AD LIBITUM DIETING

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Contents

➢ Lecture

[Ad libitum dieting]

Note: The lecture contains no unique contents, so it's optional.

Introduction

In today's fitness industry, macros and calories are the center of attention. In most diets, calories are prescribed, meaning you know you are going to eat X number of calories and you are going to select your food choices to accommodate this.

In this module of the course, we are going to discuss how to flip the variables above to construct the opposite way of dieting: we set our food choices so that we end up eating X number of calories. Researchers call this ad libitum dieting. The Latin, meaning "at one's pleasure", may make it sound as if this is a special way of dieting, but it is in fact the natural way the vast majority of the population eats: until they're full.

For most people, tracking their macros is not a feasible option in the long term. Over the span of years, permanent weight loss of 5% is considered a great achievement for any study involving a consciously calorie restricted diet. That's why 'lifestyle change' has become a cliché. It's true.

So let's go pro with ad libitum dieting. The essence of ad libitum dieting can be summarized in a single formula.

Ad libitum energy balance = *f* (appetite, diet satiety index)

Let's explain what this means.

Appetite & satiety

Your appetite is relatively stable over time [2]. Some people have a large appetite, some people have a small appetite. Most people fall somewhere in between. In statistical terms, appetite is probably normally distributed across the population.

Hunger is a feeling stimulated by certain neural processes in your brain. Just like emotions, it is an evolutionary mechanism to direct us towards certain actions. Like fear causes us to ‘avoid’, hunger causes us to seek out and consume food. When we consume food, this triggers a series of processes known as the satiety cascade which consists of a negative feedback loop to your appetite. Simply put: when we consume food, we get full (satiated).

Sensory factors like chewing and taste start the satiety cascade. When food enters your stomach, pressure receptors are activated that signal how much you’ve eaten to the brain. Later, nutrient receptors in your gut trigger the release of several peptides, notably cholecystokinin (CCK), glucagon-like peptide-1 (GLP-1), peptide YY and ghrelin. These satiety hormones activate local sensory nerves travelling to the hindbrain to tell the brain roughly what you’ve consumed, such as glucose or fatty acids. When the brain believes your body is amply nourished, it reduces your appetite so that you stop feeling the need to eat.

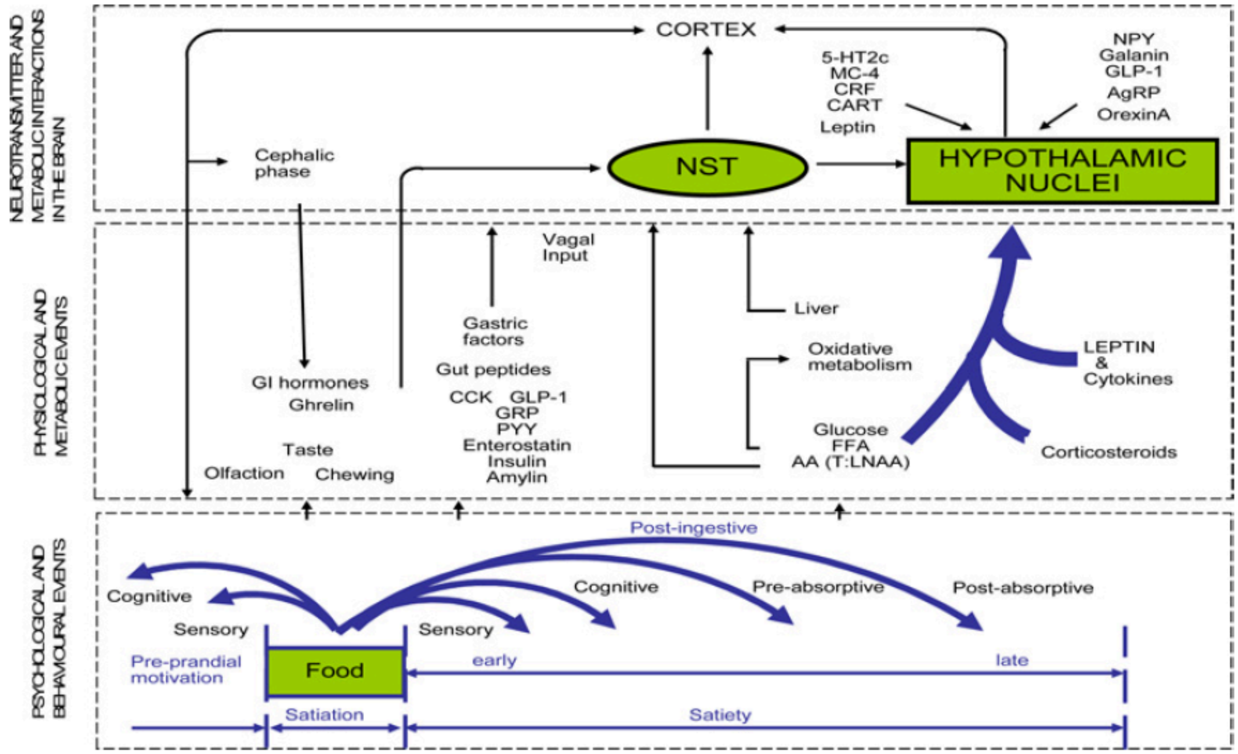


Figure 1 Simple representation of the (mainly) inhibitory mechanisms through which food consumption influences peripheral physiological mechanisms and neural pathways which bring about an adjustment in the appetite response
This scheme shows the integration between the behavioural pattern, profile of peripheral physiological events and action at brain sites. The diagram illustrates the difference between satiation (control of meal size) and satiety (control of inter-meal interval). 5-HT, serotonin (5-hydroxytryptamine); CART, cocaine and amphetamine regulated transcript; CRF, corticotropin releasing factor; FFA, free fatty acids; GRP, gastric releasing peptide; MC, melanocortin; NST, nucleus tractus solitarius; T:LNAA, tryptophan:large neutral amino acid ratio. Previously published in Boyland et al. [35].

The satiety cascade: eating results in the stimulation of gastric and neural processes that signal to your brain that you're satiated, causing your brain to reduce your appetite.

Source

Researchers sometimes distinguish between satiation (being full; the termination of food intake) and satiety (staying full; inter-meal hunger) and also between tonic satiety (your general day-to-day appetite) and episodic satiety (acute hunger). In practice, however, this distinction is often irrelevant. We just care about total energy intake regardless of when this is consumed. Moreover, the post-meal recovery of hunger is not consistently affected by food choices: it grows at a similar rate after each meal regardless of what you ate, so there's a very high correlation between satiation and satiety. Very satiating meals will leave you full for long, whereas barely satiating meals will quickly have you become hungry again afterwards.

Now that we have a concrete understanding of what hunger and satiety are, we can discuss what makes food satiating.

The satiety index

Not all foods are equally satiating. Sugar, for example, has almost zero satiating effect and barely influences subsequent energy intake when eating intuitively. In an ad libitum diet, consuming sugar will thus easily cause you to overeat. That's why sugar's notorious for being fattening even though calorie per calorie it's not more fattening than, say, watermelon (see the course module on carbohydrates). Yet if you have overweight people eat 2 cups of watermelon daily, they generally end up consuming fewer calories than they were before and over time they'll lose fat, whereas the same number of calories in the form of cookies will cause them to overeat and gain fat.

Researchers have quantified how satiating a food is as its satiety index. Since your appetite is quite constant over time, improving your diet's satiety decreases your energy intake and over time results in weight loss. It's like you have 100 units of appetite you must fill every day to avoid hunger. Each type of food fills in X units of appetite per 100 grams. By choosing foods with a higher satiety index, you fill up your appetite quicker and thus consume fewer calories. So increasing your diet's satiety index is a reliable way to lose fat without having to track your calories or suffer hunger. This type of ad libitum diet has been found to be more effective than the NHS Standard Care weight loss program in a one-year study.

Note that the satiety index of a food is not the same as how healthy it is. Many people intuitively underestimate the caloric content of healthy and organic food (the health halo effect). While satiety index and healthiness generally correlate, healthy food can still be extremely caloric and foods like nuts and dark chocolate may be generally healthy, but they're serious calorie bombs.

To rank foods in terms of how satiating they are, Holt et al. (1995) pioneered the satiety index, a percentage value for each food based on how satiating it is relative to white bread. Bakery products, snacks and confectionary generally scored poorly, except for popcorn. Less processed carb sources scored better, such as potatoes and fruits, especially those high in fiber. Lean protein sources also scored well. The exact values were not very useful though due to the limited food selection, sample size and measuring period. Fortunately, you can generally predict how satiating any food is very well based on the following factors.

Determinants of a food's satiety index

You can generally estimate the satiety index of a food well enough if you understand what makes food satiating. The following factors are important to know.

Food volume

The gut has gastric stretch receptors that signal satiation in response to pressure. These sensors quite literally measure how full your stomach is. So more food volume, even if it's just water or air as in carbonated beverages or a beaten protein shake, is more satiating than less food [2, 3].

Researchers developed a great fat loss hack based on this information: blowing up a balloon inside someone's stomach decreases the experience of hunger, though the balloon does not decrease energy intake in every study. The balloon trick works in obese and lean individuals alike. It seems a volume of 400-800 ml is required to have a reliable effect. That coincides with the food volume many strength trainees on an ad libitum diet should aim for per meal.

In fact, satiety is more strongly influenced by food volume than food energy content. Since food volume on a calorie-equated basis is the inverse of caloric density, food volume is strongly related to how few calories a food has per 100 g. The fewer calories per 100 g a diet or meal has, the more satiating it is and the fewer calories you'll probably consume on it [2, 3, 4]. We intuitively don't reduce our portion size enough to offset for higher energy densities of what we eat. We tend to eat a similar amount almost regardless of energy density, causing total ad libitum energy intake to increase along with a meal's energy density. This knowledge gives you enormous control over how satiating a meal plan is, as you now have a concrete measure of any food's satiety index, which allows you to estimate the satiety index of meals and the diet as a whole.

As an illustration of the effect of energy density, when eating ad libitum, people eat just as much pasta or rice as potato. Since potatoes in most forms have less than half the energy density of grains, potatoes have a much better satiety index than starches. You can literally cut a meal's carbohydrate-derived energy intake in half by switching from bread to potatoes. Correspondingly, when you eat a given number of calories from potatoes instead of beans or cereal, you're more satiated.

Energy density is generally the strongest predictor of ad libitum energy intake, although at very high energy densities the body does seem to register absolute calorie intake as well. Foods with a similar energy density tend to have a similar satiety index. Different types of bread, for example, tend have a relatively similar satiety index [2]. A 2021 meta-analysis concluded that compared to processed grain products, whole grain products are generally a bit more filling, but they lead to only a small, inconsistent reduction in ad libitum energy intake. There's a trend for greater satiety with more of certain fibers, more voluminous loafs and more protein, but overall, whole-grain breads don't consistently decrease ad libitum energy intake compared to white breads. Grains, beans and pulses in general have a poor satiety index and often do not reduce energy intake more than white bread. They may have a bit more fiber or protein than white bread, but they have basically the same energy density, so it's all in the same ballpark for the body's food intake sensors. As a result, consuming more whole grains does not aid fat loss compared to refined grains or habitual diets according to a 2020 meta-analysis of RCTs.

