MENNO HENSELMANS
Science to master your physique

LIFESTYLE, STRESS & SLEEP

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Contents

Circadian rhythm management & routine........ 4
Stress........ 5
- Stress and your training........ 8
- Stress and your diet........ 10
- Measuring stress........ 12
- Stress management........ 14

Sleep........ 15
- Why do we sleep?........ 15
  - Safety........ 16
  - Thermoregulation........ 16
  - Physical restoration........ 16
  - Early brain development........ 17
  - Learning and memory........ 17
  - Synaptic homeostasis........ 17
- The effects of sleep deprivation........ 18
- How much sleep do we need?........ 23
- Measuring sleep quality........ 26
  - Polysomnography........ 27
  - Subjective sleep quality & sleep debt........ 30
  - Sleep trackers........ 32
- How to optimize your sleep quality........ 34
- Alcohol........ 35

Activity level........ 36
- Habits........ 36
- Implementation intentions........ 37
- Sitting vs. standing........ 37

We are moving away from the cliché that fitness is a lifestyle. More and more emphasis is placed on living your life 'normally'. As long as you go to the gym 3 times a week for an hour and count your macros, the rest supposedly doesn't matter. This may be considered an improvement from the days of eating broccoli, rice and dry chicken 6 times a day, but as is often the case for cultural change, the pendulum has swung too far in the other direction. The cliché that fitness is a lifestyle is still true, hard work pays off and everything matters. So in this week we're going to cover the lifestyle aspects that are often considered as 'extras' that in fact are highly significant for your progress in the gym.

Circadian rhythm management & routine

As you learned in the course topic on intermittent fasting, a consistent meal frequency is beneficial for your health, body composition and mental wellbeing. So the 'eat every 3 hours' wasn't all wrong. It's better than 'eat whenever you want'. A stable biorhythm with fixed meal times, caffeine use, light exposure and exercise can also improve cognitive functioning, physical performance and overall wellbeing even when it doesn't increase sleep duration. In fact, sleep regularity is a stronger predictor of all-cause mortality than total sleep duration in some research.

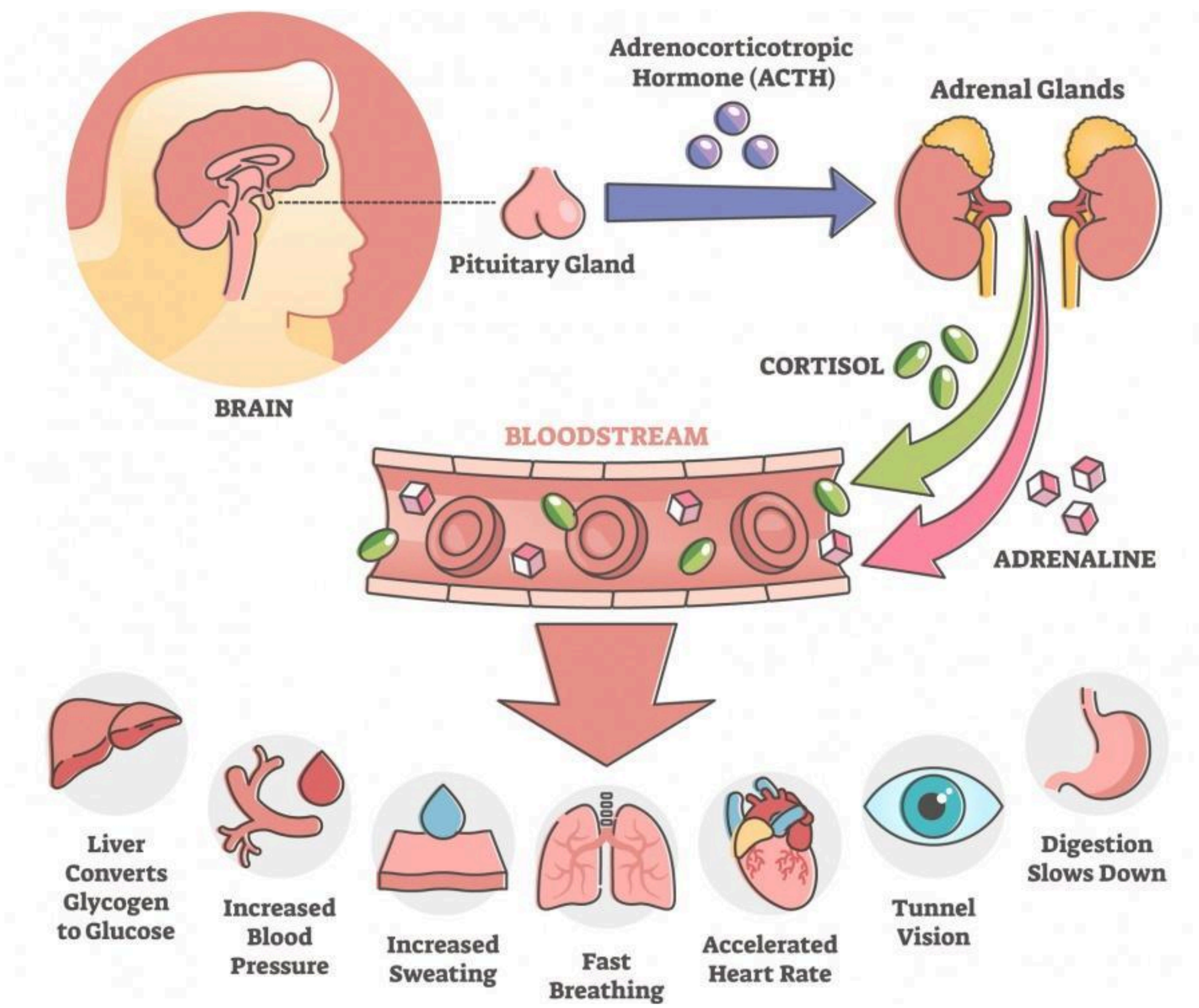
In general, successful bodybuilders have learned to harness the power of routine. Routine is efficient. People say it's obsessive, but the complete opposite is often true. Routine allows you to forget your diet. You don't have to think about what to eat, when to eat, when to train. Consistency is key and routine is the key to consistency. When your lifestyle runs on auto-pilot, success is just a matter of time.

➢ Lecture [optional]

Stress

Stress

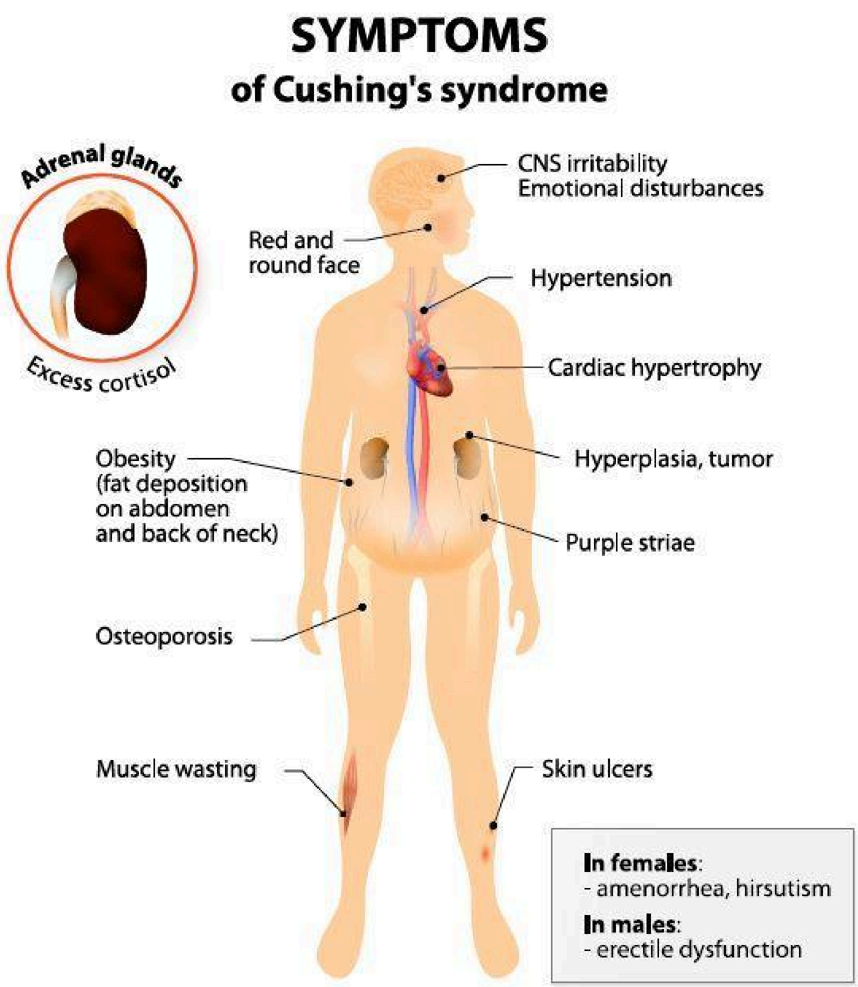
The stress-response is an ancient survival mechanism. Vertebrates have had it for hundreds of millions of years. The stress-response is chiefly characterized by cortisol, 'the stress hormone', together with adrenalin and other hormones from the adrenal gland that put our bodies in fight-or-flight mode (sympathetic nervous system dominance). When a bear leaps at you from behind a bush, the stress-response acutely mobilizes glucose, fatty acids and amino acids as energy for our muscles. Our heart and breathing rates increase to supply the muscles with blood and oxygen. Our blood vessels constrict and blood is directed away from the skin so that we don't bleed out when wounded. Our eyes focus. Our sensitivity to pain from physical stressors decreases, a phenomenon called stress-induced analgesia, and inflammation is suppressed to reduce illness symptoms. Stress mentally and physically energizes us to take action. See the image below for an overview of the stress-response.



