The Watertight Diet: Exposing the ignored secret to successful weight loss and health

PART I

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Introduction

I think we can all agree: nutrition science is a mess. It seems every day nutrition scientists, medical professionals, and dietitians have "discovered" the opposite of what they "discovered" the day before. Complex biological systems are broken down into snappy soundbites that lose all nuance. I am a nutrition scientist in the early stages of my career; I have published many nutrition papers using different methodologies to understand my specialty: the effects of hydration on appetite and metabolic health. I remember starting out on this journey being very confused about the state of nutrition science and what an optimal diet for health is. I also believed some very questionable dietary practices. Since you have started reading this diet, I imagine you might be confused too. I have spent my entire adult life sifting through thousands of research papers to understand my own personal research interest. I did not anticipate nor plan for my research ideas to hold so many answers, and I am excited to share my insights with you. I cannot promise this book will have all the answers, but I hope I offer a unique perspective to help your weight loss and health journey.

Before starting, I think we need to discuss some honest truths about nutrition science. I say this as someone who has invested my entire adult life in the system; I have gotten into tens of thousands of pounds of debt to fund my four degrees; have won over £100,000 of research funding from government, industry, and philanthropists; have been invited to attend and speak at conferences; and have had the joy of discovering some physiology myself. So I understand how the system works, both the good and the bad.

The biggest problem in nutrition science is conflicts of interest. This is where supposedly independent scientists have an agenda and/or are funded by those with an agenda, and unsurprisingly find whatever favours this agenda. We then get left with lots of positive findings; this is called publication bias and I published a paper on this in 2017, showing overall scientists thought it was too much effort to change anything in the system to prevent such a bias (Carroll *et al.*, 2017). My own nutrition research has found results going against my funders' ideologies, and as such I have gained a contrarian reputation and struggle to get others to take my work seriously. I have lived and experienced these problems, and so I understand them better than most. That is why I am so motivated to help.

Colleagues I have worked with generally seem oblivious to these problems or are adamant they are not biased. The result of this (and much more) is that we end up towing a particular line, and anyone who goes against the grain is disparaged or labelled "quack". These same scientists will cry "*ad hominem*" attack towards anyone who highlights their own bias to them. We end up with an homogeneous groupthink, and this has caused many of our problems in nutrition science.

The particular line we tow, of course, is the dietary guidelines which are touted by public health authorities to offer a well-balanced diet, optimal for health. These guidelines however, have coincided with the rise in obesity and other related diseases such as type 2 diabetes. A relatively recent addition to the dietary guidelines in Europe and the US is an explicit recommendation to drink water. It is entirely unclear why this recommendation has been included. It is based on virtually no evidence of health or appetite benefit, and was a decision predicated on the vast industry support for the dietary guidelines. For example, Public Health England (n.d.) have partnerships with Britvic and Danone—both are large corporate drinks producers.

As we have seen over the last few decades with how wrong the dietary guidelines were about dietary fat, it seems we may be heading in the same direction with the inclusion of drinking water into the guidelines. In other words, including water intake recommendations in the guidelines does not just seem benign, but likely harmful. The following sections will highlight why this might be, and how you can utilise the power of water, or rather, the lack of water, to improve your health and reduce your appetite safely and effectively.

PART I: All things water

Water is undoubtedly one of, if not the, most fascinating molecule on the planet; it is truly an honour to research it as a career. This simple molecule seems to be the unifying nutrient for all life on Earth (yes, there is even life that does not require oxygen!). You might think that such an important nutrient would be extensively studied; this is not an unreasonable expectation, but is a far cry from reality. When I started researching water during my MSc in 2012-13, I was quite shocked at how little we really knew in terms of hydration and health in everyday life. At the lack of evidence, and because water is so essential, it has been assumed that consuming more than is needed to maintain life is necessary to optimise health. This assumption is based on both scarce and somewhat dubious evidence though.

Before delving into the science of all this, it is important to define some terms. Throughout this book, I will refer to water, but within that I mean any fluid (so, for example, milk) as these fluids are nearly entirely water. Even caffeinated and alcoholic beverages are mostly water, so unless otherwise specified, when I talk about "consuming water", I also mean things like coffee and beer. It is also probably worth mentioning the difference between dehydration and hypohydration: dehydration is a process of losing water, whereas hypohydration is a state of having less body water (broadly: *hypo* meaning too little or under; *hydration* meaning water). So you could be well-hydrated at the moment, but just by existing, you will be losing body water (through sweating, breathing, and urine production) so you are dehydrating. Equally, you could be hypohydrated (e.g. after a hard gym session), but not dehydrating because you are now drinking more fluids than you are losing. However, dehydration is a more intuitive term than hypohydration so I will use dehydration throughout.

