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The effect of fat composition of the diet on energy metabolism

Einfluß der Fettzusammensetzung der Nahrung auf den Energieumsatz

Summary Animal and human studies show that polyunsaturated fatty acids (P) are oxidized more rapidly than saturated fatty acids (S). There are indications that diets high in P/S ratio result in a relatively high resting metabolic rate (RMR) and high diet induced thermogenesis (DIT). However, studies with human subjects are limited.

The effect of dietary fatty acid composition on energy metabolism was studied in 6 male subjects, age 25–48 y. Two diets were supplied, each over a period of 14 days, in a randomized crossover design with a washout period of 14 days. P/S ratios of the diets were 0.19 and 1.67.

On day 14, RMR was determined in the morning in fasting state by means of indirect calorimetry (ventilated hood), followed by a 4 hour measurement of the DIT after consumption of a standardized meal of 3.3 MJ with the same fatty acid composition as during the dietary period. The meal contained 46, 37, and 17 % energy as fat, carbohydrate, and protein, respectively.

RMR after the period with the high P/S diet was significantly higher than after the period of the low P/S diet. The average difference ($\pm$ SD) was 0.17 ± 0.14 kJ/min or 3.6 ± 2.7 % of RMR.

The DIT was also higher in all subjects during a breakfast with a high P/S ratio. The average difference was 0.29 ± 0.16 kJ/min, which is 22.1 ± 12.6 % of DIT.

The study showed that a prolonged food intake of a diet with a high P/S ratio results in a relatively high RMR and DIT. These results indicate the importance of dietary lipid profile in the treatment of obesity.

Zusammenfassung Untersuchungen an Tieren und am Menschen zeigen, daß polyungesättigte Fettsäuren (P) schneller als gesättigte Fettsäuren (S) oxidiert werden. Es gibt Hinweise dafür, daß Diäten mit einem hohen P/S-Verhältnis einen re-

lativ hohen Ruheenergieumsatz (RMR) und eine hohe diät-induzierte Thermogenese (DIT) verursachen. Untersuchungen beim Menschen sind jedoch begrenzt. Die Effekte der Nahrungsfettsäuren-Zusammensetzung auf den Energieumsatz wurden bei 6 männlichen Personen (Alter 25–48 Jahre) untersucht. In einer randomisierten Crossover-Studie wurden 2 Diäten über eine Zeitperiode von 14 Tagen mit einer anschließenden washout-Periode verabreicht. Das P/S-Verhältnis betrug bei diesen Diäten 0,19 und 1,67. RMR wurde am 14. Tag früh im Nüchternzustand mittels indirekter Kalorimetrie (ventilierte Haube) bestimmt. Daran schloß sich nach Aufnahme einer standardisierten Mahlzeit mit einem Energiegehalt von 3,3 MJ (gleiche Fettsäuren-Zusammensetzung wie während der Diätperiode) eine 4h-Messung der DIT an. Die Mahlzeit enthielt 46, 37 und 17 Energie% an Fett, Kohlenhydrate und Protein. RMR war nach der Periode mit hohem P/S-Verhältnis signifikant höher als nach der Periode mit niedrigerem P/S-Verhältnis. Die mittlere Differenz betrug $0,17 \pm 0,14$ (SD) kJ/min bzw. $3,6 \pm 2,7$ % von RMR. DIT war bei allen untersuchten Personen während eines Frühstücks mit einem hohen P/S-Verhältnis höher. Die mittlere Differenz betrug $0,29 \pm 0,16$ (SD) kJ/min bzw. $3,6 \pm 2,7$ % von DIT. Die Untersuchung zeigt, daß

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eine prolongierte Aufnahme einer Diät mit einem hohen P/S-Verhältnis zu relativ hohem RMR und DIT führt. Diese Ergebnisse weisen auf die Bedeutung des Nahrungsfettprofils bei der Behandlung der Fettsucht hin.