Nuts are another example of a food with a terrible satiety index because of their extremely high energy density. Most nuts have around 600 kcal per 100 g, yet they are no more satiating than baked goods with the same macronutrient content or high-carb snacks. Just because a food is 'healthy' does not mean its conducive to fat loss. Another study found that nuts, chocolate and rice cakes don't significantly differ in energy compensation, indicating they have a similar satiety index.

A better snack option would be popcorn. It's still corn, but blowing it up makes it fluff up with air, decreasing its energy density. 100 kcal of popcorn is significantly more filling than 150 kcal of potato chips.

Here's a visual illustration of the principle of energy density.

Some of the most satiating foods are those high in liquids. The higher the liquid content of a food, the more satiating it is, generally. Consuming more fruits and vegetables is a highly effective way to decrease ad libitum energy intake [2]. One of the key reasons food processing reduces its satiety index is because it reduces the liquids. It's why starches are so easy to overeat on compared to fruits and vegetables. If you dry out the fruit though, the difference becomes much smaller. Vegetables at some point become chips if you dry them out enough.

Consuming more water is also an effective way to decrease ad libitum energy intake. Many studies demonstrate consuming more liquids improves satiety: see the research overview below. Here too the volume, not the energy content, of the liquids is what matters. High-calorie drinks, such as sodas, are no more satiating than (carbonated) water generally, which means liquid calories should be minimized during a diet when hunger is an issue. Moreover, water and gas tend to result in only very short-term satiety and the effect is not as potent as that of solid food with comparable volume. If your meal itself just isn't satiating enough, you can only compensate for this to a limited extent by drinking a lot of water.

When drinking extra liquids during a meal though, beware not to sip a lot in between bites. Frequent switching between sipping and eating can interfere with satiation by reducing sensory-specific satiety, which we'll discuss in more detail later. Put simply, frequently rinsing your mouth makes every bite appear more like a new flavor, causing your desire to eat to remain higher.

➢ Research overview

The effect of liquid intake on satiety

Protein

An abundance of research shows high-protein diets are more satiating than low-protein diets. This has led many people to conclude 'protein is more satiating than carbohydrates and fats'. However, this is a simplification that is often incorrect.

The theory of protein's extra satiating effect is based on hormonal effects. In the gut, amino acids stimulate the release of several hormones that activate satiety centers in the brain, namely glucose-dependent insulinotropic polypeptide (GIP) and glucagon-like peptide-1 (GLP-1). There is also mixed evidence for hunger suppression by cholecystokinin (CCK) stimulation and for suppression of ghrelin release, 'the hunger hormone'. This looks like a simple and convincing theory: more protein → more appetite suppressing hormones → less appetite. However, the theory breaks down on all 3 levels in several studies. High-protein meals do not always stimulate more appetite-mediating hormone release or suppression than high-carb or high-fat meals. On the flip side, different meals with the same macros can result in major differences in gut hormone production. Higher protein meals also do not always result in greater appetite suppressing hormone levels nor lower hunger hormone levels than lower protein meals, even when the high-protein meals have a higher total energy content [3]. In fact, a 2021 meta-analysis on older adults found that when you factor in the energy content of protein supplementation, acute energy intake on average still increases as a result of protein supplementation. The response of gut hormone levels to protein also seems to depend on whether someone is lean or overweight.

Moreover, the relation between supposedly appetite suppressing hormones and actual appetite is inconsistent and, as some researchers put it, "too small to use hormone and glucose concentrations as appropriate biomarkers for appetite, at least at the individual level and probably at the group level." (Lemmens et al. 2011) [2, 3, 4]

Other researchers propose that large neutral amino acids (LNAAs) that can cross the blood-brain barrier directly alter brain activation and neurotransmitter levels with appetite suppressing effects. However, Koren et al. (2007) found that A) the amount of protein in the diet doesn't affect the level or ratio of LNAAs in the blood and B) unrestricted energy intake changed over time without changes in blood amino acid levels. So it's unlikely blood amino acid levels directly influence satiety.

A much more plausible theory to explain why high-protein diets are more satiating than low-protein diets is protein leverage theory. Put simply, protein leverage theory states that the body monitors protein consumption to ensure we consume enough of it. Since the body doesn't have an efficient storage mechanism for amino acids like it does for carbohydrate (glycogen) and fat (adipose tissue), it makes sense from an evolutionary perspective that the body has adapted mechanisms to ensure we consume enough of this vital macronutrient. Concretely, we stay hungry until protein requirements have been met. We have a 'Protein-Stat'. In other words, protein leverage theory says protein is more satiating than carbs or fats *until we've consumed enough protein for our bodily needs.*

The exact mechanisms are still being uncovered, but research indicates a link between satiety signaling in the brain and amino acid utilization in our body. Activation of anabolic signaling pathways (mTOR) and suppression of catabolic signaling pathways (AMPK) reduce food intake by acting on the hypothalamus. A key modulator in the brain may be GCN2 (general control nonderepressible 2), which quite directly monitors amino acid balance and thereby basically the protein quality of our diet. We also have receptors in our mouth that detect amino acids. It's thus plausible the brain can monitor our protein intake, compare it with our requirements and adjust our appetite accordingly.

In rodents and several other animals, including pigs, protein leverage theory has strong supporting evidence. Rats will quite reliably overeat on low-protein diets until they've consumed enough protein (= 'leveraging protein'). After protein deprivation, when given the choice between high- and low-protein food, they tend to prefer the higher-protein food. Rats can even self-select foods with complementary amino acid profiles. This preference for higher-protein foods to meet bodily demands occurs independently of energy balance.

Protein seeking correlates surprisingly well with protein needs even during periods of growth in animals. Birds intuitively self-select diets to reach a protein intake that's close to their estimated optimum. They'll increase this protein intake in periods of growth and when injected with growth hormone. Birds bred to have more muscle also select higher-protein diets and male birds eat more protein than female birds.

This protein seeking can be compared to our innate so-called 'specific appetite' for sodium and water, which we also cannot effectively store or survive without.

It should be noted our ability to leverage protein is far from perfect and quite some research finds protein intake has no effect on energy intake at all, including a 2021 meta-analysis on older adults [2].

Protein leverage in humans is more difficult to study because it's unethical to starve people of protein and difficult to restrict their food choices to a narrow selection for a long time. However, the research we have is promising. After low-protein diets, people's preference for higher-protein foods increases compared to after high-protein diets. We also have a low drive to eat protein sources with an incomplete amino acid profile lacking in essential amino acids, as we cannot meet protein requirements with those foods. These phenomena are impossible to explain with the simple model that protein is inherently more satiating than carbs or fats because it directly stimulates satiety hormones.

Another phenomenon that's impossible to explain with the traditional 'protein is the most satiating macro' theory is habituation. The satiating effect of high-protein meals decreases after high-protein diets and comes back after low protein intakes. In other words, if you consume a diet higher in protein than you need, protein will lose some of its satiating effect. The body can sense excess protein intake in the form of increased protein oxidation rates. Habituation to protein's satiation again makes evolutionary sense. If we only have access to low-protein foods, we should keep eating until we've consumed enough protein so we can survive. But if we only have access to high-protein foods, we should not stop eating before we've consumed enough other nutrients. Otherwise high protein environments would cause us to starve ourselves. When protein is abundant, high-protein foods are just an energy source like carbs or fats, so the body should treat them as such in terms of how much we need of them.

The finding that high protein intakes reduce how well protein controls our hunger also means we should be skeptical of all short-term research. Just because a high-protein diet is satiating for a couple of days, doesn't mean it will have long-term beneficial effects.

With protein leverage in mind, 'how satiating is protein?' is the wrong question to ask. We should instead ask: how much protein do we need? As you learned in the course module on protein, the answer to that is generally 1.6 g/kg (0.73 g/lb) per day. Protein leverage theory would thus predict 1.6 g/kg (0.73 g/lb) per day is the optimal protein intake for satiety as well with no further benefits of going higher in protein. In sedentary individuals, the optimal protein intake for satiety should be lower in accordance with their lower bodily protein requirement. This is exactly in line with the scientific literature.

Studies comparing insufficient protein intakes (< 1.2 g/kg [0.54 g/lb] per day) with sufficient protein intakes (> 1.6 g/kg [0.73 g/lb] per day) reasonably consistently find appetite suppressive effects of the higher-protein diets. However, studies comparing sufficient protein intakes with excessive protein intakes find no beneficial effects. This includes a randomized cross-over trial Menno co-authored.

Thus, it appears there's a ceiling effect after which protein loses its extra satiating effect. This ceiling is evident in studies comparing 3 different protein intakes. For example, Li et al. (2016) performed a long-term cross-over trial of diets with 10%, 20% or 30% protein. The 10% protein group experienced slightly lower satiety than the other groups, but there were no differences on any appetite measure between the 20% and 30% protein intakes. The researchers overall concluded that a diet's protein intake has "minimal effects on appetite control". It appears the brain directs us to consume at least ~15% of energy intake as protein, as hunger increases below this point but satiety does not increase above it [2, 3, 4, 5]. The average optimum protein intake for satiety may be a bit higher for some people though, as several studies find benefits of going higher than 15% in protein for satiety [2, 3, 4]. 15% of energy intake corresponded to only 64-75 g protein per day in these studies and it was often insufficient to optimize body recomposition, so it's not surprising the average sweet spot for hunger control was higher than that in these studies. A meta-analysis of 38 studies concluded protein is more satiating than carbs and fats in the 10-20% of energy intake range but not significantly above that, indicating the average satiety sweet spot is a protein intake of 20% of energy intake, corresponding to about 1.2 g/kg (0.54 g/lb) per day for non-strength training individuals. The optimum protein intake for satiety was thus closely in line with the optimal protein intake for body recomposition and health for sedentary individuals.

The literature is thus in line with protein leverage theory: up to the bodily protein requirement, protein is generally more satiating than carbs or fats per gram, but after protein needs have been met, the superior appetite suppressing effect of protein disappears.

Prospective and cross-sectional research in the general population also doesn't support a 'more is better' relation between protein intake and satiety. Depending on which study you look at, protein has either no relation with body fat level, an inconsistent negative one or even a positive one. The latter would suggest higher protein intakes are associated with an increased risk of becoming overweight. Some researchers indeed believe this, stating: "consuming an amount of protein above the protein intake recommended […] may experience a higher risk of becoming overweight or obese during adult life… Compared to diets with no more than 14% of energy from protein, diets with more than 22% of energy from protein were associated with a 23–24% higher risk of becoming overweight or obese."

So is it completely the other way around: are high protein intakes fattening? No, it depends on your food choices. In practice, it's silly to even think of 'protein vs. fats/carbs'. The practical question is as follows. When your protein intake is already sufficient for body recomposition purposes but you're suffering from hunger, should you increase your protein intake further?

Probably not and here's why. Let's take every bodybuilder's favorite high-protein food: chicken breast. How difficult is it to eat 200 g of chicken breast? Unless you have the appetite of a sarcopenic 80-year old, the answer is: very easy indeed. After you cook it, the food volume is tiny. Even 500 g of chicken breast is no more than a snack for most big guys when it has a nice sauce. (Tip: you can make awesome almost zero calorie sauce with Coca Cola Light.) 200 g of chicken breast generally has over 250 calories.

For those calories, you could eat about 3 pounds of zucchini, as it has only 17 kcal per 100 grams. Which is going to be more filling and appetite suppressing: the baby's handful of tender chicken or the mountain of fibrous zucchini? The answer should be obvious.

