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Benefit of more but smaller meals at a fixed daily protein intake

Der Nutzen von häufigeren, aber kleineren Mahlzeiten bei einer bestimmten täglichen Proteinaufnahme)

Summary The influence of meal frequency on change of body weight and protein status, measured by level of amino acid oxidation (decarboxylation) in the postabsorptive state, was studied at a fixed daily protein intake. Growing rats (250g) were fed through gastric canula a feeding solution based on Nutrison Standard supplying 1.6g protein and 266kJ ME daily. This amount was given in either 2 large meals at the beginning and the end, or in 6 smaller meals, or by continuous infusion during entire dark period (10 hrs). After 3 weeks of feeding the mean growth rate of the rats fed continuously was nearly 20% higher than rats fed the same amount in 2 meals. The rats fed 6 meals a day had a growth rate rather similar to the rats fed continuously. The percentile recovery of label as $^{14}CO_2$ in the breath after an intraperitoneal injection of [1-^{14}C]leucine (4 hrs after last meal) was significantly higher (p.05) for the animals fed continuously (27% sd 2.6) compared to the rats fed 2 meals (21.9% sd 4.0). The value for 6 meal group was intermediate (24.5 sd 1.8). The results indicate that the metąbolic utilization of a fixed daily amount of protein is clearly influenced by the way of supply. With respect to the change of body weight and protein status, animals have more benefit of the same amount of protein if the supply is more equable. It is suggested that the difference is caused by metabolic restriction for an adequate utilisation of large meals. Therefore large meals are supposed to cause a waste of amino acids in the postprandial phase. As a consequence amino acid amount that will be stored in the body to be available in the postabsorptive phase will be less.

Zusammenfassung Der Einfluß der Häufigkeit der Nahrungsaufnahme auf die Entwicklung des Körpergewichts und auf den Proteinstatus, gemessen auf dem Niveau der Aminosäurenoxidation (Decarboxylierung) in der postabsorptiven Phase, wurde bei einer festen täglichen Proteinaufnahme untersucht. Wachsende Ratten (250g) wurden über eine Sonde mit einer Flüssignahrung versorgt, die auf dem Nutrison Standard basiert (1,6g Protein/d, 266 kJ ME/d). Diese Menge wurde entweder in Form von 2 großen Mahlzeiten am Beginn und am Ende, 6 kleineren Mahlzeiten oder als kontinuierliche Infusion über die gesamte Dunkelperiode (10h) gegeben. Nach 3 Wochen der Fütterung war die mittlere Wachstumsrate der Ratten, die kontinuierlich gefüttert wurden, 20% höher als die Tiere, die die gleiche Menge in 2 Mahlzeiten erhielten. Die Ratten, die 6 Mahlzeiten am Tag bekamen, hatten ein Wachstum, das ziemlich den Ratten entsprach, die kontinuierlich gefüttert wurden. Die prozentuale Wiederfindung der Markierung als $^{14}CO_2$ in der Atemluft nach Injektion (i. p.) von [1-^{14}C]Leucin (4 h nach der letzten Mahlzeit) war signifikant höher (p,05) für die kontinuierlich gefütterten Tiere (27% SD 2,6) verglichen mit den Ratten, die zwei

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Mahlzeiten erhielten (21,9% SD 4,0). Der Wert für die Gruppe mit 6 Mahlzeiten lag dazwischen (24,5 SD 1,8). Die Resultate weisen darauf hin, daß die metabolische Verwertung von einer festen täglichen Proteinmenge durch den Weg der Zuführung deutlich beeinflußt wird. Hinsichtlich der Entwicklung des Körpergewichts und des Proteinstatus haben die Tiere mehr Nutzen von der gleichen Proteinmenge, wenn die Zuführung ausgeglichener erfolgt. Es wird vorgeschlagen, daß die Differenz durch die metabolische Restriktion für eine adäquate Verwertung von großen Mahlzeiten verursacht wird. Es wird deshalb angenommen, daß große Mahlzeiten zu einer Verschwendung von Aminosäuren in der postprandialen Phase führen. Eine Folge davon ist, daß weniger Aminosäuren im Körper gespeichert werden und in der postabsorptiven Phase verfügbar sind.

