to increase the amount of basal heat production. However, according to two examinations of the present measurement of caloric intake by food, patients with cervical lesion were taking less than 1500 Cal a day, and even those with thoraco-lumbar lesion were taking less than healthy persons (Ogata & Asayama, 1974). Therefore, in relation to this study, nutriological investigations must also be considered.

Before closing, the authors express their sincere appreciation to Dr. Tamikazu Amako, Director of Kyushu Rosai Hospital, for his cordial guidance.

References

脊髄損傷患者の季節的環境変化に対する適応

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要旨
著者らは脊髄損傷患者の季節的環境変化に対する適応に関して、1979年にある患者を対象として研究を続けてきた。今回の報告は同一症例に対して、基礎代謝を四季を通じて測定し、その結果を基に、若干の考査を加えたものである。

一般に脊髄損傷患者は基礎代謝が低値であり、頭髄損傷患者は胸髄損傷患者よりも著しく低値を示していた。季節別の差も、頭髄損傷患者では最も日本人にみられる夏低、冬高のパターンより逸脱する者が多く、冬に最低値を示す傾向があり、質的面に問題を生する者が多い。

これは、従来、季節を通じて、最も問題とされていた夏の適応障害ののみでなく、冬の適応にも大きな問題を有するものと考え、検討を加えたが、今後さらに、脊髄損傷患者を中心に、検討を加えるべき重要な課題であると考える。

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