



Why does muscle tend to grow faster on a mild calorie deficit than on an excessive calorie surplus?

^{1,2,3}I. Valentin Petrescu-Mag, ^{4,5}Florin D. Bora, ⁶Maria Popescu, ^{2,7}Tudor Păpuc

¹ Department of Environmental Engineering and Protection, Faculty of Agriculture, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania;

² Bioflux SRL, Cluj-Napoca, Romania; ³ University of Oradea, Oradea, Romania;

⁴ Viticulture and Oenology Department, Advanced Horticultural Research Institute of Transylvania, Faculty of Horticulture and Business in Rural Development, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Cluj-Napoca, Romania;

⁵ Laboratory of Chromatography, Advanced Horticultural Research Institute of Transylvania, Faculty of Horticulture and Business for Rural Development, University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania; ⁶ Equine Clinic, Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary

Medicine Cluj-Napoca, Cluj-Napoca, Romania; ⁷ Faculty of Animal Science and Biotechnologies, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania. Corresponding author: T. Păpuc, ptudor2008@yahoo.com

Abstract. Sometimes, in sports science, the misconception is that a substantial caloric surplus added day by day, along with sustained weight training, will lead to muscle growth commensurate with the caloric surplus, which is false. Often, practice shows us that a correctly sized diet gives much better results in terms of muscle development. A slight calorie deficit can create a more efficient metabolic environment and a hormonal balance that favors muscle development, while an excessive calorie surplus can lead to fat accumulation and negative effects on hormones and protein synthesis. We will present here some reasons why muscle tends to develop more rapidly under a slight calorie deficit. Thus, alternating 6 low-carb days with 1 high-carb-high-protein day will lead to intermittent and very effective muscle anabolism.

Key Words: calorie deficit, calorie intake, muscle building, muscular development, sport sciences.

Introduction. Sometimes, in sports science, the misconception is that a substantial caloric surplus added day by day, along with sustained weight training, will lead to muscle growth commensurate with the caloric surplus, which is false. Often, practice shows us that a correctly sized diet gives much better results in terms of muscle development. The development of muscle under a slight calorie deficit versus an excessive calorie surplus is a complex topic influenced by several factors. We will present here some reasons why muscle tends to develop more rapidly under a slight calorie deficit.

Metabolic Efficiency. In a slight calorie deficit, the body becomes more efficient at using available resources (Areta 2023). This particularity is actually an adaptation from the evolutionary point of view of the metabolism of the human species (Areta 2023). This can mean that the body utilizes proteins and amino acids from food more effectively for muscle repair and growth (Areta 2023).

Reduction of Body Fat. A slight calorie deficit can lead to a decrease in body fat, which can improve the muscle-to-fat ratio (Most & Redman 2020; Ruiz-Castellano et al 2021).

This makes the muscles more visible and can create the impression of rapid muscle development. Additionally, a leaner body will have greater muscle growth potential, as we will see in the Hormones chapter.

Protein Synthesis. A moderate calorie intake together with an adequate protein intake can stimulate muscle protein synthesis (Areta 2023). Excessive caloric intake can lead to an increase in body fat, which can mask muscle growth and inhibit protein synthesis due to increased inflammation.

Hormones. Hormones play a crucial role in muscle growth (Petrescu-Mag 2023). A slight calorie deficit can maintain a favorable hormonal balance for muscle growth, while an excessive calorie surplus can lead to increased insulin levels and fat storage, negatively affecting hormones like testosterone and growth hormone (HGH). HGH is a member of the somatotropin/prolactin family of hormones which play an important role in growth control (Criste et al 2017).

Insulin is not a hormone unfavorable to muscle development, on the contrary, insulin is the most anabolic hormone in the human body (Petrescu-Mag 2023). The bad news is that elevated insulin levels, sustained long-term, decrease the sensitivity of skeletal muscle to insulin, so the muscles will have a harder time taking up glucose and amino acids in conditions of insulin resistance, even though amino acids and glucose are abundant in the bloodstream (Petrescu-Mag & Proorocu 2022). Unable to be taken up by the muscles, a good part of the glucose will be stored in adipocytes in the form of fat (Petrescu-Mag & Proorocu 2022).

Adipose tissue, commonly known as body fat, is not just a passive storage site for excess energy, but also an active endocrine organ (Martins et al 2023). This means that it secretes various hormones and signaling molecules, called adipokines, that influence many physiological processes. We will show below a detailed explanation of why adipose tissue acts as an endocrine gland and how this relates to nutrient metabolism and storage.