In general, vegetables are far more satiating than high-protein foods. For example, a given volume of mushrooms in a lunch meal is just as satiating as that volume of meat, even though the meat contains far more protein and total calories. The mushroom eaters in the above study ended up with a lower energy intake over the next 4 days. When you equate for protein content, mushrooms are significantly more satiating than meat. Eating mushrooms instead of meat also decreased energy intake and consequently improved weight loss in a year-long study. Even bean- and pea-based meals are as satiating per calorie as higher-protein veal- and pork-based meals. The combined effects of energy density and fiber on satiety can easily overshadow the satiating effect of protein.

It thus makes no sense to talk about 'protein' and 'carbs'. Many fitness enthusiasts become so obsessed with macronutrients they forget there's more to food. Meals with the same macronutrient intake can have very different effects on our appetite. For example, a breakfast with the same macros of goat dairy is more satiating than that breakfast with cow dairy. You can easily experience this yourself as well. Just think of a tasty whey shake compared to beaten casein fluff 'milkshake' that has swollen up to three times its volume. Same macros, but the fluffed-up casein is far more satiating than the watery whey.

When we compare different foods with different macros, the differences become extreme. Sugar and vegetables are both 'carbs' and butter and avocado are both 'fats', but is there anyone in their right mind who thinks they're equally satiating? Forget macros. Think food.

In conclusion, make sure you consume enough protein to support your activity level but don't worry about having to consume more than that. Factors like energy density and fiber are far more important than protein intake for satiety after you've covered protein requirements. Protein is not inherently more satiating than carbs or fats, so if you don't like high-protein foods all that much, you can be just as satiated with other foods you like more. Being lean doesn't require living on chicken breast and protein shakes. Good alternatives for satiety, not to mention your wallet, include potatoes, beans, vegetables and most fruits. Experiment beyond protein and you may end up not just more satiated but also more satisfied.

Fats and carbs

Many textbooks state carbs are more satiating than fats. However, this is an oversimplification based largely on research on oils and butters, which at ~900 kcal per 100 g have an energy density that is not found in any other food. While it's clear that satiety is negatively related to energy density, fats are not inherently less satiating than carbs.

- When palatability and energy density are matched, high-fat *foods* are just as satiating as high-carb foods [2] and the carbohydrate and fat content of food does not predict its satiety index beyond the effects of fiber content and energy density. For example, chocolate and nuts are just as (un)satiating as rice cakes. Avocado and whole eggs are examples of high-fat foods with a relatively low energy density and consequently a relatively high satiety index. Avocado is more satiating than oatmeal and almonds seem to be slightly more satiating than cereal bars, at least according to industry-sponsored research.
- High fat *meals* are just as satiating as high carb meals when they have the same energy density.
- Secretly changing the fat-to-carbs ratio of people's meals while keeping protein and energy density the same does not affect people's total daily energy intake on a diet [2]. In other words, the relative proportion of carbs and fats in a diet doesn't affect its satiety index.
- In whole diets matched for energy intake, protein intake and energy density, higher and lower carbohydrate diets again have similar effects on self-reported appetite and hunger hormone levels [2, 3].

Carbs and fats also do not differentially affect reward pathways in the brain.

Additionally, it's an oversimplification to group all fats together. Different types of fat can have different satiety indices. For example, medium-chain triglycerides (MCTs) have a relatively high satiety index compared to long-chain triglycerides. PUFAs may also be more satiating than MUFAs, although other research finds the degree of saturation of fatty acids does not affect our appetite.

There is also a gender effect. As discussed in the course module on female specific topics, women tend to experience greater satiety from fats than men.

In practical diet settings that do not control for confounders, (very) low carb diets tend to result in more weight loss than higher carb diets [2, 3], mostly because of a higher protein intake that comes with many fat sources and the restriction of starches, which are easy to overeat on.

Nevertheless, since fat has an inherently higher energy density than carbohydrate per gram, switching to low-fat food variants is a highly effective way to reduce your ad libitum energy intake [2, 3, 4]. In practice, this is particularly useful when total energy intakes have to be pushed so low that carbohydrate intake falls below the 100-200 grams per day range in order to consume your target fat intake. In this case, it's typically best for appetite management to go with either a fully ketogenic diet or to reduce fat intake to the minimum of 20% of energy intake.

On a final note, combining carbs and fats in the same meal typically fosters overeating. The least satiating foods are consistently foods that are high in carbs **and** fats. Meals rich in carbs and fats also hyper-stimulate reward pathways in the brain.

In conclusion, the satiety index of a food is not inherently related to its carbohydrate or fat content, only to its total energy density. In practice, high fat foods are easy to overeat on because they are also highly caloric, but equally caloric starches are just as easy to overeat. Foods rich in carbs as well as fats are the worst of both worlds, as they are even easier to overeat on than you'd predict based on their energy density.

Fiber

Dietary fiber, especially soluble fiber, increases satiety via multiple mechanisms [2]:

- Fiber has few calories, generally fewer than 2 kcal per gram, so it lowers the energy density of food compared to other carbohydrate.
- Fiber slows down gastric emptying and the passage of food through your intestines, prolonging literal fullness. This effect is particularly strong in soluble, viscous fibers, because they swell up with water and become extra voluminous.
- Fiber has a relatively tough texture that stimulates chewing, which can enhance satiety signaling.
- When fiber reaches the large intestine, colonic microflora ferment it. The fermentation produces short-chain fatty acids (SCFAs). These SCFAs are taken up by the brain and trigger the sensation of fullness.

On average in research, every 14 g of fiber reduces ad libitum energy intake by 10%, though the effect is smaller for leaner individuals. That's a major effect. Increasing your fiber intake substantially may effortlessly put you in a 20% deficit.

All recommended fiber sources from the Carbohydrates course module score well on the satiety index and you should consider the recommended fiber intakes a bare minimum when hunger is a problem during dieting.

Supplements generally don't provide the same benefits as fibrous whole foods. Fiber supplements cannot (yet) rival whole foods in terms of satiety or health, since the health effects of fiber are influenced by the plant's cell walls and many of its other nutrients and phytochemicals during digestion. Some supplements are better than others, but in practice people that rely on supplements to consume enough fiber have great difficulty becoming, let alone staying, very lean.

That said, a person is better off consuming enough fiber in the form of a supplement than not consuming enough in the first place from nothing but whole foods. Soluble fiber supplements in particular can help improve fat loss [2] by reducing your appetite and thereby making you consume fewer calories.

Texture

The harder it is to eat a food, the more satiating it generally is. Foods with harder textures are generally more satiating than foods with softer textures [2, 3]. Similarly, the more viscous a food is, the more satiating it generally is. Technically, viscosity means resistance to deformation rate due to internal friction. In informal terms, viscosity is like ‘thickness’ or ‘density’. You know how with certain Greek yogurt you can hold the container upside down and the yogurt is so thick it doesn’t fall out? That’s high viscosity. You can also think of viscosity as how solid a food is. The same nutrients consumed in solid form are generally more satiating than in liquid form [2, 3, 4]. For example, in order of increasing viscosity we can list: water < milk < yoghurt < cottage cheese < hard cheese. Another example in order of decreasing viscosity and satiety index: whole apples > applesauce > apple juice > water.

Substances of increasing viscosity from left to right.

Both food hardness and viscosity increase how much oral processing, such as chewing, is required to consume the food, and this automatically reduces your eating speed. Oral processing of food stimulates satiety signals, so the more you have to chew on something or at least move it around in your mouth before you can swallow it, the more it tends to satiate your hunger.

Most people that want to stay lean are best off eliminating all liquid calories from their diet. Small amounts of coconut water, almond/cashew milk and milk in coffee (especially when beaten) and the like can be fine though.

Glycemic index

In contrast to popular belief, a food's GI does not seem to affect satiety in most studies [2, 3, 4, 5, 6], although one paper found a higher satiety response with a lower GI diet, another paper found a higher satiety score with a *higher* GI diet. A meta-analysis compared high vs. low GI breakfasts on subsequent short-term energy intake and found no differences between groups.

The impact of your diet's GI on your appetite is therefore non-existent or at best very weak. In practice, foods with a lower glycemic index do tend to be more satiating, but that is because of their lower energy density, lower palatability and higher fiber content, not their GI. For example, in Lennerz et al.'s study, a high GI meal was less satiating than a low GI meal and this was associated with increased activation of the brain's reward centers. In other words, you may eat more of higher GI foods simply because they taste better, not because of their effect on your blood sugar.

In fact, the common idea that blood sugar levels affect your appetite in the first place is largely a myth. When people are intravenously injected glucose without their knowledge (placebo blinded), their hunger doesn't decrease. Nor does their appetite increase afterwards when blood sugar levels fall below baseline. It's only when you go truly hypoglycemic that your appetite increases. This generally does not occur in non-diabetics.

The most satiating foods

The following foods comprise the top tier of the satiety index based on a combination of research and Menno's experience.

- Highly viscous (think cement) cottage cheese, quark and casein.
- Egg whites.
- Fibrous vegetables, including pumpkin, bean sprouts, green veggies, mushrooms and cauliflower (not including potatoes and similar starches that are not commonly regarded as vegetables).
- Strawberries, blackberries, grapefruit, papaya, hog plums and peaches. Fruit in general scores well on the satiety index, but some fruits are much more filling than others.

Most paleo foods score well on the satiety index. Grains score very poorly. As a result, Paleolithic diets tend to be more satiating per calorie than the Mediterranean diet and diabetes diets based on official guidelines [2]. Note that the satiating power of paleo diets has nothing to do with the foods being paleo per se. Nuts, for example, are paleo but highly caloric and unsatiating.

How to implement ad libitum dieting

In sum, the amount of energy you end up consuming in an ad libitum diet is a function of your appetite and your diet's satiety index. A person with a certain appetite will have an energy intake that is determined solely by the diet's satiety index. So instead of setting energy intake directly, you can set it indirectly by setting the diet's satiety index, which is roughly the average of the satiety index of all individual foods in the diet.

In theory, to create an ad lib diet from scratch, you set caloric intake indirectly by prescribing the selection of foods someone is allowed (or not allowed) to eat based on their satiety index. Instead of macros for each meal, you have a list of recommended foods.

However, while you can create a very meticulously calculated starting point with an exact satiety index, you don't know how much of each food someone ends up eating and which foods they pick from the allowed options, so your estimate is essentially a rough guess. Not to mention complex computations would defeat the purpose of ad libitum dieting: you then may as well compute energy intake directly. From a lifestyle point of view, it often works just as well, if not better, to simply start an ad libitum diet with however someone is currently eating and adjust that over time as needed to achieve sustainable lifestyle change.

With ad lib dieting even more so than macro tracking, the starting point of the diet is not nearly as important as how you adjust it. It's crucial to track body composition over time with objective metrics and adjust the diet's satiety index based on the measured progress. See the course topic on monitoring progress: any fat loss should generally result in objectively measurable fat loss on a weekly basis.

It's typically more effective for fat loss adherence to add low-calorie foods than to restrict high-calorie foods. Recommending people to consume more micronutrients or fiber, for example, is a positive message aimed at improving the diet. Telling people they cannot consume food X, on the other hand, is a negative message that makes people feel deprived and can instill cravings because of the forbidden fruit effect. Tangentially, for goals in general, approach-oriented goals are more effective than avoidance-oriented goals to stimulate behavioral change [2, 3].

Here's a concrete framework to implement ad libitum dieting.

