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Review of Some Medical Disorders Shown by Microcalorimetry

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Instrument:

2277 Thermal Activity Monitor

Field of Application:

Biology

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Introduction

In the last two decades microcalorimetry has been applied to the study of living cells in the medical field. This application has been made possible by the development of sensitive microcalorimeters that allow measurement of heat production rate in small samples of materials.

Thyroid disorders

It was to be expected that one of the earliest medical applications of microcalorimetry was reported in the field of thyroid dysfunction due to the fact that the thyroid gland plays a central role in the regulation of body thermogenesis. Levin (1) reported the results of the first calorimetric study showing increased leucocyte heat production rate in hyperthyroid subjects and decreased values in hyperthyroidism. Platelet heat production, on the other hand, was found to be normal in both groups of patients. Monti and Wadsö (2) measured heat production rate in erythrocytes from hyperthyroid patients and found increased values that returned to normal levels after treatment. These results were later confirmed in more detailed studies where function of the different metabolic pathways (3) and Na-K pump (4) was investigated in erythrocytes from hyperthyroid subjects: the activity of the anaerobic and aerobic pathways were found to be increased, whereas the Na-K-pump was normal.

Heat production rate has been recently (5) measured in lymphocytes from hyperthyroid subjects and increased values were found before therapy was started. In the same investigation subclinical cases of hyper- and hypothyroidism were also studied. This part of the investigation was motivated by the fact that it is clinically difficult to decide whether patients with moderate changes in thyroid hormone levels should be treated or not. The results showed that cell metabolism was not altered, thus implying that these patients do not necessarily need to be treated. Hypothyroidism has been investigated by Valdemarsson et al. (6) who have found that heat production rate was decreased in platelets and adipocytes before treatment, increasing significantly after 3 months therapy. Fagher et al. (7) have found decreased heat production rate in skeletal muscle from patients with lowered thyroid hormone concentrations. Biron et al. (8) have measured heat production rate in skeletal muscle of mice and found increased values in hyperthyroidism and decreased values in hypothyroidism. In the same investigation the energy connected with the Na-K-pump was measured and found to be normal. Clark et al. (9) found in hepatocytes from hyperthyroid rats increased total heat production rate and only small thermogenic changes of the Na-K-pump. Bachman et al. (10) recorded increased heat production rate in liver, skeletal muscle, myocardium and kidney cortex of hypothyroid rats treated with thyroid hormone. Several authors have reported a good correlation of thyroid hormone concentrations and values of heat production rate in different cells and tissues:

erythrocytes (2), lymphocytes (5), adipocytes (6), skeletal muscle (7).

In conclusion, microcalorimetry appears to be a suitable methodology for monitoring the peripheral effect of thyroid hormones. Energy expenditure has been found in different types of cells and tissues to be increased in hyperthyroidism and decreased hypothyroidism. Both the anaerobic and the aerobic pathways are influenced by the thyroid hormones. Thermogenesis connected with the Na-K-pump was found to be normal. In subclinical hyper- and hypothyroidism lymphocyte energy expenditure was normal.

Obesity

The mechanism of obesity development is still unclear in many patients. Microcalorimetry has been used to investigate whether decreased metabolic activity might be an important pathogenic factor. Heat production rate was measured in adipocytes from obese patients (11) and found to be decreased in comparison to the corresponding value in a control group. This result gave support to the hypothesis that cell metabolic derangement might be one of the causes of obesity. Further calorimetric studies (12), however, showed that the same patients after moderate weight reduction through diet had higher adipocyte heat production, but still lower than normal. Later calorimetric studies were performed in a group of obese patients with marked weight loss through gastroplasty (13) who were found to have reduced adipocyte heat production rate before surgery that increased significantly after weight loss. Thus, these results seem to indicate that decreased adipocyte heat production in obesity is a phenomenon secondary to the obese state rather than a cause of it.

Microcalorimetry has also been used to investigate whether the Na-K-pump plays a role in the development of obesity. The hypothesis has been advanced that decreased activity of the Na-K-pump might lead to reduced energy expenses and accumulation of fat tissue. Measurement of the heat production was therefore used to quantify the energy connected with the Na-K-pump in erythrocytes from obese and normal subjects (14). No difference was found between the two groups, thus speaking against the hypothesis that a defective Na-K-pump activity plays an important role in the pathogenesis of obesity.

In conclusion, microcalorimetry was found to be a useful technique for investigation of cell ther-

mogenesis in obesity in order to reach a better understanding of the pathogenesis of the obese state. The results obtained have shown that decreased adipocyte heat production rate is secondary and not the cause of obesity. Moreover, the decreased energy consumption might be a factor contributing to the perpetuation and accentuation of the obese state. The Na-K-pump does not play an important role in the development of obesity. The information thus obtained through microcalorimetric measurements must be regarded as of importance from a clinical point of view.

References

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