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SHORT COMMUNICATION

Correlation of Carnitine Levels to Methionine and Lysine Intake

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Summary

Plasma carnitine levels were measured in two alternative nutrition groups – strict vegetarians (vegans) and lactoovovegetarians (vegetarians consuming limited amounts of animal products such as milk products and eggs). The results were compared to an average sample of probands on mixed nutrition (omnivores). Carnitine levels were correlated with the intake of essential amino acids, methionine and lysine (as substrates of its endogenous synthesis), since the intake of carnitine in food is negligible in the alternative nutrition groups (the highest carnitine content is in meat, lower is in milk products, while fruit, cereals and vegetables contain low or no carnitine at all). An average carnitine level in vegans was significantly reduced with hypocarnitinemia present in 52.9 % of probands. Similarly, the intake of methionine and lysine was significantly lower in this group due to the exclusive consumption of plant proteins with reduced content of these amino acids. Carnitine level in lactoovovegetarians was also significantly reduced, but the incidence of values below 30 μmol/l was lower than in vegans representing 17.8 % vs. 3.3 % in omnivores. Intake of methionine and lysine was also significantly reduced in this group, but still higher compared to vegans (73 % of protein intake covered by plant proteins). Significant positive correlation of carnitine levels with methionine and lysine intake in alternative nutrition groups indicates that a significant portion of carnitine requirement is covered by endogenous synthesis. Approximately two thirds of carnitine requirement in omnivores comes from exogenous sources. The results demonstrate the risks of alternative nutrition with respect to the intake of essential amino acids, methionine and lysine, and with respect to the intake and biosynthesis of carnitine.

Key words

Carnitine • Vegans • Lactoovovegetarians • Omnivores

Carnitine is essential for the metabolism of long-chain fatty acids. It enables the transport of fatty acids from the cytosol to mitochondria where they are degraded by β-oxidation. The inner mitochondrial membrane is permeable only to acyl-carnitine esters of long-chain fatty acids and not to acyl-CoA components (Hoppel 1982).

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Human organism obtains carnitine from food or by endogenous biosynthesis (Feller and Rudman 1988). The highest carnitine content is found in meat, lower is in milk products, while vegetables, fruit and cereals contain very low or no carnitine at all (Borum 1983). This means that individuals on alternative nutrition excluding either meat (lacto- and lactoovovegetarians) or all components of animal origin including milk (strict vegetarians – vegans) can exhibit carnitine deficiency. Carnitine biosynthesis requires the presence of amino acids methionine and lysine as substrates (Rebouche 1986). Plant protein sources have a significantly reduced content of these amino acids (Krajčovičová-Kudláčková 1992). Alternative nutrition can thus have an adverse effect both on carnitine intake and its biosynthesis.

In this paper we have correlated free carnitine levels in vegans and vegetarians (groups with negligible values of exogenous carnitine) with the intake of substrates of endogenous carnitine biosynthesis. Characteristics of the investigated groups are shown in Table 1. The average group of probands on a mixed diet (omnivores) was selected from a group of 489 examined probands – the average values of basic biochemical and hematological parameters were within the normal range for the whole group. Free carnitine levels in the plasma were measured by a spectrophotometric DTNB method (Pearson *et al.* 1974). The nutritional regime was estimated from frequency questionnaires aimed at the intake of selected food ingredients. Dietetic questionnaires were computer-evaluated according to the food data bank of the Food Research Institute (Strmiska *et al.* 1992). Statistical evaluation of the data was performed by Student's t-test.

The carnitine content in fruit and vegetables is lower than 1 % and lower than 5 % in cereals compared to meat (Lombard *et al.* 1989). Therefore the substantial part of carnitine requirement must be covered by its endogenous synthesis in strict vegetarians (Rebouche and Seim 1998). In non-vegetarians, approximately one-third of the daily requirement comes from endogenous biosynthesis (Krähenbuhl 1996). The four-carbon chain of the carnitine molecule is derived from lysine, its methyl group from methionine.