1. Determine your current eating pattern by assessing your food logs and macronutrient intake; measure your body composition change.
2. Stop measuring macronutrient intake accurately: only keep estimating protein intake from high quality sources and total energy intake.
3. When you've established that body composition is still changing as planned, stop measuring energy and protein intake altogether and switch to a set of guidelines to sustain the current eating pattern.
4. When body composition is no longer changing as planned, make changes to your food choices based on their satiety index accordingly. Example: You see you start gaining rather than losing fat. After assessing your food choices, you've determined that you should consume many more starches and fewer vegetables.
5. Keep adding in more high-satiety index foods as needed to achieve fat loss or, if really needed, reduce intake of less satiating foods (or vice versa during a bulk).

➢ Case study

Case study of an ad libitum diet for a client with anorexia and digestive problems

Note that these are just 2 options. To broaden your mind, here are some more options.

- You can combine ad libitum dieting with macro tracking by tracking some but not other foods or meals in the diet. Example: not tracking foods with fewer than 50 kcal per 100 g but otherwise tracking macros normally.
- You can aim for certain quantities of must-have foods. Must-haves tend to be preferred to may-nots. This can work well to ensure sufficient fiber, omega-3 or total fat intake.

Moreover, the diet's satiety index is only one side of the equation. So far, we've pretended that someone's appetite is constant; you're probably aware that it's not quite that simple in reality. You can change someone's appetite just as you can change someone's diet and the result in terms of energy intake can be the same. So let's delve into the psychology of human appetite.

Ad libitum dieting vs. macro tracking

Ad libitum dieting's main advantage over macro tracking is of course not having to track your macros. This saves time, effort and sometimes stress. Ad libitum dieting approaches are generally more sustainable and have lower attrition rates than diets with prescribed macronutrient intakes [2, 3]. Intuitive eating is associated with high wellbeing, low distress and good psychological adjustment. That's not to say everyone will be happiest on ad libitum diets though. A concurrent cognitive behavioral therapy may reduce any negative psychological effects of calorie tracking, so when properly implemented, some people may prefer calorie tracking even given the same results.

The main downside of ad libitum dieting is worse results. Without the precision from knowing your exact energy intake, it's difficult to be at the optimal level of energy balance for your goals, such as a 15% energy deficit. While you can come close by monitoring your body composition and adjusting your food choices systematically, your results will never be quite as good as with strict calorie tracking. This is especially true for less experienced dieters, who may not consume enough protein or other vital nutrients yet if they don't keep meticulous track of their diet. In research we also see that dieting approaches with prescribed macronutrient intakes generally result in faster fat loss than dieting approaches that focus solely on changing someone's dietary habits and food choices [2, 3].

To make ad libitum dieting very effective, someone generally needs to have very good calorie awareness and a basis of engrained dietary habits that ensure sufficient intakes of essential nutrients, notably protein for strength trainees. Someone that hasn't dieted to a low body fat level yet and learned to manage his or her appetite with the objective feedback of energy intake, will need much longer to be successful on an ad libitum diet than someone who essentially just has to stop tracking but keep eating as they are. It's one thing to think you might have overeaten, but it's much more educational to find out you overate by 3500 kcal and then to have experienced afterwards exactly what it takes the next 7 days to create a 500 kcal daily deficit to offset that overeating. This experience teaches you which foods are worth their calories for you and which aren't, which is crucial to make ad libitum dieting successful.

The latter is a perfect candidate for ad libitum dieting: someone who knows how to diet well but simply wants to stop tracking everything meticulously. The worst candidate for ad libitum dieting is someone that thinks ad libitum dieting is a magical solution that allows them to eat whatever they want and get lean without effort. Ad libitum diets are no different than calorie-prescribed diets in that successful long-term weight loss requires behavioral change: cognitive therapy alone, for example, has minimal effectiveness for fat loss.

Intuitive eating is a skill that takes time to master, but it's the natural way to eat, evolutionary speaking, so it should be feasible for everyone. It may take time if your eating intuitions have been wiped out by rigid calorie tracking, but even individuals with eating disorders can improve their intuitive eating skills.

Paradoxically, ad libitum diets offer lower flexibility with food choices than calorie tracking. When you track your calories, you can in principle fit in ice cream and 'cheat foods' as you wish, as long as your total energy intake still ends up on target. With ad libitum dieting, it's very difficult to know how much compensation is required. In practice, most people majorly underestimate how much compensation is needed to offset high energy density foods. For example, a single 110 g bar of chocolate may have 700 kcal. If you add that to energy maintenance, it will take 7 days with a roughly 100 kcal daily deficit to offset that. For a woman with a 1500 kcal energy expenditure, that can already be very difficult on an ad libitum dieting, meaning chocolate is basically off the menu completely when a good fat loss rate is the goal. Most people don't nearly compensate enough for overeating when they don't track their macros and if weight returns to baseline at all, it can take a long time, e.g. many weeks after a single week of overeating. So successfully incorporating cheat meals in an ad libitum diet often requires major compensation in food choices the surrounding days.

A good mindset during ad libitum dieting is that you're choosing to exchange food variety for leanness. You choose to forego certain higher-calorie foods and in return for that you achieve a lower body fat level.

Cutting vs. bulking

This module is written from the perspective of someone who's cutting, since that will be the case the majority of the time. All of these tips and findings also apply to bulking in reverse, but it is exceedingly rare to find a natural trainee that truly has problems consuming enough calories. This is what we call a luxury problem, and choosing less satiating foods will suffice in the majority of cases without the need for behavioral change or psychological tricks.

Moreover, ad libitum dieting is much less suitable for a lean bulk than a cut because you can't control energy intake as meticulously. During a cut, you have significant leeway with your day to day energy intake. As you learned in the course module on energy, given the same weekly energy intake, fat loss will be similar in practice regardless of the distribution of said energy intake. Thus, if you end up in 10% deficit one day and 15% the next instead of in a 12.5% deficit every day, that's perfectly fine. Even if one day you end up with a much greater deficit than planned, that's similar to a planned PSMF day, and it will not adversely affect progress as long as your average daily energy deficit over the surrounding days is on target.

During a lean bulk, however, you do not have this luxury. As you learned, there's quite a precise optimum level of energy surplus that maximizes muscle growth and any net energy surplus beyond that mostly ends up as fat storage. Your body can only build so much muscle in one day. Conversely, because the sweet spot energy surplus is so small for most people, eating a little less will not achieve energy surplus and therefore not maximize muscle growth, especially if this occurs during your anabolic windows. As such, while cutting on an ad libitum diet is very viable, bulking without precisely tracking your energy intake will typically either results in excess fat gain or a significantly reduced rate of progress, if not both.

Hunger management

If people were rational, dieting would be easy. It would purely be a matter of setting your calories at the optimal deficit and having patience. But the mind is weaker than the flesh. The older systems of the brain, specifically the limbic system, located below the rational systems, namely the prefrontal cortex, have evolved to resist weight loss. And they do not differentiate between trying to get a sixpack for the beach and starving in the desert.

In the fight for domination of your body's primitive emotional system, the chief villain is hunger. Your deliberate mind may want to put your body in a state of negative energy balance, but hunger will trigger the desire to indulge yourself.

So how do we conquer our hunger? Like any other system in the body, it can be manipulated if you know how it works. The regulation of your appetite is not nearly as simple as many people think. It goes far beyond literal fullness or nutrient registration. Our hunger is influenced by many psychological factors in addition to physiological ones. For example, telling someone a food is healthy immediately makes them perceive the food as less tasty [2]. Not only that, but your perception of how many calories are in a food affects how satiating it is. This nocebo effect even affects the behavior of the hunger hormone ghrelin, showing that psychological problems can physically manifest themselves.

Hunger is a negative emotional state that interferes with our anterior cingulate's cortex's ability to maintain our attention. It can thereby reduce our ability to focus on our goals, keep pushing out that extra rep and resist the temptation of food. For example, consuming more satiating meals with identical macros has been found to increase how many reps of squats trained men can do.

Below we'll discuss the relevant determinants of your appetite.

Perceived intake

So far we've treated our appetite as a largely biological construct related primarily to literal fullness and digestive factors, but our appetite is also strongly psychologically driven. A general feature of our appetite is that our brain estimates how much we've eaten rather than actually measuring it. Our appetite is significantly affected not just by how much we've actually eaten but also by how much we *think* we've eaten. For example, when people are made to believe they've eaten more than they actually have in experiments, such as by saying there were 4 instead of 2 eggs in an omelet, people intuitively eat less food throughout the rest of the day without reporting greater hunger.

Similarly, people that believe they haven't eaten as much as they actually have, eat significantly more. In a famous study design, people consistently consume more soup from secretly-refilling soup bowls than from regular bowls. 74% of participants did not notice and most people were unaware that it made them eat more. In fact, on average the participants thought they consumed less soup. This illustrates how our brains use visual cues – the amount of soup in the bowl – over internal measuring of food intake. We don't have calorimeters in our stomach, so our brains estimate how much we've eaten based on other cues.

Many of the following factors we'll discuss result from the brain *estimating* satiety rather than directly measuring food intake.

Serving size

Wansink & Kim performed a study in commercial movie theaters. They handed out a serving of free popcorn to 4 groups that varied in 2 ways: their popcorn was either fresh or stale and the bucket of the popcorn was either medium or large. The results: “Moviegoers who were given fresh popcorn ate 45% more popcorn when it was given to them in large containers. This container-size influence is so powerful that even when the popcorn was disliked, people still ate 34% more popcorn when eating from a large container than from a medium-size container.”

In a survey after the movie, the movie goers were asked if they felt the size of the bucket influenced how much they had eaten. The vast majority adamantly said no.

We tend to eat what we’re served and have little objective idea of actual portion size or energy intake. We’re even fundamentally unaware that we’re unaware.

Appetite is not purely something that builds up over time and is satiated via eating. To decide when the body has had enough food, it cannot simply register nutrients and send a stop signal when enough nutrients have been consumed. The digestive process takes far too long for this to work. So the brain needs to *estimate* how much appetite should be generated.

Like a statistical model – the brain in several cognitive domains functions like a Bayesian computer – the brain uses all the information with predictive value to determine how much appetite is needed to consume enough food, even if these cues do not make logical sense. Even just telling someone a meal is very filling vs. very light generally reduces how much they eat of the meal.

An important cue your brain uses to estimate how much you should eat is your serving size. Rather than you deciding how much you're going to eat and basing your serving size on that, a lot of research indicates your serving size also greatly influences how much you eat. Psychologically, your serving size suggests this is the expected amount of food you should consume. In various settings, larger serving sizes result in considerably higher energy intakes [2, 3, 4, 5]. We tend to interpret the serving size as a social norm or an implicit recommendation of how much we should eat.

Most people's food intake also increases almost linearly with serving size when we serve it ourselves: we eat on average 92% of the food we serve. This finding is called 'the clean plate effect'.

The common dietary strategy of learning to eat less, or eat like a Frenchman, does not protect you from portion size effects. People that have been extensively trained to reduce their portion sizes are just as susceptible to serving size effects as untrained individuals: when you serve more food, they eat more.