The flipside of this is hyperhydration which is too much (*hyper*) water (*hydration*) (again, for ease, I will call this overhydration), often accompanied by hyponatraemia (too little, *natrium* meaning sodium, and *aemia* meaning blood; thus too little sodium in the blood). We will discuss this more later, but for now you might be asking "too much or too little water compared to what?" This is an excellent question which seems simple but as yet no one quite agrees. When someone is in perfect water balance, so they are losing the same amount of water as they are gaining, we call this euhydration. But defining euhydration is nigh on impossible as it lies on a wide spectrum. This, in part, is where some confusion in hydration and health becomes apparent.

To help explain the confusion, we need to delve into some hydration physiology. When you stop drinking, your blood osmolality increases. High osmolality is a fancy way of saying your blood is more concentrated (so I will call this "blood concentration" going forward). You can think of this like a drinking squash: if you add loads of water to your squash, it becomes very dilute; this is your well-hydrated blood (low blood osmolality or concentration). If you don't add very much water to your squash, it is very concentrated; this is your dehydrated blood (high blood osmolality/concentration).

High osmolality (more concentrated blood) gets detected by special cells in the brain called magnocellular neurons leading to lots of physiological changes, such as causing a hormone called arginine vasopressin (AVP, also known as antidiuretic hormone or ADH) to increase. When AVP is high, it tells the kidneys to reabsorb water. That means it tells the kidneys to keep water in the body rather than letting it be excreted in urine. This is why when you are dehydrated, your urine gets darker—it is simply AVP telling your kidneys to not waste water through urination, so all the other things your kidneys excrete become more concentrated.

As such, difficulties arise when trying to define proper hydration (euhydration) because in the early stages of dehydration (losing water), our body water will remain the same. It is does this because our physiology has changed and responded to the reduction in water intake by increasing AVP. Some have called this state 'underhydration' (Kavouras, 2019). Even this is not clear-cut though, as there are many examples of when people may have low blood concentration but high AVP or vice versa, with a range of body water states (Carroll, 2020a). Broadly speaking though, we know with quite some certainly the physiological impacts of dehydration and overhydration/hyponatraemia, but we do not know with much certainty this middle ground area we live most of our lives in: euhydration and underhydration (Perrier, 2017). Yet, dietary guidelines are once again rushing in with recommendation to consume more water without knowing the full health benefits or risks.

Moreover, the risks of not consuming fluid have been vastly overblown and the benefits of avoiding excess water are ignored. At the same time, the risks of drinking more than needed water are downplayed and the benefits based largely on speculation. The following sections will outline common, often hidden, misnomers regarding water intake and hydration status. My aim is not to bog you down with excessive scientific detail, but rather provide you with enough data and detail to help you have an informed opinion. How this information can be used to help you on your weight loss and health journey will also be explained.

1.1 Water kills
A commonly stated "fact" is that we cannot survive more than a few days without water (three to five days is most often cited). I am unable to find a source for this myth, and academic papers that cite this statistic often do not have a reference for their source, or their reference does not actually provide evidence of this claim. I know this is a lie because I tried it myself and survived comfortably (Carroll, 2020b); I will get back to that later though. Contrary to popular claims, there are ample documented cases of humans far exceeding a few days of fluid restriction, including in extreme circumstances. Two quite famous cases demonstrate this.

Firstly, the case of Mauro Prosperi, an endurance runner who, midway through a marathon in the Sahara in 1994, became lost during a sandstorm and ended up running hundreds of miles away into Algeria. Within 24 hours he had run out of food and water. Prosperi survived nine days before finding civilisation, and lost a total of 18 kilograms (about 40 lbs). In an earlier case in 1979, albeit in much less severe conditions, Andreas Mihavecz was mistakenly put into custody and forgotten about with no food or fluid for 18 days. He lost a total of 24 kilograms (about 53 lbs) and was recognised by the Guinness World Records as achieving the longest complete fast. There is no doubt in my mind that there are countless other cases that have gone undocumented, for example refugee trips across gruelling conditions with limited food and water.

