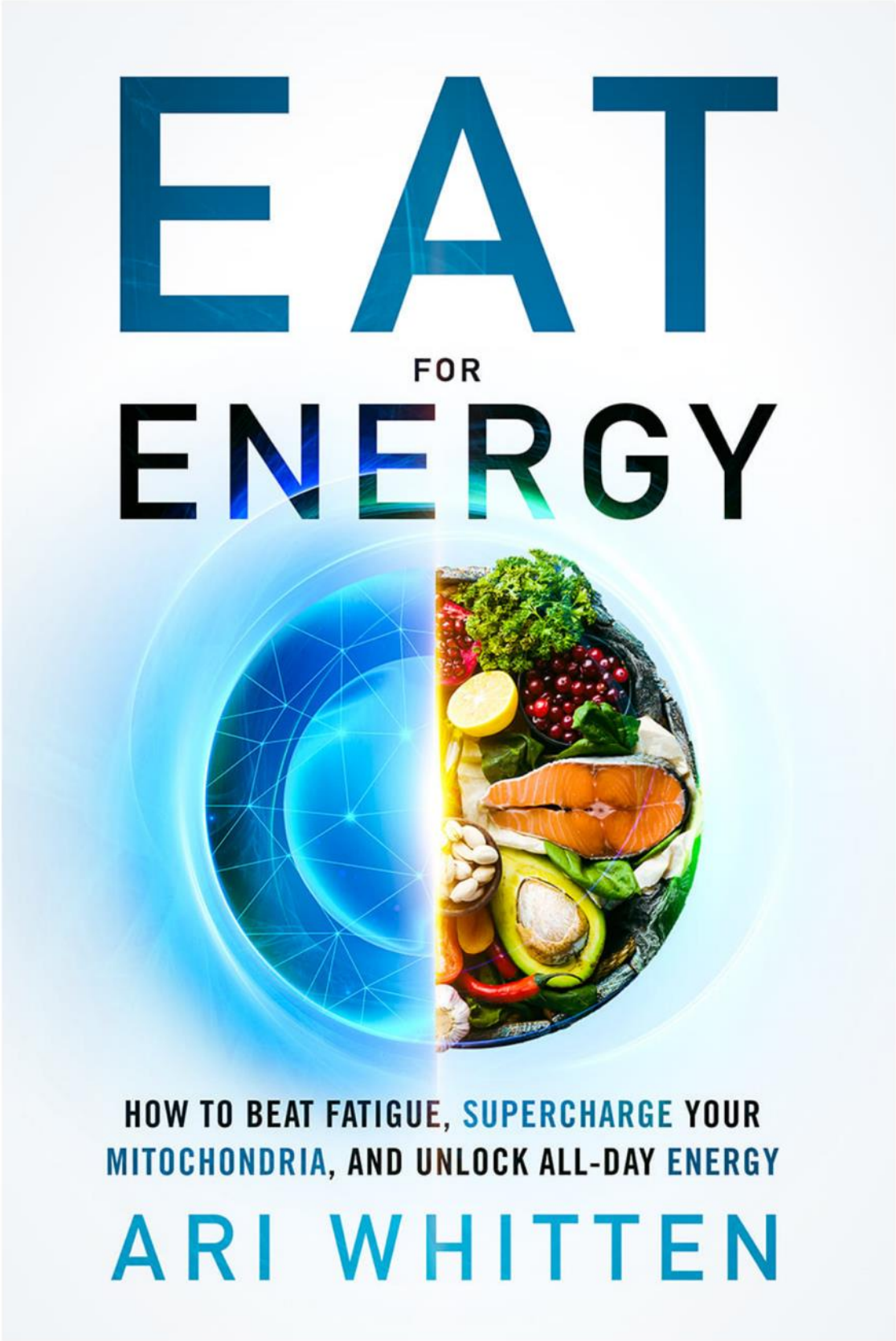

BONUS CHAPTER: Energy Flux

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When you are battling chronic fatigue, being active can seem impossible. Forget exercise, just doing your daily chores can be exhausting. But, while that exhaustion is understandable given that your mitochondria aren't producing the energy you need to get through the day, it's not an excuse to be inactive.