Key words Energy metabolism – diet – fat composition – fatty acids – thermogenesis – obesity – indirect calorimetry

Schlüsselwörter Energieumsatz – Diät – Fettzusammensetzung – Fettsäuren – Thermogenese – Adipositas – indirekte Kalorimetrie

Introduction

To date, emphasis with regard to weight balance has been placed on the amount of fat in the diet, while the role of fat composition on substrate metabolism and balance has often been ignored. Previous studies (1, 2), however, suggest that the degree of unsaturation of dietary long chain fatty acids influences the partitioning of fat between oxidation and storage. Animal (3) and human (1, 4) studies show that polyunsaturated fatty acids (P) oxidize more rapidly than saturated fatty acids (S). A high P/S ratio results in a relatively high resting metabolic rate (RMR), high diet induced thermogenesis (DIT), and higher fat oxidation (5). A recent study confirms that a significant increase of whole body oxidation of long-chain fatty acids occurs with a diet high in polyunsaturated fat compared to one high in saturated fat (6). These results may be explained by a more efficient absorption of PUFA's (7), preferential transport by the portal circulation (6), and/or a more rapid diversion into pathways of keton body production compared to the unsaturated fatty acids (5). The increased fat oxidation following a meal high in PUFA's was not completely compensated for by a reduction in carbohydrate oxidation (5). It is remarkable that hardly any studies followed that focussed on these phenomena.

This study, therefore, aims at investigating the effect of dietary fatty acids composition in the diet on resting energy expenditure and diet induced thermogenesis.

Materials and methods

The effect of dietary fatty acid composition on energy metabolism was studied in 6 male subjects, age 25-48 y. Two diets were supplied, each over a period of 14 days, in a randomized crossover design with a washout period of 14 days. P/S ratios of the diets were 0.19 and 1.67 (Fig. 1).

After the 14 day dietary period fasting blood samples were taken in which serum fatty acids profile and cholesterol were determined. On day 14, RMR was determined in the morning in fasting state by means of indirect calorimetry (ventilated hood), followed by a 4 hour measurement of the DIT after consumption of a standardized meal of 3.3 MJ with the same fatty acid compo-

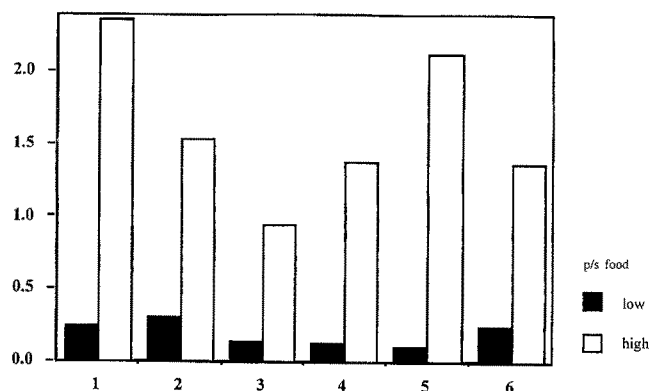


Fig. 1 P/S ratio in the food during the dietary periods in the different subjects.

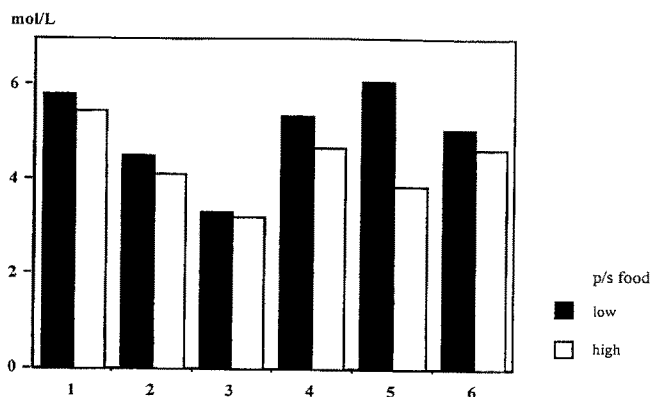


Fig. 2 Serum cholesterol levels in each subject during different dietary regimes.