The stress-response.

Occasional stress can be healthy for the body to stay strong and active: ‘eustress’ is hermetic. The stress-response is also great for combat or running for your life. However, our bodies don’t distinguish very well between an attacking lion and a job interview or public speaking, so in modern life most stress is psychological rather than physical. The problem with psychological life stressors is that they’re often chronic and the stress-response evolved to be episodic, not chronic. The stress-response prioritizes immediate action over long-term maintenance of the body. Being in fight-or-flight mode (sympathetic nervous system dominance) all the time doesn’t leave enough room for rest-and-digest mode (parasympathetic nervous system dominance).

Stress slows down our immune and digestive systems and suppresses reproduction, growth, repair and digestion. As a result, we age faster and we accumulate oxidative stress. [When you live a very stressful life, you die sooner] [2, 3, 4]. [Chronically elevated cortisol production can also disrupt the hypothalamic-pituitary axis]. Since your hormones are the messenger systems of many different systems in your body, disruptions in the hormonal system can affect virtually all parts of your body. The effects are evident in high-stress conditions such as burnout and Cushing's syndrome, illustrated below.



Symptoms of Cushing's syndrome, characterized by chronically high cortisol levels.

[Source]

Stress and your training

Hollander et al. have performed an unpublished study of the effect of academic stress in students. In their study, the highest stress group gained less than half the leg press strength of the lowest stress group. The highest stress group also gained body fat and lost thigh circumference, whereas the lowest stress group lost body fat and gained thigh circumference. This study included both men and women and the researchers found no sex-specific effects.

A similar study by Bartholomew et al. (2008) also found a significant difference in strength development when comparing high vs. low academically stressed students over a 12-week strength training program. This study also found a greater percentage change in thigh circumference in the low stress group compared to the high stress group, but this did not reach statistical significance: see the data below. Limb circumference is a notoriously inaccurate measure of muscle size due to the confounding effects of muscle swelling, regional muscle growth, water retention, fat mass and changes in fat distribution.

Table 1. Pre and post data for bench press, squat, arm, and thigh size.

	Bench 1	Bench 2	%Change
Low stress	129.73 (55.88)	148.67 (60.34)	14.60
High stress	127.16 (62.57)	142.02 (67.57)	11.68
	Squat 1	Squat 2	
Low stress	177.66 (67.70)	222.19 (71.98)	25.06
High stress	173.88 (86.54)	212.84 (93.58)	22.41
	Arm size 1	Arm size 2	
Low stress	15.04 (7.25)	18.00 (6.97)	19.68
High stress	14.36 (6.75)	16.82 (6.78)	17.13
	Thigh size 1	Thigh size 2	
Low stress	33.70 (7.83)	34.16 (8.93)	1.36
High stress	32.45 (8.85)	32.50 (9.27)	0.15

Values are means (standard deviation).

Stress also impairs our recovery capacity. One study found that the difference between high and low stress made a twofold difference in the rate of recovery after strength training. In other words, experiencing high psychological stress can double the time you need to recover from your workouts. Another study found that the risk of injury roughly doubled during periods of high academic stress in division 1 football players. Changes in academic stress even seemed to be more strongly related to injury risk than changes in training stress. In medical communities it has long been known that stress considerably impairs the healing time of various pathologies, including that of simple wounds [2]. Some research also suggests we can roughly monitor the training status of athletes based on their testosterone-to-cortisol ratio (TC ratio). Stress elevates cortisol, which antagonizes testosterone, so stress predictably lowers the TC ratio.

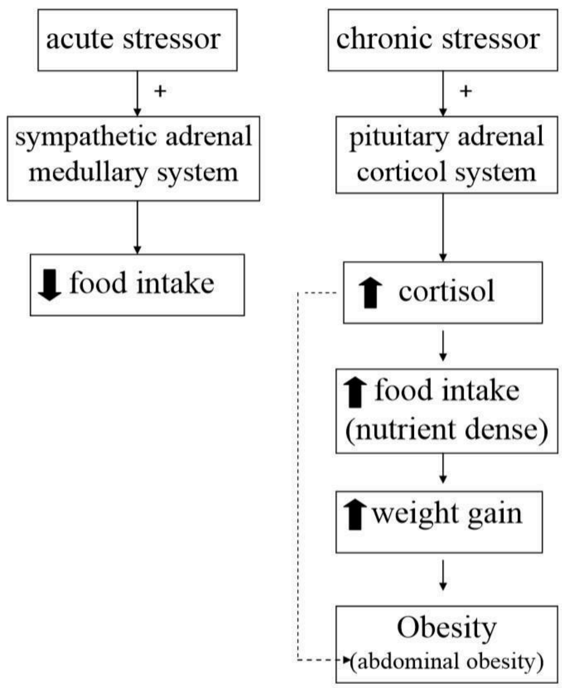
As such, a good training program should take into account the stress experienced by the individual. Stressed trainees need a lower training frequency or training volume to be able to recover from their training. In practice, it's easier to modify the training volume than the training frequency, as this would require changing the entire program structure every time someone's lifestyle changed. In the Periodization module, we'll discuss autoregulation strategies to manage training volume.

Stress and your diet

A little stress is good for diet adherence. If you're stressed, that means you're busy, your attention is not on eating and you're probably not hungry. Psychological stress has potent appetite-suppressing effects: when you're extremely stressed, it's outright difficult to get any food down. These effects of stress are primarily caused by the sympathetic nervous system and the hormones adrenaline and noradrenaline, which make your body go into 'fight or flight mode'.

However, high amounts of stress, especially chronic stress, can paradoxically increase your desire for food, an effect mediated by cortisol, the stress hormone. Although stress tends to acutely decrease physical hunger, it can still induce emotional eating. Excess stress can make you want to self-medicate on aptly named comfort foods: stress induces comfort eating [2, 3]. The worse people feel, the more comfort food they eat. People vary significantly in how vulnerable they are to self-medicate on food, based on how much cortisol they secrete. Women generally rely more on comfort food to counteract unhappiness and stress than men [2, 3].