Table 1 shows that the levels of methionine and lysine intake are significantly lower in alternative nutrition groups. These amino acids are essential and human organism is dependent on their external supply in food. Estimated levels of intake correspond to free carnitine levels (Table 1). The average value of carnitine is significantly lower in vegans with the incidence of hypocarnitinemia by 52.9 %. Similarly, the content of carnitine in the blood of lactoovovegetarians is significantly lower, 17.8 % of probands have values below 30 μmol/l (Wagner 1996) compared to 3.3 % in omnivores. The intake of methionine and lysine in omnivores covers the recommended daily dose (Met: 1.1-2.2 g, Lys: 3-5 g). Daily protein intake in vegans represents only 56 % of recommended daily dose of proteins whereas it amounts 97 % and 143 % in lactoovovegetarians and omnivores, respectively (Krajčovičová-Kudláčková *et al.* 1999). The contribution of plant proteins to the total protein intake represents 100 % in vegans, 73 % in vegetarians and 48 % in omnivores.

Table 1. Group characteristics, free carnitine levels and values of methionine and lysine intake

	Vegans	**Lactoovovegetarians**	**Omnivores**
n (males + females)	17 (5+12)	28 (9+19)	30 (13+17)
Age range (years)	19-72	19-65	27-62
Body mass index (kg.m^{-2}, 20-25)	22.4±0.6^{xxx}	22.9±0.4^{xxx}	25.1±0.5
Period of vegetarianism (years)	6.75±0.48	7.71±0.67	–
Free carnitine (μmol/l)	32.3±1.5^{xxx}	40.1±1.2^{xxx}	47.8±1.4
below 30μmol/l	52.9 %	17.8 %	3.3 %
Methionine intake (g/d)	0.80±0.06^{xxx}	0.90±0.04^{xxx}	1.46±0.05
Lysine intake (g/d)	2.56±0.12^{xxx}	3.13±0.16^{xxx}	4.38±0.17

Data are mean ± S.E.M. ^{xxx} *significantly different $p<0.001$ from omnivores reference value for carnitine (Wagner 1996)*

Compared to the reference protein, abundance of methionine is 18-41 % in pulses, 45 % in cereals and 70-90 % in animal proteins (Krajčovičová-Kudláčková *et al.* 1999). Lysine content in cereals is 31-60 % vs. 119-151 % in animal proteins (both compared to the reference protein). Thus the amino acid content in food as well as the fulfillment of the requirements of recommended protein dose and composition of proteins contribute to the observed significantly lower intake of methionine and lysine in alternative nutrition groups.

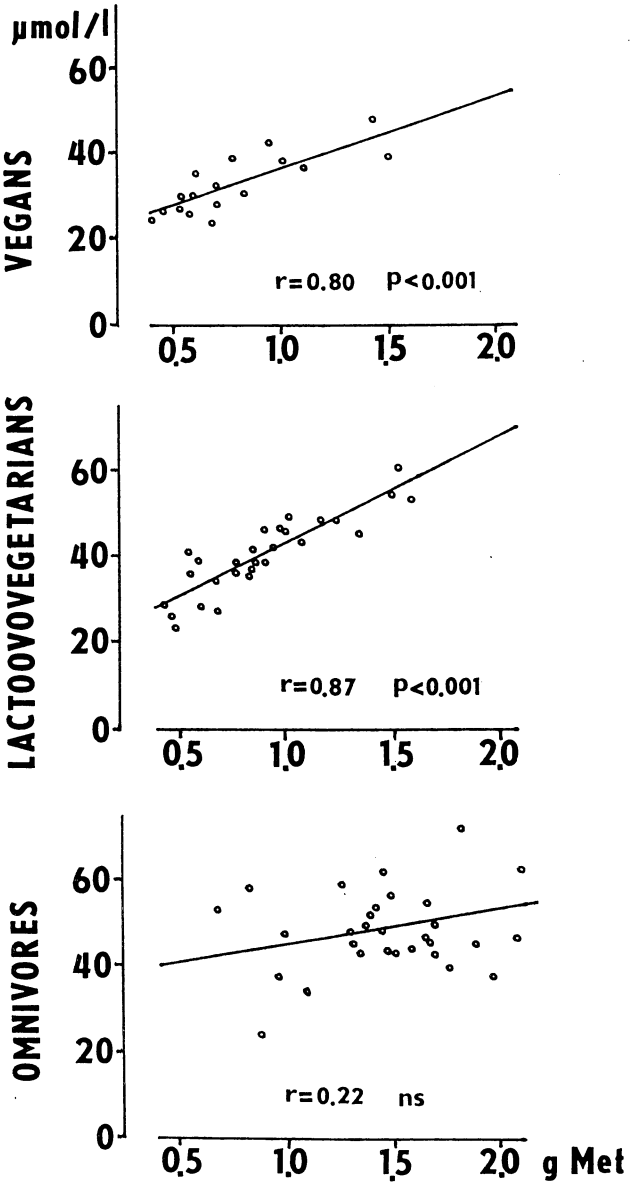

Fig. 1. *Correlation between free carnitine levels and methionine intake in vegans, lactoovovegetarians and omnivores.*