Your activity and energy levels work in a positive feedback loop, where the increase of one increases the other and vice-versa. You can clearly see this in your daily life. Your lack of energy leads you to be inactive, but this inactivity only perpetuates your lack of energy. Reclaiming that youthful vitality requires that you break this vicious cycle and start moving.

The best way for you to visualize this information is with the concept of *energy flux*, the sum of your daily energy expenditure and daily energy intake. When you are sedentary and have dysfunctional mitochondria, your energy expenditure will be lower because your body isn't using a lot of energy. In turn, this lowers your energy intake, since your body needs less energy to support its daily requirements.

Low energy expenditure + low energy intake = low energy flux

High energy expenditure + high energy intake = high energy flux

Our goal with increasing energy flux can be easily expressed as *eat more, move more*. As you become more active and build stronger mitochondria, your energy expenditure increases and your energy intake rises to support it.

Maximizing your energy flux can have profound benefits for your energy levels through a variety of mechanisms, not the least of which being that it allows you to eat more food and ensure you are obtaining adequate nutrition to support your mitochondria and overall health. But it also directly improves mitochondrial function and physical capabilities.

The Flux-Mitochondria Connection

Most energy that you need to survive and function on a daily basis is created within your mitochondria, which is the central reason why mitochondrial health is directly related to energy flux. Your daily energy expenditure is made up of three main components:

- Resting (or basal) metabolic rate (RMR) that represents the amount of energy you need to support essential functions and stay alive.

- Thermic effect of food that represents energy losses during digestion and nutrient metabolism.
- Thermic effect of activity that represents energy requirements for any and all movement.

Other than the thermic effect of food, your mitochondria are the central determinants of energy expenditure because they are what keep you alive and power your movement. Roughly two-thirds of your resting metabolic rate (the energy needed to keep you alive) is explained by your mitochondria's ability to utilize oxygen, and most signals that work to alter energy expenditure do so through effects on mitochondrial function.

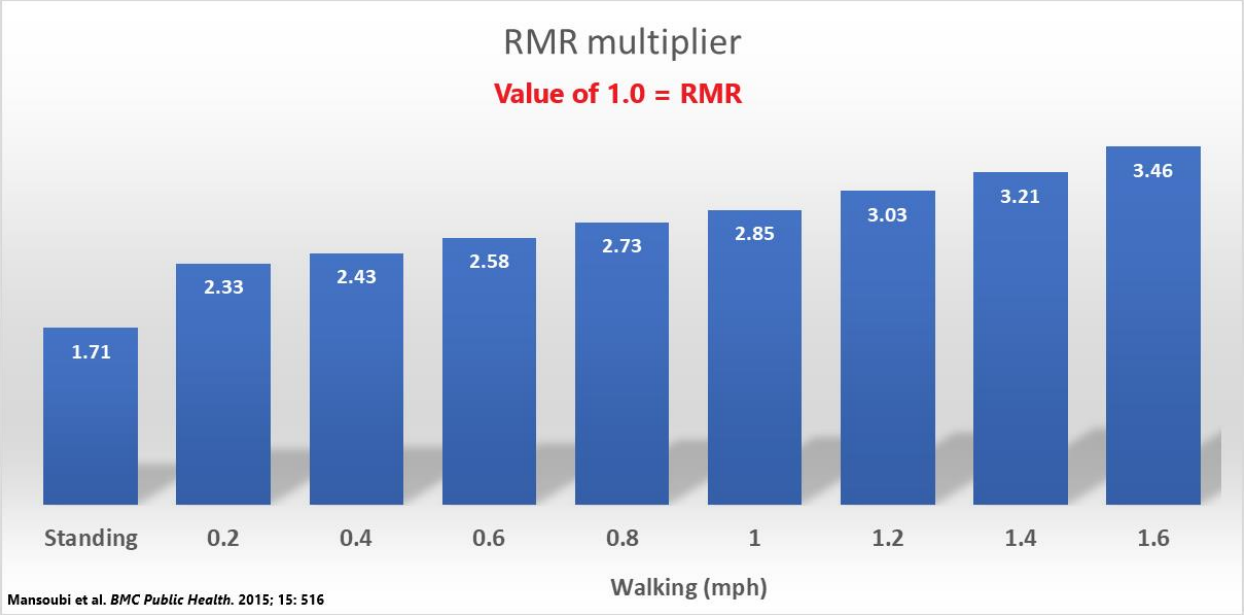
One of the most well-established benefits of regular physical activity is enhanced mitochondrial function. Exercise is a stressor on the body that tells our mitochondria they need to adapt, causing compensatory mechanisms to activate:

- **Mitochondrial fission/fusion**. Damaged parts of mitochondria are removed and healthy parts fuse together.
- **Mitophagy**. Irreparably damaged mitochondria are eliminated.
- **Mitochondrial biogenesis**. Creation of new mitochondria.