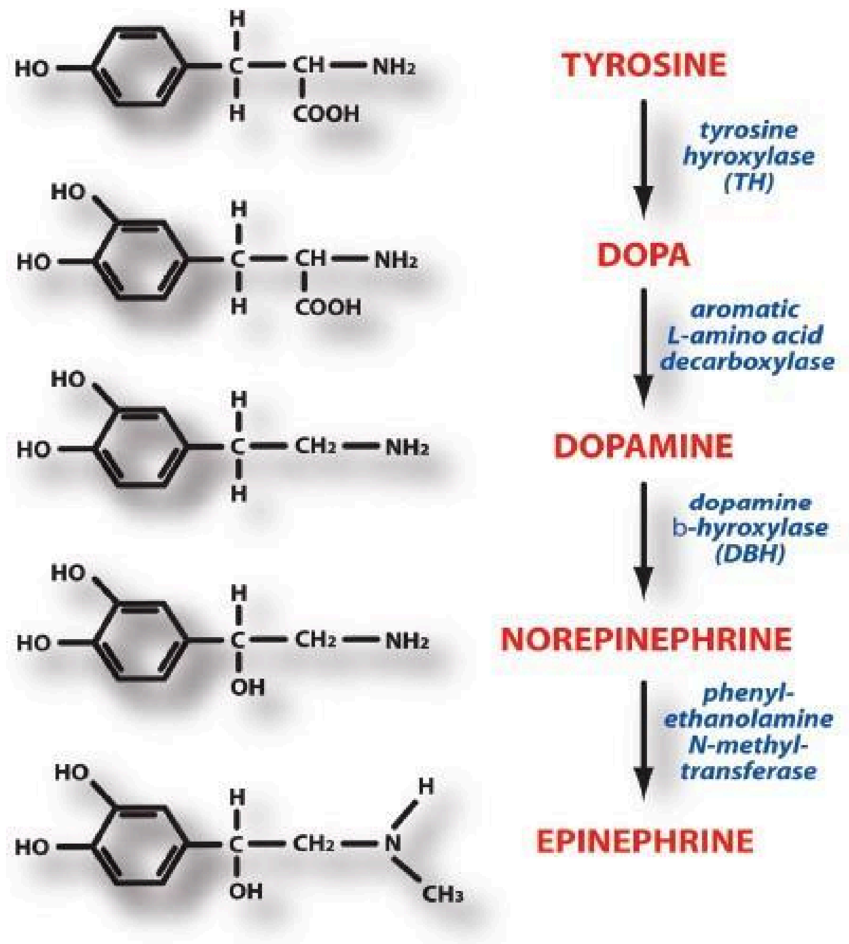
Problematically, comfort eating doesn't help much. Theoretically, it could, because food stimulates the production of feel-good opioids. These opioids inhibit the HPA axis, thus causing a negative feedback loop for cortisol secretion. Food in general stimulates parasympathetic dominance in your nervous system: rest-and-digest mode. However, the pleasurable sensation of eating is very brief and you simply don't derive that much biochemical reward from food compared to important life events, so consuming food does very little to combat chronic stress. Moreover, unhealthy foods do not appear to be more effective than healthy foods to reduce stress [2, 3]. Nevertheless, most people choose comfort foods high in carbs and fat and not protein, so it's very easy overeat on them. Stress-induced comfort eating can quickly lead to fat gain. The schema below summarizes how acute and chronic/high stress differ in their effect on *ad libitum* energy intake and general eating behavior.



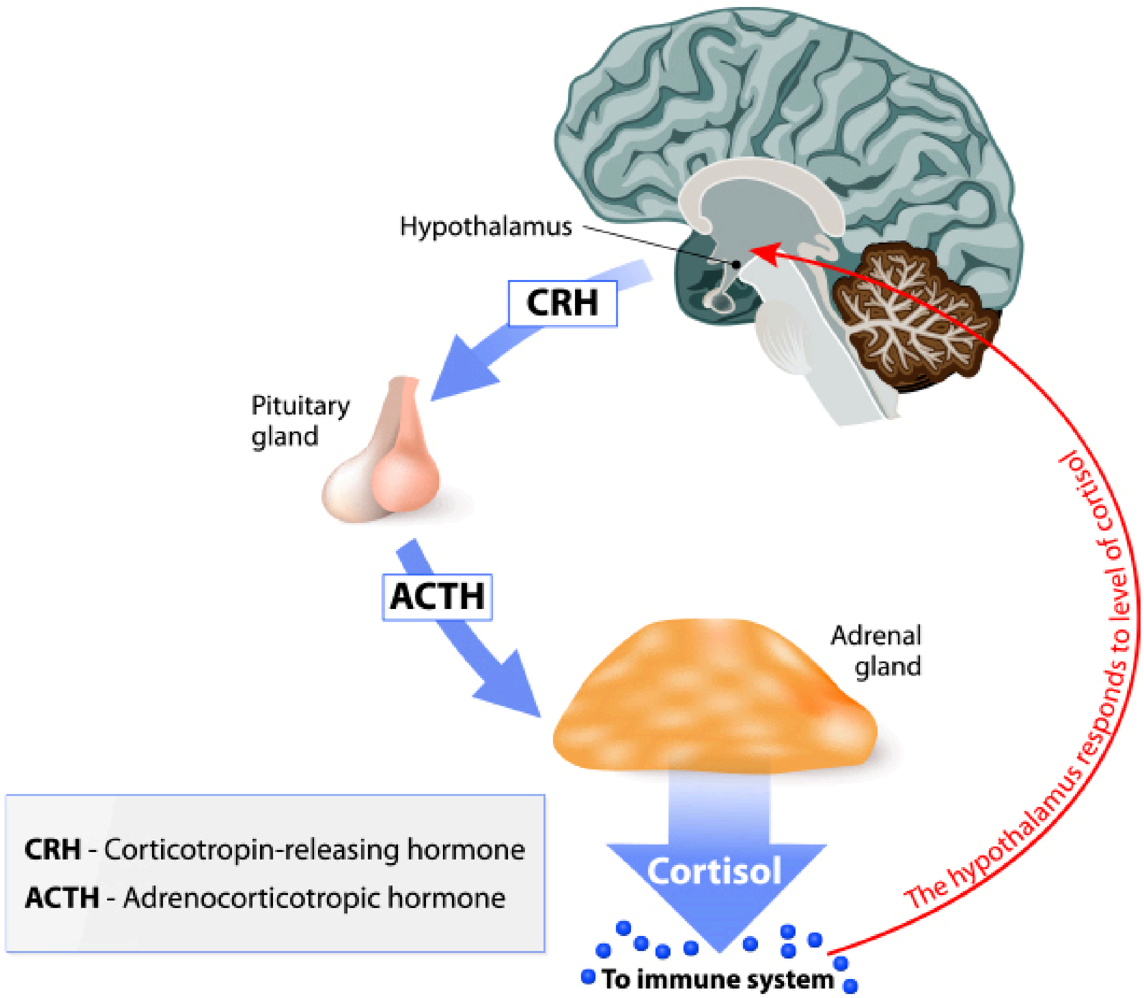
In addition to stimulating snacking, chronic stress can also reduce energy expenditure. Kiecolt-Glaser et al. (2015) found that even a single stressful life event the day before a test meal of 930 kcal decreased TEF by 104 kcal. Insulin secretion also increased and fat oxidation was impaired.

Measuring stress

The stress response is characterized by activation of the sympathetic 'fight or flight' nervous system and the release of adrenal hormones (catecholamines, illustrated below) and glucocorticoids, chiefly cortisol.



The catecholamine production pathway. [Source]



Cortisol production occurs in the adrenal gland and is initiated by the hypothalamus in the brain.

However, the biological stress response only moderately correlates with our subjective perception of stress [2]. As Lupien et al. (2022) concluded: “when people complain of being ‘very stressed out’, what they may really be alluding to is an experience of psychological distress that is related to poor emotion regulation capacities. It is thus possible that the construct of stress used by people to discuss their internal state of 'stress' is quite different than the construct of stress measured in animal and human laboratories using biomarkers of 'stress'.” We seem to be poorly capable of differentiating between biological stress, anxiety and unhappiness in general. These data suggest that we should be skeptical of self-reported stress levels as a marker of biological stress. Stress at the psychological level may not necessarily suppress neuromuscular recovery when it's not associated with a biological stress response and suppression of the parasympathetic nervous system. However, even purely subjective, psychological stress is still very real in the mind of the person experiencing it and can still interfere with dietary adherence, training motivation and sleep quality, which could in turn interfere with muscular recovery. Thus, asking yourself how stressed you feel is still very useful. Just be aware that people can radically differ in how emotionally affected they are by a given biological stress response.

Stress management

Since stress management is such an important and underrated aspect of the fitness lifestyle, here's a full guide on stress management.

➢ Guide

Stress management

Sleep

To accurately describe sleep, we first need to differentiate between a ‘sleep’ state and a ‘wakeful’ state. If you’ve ever seen someone sleepwalking, you’ll appreciate it’s not quite as simple as having your eyes open versus having your eyes closed. Sleepwalking individuals don’t always just walk around like a zombie. They can do many things you’d normally have to be awake for, including at times even having a conversation. This is part of the reason why we rely on several objective measures (brain waves, eye movement, etc.) to assess whether someone is actually asleep. These markers indicate when someone is in a sleep state, as well as what stage of sleep someone may be in at any given time. Wakefulness describes the daily recurring state in which an organism engages in coherent cognitive and behavioral responses to the external world. Researchers then define sleep under normal conditions as “a reversible behavioral state of perceptual disengagement from and unresponsiveness to the environment.”

➢ Lecture [optional]

Sleep

Why do we sleep?

This is still a matter of extensive debate among scientists.

There are several reasonable theories. The idea that sleep is just ‘downtime’ is about as outdated as the idea that the earth is flat. Instead, sleep appears to be an ‘altered state’ that is necessary for most mammals to survive.

Safety

Since the night is dark and full of terrors, having to curl up someplace safe may improve your chances of survival compared to staying up and wandering into something with better night vision and bigger claws. If sleep was just for recovery, you'd expect us to sleep equally well at any time, but instead we sleep most soundly and most easily at regular hours when it's dark and during the daytime, it's relatively difficult to fall asleep.