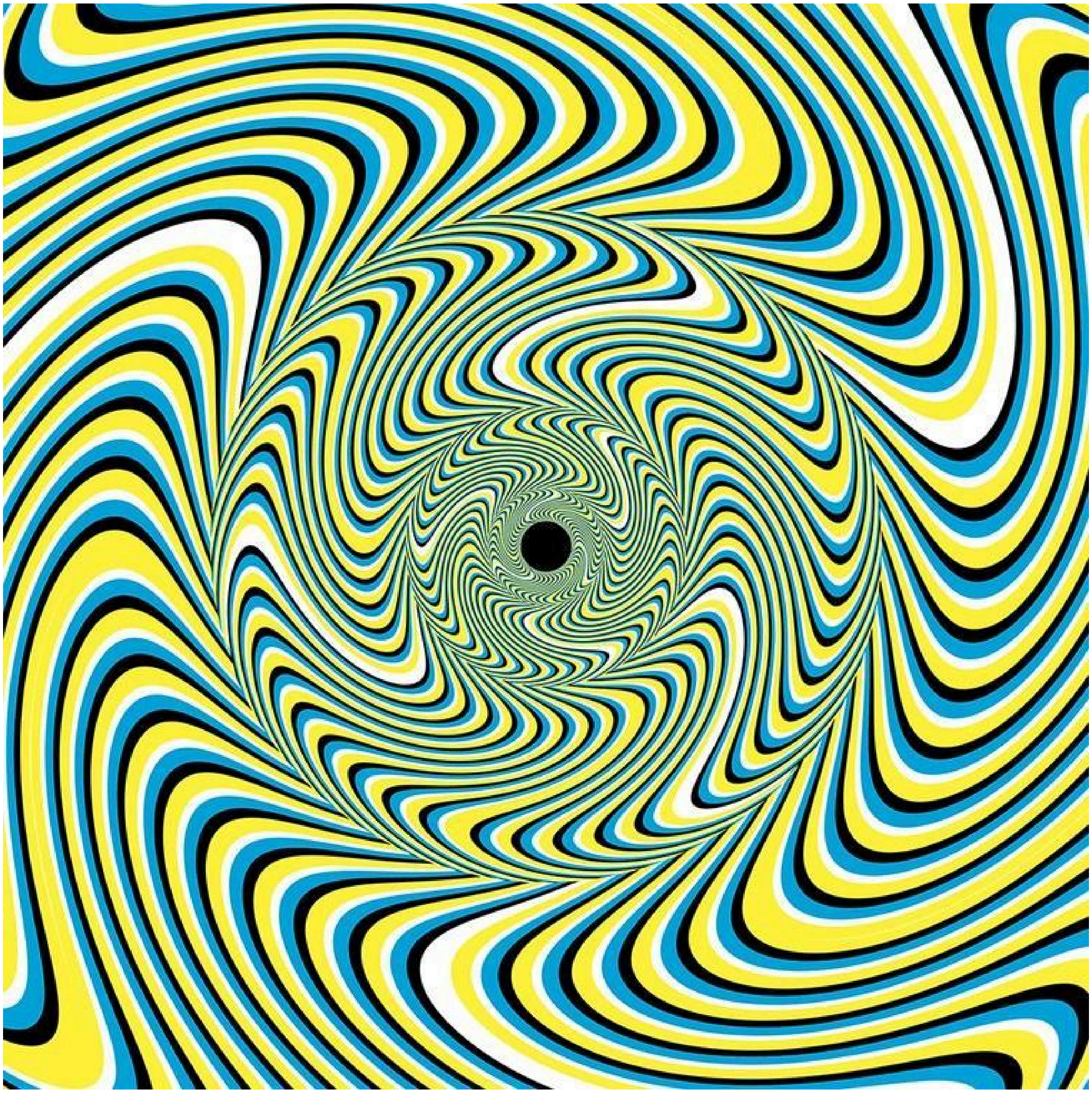
While perhaps not as elegant as 'eating like a Frenchman', doggy-bagging does reduce the clean plate effect: packaging and storing your food for later consumption reduces our tendency to overeat large portion sizes. So it's good to always keep in mind you can put your food in the fridge and eat it later.

Not only do we typically eat most of what we're served regardless of how much it is, we're also susceptible to what a portion size is called. Changing the label of a fixed portion size from 'regular' to 'half-size' can cause us to eat 41% more food. Most people have a mental reference of how much of an appetite we have. "I'm a big eater." or "I despise stuffing myself and prefer to snack, like the French." We use this mental reference to select what portion size we likely want and then we eat most of that even if it's more than we need.

Crucially, people don't typically have higher meal satisfaction after larger portion sizes. Portion size does not affect the activity of reward pathways in the brain. It's the satiety, not the total amount of food you ate, that makes you happy.

You may think that eating more at one meal balances out, as you'll eat less at another meal. However, this is not generally the case because your body uses so many other cues than energy intake to regulate satiety. Moreover, subjective appetite isn't even related to actual energy intake that well, which is why you typically finish your plate regardless of how hungry you were beforehand. For example, we previously discussed how potatoes are far more satiating than grains like rice and wheat. However, if you eat a fixed-calorie portion of potatoes, rice, pasta or bread at breakfast, you eat the same amount afterwards at lunch even though the potatoes were subjectively more satiating than the rice and pasta.

Since appetite regulation is very meal-specific with imperfect compensation in subsequent meals, instructing people to limit their portion sizes has been found to increase weight loss success in various settings [2, 3]. Even if you are aware of the self-trickery, it still works. This is a common finding in psychology: humans are only partially capable of rationally overriding their emotional system. It's just like with visual illusions: knowing the illusion doesn't make it go away.



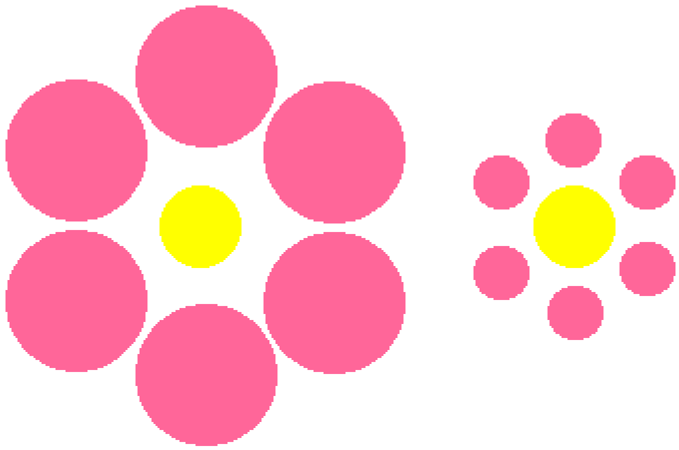
Look at the black dot in the middle. Now realize that this is a static image. It's not moving. Your brain is tricked into seeing movement by the pattern.

Tip: Conservatively serve only as much food as you think you need. You will eat less this way than if you serve a mountain of food and just eat until you're full, yet you can be just as satiated.

Dinnerware

Your brain is also susceptible to the size of your plate and its spatial orientation and color in relation to the food on it. This results in the Ebbinghaus-Titchener size-contrast illusion and the Delboeuf effect [2, 3, 4]. Specifically, you tend to perceive your food intake as larger in the following scenarios.

- The food is served on a small plate: this increases the proportion of the plate occupied by the food, which the brain uses as a cue for how much food it is, so people tend to eat less.
- The plate's color is very different from the food's (high contrast): this makes the food easier to see and thereby appear larger, so people tend to eat less.



The yellow circles are the same size.

Smaller plates are not always better, however. When the plate is obviously too small to hold someone's desired serving size, they will simply serve new food afterwards [2]. There's a limit to how much we can be psychologically tricked.

Food servings are also perceived as larger and better liked when they are put in the center of the plate (rather than on the side) and arranged horizontally instead of vertically.

It's not just the size of your plate and cutlery that matters. In general, larger food packages and tableware result in significantly greater ad libitum energy intakes. Conversely, using smaller dinnerware tends to result in smaller ad libitum serving sizes.

Not everyone seems to be consistently tricked by their dinnerware, as the effects of dinnerware on energy intake are very mixed in research.

Tips

- Serve your food on plates that are only just big enough to hold the food.
- Serve your food on brightly colored plates that contrast strongly with your food.
- Serve your food on the center of the plate and arrange it horizontally.
- Use relatively small cutlery.

Availability

Another cue your brain uses to determine how much to eat is the availability of food. Your brain is constantly estimating the availability of food. Evolutionarily speaking, if there is no food around, there is little point in being hungry. You may have experienced this yourself at a restaurant sometime. Even though the serving size was that of someone who doesn't (even) lift, it still satiated because you knew that was all you were going to get.

More generally, proximity to food increases your appetite. Put a bag of nuts next to someone's computer and it's likely empty at the end of the day. This can make a huge difference in energy intake with little effect on satiety. People in households in which junk food is visible on the kitchen counter have been found to be over 30 pounds heavier than people in households with a clean kitchen counter.

Tip: Don't store food in your kitchen that you don't intend to eat. Simply knowing it's there will increase your appetite and can induce a craving.

Variety & sensory-specificity

The body has evolved to cause you to stop eating when you have consumed enough. What is enough? It depends on what you're eating. If you only have access to fish, you will not eat as much as when you also have access to steak, even though these foods may have the same satiety index. Since they contain different nutrients, it is in the interest of the body to consume both of them.

Physiologically, the mechanism that governs this is sensory-specificity. Your appetite's negative feedback loop is sensory-specific [2]. You do not simply become 'full'. Rather, you become demotivated to consume certain flavors. Changing the portion size of one type of food, such as your starter, has little effect on ad libitum portion sizes of other type of food in the same meal, such as dessert. This is why you always have room for dessert. You may have satiated your appetite for sushi, but you still have an appetite for strawberry ice-cream.

The practical result of this is that the greater the variety of foods in a meal, the greater our ad libitum energy intake of the meal, all else equal, according to a 2021 meta-analysis. As such, reducing the variety of foods in your diet is an effective method to decrease ad libitum energy intake [2]. Since sensory-specificity is particularly relevant during a meal, reducing per-meal variety is particularly effective. Reducing the variety of foods in the diet as a whole may not be needed to curb your appetite.

Research has also found that consuming fruits before a meal induces greater satiety than consuming them afterwards. Fruit is a highly satiating food group, so consuming it before a meal generally reduces total energy intake, but consuming it afterwards, as is traditionally done during a dessert, may partially reawaken your appetite. Anecdotally, it's most effective to end every meal with a flavor you can fully satiate.

Attentional focus

Since your appetite is largely controlled by the brain and not your digestive system, being distracted while eating increases voluntary food intake. When your attention is not on your food, the brain is busy with other things than registering your food intake. As a result, it sends a weaker 'stop eating' signal. Mindless eating is part of the reason why people eat more during social events and when eating in front of the TV or when using their smartphone [3]. Music or ambient noise does not seem to significantly increase ad libitum food intake though.

So focus on your food. What's the point of eating if you're not enjoying it?

The satiation point

“The meal isn’t over when I’m full, the meal is over when I hate myself.”

This joke by comedian Louis C. K. illustrates the effect of your mindset on how much you eat. There’s a difference between eating until you’re no longer hungry, until you’re comfortably full and until you’re completely full. For maximum wellbeing, men typically prefer to eat until they’re very full, whereas women prefer to eat until they’re *almost* full. In general, research supports that men’s eating behaviors are more strongly based on their physical appetite and previous energy intake, whereas women’s appetite is not influenced as much by previous energy intake and probably more strongly by environmental and cognitive factors.

It’s good to realize this and ask yourself where on this spectrum you stand and if you’re still enjoying your food. Is the next bite going to be enjoyable or are you mindlessly stuffing yourself even though your stomach already hurts?