This is why **several studies have shown that maintaining a high energy flux by virtue of being regularly active and eating to support this greater activity increases RMR.**

You needn't get on a treadmill and slave away with dedicated exercise, either. One of the best ways to increase physical activity energy expenditure is through being more active in your leisure time (called non-exercise activity thermogenesis, or NEAT).

For example, one study calculated that if someone with obesity were as leisurely active as the average normal-weight person, they would burn an extra 350 calories per day from all the extra small activities that add up throughout the day. Even just standing burns 1.7 times as many calories than if you were laying around all day.



Exercise and Chronic Fatigue

Being more active when you struggle to finish daily chores may seem counter-intuitive, but it's incredibly therapeutic for long-term vitality. In a systematic review of 26 different drug and lifestyle interventions for those with fibromyalgia fatigue, regular exercise was the only "strong" recommendation to help alleviate symptoms.

Specifically, the researchers noted improved physical function and wellbeing with exercise programs in which aerobic exercise was performed for 20 minutes once per day or 10 minutes twice per day, 2–3 days a week, and resistance training was performed 2–3 days a week with at least 8 repetitions per exercise.

Another systematic review by the Cochrane Collaboration made similar observations when evaluating 8 randomized controlled trials in adults with chronic fatigue syndrome — regular graded exercise training significantly lessened fatigue, improved physical function, and increased quality of life.

None of this means going to a gym and maximally exerting yourself. That's a good way to make yourself bedridden with fatigue and malaise for days afterwards. The interventions used in these studies were no more than walking, cycling, swimming, and engaging in "individualized pleasurable activities". Basically, find some activity you enjoy doing regularly, and do it.

Whatever you end up doing for exercise, be it aerobics or resistance training, it's up to you to figure out where to start. No one knows your exercise tolerance better than you do, and the goal

is to gradually increase the duration and intensity of your activity as time passes and your fitness improves.

Also, keep in mind that some discomfort during and after exercise is normal and a good sign that you are doing enough, but complete exhaustion the days following is a sign to scale things back. The goal is gradual improvement, not worsening your fatigue.

There are many types of gentle (low-impact) exercise that you can partake in:

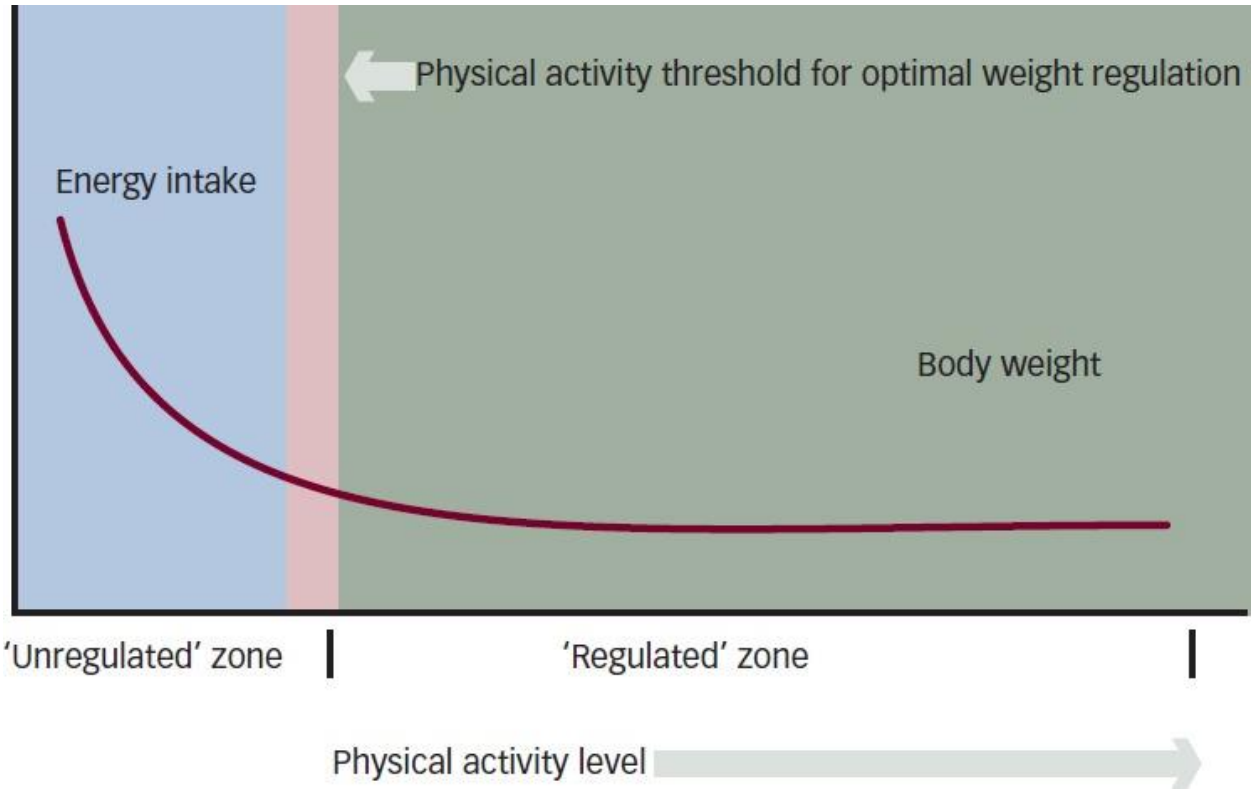
- Swimming
- Yoga
- Qigong
- Pilates
- Cycling
- Walking
- Gardening

If you opt to hit the weights, then it's best to center your lifting routine around using machines, resistance bands, and your own body weight (calisthenics). These are generally safer forms of resistance training than using free weights, while still allowing for that progressive overload you need to gradually build bigger and stronger muscles.

Added Benefit: Appetite Regulation

Another lesser known benefit of maintaining a higher energy flux relates to body composition and maintaining a lean physique, which is important for overall energy levels as discussed in *Eat For Energy*. While the fat loss benefits of greater energy expenditure are straight-forward, a high energy flux also improves appetite regulation.

We've known since at least 1956 that people who are more active have an appetite better coupled to their requirements — sedentary workers eat more food than their body needs while workers with physically demanding jobs eat an appropriate amount of food. People's appetite was linked to their needs only as energy flux increased after a certain point. Below this threshold, in what was termed the *"unregulated zone"*, food intake increased as energy expenditure decreased.



Appetite is better regulated with a high energy flux!

This is probably because regular exercise heightens the brain's sensitivity to leptin and insulin, two powerful satiety hormones, and enhances satiety signals coming from the gut. We have a lot of data showing that regular physical activity, thereby contributing to a higher energy flux, helps slash hunger and promote fat loss.

In one study, researchers locked some men in a metabolic ward for one week and had them exercise or remain sedentary with unlimited access to food. A metabolic ward is really cool because it allows the researchers to have complete control over the participants' lives. It's like a studio apartment set up to precisely measure everything the researchers are interested in.