However, the need for safety can't explain why we lose consciousness during sleep, leaving us extraordinarily vulnerable. Furthermore, we know that sleep is not merely a passive state of 'removal' from the environment, but a basic behavioral drive we actively seek to engage in, like hunger and sex.

Thermoregulation

Sleeping somewhere warm while being physically inactive conserves energy. Since at night humans can't do many useful things anyway, or at least we couldn't before we learned how to make fires and artificial light, it may have been more evolutionarily advantageous to 'hibernate' at night than to stay up.

Physical restoration

Sleep seems to be closely linked to the functioning of our immune system. Indeed, sleep is an important modulator of endocrine function (incl. hormone production). For example, stage N3 (slow-wave sleep) has been associated with increases in growth hormone production. Athletes spend a larger proportion of total sleep in a slow-wave state, while older populations show decreasing time spent in a slow-wave state, in line with their physical recovery requirements.

Early brain development

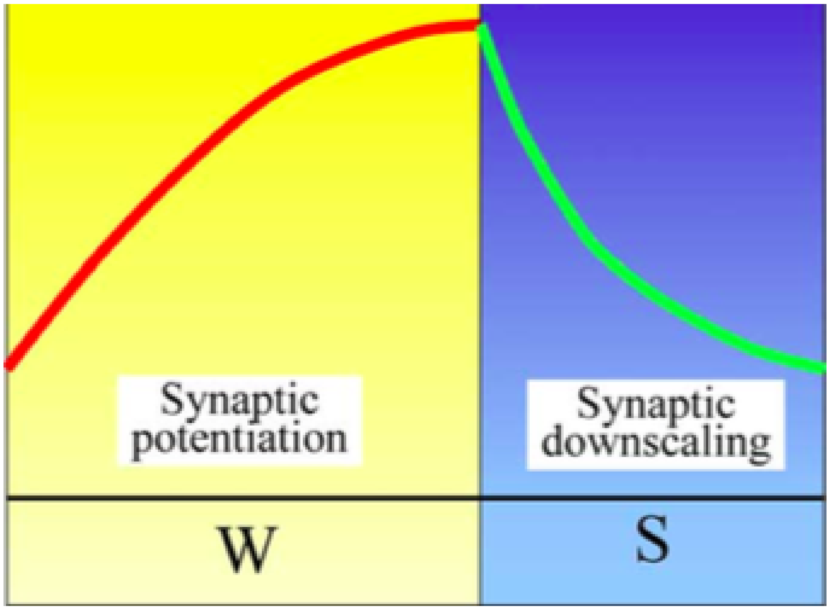
Sleep may be important for early brain development. Newborns sleep substantially more hours than adults. Interestingly, about 50% time spent asleep shortly after birth is spent in REM sleep phases (detailed later), but the significance of this is still debated, because there is no significant association between REM sleep and relative neonatal brain mass. While REM sleep is not related to brain mass development, it may play a role in the neural development of different brain structures during this stage of life, like the visual system.

Learning and memory

Tasks and skills are better learned and memorized if you sleep in between sessions. Sleep is an important part of memory reprocessing. We can even see that the brain activity patterns that correspond with practiced movements are repeated at night. So after a squat workout, at night your motor cortex is again practicing the squat.

Synaptic homeostasis

One of the most prevalent theories, which is also consistent with multiple empirical findings, suggests that sleep allows our brain to reestablish synaptic and cellular homeostasis. Synapses are essentially the connections between our nerve cells. When we are in a wakeful state during the day, our brain is challenged by plastic changes that need to take place in order to process the information we acquire through our sensory organs. According to the theory, there is a net increase in synaptic strength during this time. This waking plasticity is energetically costly and saturates our capacity to learn. During sleep, synaptic strength is downscaled to maintain homeostasis (see image below).



Source

The effects of sleep deprivation

Regardless of why we sleep, the importance of sleep has been firmly established by research. Sleep deprivation is arguably even more of a hindrance to strength training than chronic stress, because it makes you more vulnerable to stress and on top of that it has tons of negative effects on basically every system in your body. While simplistic, the analogy of recharging your batteries or recovery mode is fitting with respect to your body composition and strength training. Without spending hundreds of words on why you should be getting enough sleep, here's a summary of the negative effects of sleep deprivation.

1. Hugely unfavorable alterations in nutrient partitioning.

Sleep deprivation directly reduces our rates of (myofibrillar) protein synthesis [2] with the potential for major effects on our body composition.

In a randomized cross-over trial by Nedeltcheva et al. (2010), sleeping ~5 hours compared to ~7.5 hours a day in the researchers' lab decreased the proportion of weight lost as fat by 55% and increased the loss of fat-free mass by 60%(!) Sleep deprivation decreased fat loss from 1.4 kg to 0.6 kg and increased fat-free mass loss from 1.5 kg to 2.4 kg.

Jabekk et al. (2020) compared body composition changes in a group strength training twice a week without changing their sleep practices compared to a group training and also optimizing their sleep quality. Over 10 weeks, the sleep-optimized group lost 1.8 kg fat compared to a 0.8 kg *gain* in the regular sleeping group. Despite being in energy deficit rather than surplus, the sleep optimizers also gained 1.7 kg lean body mass instead of 1.3 kg. The difference in muscle growth didn't reach statistical significance though.

An RCT by Wang et al. (2018) found even worse effects of sleep deprivation during an 8-week weight loss diet. Sleeping 40 fewer minutes during the midweek caused the percentage of lean mass from total weight loss to shift from a mere ~20% lean mass loss to **~80%** lean mass loss. However, the ratios reported are in the paper incongruent with the absolute values. The authors told us it's due to the difference between the average ratio and the ratio of the averages, but we've been unable to replicate these calculations.

A study by Borba et al. (2024) did not find significant negative effects in people sleeping ~1.5 h less per day than recommended on strength-endurance or body composition. However, this was a small (n = 24), just-over 5-week study that used circumference and skinfold measures to estimate muscle mass and size. Moreover, there was no randomization or sleep restriction intervention: the researchers looked at people who naturally slept less or more. This confounds the results, as some people naturally need less sleep than others. Moreover, excess sleep is associated with depression and many other lifestyle and personality factors. On top of that, the training was done with elastic bands and neither group gained a significant amount of total muscle mass, so even if there were differences between the groups, this study would have been underpowered to detect them.

Longer-term research has found that fixing your sleep (with melatonin supplementation in this study) can make you gain pounds of muscle and lose pounds of fat *without exercise or dieting* over the course of a year. In contrast, reductions in sleep quality have been associated with negative body recomposition.

In conclusion, most studies support that common levels of sleep deprivation can significantly impair our gains. Even worse, fat gain during sleep restriction tends to go preferentially towards the abdominal area, promoting an unhealthier body fat distribution.

2. Increased appetite [2, 3, 4]. Sleeping ~6 hours instead of 8 hours a day for just 4 days can increase your *ad libitum* energy intake by 20%. Conversely, catching up on your sleep debt for 2 weeks can reduce your ad libitum energy intake by a several hundred Calories.

3. A 2-8% decreased basal metabolic rate with often no change in total energy expenditure, despite a generally higher activity level [2, 3, 4].

4. Deregulated hormone production. Sleeping 5 hours a night can decrease testosterone production by ~13% and a night without sleep can impair testosterone production by 24%.

Growth hormone production may also decrease with extreme sleep deprivation, but during mild sleep deprivation, the body compensates for lack of nighttime growth hormone production with increased daytime production.

Cortisol production generally stays roughly the same, though it can become more variable: some research finds decreased cortisol levels in serum, whereas other research [2] finds increased spikes. The differences are likely attributable to the different measurements times, as lack of sleep will disrupt cortisol's biorhythm.

5. Increased insulin resistance, both acutely and chronically. As a result, sleep deprivation increases systemic inflammation levels.