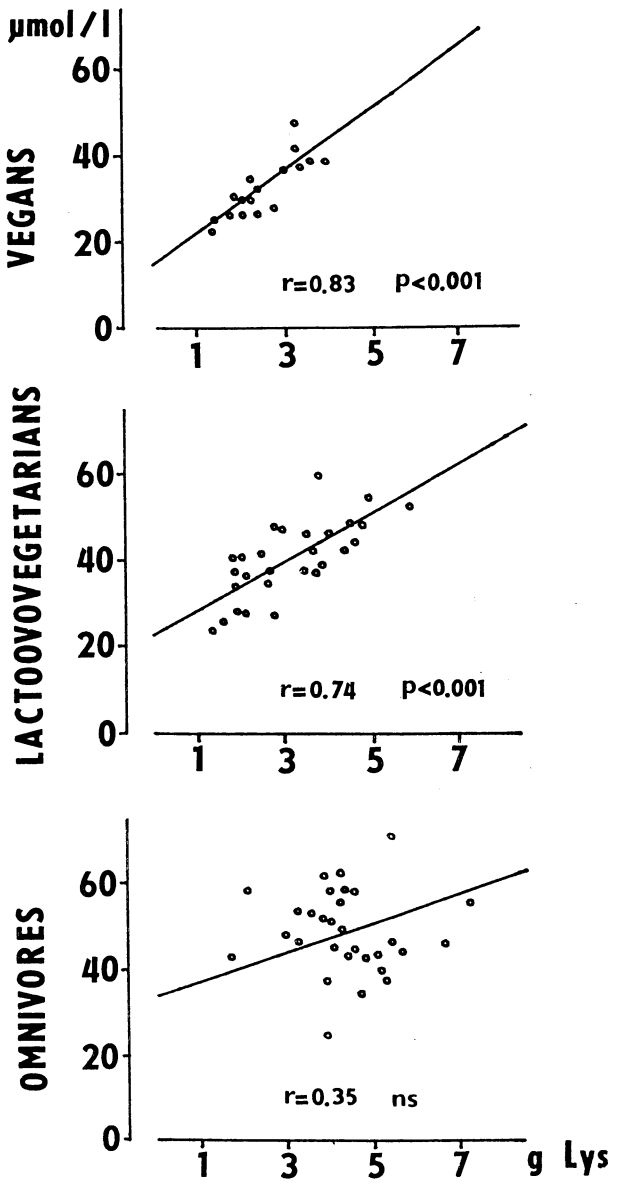

Fig. 2. *Correlation between free carnitine levels and lysine intake in vegans, lactoovovegetarians and omnivores.*

Figures 1 and 2 show the significant positive linear correlation between plasma carnitine levels and the intake of methionine and lysine in vegans and lactoovovegetarians. The correlation was insignificant in omnivores which proves a substantial contribution of carnitine intake (in addition to its biosynthesis) to total carnitine levels. These results are in agreement with the conclusions of Cederblad (1987) who found an increase of carnitine level in omnivores induced by a high-fat and low-carbohydrate diet compared to low-fat and high carbohydrate diet (which is actually equivalent to a vegetarian diet). Reduced levels of carnitine in

lactoovovegetarians and vegans vs. omnivores were reported by Lombard *et al.* (1989). A higher incidence of low plasma carnitine values was found in the general population of countries with frequent malnutrition (Khan-Siddiqui and Bamji 1980). Finally, it is necessary to mention the cofactors of carnitine biosynthesis. It is known that a deficiency in vitamin C, vitamin B6 and in iron reduces carnitine levels in the organism (Borum 1983, Rebouche 1986). Individuals on alternative nutrition are well saturated with both vitamin C and vitamin B6 (Krajčovičová-Kudláčková *et al.* 1993, 1995). However, this nutrition can represent a risk with respect to iron deficiency (Dwyer 1991). We observed a high incidence of hyposiderinemia (58 %) in the group of vegans (Krajčovičová-Kudláčková *et al.* 1998). The incidence of subthreshold iron values was 20 % in the group of vegetarians who enrich their nutrition with eggs and milk products.

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