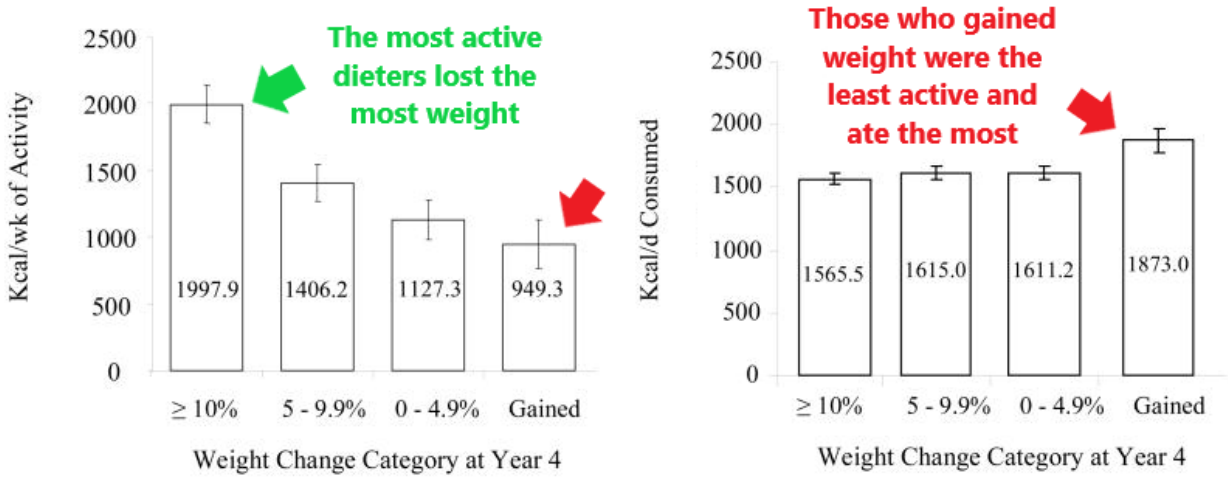
In this case, the researchers precisely measured everything that each of the men ate, and they found that they ate the same amount of calories when active and when sedentary — despite burning 30% less calories when sedentary! The men actually had greater preoccupation with thoughts of food and urges to eat when sedentary.

In another study, some college guys completed three test sessions where they remained sedentary all day, went for a 25-minute walk 7 times per day, or went for a 25-minute jog 7 times per day, culminating in a delicious dinner buffet that the researchers used to determine the effects of these different activity levels on food intake.

Just like with the last study, there was no difference in how much food the men ate regardless of how much activity they performed earlier in the day, meaning that being sedentary led to overeating relative to energy requirements.

Other research has followed groups of people for years and observed how their weight relates to their activity levels. One of these studies found that people with low levels of physical activity experienced the largest gains in fat mass of all individuals over 1 year, resulting in a 2- to 4-fold higher risk of gaining clinically significant amounts of fat mass.

Another of these studies followed people participating in a weight loss intervention for 4 years. The most successful dieters were those who were the most active, while the least successful were the least active and ate the most food.



Wadden et al. *Obesity (Silver Spring)*. 2011; 19(10): 1987-98

Overall, it shouldn't be any surprise that the people who are best able to maintain significant amounts of weight loss do so by maintaining a higher energy flux. Basically, maintaining a high energy flux is key to successful fat loss and fat loss maintenance in three ways:

1) Maintains overall higher energy expenditure by maintaining muscle mass, thermic effect of food, and a higher RMR. A person in high energy flux will expend more energy in PA and need to eat more food to cover their energy needs.

2) Heightens sensitivity to appetite control through its impact on appetite-regulatory hormones and food preferences. Thus, the desire to over-consume food is dampened and the total energy intake modified.

3) Allows for more appropriate energy intake or volume of food consumed, thus, reducing the probability of overeating. Sedentary individuals (e.g., in low energy flux) can have

> daily energy needs that are so low that it is easy to consume more food (e.g., calories) than needed in our current obesogenic environment.

As a group of researchers from the Nutrition and Metabolic Fitness Laboratory of Colorado State University sum this all up nicely:

> *"One promising approach to tackle the elevated hunger and reduced energy expenditure that occur with weight loss is the establishment of a high energy flux state in which a high throughput of calories occurs, owing to high daily energy expenditure and matching energy intake… energy intake may be more accurately regulated to match energy expenditure in a high flux state."*

Summary

Energy flux is the sum of your daily energy expenditure and intake. It's a key determinant of one's energy levels and health primarily through its benefits on mitochondrial function — increasing mitochondrial fusion and fission reactions, mitophagy, and biogenesis. In essence, maintaining a high state of energy flux strengthens mitochondria.

The most straight-forward way to increase energy flux is by being more active, either through dedicated exercise or leisure activity. As someone with chronic fatigue, it is critically important to find an activity that you enjoy performing regularly without overdoing it. Even just an extra 10–20 minutes per day of physical activity has been shown in clinical research to reduce fatigue and improve physical function.

Additionally, for those of you who are attempting to lose body fat, a high energy flux not only intrinsically means that you are burning more calories each and every day, but also that you'll have a far more regulated appetite. That means less hunger and greater satiety from eating, which can make the dieting process feel effortless.