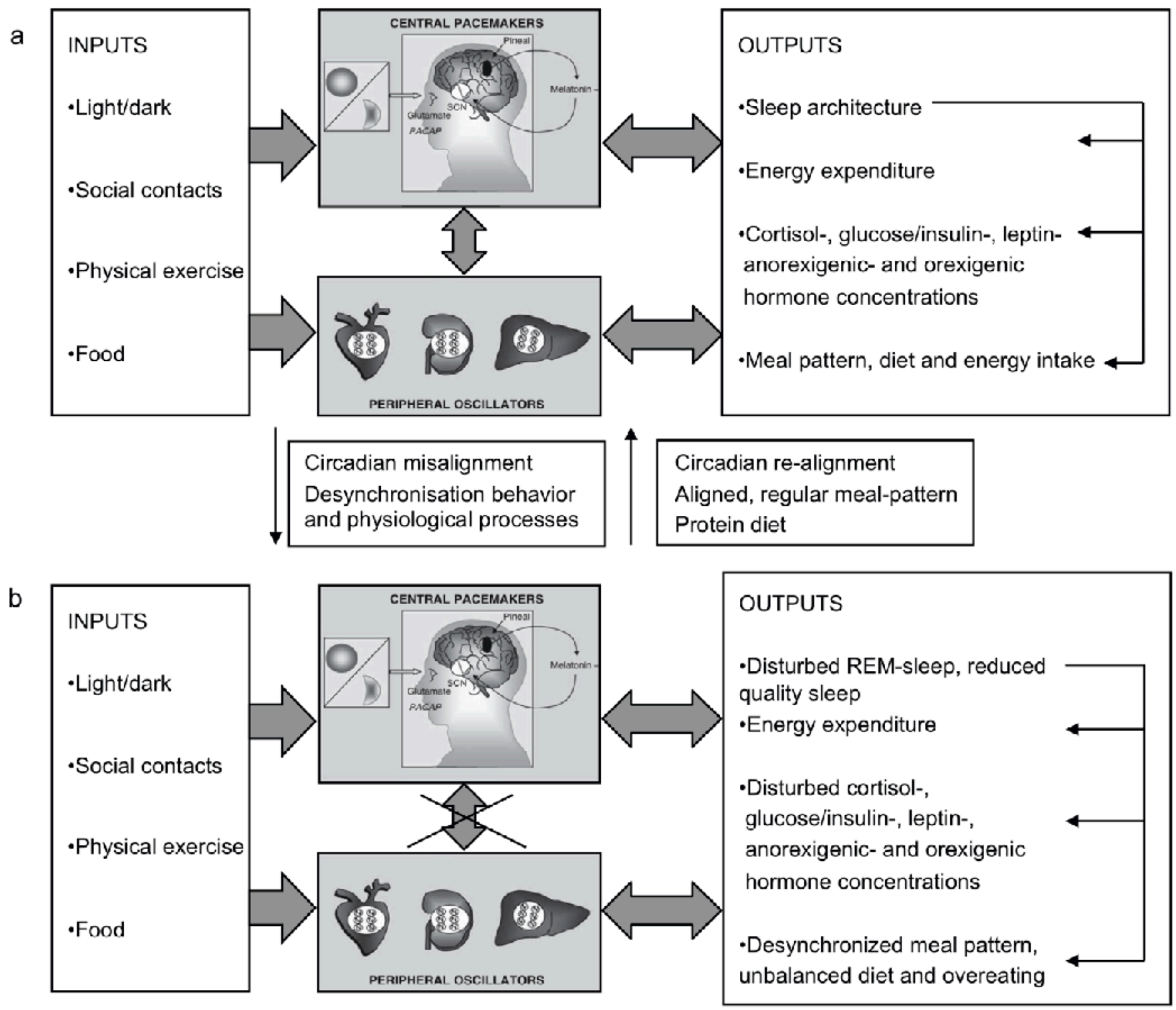
6. Decreased wellbeing.

7. Decreased cognitive functioning, including impaired self-control [2, 3] ('intelligence'). Pretty much anything you brain can do, it does so worse when you haven't slept well.

8. Impaired exercise performance [2, 3]. Most of the effect seems to be from underrecovery and reduced willpower and motivation after sleep deprivation, not impaired contractile functioning, as a 2022 meta-analysis found strength is only 3% lower in studies after sleep deprivation. For example, one study found that national level Olympic weightlifters did not have any impairment of their lifting performance after **24** hours of sleep deprivation, despite obviously *feeling* far worse. Sleep deprivation increases training distress and perceived effort far more than it objectively reduces strength or work capacity. You can thus compensate for feeling fatigued to a large extent with willpower and motivation, though recovery afterwards may be an issue. It may also help to lift a bit earlier than normal after sleep

deprivation, as the impairment of exercise performance increases the longer you are awake.

Here's a schematic overview of the effects of sleep quality on the human body (from Gonnissen's thesis in 2013).



Partly after M. Garaulet et al. 2010

In line with all the negative effects of sleep deprivation, [helping people sleep more increases how much control they have over their diet](). [Virtually every lifestyle]()

intervention to improve sleep quality, including napping, improves athletic performance and recovery; however, nothing works as well as simply sleeping more at night.

In conclusion, sleep is incredibly important. Many people underestimate the impact of sleep because sleep deprivation does not have much negative effect on acute strength levels [2]. However, physical performance starts to deteriorate after a few days of insufficient sleep in athletes. The long-term effects of your sleep duration are more important than many aspects of your training and nutrition program design. Sleep is among the top of the hierarchy of importance for our physique, health and performance.

How much sleep do we need?

The benefits of enough high-quality sleep are clear, but how much is enough? Average sleep duration varies drastically between mammals; elephants sleep as little as 3-4 hours while the daily sleep time of bats can reach up to 20 hours. Sleep recommendations for human adults age 18 to 60 are 7-9 hours per night [2]. Sleeping less than 7 hours is associated with many of the negative health outcomes mentioned above. Sleeping more than 9 hours on a consistent basis (unless you are in sleep debt or underage) may be associated with health risks as well, though this is probably due to the association with depression and boredom. People that sleep 10+ hours a day evidently don't have many preoccupations in life. It is physiologically implausible that sleep itself directly impairs your health in any way.

To maximize the beneficial effects of sleep as a strength trainee, it's advisable to aim for 9 hours of sleep per night, after having corrected your sleep debt which may require even more sleeping for a period.

The research consensus is that 7.5-8 hours is sufficient, but this is primarily for sedentary individuals. Since most of the above systems are influenced by resistance training, it is plausible that sleep requirements increase as a result of intense training. Indeed, meta-analytic research confirms the duration of sleep increases after exercise, though the effect is only 10 minutes on average.

Anecdotally, it also seems that sleep requirements increase as our body fat percentage decreases. This may be due to an overall lower tolerance for stress rather than a physically increased need for more sleep per se.

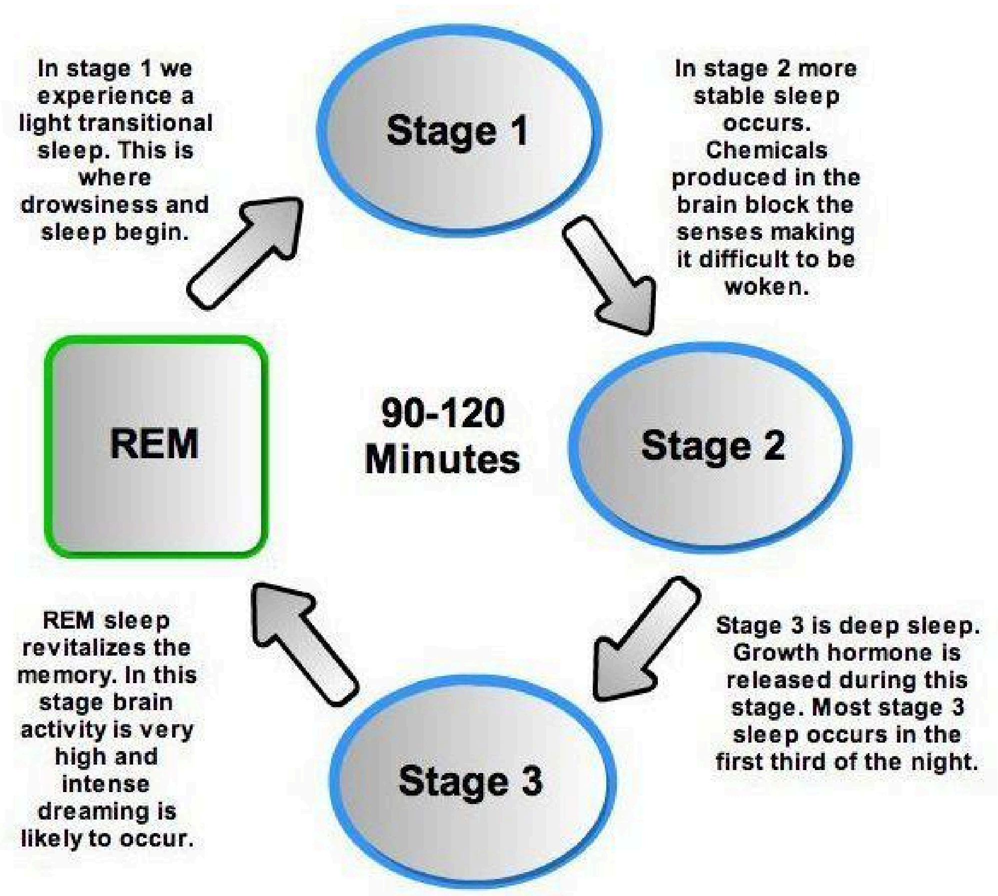
Then again, strength training improves sleep quality [2, 3, 4, 5, 6, 7, 8]. The idea that hard workouts disrupt sleep quality seems to be mostly nocebo or an effect of consumed pre-workout caffeine, as there is no relation between sleep quality and workout intensiveness in elite athletes [2]. Even late-night workouts improve rather than impair sleep quality according to a 2019 meta-analysis [2], though vigorous exercise literally right before going to bed can in some cases reduce sleep efficiency and make it a bit harder to fall asleep, especially if you're not used to it yet [2]. Some research even finds afternoon workouts may improve sleep duration compared to morning workouts, but most research finds the timing of exercise is trivial for sleep quality. Strength training is in fact an effective treatment for a wide range of sleep disorders, including sleep apnea. So 8 hours of high quality sleep may still be sufficient. If you wake up naturally and refreshed after 8 hours of sleep, there's no need to force yourself to sleep longer. More generally, if you wake up naturally at the same time every day and feel completely refreshed, you have probably slept enough regardless of sleep duration. Some people, especially older individuals, can get by with less than 8 hours of sleep.