Adipose tissue as an endocrine gland

Secretion of hormones and adipokines

Leptin regulates appetite and energy balance (Carşai et al 2005; Cicchella et al 2020). High levels of leptin signal the brain to reduce appetite and increase energy expenditure (Carşai et al 2005).

Adiponectin enhances insulin sensitivity and has anti-inflammatory effects. Higher levels are associated with a lower risk of type 2 diabetes and cardiovascular disease (Zaidi et al 2021).

Resistin is linked to insulin resistance (Fortes et al 2023). Elevated resistin levels can impair glucose metabolism, which also involves other sugars like galactose or fructose (Kovacs & Petrescu-Mag 2023).

Cytokines (e.g., TNF- α , IL-6) are inflammatory molecules that can affect insulin sensitivity and contribute to chronic inflammation, which is associated with obesity and metabolic syndrome (Aguiar et al 2020).

Regulation of energy balance

Adipose tissue helps regulate the body's energy balance by storing excess energy as fat and releasing it when needed. The hormones and adipokines secreted by adipose tissue help coordinate this process by influencing appetite, metabolism, and insulin sensitivity.

Impact of increased fat storage on nutrient metabolism

Insulin resistance

As adipose tissue expands, particularly visceral fat (fat around the organs), it can lead to insulin resistance. Insulin is the hormone that facilitates glucose uptake into cells, including skeletal muscle cells (Petrescu-Mag & Proorocu 2022). When cells become resistant to insulin, glucose is less efficiently transported into these cells and is more likely to be stored as fat (Petrescu-Mag & Proorocu 2022).

Preferential fat storage

High levels of insulin, often seen with insulin resistance, promote the storage of macronutrients (especially carbohydrates) as fat rather than their utilization by skeletal muscle (Petrescu-Mag & Proorocu 2022). Insulin promotes the uptake of glucose by adipose tissue and inhibits the breakdown of stored fat (Petrescu-Mag & Proorocu 2022).

Altered lipid metabolism

With increased fat stores, the body tends to enhance the mechanisms for fat storage. This includes increasing the activity of enzymes involved in lipid synthesis (lipogenesis) and decreasing the breakdown of fat (lipolysis).

Inflammation

Expanded adipose tissue, particularly when it becomes hypertrophic (large fat cells), can become hypoxic (low oxygen levels) and stressed. This condition promotes the release of pro-inflammatory cytokines. Chronic inflammation can further impair insulin signaling and promote a cycle of increasing fat storage and insulin resistance.

In summary, adipose tissue acts as an endocrine gland by secreting various hormones and signaling molecules that regulate metabolism, appetite, and energy balance. When fat storage increases, these secretions can lead to insulin resistance and altered nutrient metabolism. As a result, macronutrients from food are more likely to be converted to fat and stored in adipose tissue rather than being transported to and utilized by skeletal muscle (Martins et al 2023). This creates a feedback loop that promotes further fat accumulation and metabolic dysregulation, contributing to obesity and related metabolic disorders.

Maintenance of Muscle Mass. In conditions of a moderate calorie deficit, the organism tends to conserve muscle mass to maintain functionality (Areta 2023). If training is adequate and protein intake is sufficient, the body will prioritize maintaining and building muscle mass (Areta 2023).

Adaptation to Exercise. Under conditions of a slight calorie deficit, the organism can become more sensitive to anabolic stimuli from exercise (Areta 2023). This means that the adaptive response to training can be more efficient in a slight calorie deficit (Areta 2023).

Six Days "Low-Carb", One Day "High-Carb-High-Protein". Although the calorie deficit creates the pre-conditions for muscle anabolism, it is certain that muscles cannot grow on a caloric deficit (Areta 2023). It is impossible to produce something from nothing. It is certain that the abundance of amino acids, glucose and insulin levels must occur, but it would be good if they occur "by surprise", suddenly, intermittently and in the short term. This strategy will take the metabolism and the endocrine system "by surprise"; when insulin sensitivity is maximum, metabolism is economical, and protein synthesis is working efficiently. Thus, alternating 6 low-carb days with 1 high-carb-high-

protein day will lead to intermittent and very effective muscle anabolism (personal unpublished data).

Conclusions. A slight calorie deficit can create a more efficient metabolic environment and a hormonal balance that favors muscle development, while an excessive calorie surplus can lead to fat accumulation and negative effects on hormones and protein synthesis. It is essential to find an adequate balance between caloric intake, training, and recovery to optimize muscle growth.

