The presence of uncoupling protein in «brown» adipose tissue of reindeer

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Abstract: Brown adipose tissue (BAT) is a specific organ for thermoregulatory heat production by nonshivering thermogenesis (NST) in the newborn and young of many mammalian species. The importance of NST in the defence against cold has been demonstrated previously in reindeer calves (Hissa *et al.* 1981, Markussen *et al.* 1985, Soppela *et al.* 1986). Histological evidence has suggested that BAT is present in newborn reindeer (Hissa *et al.* 1981), and the distribution, cell-morphological development and respiratory characteristics of the tissue have been examined (Soppela *et al.* 1990). However, definitive differentation of BAT from white adipose tissue necessitates the use of powerful and specific biochemical techniques.

The thermogenic capacity of BAT depends on the presence and amount of a 32.000-molecular weight protein; this mitochondrial uncoupling protein (UCP) is a rate-limiting factor for thermogenesis. In the present study we have examined various locations of adipose tissue in foetal, newborn and young semi-domesticated reindeer (*Rangifer tarandus tarandus* L.) for the presence of UCP. The reindeer ranged in age from 7 months gestation to 3 months *post partum.* Using the presence of the tissue-specific UCP as a definitive criterion, we have aimed to identify the presence and critical development of BAT in reindeer.

Material was collected from the experimental reindeer herd of the Finnish Reindeer Herders' Association near Inari, Northern Finland (69° 10′ N). The tissues were frozen and sent to Aberdeen in solid carbon dioxide. Mitochondria were prepared and mitochondrial proteins separated according to molecular weight by SDS-polyacrylamide gel electrophoresis, and then blotted onto nitrocellulose membranes (Trayhurn *et al.* 1989, Milner *et al.* 1989). The membranes were probed with an anti-(ground squirrel uncoupling protein) serum (Milner *et al.* 1989) and antigen-antibody complexes were detected with goat anti-rabbit IgG horse radish-peroxidase conjugate (Scottish Antibody Production Unit).

Immunoreactivity at the molecular weight characteristic of UCP was present in perirenal, abdominal, interscapular, peristernal, intralumbar, vertebral, peritracheal, inguinal and omental adipose tissues of newborn reindeer (0-2 days of age), indicating that these tissues are functionally «brown». Interestingly, no immunoreactivity was found in coronary adipose tissue, implying that this particular adipose tissue is functionally «white». UCP was evident at high levels in perirenal and interscapular adipose tissues in foetal reindeer, aged 7 and 7.5 months. Although it was present during the first few days *post partum*, little immunoreactivity was found at 1 month of age, and none was apparent by 2 months of age.

It is concluded, on the basis of biochemical criteria, that BAT is present in foetal and newborn reindeer, and that during the immediate

postnatal period most adipose tissues in this species are functionally «brown». When comparing the presence of BAT, as defined by UCP, with the previous description of the distribution of the tissue by histological and respiratory characteristics (Soppela *et al.* 1990) a high correspondence is obtained. However, it appears that by the second month of postnatal life BAT has been «converted» to white adipose tissue. This transition parallels the fall in the capacity for noradrenaline-stimulated thermogenesis in young reindeer (Soppela *et al.* 1986). The mechanisms underlying the transition of BAT to white adipose tissue have not been identified.

The reindeer is the most northerly mammal, and the only *Cervidae* species, in which the presence and development of BAT have been definitively documented through the identification of uncoupling protein.

References:

Hissa, R., Saarela S. & Nieminen, M. 1981. Development of temperature regulation in new-born reindeer. – *Rangifer* 1:29-38.

Markussen, K. A., Rognmo, A. & Blix, A. S. 1985. Some aspects of thermoregulation in newborn reindeer calves (*Rangifer tarandus tarandus*). – *Acta Physiol. Scand.* 123:215–220.

Milner, R. E., Wang, L. C. H. & Trayhurn, P. 1989. Brown fat thermogenesis during hibernation and arousal in Richardson's ground squirrel. – *Am. J. Physiol.* 256:R42–R48.

Soppela, P., Nieminen, M., Saarela, S. & Hissa, R. 1986. The influence of ambient temperature on metabolism and body temperature of newborn and growing reindeer calves (*Rangifer tarandus tarandus* L.). – *Comp. Biochem. Physiol.* 83A:371–386.

Soppela, P., Sormunen, R., Saarela, S. & Nieminen, M. 1990. The distribution, cellular morphology and respiratory characteristics of «brown» adipose tissue in reideer. – *Manuscript.* 20 pp., 3 Tables, 3 Figures.

Trayhurn, P., Temple, N. J. & Van Aerde, J. 1989. – Evidence from immunoblotting studies on uncoupling protein that brown adipose tissue is not present in the domestic pig. – *Can. J. Physiol. Pharamacol.* 67:1480–1485.