Note that continuous sleep means you don’t wake for any extended period other than to go to the bathroom in a semi-comatose state.

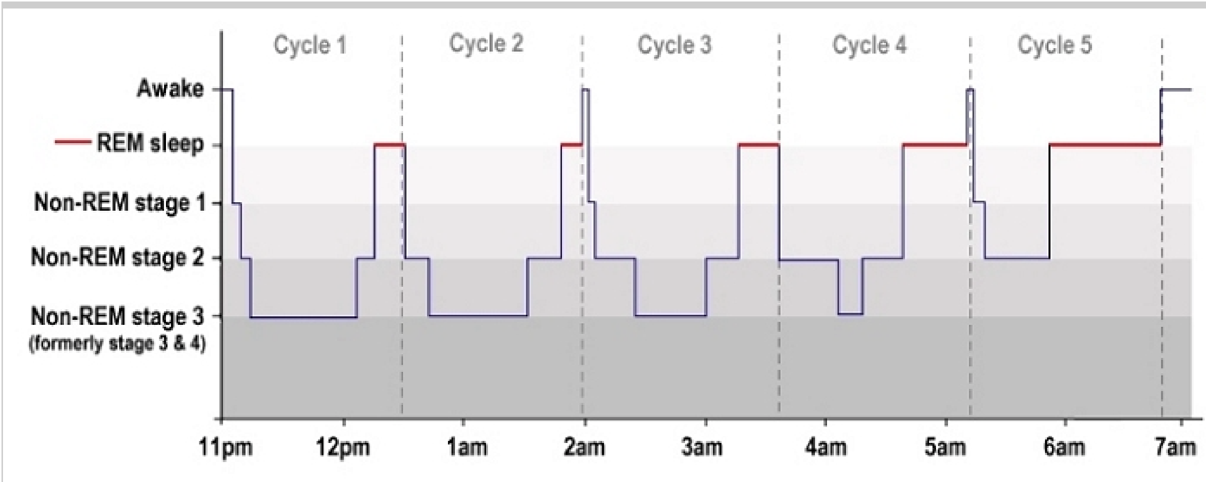
If you’re sleep deprived, naps are also highly effective to counteract physical as well as mental fatigue acutely. A big advantage of 20-30 minute ‘power naps’ is that they don’t cause sleep inertia, so you can wake up refreshed instead of groggy and wondering which planet you’re on. However, unless you nap for a full sleep cycle of ~90 minutes, you won’t enter deep sleep, so naps are no replacement for night-time sleep. Naps are essentially pit stops for a quick patch-up, not full repair. Naps can also decrease sleep quality, especially if you nap later in the day, so it’s generally best to limit your naps to the late morning or early afternoon.

Measuring sleep quality

While it sounds counterintuitive, our brain is quite active during sleep and its activity changes systematically across different stages of sleep. Sleep can be categorized into 3 stages (N1-N3) of non-Rapid Eye Movement (REM) sleep in addition to REM sleep. During a full night's sleep, we generally go through 5 cycles of the 3 sleep stages, each ending in a REM phase. Anyone above the age of 2 generally experiences 4-6 REM phases during each night of sleep. As you get older, the amount of time spent in stage N3 (deep sleep) generally decreases.



The different sleep stages 101.



Prototypical display of a night's sleep with 5 sleep cycles (approximately 90 minutes each).

For adults, sleep ordinarily starts at a 'shallow depth' (N1), getting deeper over time and eventually leading to slow-wave sleep (deep-sleep, N3). Most bodily functions are reduced during this stage; both your heart and breathing rates are reduced and your pupils narrow, signaling a more parasympathetic tone.

REM sleep is very different. While muscular tone (tension) is essentially reduced to zero, your heart rate, breathing rate, blood pressure and cerebral blow flood all rise.

REM sleep is also the stage where dreams ~~come true~~ take place. Nerve cell activity can exceed a waking state, and your eyes move in a rapid manner (hence the name) underneath your eyelids corresponding to the content of your dream.

Polysomnography

Polysomnography ('several sleep graphs') has cemented its place as the most reliable method of quantifying sleep stages. This method utilizes sensors applied to different areas of the body to measure small electrical currents that are emitted by all mammals and birds. Four markers are subsequently analyzed, each stage corresponding with a different level of activity for each measurement:

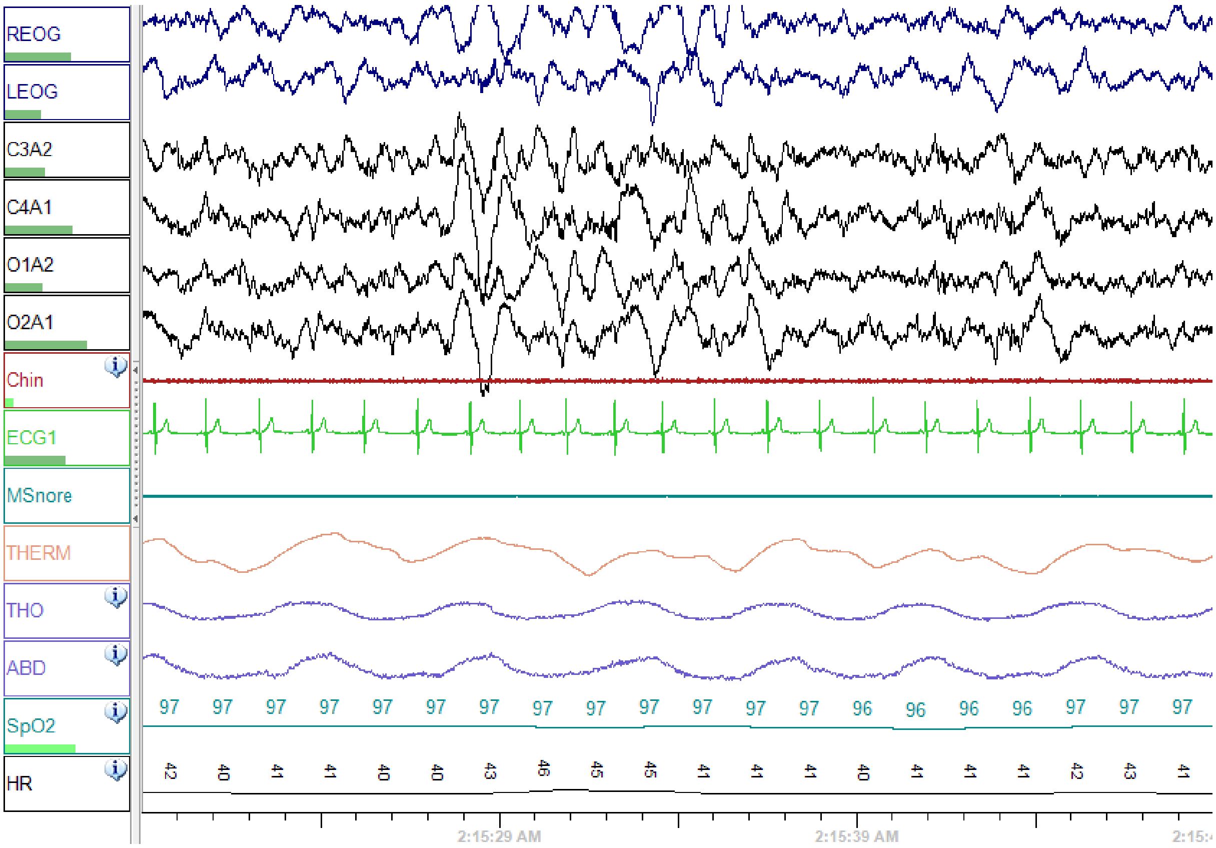
a) Brain wave recording, medically termed an electroencephalogram (EEG)

b) Eye movement recording, medically termed an electrooculogram (EOG)

c) Muscle activity recording, medically termed an electromyogram (EMG)