Conflict of Interest. The authors declare that there is no conflict of interest.

References

- Aguiar S. S., Sousa C. V., Deus L. A., Rosa T. S., Sales M. M., Neves R. V. P., Barbosa L. P., Santos P. A., Campbell C. S., Simoes H. G., 2020 Oxidative stress, inflammatory cytokines and body composition of master athletes: The interplay. *Experimental Gerontology* 130:110806.
- Areta J. L., 2023 Physical performance during energy deficiency in humans: an evolutionary perspective. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* 284:111473.
- Carșai T. C., Vlaic A., Coșier V., Mag I. V., 2005 [Selection assisted by molecular markers in the improvement of taurine herds II. Genetic markers associated with meat production]. *Agricultura – Revistă de Știință și Practică Agricolă* 55-56:115-123. [In Romanian].
- Cicchella A., Carluccio M., Scoditti E., Kaltsatou A., Massaro M., 2020 Leptin and exercise: An update. *Gazzetta Medica Italiana. Archivio per le Scienze Mediche* 179(7-8):468-473.
- Criste F. L., Oroian I. G., Petrescu-Mag I. V., 2017 Eat pork without concern. EU pork does not have exogenous Growth Hormone. *Porc Res* 7(1):17-19.
- Fortes Y. M., Souza-Gomes A. F., Moreira A. R. S., Campos L. N., de Moura S. S., Barroso L. S. S., de Faria M. H. S., Fernandes H. B., de Miranda A. S., Martins-Costa H. C., e Silva A. C. S., Moreira J. M., Nunes-Silva A., 2023 A single session of strength training changed plasma levels of resistin, but not leptin in overweight and obese men. *Sports Medicine and Health Science*. Available at: <https://doi.org/10.1016/j.smhs.2023.12.001>
- Kovacs E., Petrescu-Mag I. V., 2023 Fructose: the good news and the bad news. *AAB Bioflux* 15(1):53-54.
- Martins F. F., Souza-Mello V., Aguila M. B., Mandarim-de-Lacerda C. A., 2023 Brown adipose tissue as an endocrine organ: updates on the emerging role of batokines. *Hormone Molecular Biology and Clinical Investigation* 44(2):219-227.
- Most J., Redman L. M., 2020 Impact of calorie restriction on energy metabolism in humans. *Experimental Gerontology* 133:110875.
- Petrescu-Mag I. V., 2023 Muscle fiber development in humans and other mammals. *ABAH Bioflux* 15(1):21-23.
- Petrescu-Mag I. V., Proorocu M., 2022 Causes of insulin resistance - beware of gray literature! *Porc Res* 12(1):9-11.
- Ruiz-Castellano C., Espinar S., Contreras C., Mata F., Aragon A. A., Martínez-Sanz J. M., 2021 Achieving an optimal fat loss phase in resistance-trained athletes: A narrative review. *Nutrients* 13(9):3255.
- Zaidi H., Byrkjeland R., Njerve I. U., Åkra S., Solheim S., Arnesen H., Seljeflot I., Opstad T. B., 2021 Adiponectin in relation to exercise and physical performance in patients with type 2 diabetes and coronary artery disease. *Adipocyte* 10(1):612-620.

Received: 08 May 2024. Accepted: 14 June 2024. Published online: 05 July 2024.

Author:

Ioan Valentin Petrescu-Mag, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Agriculture, Department of Environmental Engineering and Protection, 3-5 Calea Mănăştur Street, 400372 Cluj-Napoca, Romania, e-mail: zoobiomag2004@yahoo.com

Florin Dumitru Bora, Viticulture and Oenology Department, Advanced Horticultural Research Institute of Transylvania, Faculty of Horticulture and Business in Rural Development, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Calea Mănăştur Street, 400372 Cluj-Napoca, Romania, e-mail: florin-dumitru.bora@usamvcluj.ro

Maria Popescu, Equine Clinic, Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Mănăştur Street, 400372 Cluj-Napoca, Romania; maria.popescu@usamvcluj.ro

Tudor Păpuc, Faculty of Animal Science and Biotechnologies, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Calea Mănăştur Street, 400372 Cluj-Napoca, Cluj County, Romania, e-mail: ptudor2008@yahoo.com

This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

How to cite this article:

Petrescu-Mag I. V., Bora F. D., Popescu M., Păpuc T., 2024 Why does muscle tend to grow faster on a mild calorie deficit than on an excessive calorie surplus? ABAH Bioflux 16(1):9-13.