Key words Meal frequency - utilization – rat – ^{14}C labeled amino acids – leucine

Schlüsselwörter Fütterungshäufigkeit – Verwertung – Ratte – ^{14}C-markierte Aminosäuren – Leucin

Introduction

The metabolic utilization of amino acids undergoes diurnal protein cycling caused by periodical intake of food (1). This process requires a mechanism of postprandial gain and post absorptive mobilisation of dietary protein. Amino acids supplied by a meal enter the pool of free amino acids and are primarily subject to protein synthesis. Amino acid intake could exceed protein synthesis capacity. A relative excess which depends on the absolute amount and profile of amino acids in the meal, undergoes degradation by decarboxylation and total oxidation. This suggests that at a fixed protein daily intake, large meals compared to more frequent feeding may tend to increase amino acids degradation in postprandial phase. As a consequence, less amino acids will be stored in the body to be available in the post absorptive phase. In case of marginal daily protein intake, large vs. small meals can affect body weight of growing animals.

The aim of the experiment was to determine the influence of meal frequency at a fixed marginal daily protein intake on protein status expressed as a level of leucine oxidation (decarboxylation) in the post absorptive state and on body weight development.

Animals and methods

Eighteen eight week old male Wistar rats (ca. 250 g) were fitted with gastric canula and randomly assigned to 3 groups. Animals were maintained on a 14h light (19.00-9.00) - 10h dark (9.00-19.00) cycle. Rats were given free access to water and fed per canula 43.6 ml feeding solution based on Nutrison Standard and glucose (containing 266 kJ ME and 1.6 g protein) for 3 weeks. This amount was supplied in either 2 large meals at the beginning and the end (group "2") or 6 smaller meals (group "6") given regularly during the feeding period (9.00 - 17.00). Infusion rate was 0.76 ml/min. The third group was fed continuously (group "C") during the feeding period at an infusion rate of 0.09 ml/min. Animals were weighed every day just before the feeding procedure started.

After 3 weeks of feeding rats were subjected to $^{14}CO_2$ breath test (3). The oxidation measurements were started 4 hours after the end of feeding period. Animals were injected intraperitoneally with [1-^{14}C] -Leu (1 µCi) and placed in a respiration cage. Expired CO_2 was trapped in a KOH solution sampled every 15 minutes during 4 hours and analysed for radioactivity. $^{14}CO_2$ output was expressed as a percentage of injected dose.

Results

Body weight development

During the 3 weeks of feeding the mean growth rate (Table 1) was nearly 20% higher in rats fed continuously (2.6 g/day) compared to rats fed the same amount in 2 meals only (2.2 g/day). Rats fed 6 meals a day had a growth rate similar to rats of group "C" (2.6 g/day).

Leucine decarboxylation

Level of Leucine decarboxylation (Table 1) expressed as the percentage of label recovered as $^{14}CO_2$ after an i. p. injection of [1-^{14}C]-Leu was significantly higher ($p \leq 0.05$) for the animals fed continuously (27.0 ±2.6%) compared to rats given 2 meals (21.9 ± 2.9%). The value for 6 meal group was intermediate (24.5 ± 1.8%).

Table 1 Relative body weight gain and [1-^{14}C]-Leu decarboxylation in post absorptive state

Mealfrequency	Decarboxylation of [1-^{14}C]-Leu	Growth rate
	% of injected dose	g/day
2 meals	21.9 ± 2.9 ^{a}	2.2
6 meals	24.5 ± 1.8 ^{ab}	2.6
Continuous feeding	27.0 ± 2.6 ^{b}	2.6

Values marked with various characters are significantly different ($p \leq 0.05$)

Discussion

The results obtained indicate that metabolic utilization of a fixed daily amount of protein at a marginal intake is clearly influenced by the way of supply. With respect to growth rate and protein status, animals benefit more from the same amount of protein if the supply is more equable. These findings are in agreement with results of earlier studies performed in adult rats (2, 3). It is suggested that differences are caused by metabolic limitation for an adequate utilization of large meals. Large meals are supposed to cause a waste of amino acids in the post prandial phase. As a consequence less amino acids will be stored in the body to be available in the post absorptive phase.

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