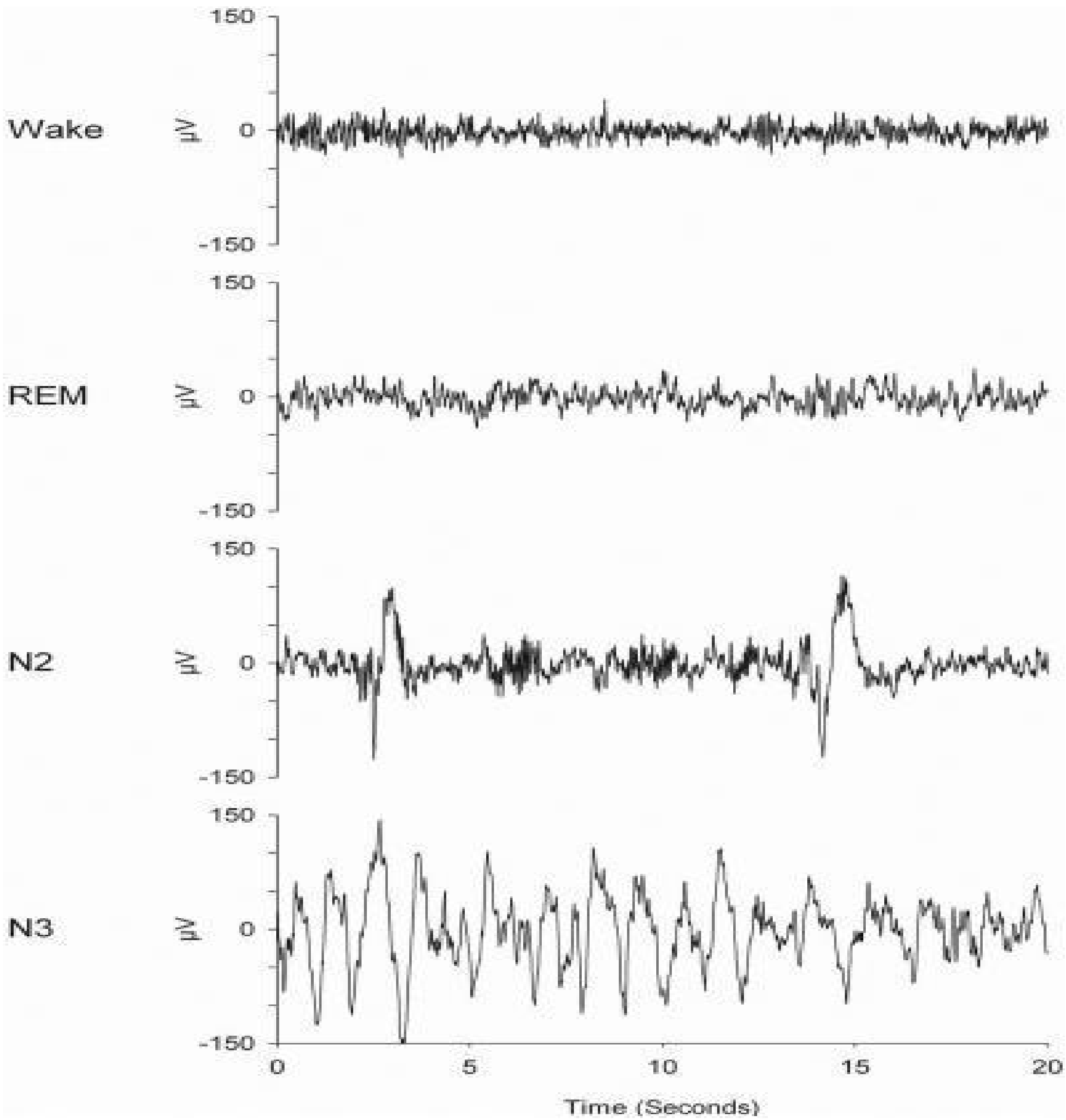
d) Heart rate recording, medically termed an electrocardiogram (ECG)

A polysomnogram displays waves in multiple rows, with each distinct wave corresponding with any one of the markers mentioned above.



Polysomnography of stage N3 sleep (source).

In the diagram below, you can see how each stage of sleep corresponds with a different EEG reading. Each sleep stage emits a different frequency and intensity of EEG waves, which helps distinguish one stage from another.



EEG Data: Dominant brain waves during different stages of sleep [(source)]

Since most people don't have access to polysomnography outside of a laboratory, we have to measure sleep quality with more basic tools.

Subjective sleep quality & sleep debt

One simple and practical option is going by subjective sleep quality. We have some idea of how good we slept and this correlates with objective sleep quality. Subjective sleep quality overall correlates quite well with objective sleep quality in healthy people. A good reference is that healthy sleep entails falling asleep within 30 minutes, not being awake for more than 20 minutes at night and, if you can measure it somehow, having a sleep efficiency of at least 85%. If you want to go into great detail, you can use the Pittsburgh Sleep Quality Index (PSQI; see questionnaire at the end).

However, there are a few things you need to watch out for when basing your sleep quality on a subjective assessment. First, we typically overestimate our sleep duration by about half an hour a day.

Second, many people also associate dreaming with deep sleep. In fact, remembering your dreams is not a sign of good sleep quality. While some people naturally remember their dreams more effectively than others, the fact you remember your dreams suggests you spent a relatively large amount of time in REM sleep instead of deep sleep and, more importantly, that you were conscious enough to process and store the dreams in memory. After a night of perfect sleep, in theory you'd wake up without any awareness of what happened the past ~8 hours.

Third, subjective sleep quality is dissociated from objective sleep quality during high levels of sleep deprivation. Researchers generally divide between acute sleep loss (one continuous, extended waking episode) and chronic sleep loss (insufficient sleep across multiple days). Acute sleep deprivation only appears to affect measures of attention or wakefulness, leaving more complex mental tasks unharmed.

When sleep loss becomes chronic, the detrimental effects we discussed earlier start manifesting. In a pair of experiments by the same research group, subjects were either restricted to 6 or fewer hours of sleep per night for 14 days, or were completely deprived from sleep for 3 consecutive nights. In both scenarios, chronic and total sleep deprivation proved to be detrimental for cognitive performance across several measures. Basically, the greater their sleep debt became, the dumber they became. There was a nearly linear dose-response relationship between additional waking time and decreased cognitive functioning: each hour of additional sleep debt continued to decrease brain functioning almost as much as the hour before. When the sleep debt reached the same level, the subjects who were chronically sleeping for 6 or fewer hours per night showed similar performance detriments as those who were up for 2 nights straight(!)

When you're chronically sleep deprived, you don't notice just how bad the effects are. Our brains are very sensitive to changes but not to absolute amounts. As a result, we adapt to more subtle, chronic sleep deprivation and mainly feel acute sleep deprivation, even though objectively the detrimental effects are opposite to our feelings in severity. Individuals who were allowed to sleep for 6 or fewer hours per night initially reported increased levels of subjective sleepiness, as expected. However, additional sleep restriction caused only a trivial increase to those levels of sleepiness and eventually hit a plateau. On the other hand, individuals who were not allowed to sleep at all reported considerably greater levels of sleepiness with no indication of adaptation. This suggests that while objective measures of mental performance continue to decrease nearly linearly and are not compensated, there seems to be a mental plateau for how bad you feel during chronic partial sleep deprivation. Basically, once you've hit 'zombie mode' and you think you've hit cognitive rock bottom in terms of how tired you are, you're wrong. Things keep going downhill as long as you don't increase how much sleep you're getting. While you may feel 'normal' or adapted to chronically sleeping fewer hours per night, you are sinking deeper and deeper into a cognitive hole.

After a certain length of chronic sleep restriction, you may suffer permanent brain damage. In animal research we see that there's a certain level of sleep debt that you cannot recover from. Even after catching up sleep subjectively, the lifetime risk of neural diseases and memory impairments persists.

With the above 3 caveats in mind, subjective sleep quality is for most people all they need to monitor.