On the other hand, you should also make sure you at least come close to your optimum level of satiety. Trying to train yourself to just eat less doesn’t work [2]. You have a certain appetite and you need to satiate that. Just eating less isn’t a solution, as it doesn’t suppress the fundamental reason you want to eat: hunger. The truly effective solution is to manage your appetite better, such as by eating foods with a lower caloric density and a higher satiety index.

Certain people that researchers call restraint eaters are particularly susceptible to psychological eating rather than eating in line with their physical hunger [2, 3]. Restraint eating shares many traits of eating disorders and is characterized by the following traits:

- A tendency to binge-eat after deviating from the diet, rather than eating less due to fullness.
- High preoccupation with food and consciousness of what you're eating, especially in front of others.
- Restraint eating in front of others while binge-eating alone.
- The experience of guilt after eating.

Restraint eaters will have a much harder time with ad libitum dieting than unrestrained eaters who are more in touch with their intuitive hunger signals. They'll need to spend considerably more time on learning how to eat mindfully, especially in the company of others.

In conclusion, make sure to satiate yourself, but don't eat more than you need to achieve this.

Meal recall

Remembering you had a meal before can reduce intake of a subsequent meal. This is called the meal recall effect. The meal recall effect may be potentiated by pretending the recent meal was bigger: visualizing a recent meal as bigger reduces subsequent snack intake more than just remembering the meal. It's not clear yet how meal recall reduces subsequent energy intake, but the effects are often over 10% and sometimes as large as 40%, meaning they are practically meaningful. Two plausible mechanisms of action are that recalling a meal promotes interoception, our attention to internal satiety cues, and re-activates satiety signals from the former meal, providing a 'sensory shadow' of the meal. These mechanisms are closely related to the effects of perceived food intake and of mindful eating. When our brain registers greater food intake, it does not stimulate as much future food intake.

Eating speed

This one's controversial. A slower eating speed lowers ad libitum energy intake in the majority of research: see our research overview below.

➢ Research overview

The effect of eating rate on satiety

However, the majority of research is also incredibly artificial, which can limit the extent to which we can put it into practice. First, people with a larger appetite generally eat faster, as people typically eat faster when they're hungrier. So a correlation between eating speed and total consumption is to be expected. Ideally, researchers should normalize eating rate relative to a subject's regular eating speed and appetite to assess what the effect of eating fast*er* or slow*er* than normal is.

Second, many studies employ highly artificial measures to set eating speed, such as chewing a fixed number of times or having to eat food to a stopwatch. Under these conditions, it's no surprise that slower eating results in less consumption.
For example, have you ever tried chewing each bite **30** times? When you do this with bread, it's like you can taste the fermentation process starting in your mouth. These aren't exactly conditions for an enjoyable meal and we see that in several studies people complain about the slow eating rate and they report lower meal enjoyment [2, 3]. As such, it may be that people eat less when eating very slowly mostly because they just get sick of eating rather than that they feel fuller.

A 2023 RCT found that instructing obese individuals to chew their foods more thoroughly led to significant fat loss over the 6-month study. However, the extra-chewing group was not just instructed to chew their food more but also "specifically instructed on **how to select foods that require more chews and longer chewing duration, how to prepare food,** how to put down chopsticks after each bite, and how to chew > 30 times per bite." Changing their food selection makes it impossible to determine if it was the chewing per se or just the better food selection that resulted in the greater fat loss.

That said, chewing does have a direct link with satiety independent of palatability. The very act of chewing is registered by the brain as a signal to desensitize food cues and promote satiety. Chewing gum also significantly increases satiety and lowers energy intake [2, 3].

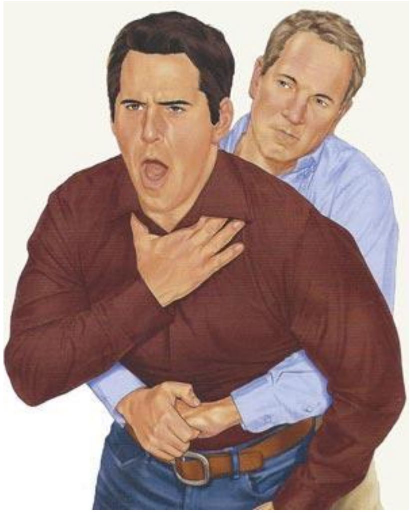
As such, it's advisable to properly chew your food, but it's not necessary or sustainable for most people to chew their food to the point of unpleasantness.

Other measures of controlling eating speed include computer feedback of the participant's eating rate, changing the spoon size and changing the texture of the food. However, these measures all confound the result. Food texture is, as you've learned, a known determinant of the food's satiety index, so mashing the potatoes in a meal, as is done in some research, reduces the food's satiety index, thereby increasing energy intake. Spoon size is, as you've learned, a determinant of the brain's perception of the amount of food, thereby affecting satiety independent of the eating rate. A large spoon makes the meal appear smaller. Computer feedback on your eating rate can affect how mindful you eat. If you have to speed up your eating, you'll likely focus less on its enjoyment and rather focus on just munching it down. That's different than intensely but rapidly enjoying a meal.

Third, many studies don't control for distractions and fluid intake. A slower eating speed tends to be accompanied with more fluid consumption and, as you've learned, drinking more can decrease energy intake and increase satiety. This means that it may not be the eating speed itself but mostly the greater fluid consumption that makes 'slow eaters' eat less.

Fourth, many studies don't control for gender differences. Men tend to eat faster than women and they tend to eat more, so if you lump all data together, you'll find that fast eating people eat more. Some research also finds that eating slower only decreases ad libitum energy intake in men, not women.

Fifth, many studies look at highly processed foods, which are very easy to consume quickly. Eating speed seems to mostly make you eat more of highly energy dense food. This means the effect of eating speed is likely far less pronounced for wholesome food that you have to chew on before you can swallow it, like steak or vegetables. It's easy to gorge down a 400-calorie donut and remain hungry, but if you try to gorge down 4 apples in that same time, you better have someone nearby that knows the Heimlich maneuver.



The Heimlich maneuver (not to be confused with Brokeback Mountain: great movie, different topic).

As a result of these limitations in the literature on eating speed and satiety, self-reported eating speed and eating speed in laboratory conditions don't reliably align with actual free-living eating speed.

In more natural conditions, several studies have found that purposefully eating slower does not affect how much you eat or your satiety. Bite size and the resulting speed at which you eat don't affect how much you eat in total. They just change how long it takes you to consume that amount. Moreover, forcing people to pause intermittently while eating can make them eat *more* and can decrease meal satisfaction.

So eating rate per se may not matter, but mindfulness certainly does and these two strongly correlate. Indeed, eating mindfully and eating slow has only marginal effects on energy intake compared to just eating slowly, suggesting they operate via a similar mechanism. Unfortunately, there's no direct comparison of eating mindfully but not intentionally slowly vs. eating slowly. Regardless, if you're distracted and you're just shoving down your food in front of the TV, you will tend to overeat compared to if you sit down in a relaxed environment and you focus on enjoying your food. Especially if the meal size is unlimited: then being distracted will generally cause you to continue eating for much longer.

Oh, and as for the often-heard factoid that 'it takes 20 minutes for your body to register you're eating and become full', this is nonsense. In fact, few people eat for more than 20 minutes straight when they're at home and if you wait 20 minutes in between rounds of sushi for Menno, you're in for a very long night. The body's registration of food already starts in the mouth.

Palatability

The more you like food, the more you eat of it. In natural/paleo settings, we tend to like food that we need. So it makes sense to eat what we want. This is what our feelings do. They are the messengers of our genes that make us act on their behalf. The survival of our genes is all that matters in evolution's never-ending competition.

Unfortunately for us, what our conscious mind wants and what our genes want is not always the same. And in modern society, what we like to eat is no longer what we need. Needs are no longer on the table.

To really limit your appetite, it can be a good idea to follow a typical bodybuilding diet. Sure, broccoli and white fish aren't very tasty. But sometimes it's most important to just not be hungry. It's all the rage to tell people everyone can get into contest shape while eating ice-cream, but without drugs that likely requires being hungry. Very hungry.

On the bright side, the body learns to like what we eat. Many people have experienced this themselves. You become accustomed to healthy foods, and hyper-sweet beverages end up tasting like poison when you've become used to eating whole foods. And most people don't need to diet below the healthy body fat range anyway.

Social effects

The social situation in which you're eating can greatly influence how much you eat. We've already seen how just the presence of other people can make you overeat, mostly by distracting you. However, the implied social norms of the environment also play a strong role. If your eating company orders salads and low-calorie foods, you likely won't be in the mood to completely stuff yourself, whereas if everyone's stuffing themselves, you'll probably be inclined to join them.

The effect of social norms, even if they're only implied, is so strong that people in restaurants are 4 times as likely to order dessert from a fat waiter as from a normal-weight waiter.

The gender of your company matters as well. Men tend to eat almost twice as much when in the company of women, presumably as a demonstration of their masculinity. Women eat the same amount of food regardless of their company's gender, though they tend to falsely believe that they eat more in the company of men.

Decision fatigue

Note: willpower will be discussed in greater detail in the course topic on adherence.

‘Executive function’ is your ability to intentionally override what your instincts tell you to do, amongst other higher-level brain functions. Not giving in to your hunger requires executive function. Your rational system has to override the decision-making process of your emotional system.

Executive functioning is an intensive process that seems to ‘fatigue’ with use. This decision fatigue is why people generally experience willpower failure at night. Throughout the day, they have accumulated ‘decision fatigue’ by mostly attending to things, often their work, that didn’t result in a lot of immediate pleasure. So when they get home, the brain is yearning for immediate gratification and you are prone to nighttime binging as a form of dietary self-medication.

Overcoming decision fatigue is achieved first and foremost by awareness. Realize that you have a limit in terms of how much attention you can spend on non-pleasurable activities that demand willpower to keep at them and plan in more pleasurable break activities. You’re not a robot. Remember, the first step to becoming strong is to accept that you’re weak.

More generally, take care of your overall wellbeing. There’s no need for comfort food if you’re already comfortable.

Secondly, plan your day so that you do not have to make decisions about your diet when you are in a state of decision fatigue.

- Don’t go shopping when you’re hungry.

- Always have a grocery list with you when you go shopping. Systematically purchase what's on the list and leave. You often only have to be in the outer isles of most supermarkets, since the inner isles are just filled with processed crap.
- Don't do your meal planning after work.

Another solution to decision fatigue is to avoid it in the first place. This largely falls under stress management, which is discussed in the course topic on stress.

Hunger entrainment

As you know, basically every system in the body has a circadian rhythm. Hunger is no exception. Not only that, but food itself sets hunger's circadian rhythm. Insulin has a particularly strong effect on your hunger's circadian rhythm. This means that you become hungry when you normally eat. When you measure someone's hunger hormones, you can see they go up and down in line with someone's habitual eating frequency: people that eat more often experience more but smaller spikes in ghrelin across the day than people that only eat a few meals, who experience fewer but bigger spikes in ghrelin.

This is essentially part of your body's prediction of food availability that we covered in point 3.

Switching your dietary pattern is always difficult, because it disrupts your body's entrained meal pattern. You eat at different times, so you have to cope with hunger while your hunger's circadian rhythm adjusts.

