

## **Post-meal time aspects and the consequence of food composition on diet induced thermogenesis (DIT)**

The definition of diet induced thermogenesis (DIT) is the increase in energy expenditure above basal fasting level divided by the energy content of the food ingested and is commonly expressed as a percentage. The daily energy expenditure is the sum of the basal metabolic rate, DIT and activity induced thermogenesis. The basal metabolic rate is about 5% higher than sleeping metabolic rate (1). In healthy subjects with a mixed diet, DIT represents ~10% of the total amount of energy ingested over 24h.

DIT is related to the stimulation of energy-requiring processes during the post-prandial period such as intestinal absorption, the initial steps of their metabolism and the storage of the absorbed but not immediately oxidized nutrients (2).

The main determinant of DIT is the energy content of the food, followed by the fraction of the different energy substrates in the meal (protein, carbohydrates and fat).

For protein, most of the metabolic cost is attributed to peptide-bond synthesis (the bond between amino acids in proteins), urogenesis and gluconeogenesis (the production of glucose from amino acids). In comparison with high vs. low protein meals, the postabsorptive protein synthesis increases 10% to 25% (3, 4) which account for a great part of the thermic effects of dietary protein. For carbohydrates, the thermic response are attributed to glycogen synthesis and lipogenesis (5).

The amount of ATP required for the initial steps of metabolism and storage determines the DIT and is different for each nutrient. The reported values for separate nutrients are 20 to 30% for protein, 5-10% for carbohydrates and 0-3% for fat (6). The thermic response 2.5h post-meal averages about twofold higher on a high protein/low fat diet vs. a high carbohydrate/low-fat diet (7, 8). A regression analysis of 19 studies revealed that an increase in the protein fraction in a meal of 1% resulted in a significant increase of DIT with  $0.22 \pm 0.42\%$  (9).

The postprandial rise in resting energy expenditure (REE) lasts for several hours and is often regarded as “completely“ terminated at approximately 10 hours after the last meal but are usually close to baseline after a few hours. However, there are great differences between the different energy substrates regarding the time and increase of REE.

Following protein consumption, postprandial REE rises rapidly and is sustained for as long as four to five hours post meal (10-12), whereas carbohydrate consumption induce a more modest rise in REE and falls rapidly one to two hours after ingestion (10, 12).

Another study where DIT tests from a wide range of subjects ingesting meals of varying sizes and composition showed that DIT lasted for more than 6 hours (13).

The thermic effect of carbohydrates is lower post breakfast since the ingested glucose is readily utilized by the body tissues and the availability for glycogen synthesis is lower. Due to the increased nutrient availability with repeated food ingestion during the day, the nutrient storage is enhanced with a greater induction of DIT as a result.

DIT results in increased oxygen consumption and is not favourable for the breath hold diver. Since protein contributes to the greatest increase DIT which is sustained for a longer time in comparison with carbohydrates, its probably best to reduce/avoid protein intake at the day of a competition. For dynamic apnea and constant weight, it is probably suitable to ingest carbohydrate rich foods the days before and a small meal high in carbohydrates (lowest possible protein content) a few hours before. This is due to the importance to have a considerable amount of glycogen stored in the muscles. Utilizing glycogen as an energy

substrate demands the lowest oxygen possible when compared with any other substrate (3 ATP produced oxygen free per molecule). When the body is depleted of glycogen, a greater part of the energy is produced through the catabolism of lipids (fat). Fat metabolism requires more oxygen than carbohydrate metabolism. As mentioned earlier, the increase of REE due to the consumption of pure carbohydrates falls rapidly and should not be a problem after a few hours.

For static apnea, over night fasting may be suitable since a low metabolic rate is of most importance. However, due to the lower thermogenic effects of carbohydrates post breakfast or after a fasting period there may be a small advantage if one ingests a very small amount of pure carbohydrates (e.g. maltodextrine) before the static apnea which may contribute to a lower fat metabolism during the static apnea with lower oxygen consumption as a result. This is however not proved and there is a risk that the gain in lowering the fat metabolism may be abolished by the slightly induced REE. Great inter individual variations may also exist regarding the thermic effects on post fasting ingestion.

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