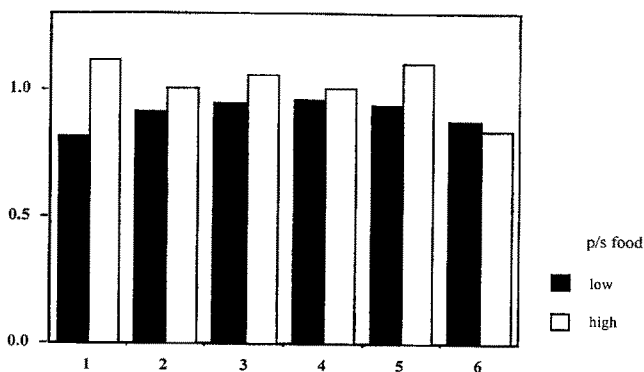


Fig. 3 Serum P/S ratio in each subject during different dietary regimes

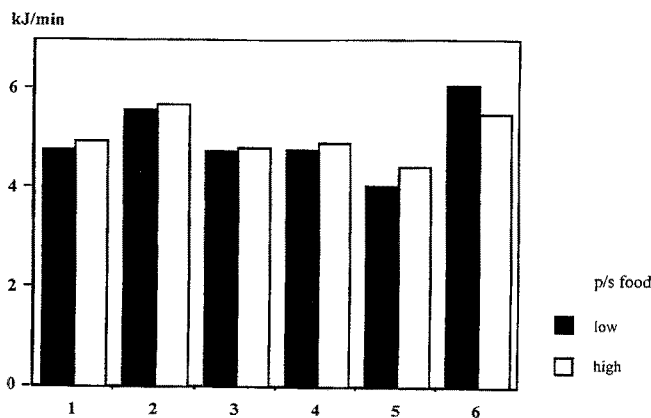


Fig. 4 Resting metabolic rates as measured in individual subjects after the two dietary periods.

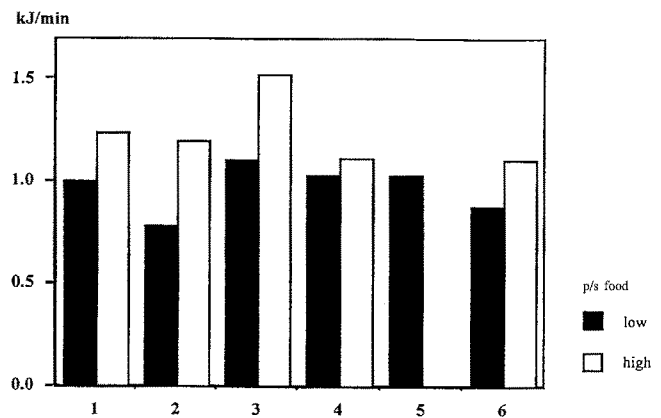


Fig. 5. Diet induced thermogenesis as measured in individual subjects after the two dietary periods.

sition as during the dietary period. The meal contained 46, 37, and 17 % Energy as fat, carbohydrate, and protein, respectively.

Results

In all subjects serum cholesterol levels were elevated after the dietary period with a low P/S ratio compared to the high P/S ratio (Fig. 2). P/S ratio in serum was significantly higher after the dietary period with fats with the high P/S ratio (one exception, Fig. 3).

RMR after the period with the high P/S diet was significantly higher than after the period of the low P/S

diet with one exception (Fig. 4). The average difference was 0.17 ± 0.14 kJ/min $\pm$ SD, or 3.6 ± 2.7 % of RMR. The DIT was also higher after a breakfast with a high P/S ratio (Fig. 5). The average difference was 0.29 ± 0.16 kJ/min, which is 22.1 ± 12.6 % of DIT.

Conclusion

The study shows that a prolonged intake of a diet with a high P/S ratio results in a relative high RMR and DIT. These results indicate the importance of dietary fatty acids composition on substrate utilization.

References

1. Jones PJH, Pencharz PB, Clandinin MT (1985) Whole body oxidation of dietary fatty acids: implications for energy utilization. *Am J Clin Nutr* 42:769-77
2. Pan DA, Hulbert AJ, Storlien LH (1994) Dietary fats, membrane phospholipids and obesity. *J Nutr* 124:1555-65
3. Leyton J, Drury PJ, Crawford MA (1987) Differential oxidation of saturated and unsaturated fatty acids in vivo in the rat. *Brit J Nutr* 57:383-93
4. Emken EA (1994) Metabolism of dietary stearic acid relative to other fatty acids in human subjects. *Am J Clin Nutr* 60:1023S-8
5. Jones PJH, Schoeller DA (1988) Polyunsaturated:saturated ratio of diet fat influences energy substrate utilization in the human. *Metabolism* 37:145-51
6. Clandinin MT, Wang LCH, Rajotte RV, French MA, Goh YK, Kielo ES (1995) Increasing the dietary polyunsaturated fat content alters whole-body utilization of 16:0 and 10:0. *Am J Clin Nutr* 61:1052-7
7. Cunningham KM, Daly J, Horowitz M, Read NW (1991) Gastrointestinal adaptation to diets of differing fat composition in human volunteers. *Gut* 32:483-6