Sleep trackers

There are several commercial devices, like the FitBit, and mobile apps that measure your sleep quality. Many of these types of software have not been validated in scientific research. The ones that have, generally don't perform as well as laboratory grade polysomnography. Total sleep time (TST) can be estimated reasonably well by most activity trackers, but there are blatant errors over 50% on some days, e.g. claiming you slept 12 hours while you only slept 8 hours; sleep efficiency can only be measured with mediocre accuracy by current consumer grade activity trackers [2, 3]. Specifically, consumer-grade activity trackers tend to overestimate sleep quality and sleep time.

The problem with practically all mobile, wearable and affordable sleep trackers is that they don't measure brain activity but try to infer sleep quality from other bodily measurements like wrist movements. By design, such devices can thus never rival polysomnography. The inference of sleep quality from bodily measurements also requires the algorithms to be made based on population averages. This means individuals with sleep disorders, who are generally not average in their sleep biology, are least likely to register accurate sleep quality measurements. Indeed, mobile, consumer-grade sleep trackers are less accurate in clinical than healthy populations. Thus, wearable sleep trackers are least accurate for the people that need them the most.

For a comprehensive list of specific brands and whether they have research support as of a 2018 review by Peake et al., click here. Note how there was no product that is both validated and has reliability testing and we're still not aware of any.

In fact, Lenneis et al. (2024) found that subjective sleep quality made actigraphy-estimated sleep quality redundant to predict next-day wellbeing: the sleep tracker measurements added no predictive value over simply asking people how satisfied they were with their sleep. Some wearable sleep quality trackers include more information than just physical movement, such as heart rate and temperature, which should make them closer to gold-standard polysomnography, but the most fundamental measurement always lacks: brain waves (and eye movement for REM sleep).

Even if you can obtain a device that conveniently and accurately measures your sleep quality, then what? Most people already know they need more sleep and everyone should try to optimize their sleep quality regardless of what their ActiWatch says. Anecdotally, for many individuals trying to objectively measure sleep quality creates more problems than it solves. Thinking about your sleep quality is one of the worst things you can do to fall asleep. It's like telling someone "Do not think about pink elephants!" Guess what's the first thing that just popped up in your mind?

In conclusion, it's not worth purchasing and wearing a sleep quality device for most people. Everyone should try to optimize their sleep quality with the low-effort strategies from this course, regardless of what a sleep tracker says. Then the old golden rule of sleep quality is generally all you need in practice: are you waking up without an alarm every day around the same time feeling fully refreshed? Great, you don't need to worry about your sleep quality further. If not, prioritize getting more sleeping time and implement additional sleep optimization strategies.

How to optimize your sleep quality

Given the importance of sleep, here's a guide on how to improve your sleep quality.

➢ Guide

[Sleep optimization]

As practical examples of how major the effects of lifestyle improvement can be, see the following 2 case studies. These are not your average results resulting from typical stress but rather significant systemic deregulation caused by major sleep deprivation and/or chronic stress. Many armchair experts would say these findings are impossible, yet many high-level coaches Menno has talked to have reported similar cases. As burn-out so clearly illustrates, stress can be damaging in ways that we don't even yet fully understand.

Alcohol

Many people use some alcohol to help them fall asleep, because it helps them relax and fall asleep. A 2024 meta-analysis of 27 studies found that while alcohol indeed helped people fall asleep, this came at the expense of sleep quality, resulting in a net negative result for most people. Alcohol only significantly helped people fall asleep after ~5 consumptions. Alcohol already started interfering with sleep architecture after ~2 drinks and the more people drank, the less rapid eye movement (REM) sleep they got. "Disruptions to REM sleep are suggested to impair memory consolidation, cognitive function, and emotional regulation, highlighting the negative effect alcohol induced sleep disruption may have on wellbeing." The researchers therefore concluded that "the use of alcohol as an aid to promote sleep is not an appropriate strategy. While a high dose may shorten the time to sleep initiation, larger doses of alcohol increase subsequent sleep disruption which outweighs any potential benefit."

➢ Case studies [optional]

The importance of lifestyle factors

David case study

Activity level

The problem with weight loss diets comes down in physical terms to the difficulty in creating a sustained energy deficit. We have discussed the energy intake side of the equation in detail, so now let's discuss the energy expenditure side.

Other than your formal training program, your overall activity level has a substantial effect on your energy expenditure. This has resulted in the common mantra of 'eat less, move more'.

Common advice is to take the stairs instead of the elevator. Or park your car further away from work or your house so you have to walk a bit. However, the benefits of this are often trivial.

- You burn 19.7 Calories when climbing 11 floors of stairs. That means if you climb 29 floors of stairs every day, you burn off 1 small apple worth of energy. The energy expenditure of descending stairs is less than half of that.
- If you park your car a mile away from work (1.6 km), you burn 80 Calories to walk to work. Less than in a banana.

Habits

Rather than spending your days making trivial decisions about whether or not to take the stairs, the key to increasing your activity level successfully is making *lifestyle* choices, not day-to-day choices. Can you take the bicycle to work? Make it a habit. Decide that you'll go to work by bicycle every day, even if it rains.

Implementation intentions

Of course, sometimes life prevents us from always doing something. Maybe the weather can get so bad that you really can't go to work by bicycle some days. In that case, psychologists have found that you can get all the benefits of habits without the actual habit by forming implementation intentions. Implementation intentions are clear, concrete if-then rules for your life. "If it rains, I go to work by car. Otherwise, I go by bicycle." Implementation intentions have also been called action triggers.

Sitting vs. standing

Humans have not adapted to living their life seated. The human body is an organism that requires activity to stay alive. The analogy with bodies of water is particularly fitting here, since our bodies consist of ~60% water. What happens to a body of water when there's no flow? It rapidly turns into a cesspool. Even when you exercise regularly, the time you spend seated is still an independent predictor of dozens of health complications.

Now, if you understood why 'move more' is a recipe for failure, you also understand that just standing up and walking around at random times of day is generally very ineffective. Instead, here are 2 concrete tips to increase your activity level when you spend a lot of time behind a desk or working from a computer.

First, make a habit of drinking lots of fluids when working from behind a desk. It automatically prevents prolonged sedentary posture, helps to suppress your appetite – herbal/decaff tea and decaff coffee have this effect in particular – and slightly raises your metabolism to boot. It helps to put a large bottle filled with water (or your favorite calorie-free beverage) on your desk. Make sure it's empty at certain times of day, like before meals or before you go to the gym.

Second, get a standing desk, preferably even a treadmill desk. Yes, they have a reputation for being weird and geeky, but rationally speaking, they are amazing. In contrast to what most people expect before they've tried a standing desk, standing or even slowly walking or standing on a balance board while performing office work doesn't disrupt your work quality or productivity [2, 3, 4, 5], it doesn't increase your appetite, and it's a uniquely effective way to increase your activity level without requiring any effort.

- An afternoon of standing office work burns 174 kcal extra compared to staying seated in a population of 80% women. Indirect calorimetry shows an 11.5% increase in energy expenditure when performing deskwork standing instead of seated and a 7.8% increase when alternating sitting and standing. Other research confirms a 10-12% increase in energy expenditure per minute of standing vs. sitting [2, 3, 4].
- A treadmill desk can increase energy expenditure by 100 – 150 kcal per hour, even for women and a year-long prospective trial found a 33% increase in activity level after office workers implemented a treadmill desk, which was associated with significant weight loss without any dieting efforts.

As such, heavier male strength trainees could increase their energy expenditure by several hundreds of Calories a day by working while standing instead of sitting.

Unfortunately, in practice you won't achieve that major of an increase in energy expenditure, because we're intuitively inclined to lower our spontaneous physical activity level after periods of higher activity. So you can only increase your energy expenditure effortlessly so much with a standing desk.

Standing desks have health benefits too though. Standing desks have also been found to improve blood sugar control, lower your risk of heart disease, decrease back pain, increase your life expectancy and improve your mood [2].

Treadmill desks can be expensive, but they're a legitimate business investment. If you have an employer, see if you can get one from the company. If you're self-employed, you can declare its cost as a business expense to save tax money.

When you first start standing more, your legs will fatigue. That's fine. Just sit down for a period and go back to standing. This is where implementation intentions come in handy again. "I always start working standing. When my legs fatigue, I sit down. Whenever I have to get up for any reason, I go back to my standing desk." Ergonomic alarms can be helpful too, though more natural cues tend to be more sustainable as implementation intentions.

An anti-fatigue mat, commonly used in lines of work where prolonged standing is required, can significantly ease joint discomfort [2]. Shoe inserts can be equally effective if you can't bring a mat to work.

An anti-fatigue mat reduces joint discomfort from prolonged standing.

If you do have to sit a lot, be sure to create an ergonomic work place as illustrated below.