To avoid getting hunger pangs, it is therefore best to maintain relatively strict meal times. You don't have to eat at the exact same times every day though. Menno's general recommendation based on the research and his experience is that 2-hour windows for your meal times are sufficiently consistent to avoid considerably increasing your appetite.

Meal frequency

Conventional wisdom says you should eat 6 meals a day during a weight loss diet to keep your appetite under control. However, there has never been much scientific support for this idea other than some studies by Speechly et al. These were studies lasting only 5 hours, comparing a preload consumed in one or 5 hourly sittings before consuming an ad libitum meal. These studies' short-term nature does not allow for habituation and compensation effects to occur, which we know are extremely significant due to appetite's strong but adaptable circadian rhythm. Notably, the single meal preload groups had less hunger after the test meals. Other short-term research has basically found the opposite: if you eat only breakfast and lunch, you'll eat less at dinner than if you ate 5 meals spread across the day. So what does the weight of the evidence say when we look at satiety across whole days?

A 2010 review concluded that in long-term research, how many meals you eat does not generally affect your appetite across the day as a whole. A 2014 review of prospective cohort studies and controlled trials confirmed this conclusion: changes in eating frequency did not result in body weight changes. In 2015, a systematic review again concluded: your meal frequency does not affect energy intake or body composition change over time.

The lack of an effect of meal frequency on ad libitum energy intake also holds in tightly controlled metabolic ward experiments, such as Taylor & Garrow (2001)'s study comparing a meal frequency of 2 vs. 6. Moreover, in Taguchi et al. (2020), a study comparing a meal frequency of 3 vs. 6 in bulking rowers that had their meals provided to them during the study, appetite ratings didn't differ between the groups.

However, several more recent studies indicate higher meal frequencies may be detrimental for satiety.

- Ohkwara et al. (2013) is one of the most controlled studies we have on the effect of a 3 vs. 6 meal frequency on satiety: a randomized cross-over trial with wash-out in a whole-room calorimeter in healthy men and women. Hunger levels were higher in the 6-meal group. However, during the wash-out periods in between the study days, the subjects were consuming 3 meals a day. As such, it's possible that the negative effect was because of the switch from their regular meal frequency instead of the high meal frequency per se. As per the circadian rhythm topics, irregular eating patterns can increase your appetite regardless of meal frequency.
- Perrigue et al. (2016) found higher hunger levels in a group eating 8 meals a day compared to a group eating 3 meals in free-living conditions with the same macronutrient intakes.
- Based on a cross-sectional literature overview, people tend to eat less when consuming 2 meals instead of 6 meals a day (Varady, 2016).
- A 2016 meta-analysis by Wang et al. found that higher eating frequencies are associated with higher energy intakes yet a lower risk of developing obesity. The lower obesity risk is probably related to having a more structured diet with better food choices, as many people in the general population that eat only 1-2 meals a day simply don't take good care of themselves. This is very different from the fitness population that 'does intermittent fasting'. So this finding isn't particularly relevant for strength trainees but the higher energy intake certainly is undesirable for ad libitum dieting.

In contrast, in diabetics, only consuming breakfast and lunch had a similar effect on satiety hormones as consuming 6 meals a day (Belinova et al., 2017).

In conclusion, ad libitum diets can be successful on practically any meal frequency. However, several studies suggest eating 6 or more meals per day can increase energy intake. Given that eating just 2 meals a day may not allow you to maximize protein balance across the whole day and implement optimal nutrient timing (see previous course topics), it's generally advisable to consume 3-4 meals a day with the occasional situation where 2 or 5 meals fit best into a person's lifestyle. Anecdotally, lower meal frequencies tend to be more convenient when energy intake is low, simply because with a higher meal frequency your serving sizes end up impractically small and satiety after meals will be low. For individuals that have to force-feed when bulking, 6 meals a day may make it easier to get all calories in.

Sleep

Sleep regulates everything, including your appetite, and sleep deprivation is pretty much always bad. 4 Nights of sleeping 4-7 instead of 8 hours a day increase your appetite by 20-22% [2]. In other words, a moderately sleep deprived person on an ad libitum diet that's currently eating at maintenance level can go into a 20% deficit simply by getting more sleep without any change in the diet.

Sleep deprivation can also decrease your metabolism. Together with the increase in appetite, this creates what is known as the 'energy gap': a mismatch between energy balance and appetite that causes you to overeat.

On an ad libitum diet, getting enough sleep and, just as importantly, having high quality sleep, is crucial. Everything related to perfecting your sleep-wake cycle can be found in the corresponding course topic on sleep.

Body fat percentage

Fat mass has a negative feedback loop to your appetite via various mechanisms, including directly by secreting leptin. Leptin is an appetite suppressing hormone. So in general, the less fat mass you have, the greater your appetite. This is most evident at very low body fat percentages. In contest prep, almost everyone notices the increase in appetite. Unfortunately, there's nothing we can do about our appetite increasing as we get leaner. It simply means we have to use more appetite suppressive strategies the leaner you get.

Our increasing appetite is a key reason why it's so difficult to get into contest shape without tracking and restricting your macros directly. Your appetite soars too high and your cognitive resources become too fatigued. In evolutionary terms, it would be very maladaptive for the body to be able to lean down below a healthy body fat percentage while eating as much as it wants.

However, the vast majority of people can get a sixpack on an ad libitum diet, provided they are strict with it of course.

And fortunately, our taste also broadens as our body fat percentage decreases. It's not uncommon for individuals in contest prep to genuinely enjoy many vegetable or zero-calorie based dishes they can't stand when bulking. In the Netherlands, there's a saying "Hunger makes raw beans taste sweet." There's a deep truth in this saying. There's even an acute effect. Our sense of smell improves while fasting and decreases when we're satiated.

One exception to the rule that our appetite decreases as get fatter is morbid obesity. At very high body fat percentages, the relation between leptin and appetite weakens, since obesity can disrupt the hormonal regulation of satiety, resulting in leptin resistance and an increase in your appetite [2].

Lean body mass

Your body's appetite has a strong homeostatic regulation: it not only increases when you're losing fat and decreases when you gain fat, it is also strongly linked with your total lean body mass. The correlation between lean body mass and your appetite is even stronger than the relation between fat mass and your appetite [2, 3].

Most strength trainees have personally experienced this. After you've built up an appreciable amount of muscle mass, you should notice that your appetite has increased considerably and you can no longer live without hunger on the relatively puny amount of food you consumed before your lifting days.

A direct correlation between lean body mass and your appetite makes perfect sense from an evolutionary point of view. The more lean body mass you have, the greater your energy expenditure and so the greater your energy requirement. To maintain homeostasis between energy intake and energy expenditure, a greater appetite is needed to fuel a person with more lean body mass.

The mechanisms that link your lean body mass and appetite are not yet clear. Proposed mechanisms include the detection of energy balance via AMPK and the secretion of myokines like IL-6 and irisin by muscle tissue. Both theoretically and empirically, the current evidence suggests that the relation between your appetite and fat-free mass is strongly mediated by your metabolic rate: see the diagram below.

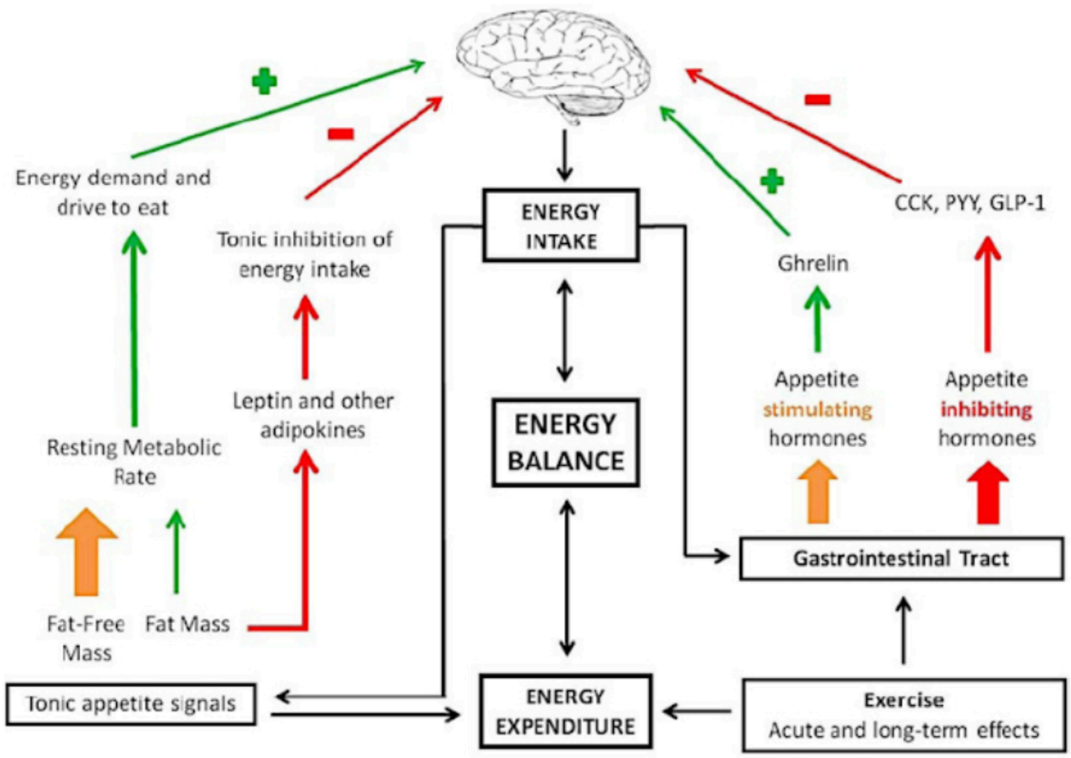


Figure 4 **Formulation of the major influences on appetite control using an energy balance framework**
Green arrows denote processes that stimulate feeding, whereas the red arrows demote processes that inhibit feeding. There is a distinction between tonic and episodic processes, with episodic signals arising as a consequence of food consumption whereas tonic signals arise from body tissues and metabolism. The effect of fat mass on energy intake reflects a lipostatic view of appetite control; leptin is a key mediator of the inhibitory influence of fat on brain mechanisms. The metabolic demand for energy arises from energy requirements generated by the major energy using organs of the body (heart, liver, brain, GI tract, skeletal muscle) and reflected in RMR. The overall strength of the drive for food is the balance between the tonic excitatory and inhibitory processes. It is proposed that, as adipose tissue accumulates in the body, the tonic inhibitory effect of fat on energy intake becomes weaker (due in part to leptin and insulin resistance). Therefore as people become fatter it becomes more difficult to control appetite. Figure originally published in Blundell et al. [60].

Source

Exercise and activity level

Contrary to popular belief, exercise generally does not stimulate your appetite [2]. In fact, exercise, including strength training, is significantly appetite *suppressing*, especially directly post-workout [3, 4, 5]. Exercise engages the sympathetic nervous system and puts you in fight-or-flight mode. The desire to eat is more of a parasympathetic rest-and-digest drive. In addition to our neural state, we can see the appetite suppression somewhat consistently in our appetite-related hormone concentrations, such as 'the hunger hormone' ghrelin. Some of the metabolites produced during and after high-intensity exercise also suppress your hunger. The resulting appetite suppression is formally called exercise-induced anorexia.

Over the day as a whole though, most people end up consuming a similar amount of food regardless of whether they exercise or not, meaning there is no compensatory hunger response to the increased energy expenditure [2, 3]. However, some research finds that exercise reduces the appetite increase during fat loss diets. In cases where exercise does increase your appetite, this is generally offset by greater food-induced satiety and the energy expenditure from the training, so that exercise retains a net negative effect on energy balance. Even if you experience a slight increase in your appetite, you are generally also satiated easier and therefore do not end up in greater energy balance.

When you exercise does not seem to matter for your appetite. A 2024 meta-analysis found no significant difference in ad libitum energy intake between morning and evening workouts. We've compiled a more comprehensive literature overview here for those interested in the specific studies. Research findings are highly mixed without a clear trend in favor of any one optimal time.

The type of workout you do also does not seem to matter much. The greatest appetite suppression seems to be achieved by high-intensity, high-volume exercise, such as a full-body strength training workout. However, research findings are highly mixed with no clear, consistent advantage of any one workout type over another for appetite suppression. We've compiled the relevant literature for you here.

Overall, exercise has an advantage over reducing your energy intake in terms of appetite. Whereas eating less generally increases your appetite, exercising more reduces your energy balance without a corresponding increase in appetite, and possibly even a decrease.

Activity level

Exercise's effect on your appetite also appears to depend on your total daily activity level. Several lines of research have found there is an optimum level of physical activity for maximum appetite suppression. Compared to being sedentary, which is an evolutionarily alien level of activity for humans, a more active lifestyle decreases your appetite (win-win). However, as your activity level increases to very high levels, as commonly researched in high level endurance training, your body tries to offset the increased energy expenditure by stimulating you to consume more food. See the graph below for the relation between activity level and ad libitum energy intake.

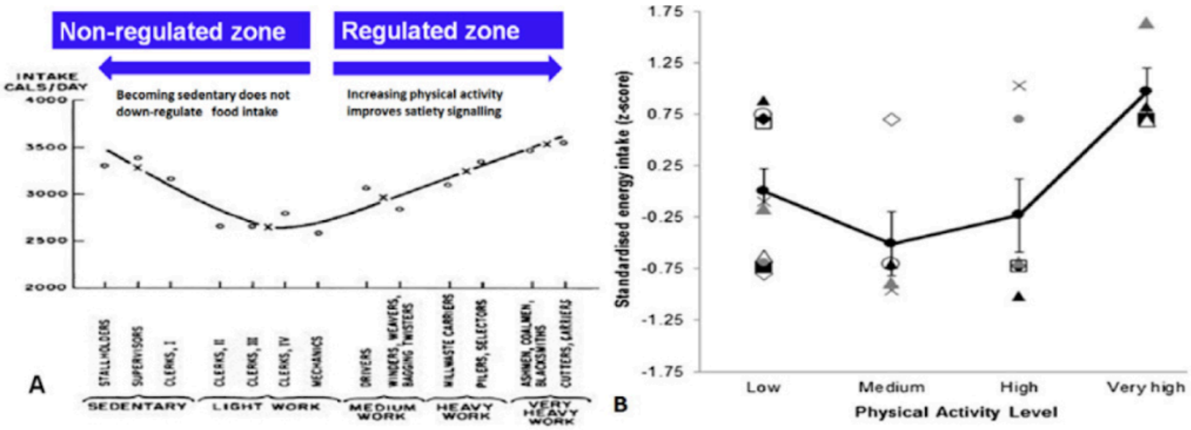


Figure 5 **J-shaped relationship between physical activity level and energy intake**
(**A**) Regulated and non-regulated zones of appetite with varying levels physical activity [120]. Model based on Jean Mayer's study in Bengali jute mill workers [118]. Figure previously published in Blundell [120]. (**B**) Standardized energy intake versus physical activity level from ten cross-sectional studies comparing energy intake between active and inactive individuals. Trend analysis confirmed significant linear ($P < 0.05$) and quadratic ($P < 0.01$) relationships between physical activity level and energy intake. The thick black line indicates the mean of the *z*-scores. Figure previously published in Beaulieu et al. [125].

Most people consume the least amount of energy when they're active but not involved in manual labor or endurance training. Source

You may have experienced that being sedentary doesn't prevent you from getting hungry. In fact, you're probably less hungry in general when you're busier. However, on days with an *extraordinarily* high activity level, you may also notice you have an above average appetite.

Outside the lab

In contrast to what you may expect based on the research, many people do eat a lot of food post-workout, often more than in a regular meal. There are 2 reasons for this.

First, a reason some people experience regular hunger after training is because they always eat a post-workout meal. So the post-workout hunger is entrained in their biorhythm, not stimulated by exercise.

Second, people generally plan to eat larger portion sizes post-workout, so many people eat more despite not being physically hungrier. This seems to be a psychological effect, akin to believing you've earned the food. Even just thinking about exercise can make people snack more. Some research also finds people intuitively eat more in meals *before* exercise, but over the day as a whole they still end up in more negative energy balance.

Third, some people do in fact appear to be 'compensators' to exercise-induced energy expenditure. These people do get hungry from exercising.

Artificial sweeteners

How do artificial sweeteners affect our appetite? It is hypothesized that sweeteners conflict with our sense of recognizing sweet tastes and influence the associative learning component that is related to taste perception, tricking our body into believing it's receiving energy and simultaneously activating all metabolic pathways associated with food digestion and absorption. Supposedly, when the body realizes it is not receiving actual energy, it increases your appetite. Although this hypothesis has some backing in rodent experiments, human data paint a very different picture [2]: most studies do not support that consuming low-calorie sweeteners increases our appetite or sweet taste preferences [4]. In some studies, consumption of low-calorie sweeteners even *improves* diet adherence.

1. Peters et al. (2016) compared the effects of water and water sweetened with zero calorie artificial sweeteners on weight related outcomes over a 12-week weight loss period, followed by a 40-week weight maintenance period (full year study). The participants regularly consumed zero calorie sweeteners. Both groups had to consume a minimum of 720 ml of water with or without sweeteners every day. The water group was not allowed to consume sweeteners. The sweetener group lost more fat and did not regain as much fat after the weight loss diet. In contrast to what you might expect, the sweetener group was less hungry overall during the diet. Most importantly, they had better dietary compliance (evidently).
2. In Blackburn et al. (1997), 163 obese women were randomly assigned to consume or to abstain from aspartame-sweetened foods and beverages during a 16-week weight loss program, a 1-year maintenance program, and a 2-year follow-up period. The sweetener group again lost more fat and was better capable of maintaining the fat loss. Moreover, within the sweetener group, sweetener consumption was positively correlated with weight loss success.

3. Tate et al. (2012) studied the replacement of caloric beverages with either water or diet sodas as a method of weight loss over 6 months. They also compared both to a control group with a similar weight loss program without any specific beverage replacement instruction. The combined beverage replacement groups were more effective than the control group at losing weight (data reanalyzed here), though the direct between-group comparisons did not reach statistical significance. Both the water and diet soda groups achieved significant reductions in energy intake. In contrast to the associative learning hypothesis, the diet soda group had a lower desire to eat sugar-rich desserts: the diet drinks served as a successful replacement of caloric sweet foods with no compensation.
4. Harrold et al. (2024) compared consuming at least 2 glasses of water a day VS at least 2 glasses of diet soda a day in a year-long study with 262 participants. All participants were put on a 3-month weight loss program followed by 9 months of weight maintenance. Other than the water vs soda, their programs were the same. The diet soda group lost significantly more weight. There were no negative effects on their appetite or their bloodwork, including a wide panel of cardiometabolic health tests.

How can low-calorie sweeteners improve fat loss? The most established mechanism is that sweeteners can displace higher-calorie sweet foods. Sweeteners to some extent satiate our sweet tooth, resulting in less preference for and consumption of sweet foods. The clearest beneficial substitution is switching from sugary to diet sodas, but people seem to reduce their intake of sweet foods in general when they consume more sweetened beverages.

Sweeteners, regardless of how artificial they are, do not generally affect our overall sweet taste preferences compared to sugar [2]. Our body does not seem to differentiate between natural sugar or artificial sweeteners in this regard: it only registers taste, not the source thereof.

Some RCTs have also found that drinking no-calorie sweetened beverages with stevia can decrease subjective appetite [2, 3], but the effects of low-calorie sweeteners on appetite and body composition may differ by sweetener. Higgins & Mattes (2019) found that aspartame, rebA (a stevia metabolite) and sucralose did not affect appetite, whereas saccharin increased appetite. However, the sweeteners did not significantly differently affect energy intake, so any difference between sweeteners may be trivial in practice. Indeed, a 2021 meta-analysis by Lee et al. found no significant difference in the acute effects of sweeteners on appetite: they reduced ad libitum energy intake compared to caloric sweeteners and, interestingly, showed an inconsistent trend to improve satiety in isocaloric comparisons.

Maloney et al. (2019) directly studied the effect of low-calorie sweeteners on measures of diet adherence in 2 experiments. In experiment 1, they found that frequent consumers of low-calorie sweeteners were less susceptible to overeating due to cravings than people who didn't consume sweeteners. However, experiment 2 did not support this finding. In experiment 2, they also found that frequent sweetener consumers' diet adherence suffered when sweeteners were unavailable: they overate more due to cravings, experienced more guilt, enjoyed their meals less and felt they had less control over their diet. Together, these findings suggest that consuming low-calorie sweeteners may improve diet adherence, but the effectiveness may vary per person.

Other research finds that artificial sweeteners don't improve adherence or reduce energy intake and there are *some* data suggesting harmful effects of diet sodas. Madjd et al. (2015) randomized overweight and obese women who usually consumed diet beverages into two weight loss groups (followed up in 2018). One group continued their intake of diet beverages while the other group changed to only drinking water. They found that the water group had the greatest decrease in weight. Waist circumference did not decrease more, suggesting the difference may have been due to bloating from the carbonated beverages. However, it's possible that in some individuals, reducing the intake of sweets, even if they're calorie-free, and drinking 'pure, natural, healthy' water instead of artificial sweeteners may psychologically foster the development of more healthy eating habits.

Overall, the totality of evidence to date indicates zero-calorie sweeteners have a neutral effect on our appetite, energy intake and energy balance. They aid fat loss in so far as they replace more caloric foods with similar effects as water. A 2023 meta-analysis of RCTs found that replacing sugar-sweetened beverages with artificially-sweetened beverages resulted in weight loss. The effect of artificially sweetened beverages was the same as that of water. Two 2020 meta-analyses of RCTs [2] found that zero-calorie sweeteners improve weight loss compared to sugar, but compared to water, nothing or placebo, they didn't significantly affect weight loss. The overall trend was slightly in favor for sweeteners in all comparisons though, supporting that the use of sweeteners may be beneficial for dietary adherence as a means to displace energy from (sweet) foods and beverages.

The verdict on sweeteners for weight loss

Low-calorie sweeteners, artificial or natural, are a very useful weight loss tool. They do not normally increase your appetite compared to water and can be a successful replacement for other sweet foods that have many more calories. Not allowing low-calorie sweetener consumption may needlessly increase the difficulty of complying with the diet and increase the likelihood of consuming sweet cheat foods, resulting in poorer diet adherence.

Conclusion

We've now covered how to determine your diet's satiety index and how to manipulate your appetite.

Ad libitum energy balance = f (appetite, diet satiety index)

To put this knowledge into practice, here's a guide on how to make your meal plans more satiating.

➢ Guide

How to: hunger management

Note: Appetite suppressing supplements will be covered in the Supplements course topic.