In more controlled settings, several studies have been conducted whereby volunteers have been deliberately deprived of fluid for extended periods of time. Many of these studies were conducted in the 1930s to 1940s (e.g. Chesley, 1938; McCance & Young, 1944; Nadal *et al.*, 1941) and included restricting fluid intake in participants for days at a time and measuring what happened (hint: no one died, or even came close to harm). A more recent study, subjected volunteers to five days of no food or fluid (Papagiannopoulos *et al.*, 2013). No one died here either.

To be honest, the idea that humans can only live three or so days without water was so ingrained that when it was initially suggested to me that this might be a myth, I almost could not believe it. Being a keen scientist (with some lockdown boredom), I decided to try it out myself. So for 72 hours, I consumed basically no fluid (less than 50 grams per day from food) (Carroll, 2020b). As you may have guessed, I also did not die, nor did I come close to even notable discomfort. I will talk about the findings of these studies in the relevant sections below.

Key message:
Our water needs for survival are vastly exaggerated

To put this in perspective, we can look back at our evolution. Less than two percent of the worlds water is drinkable, and we evolved on the plains of Africa which for the most part is not the most water-rich area on the planet. It would be poor design if we could not survive more than three days without fluid. Consider that additionally, we evolved in a hot climate and needed to hunt and gather for survival. Those who could not survive these harsh conditions would not be able to pass on their genes; thus we as a species have evolved to endure harsh conditions which undoubtedly included periods of relative drought.

On the other end of the spectrum, in terms of drinking, we can look at other animals. Animals drink according to two factors: thirst and availability. If an animal is thirsty but there is no water available they will not drink; equally if there is ample water available, but the animal is not thirsty, they will also not drink. Thus we need the two factors together to make us drinking (Carroll, 2020a). What animals (with few exceptions for good evolutionary reasons) do not typically do is drink excessively, or “stock up” on fluid. Yet, this is essentially what the recently updated dietary guidelines are telling us to do, with no consideration for (a) how unnatural this is, and (b) the potential risks this may have.

And this is the crux of the problem that no one likes to talk about: water kills. To my knowledge, no one has ever died straight up of dehydration. There have of course been cases where dehydration has been a comorbidity (in other words, other heath problems have caused death, and dehydration occurred at the same time as this perhaps even contributing to the primary health problem), but I have never come across a case whereby lack of body water has been the actual cause of death. On the other hand, there are ample examples of water causing death.

Firstly, we can look at exercise. I have already highlighted an extreme case of a lost marathon runner in the Sahara, but in less extreme events, it is not uncommon for endurance athletes to lose over 10 % of their body mass in water (Del Coso *et al.*, 2013; Hoffman *et al.*, 2013; Sharwood, 2004; Wharam *et al.*, 2006). Moreover, these athletes are the ones who typically win the races (Hoffman *et al.*, 2013; Sharwood, 2004; Wharam *et al.*, 2006). Contrarily, many athletes finish marathons with hyponatraemia (too little sodium/salt from diluting their blood so much with excessive water drinking) (Hoffman *et al.*, 2013). Resultantly, there have been several cases of athletes dying of overhydration (too much water), yet none dying of dehydration (too little water). These observations have been noted enough that many marathons now do not offer free water along the race route. From an evolutionary perspective, it of course makes sense that we can perform well without the need for fluid. Hunting in arid conditions means regular fluid stops are infeasible, both on a physical level (i.e. there is no water available) and practical level (i.e. stopping to drink increases our risk of being predated, as does stopping to urinate).

Secondly, we can look at drug use. One drug is particularly interesting: 3,4-methylenedioxymethamphetamine (MDMA), more commonly known as the party drug ecstasy. This drug is fascinating because it gives all the symptoms of dehydration (for example, increased thirst and body temperature), whilst simultaneously causing overhydration at a cellular level (Carroll & James, 2019). This effect is driven by ecstasy causing AVP (the hormone described above) to raise considerably, therefore telling the kidneys to stop wasting water by urinating it out. Because ecstasy also causes an increase in thirst, users often drink more which exacerbates overhydration, causing cells to swell up with water, and diluting the blood leading to hyponatraemia (Baggott *et al.*, 2016; Brvar *et al.*, 2004; Wolff *et al.*, 2006). From a physiological perspective, this is quite an incredible phenomenon, but on a personal level, this overhydration is the leading cause of death and injury in MDMA/ecstasy users. Most famously was the case of Leah Betts who thought her insatiable thirst was caused by dehydration, so drunk excessively, leading tragically to her death.

Thirdly, we can look at hydration-related diseases. Diabetes insipidus is an illness whereby AVP production is disrupted in such a way that it is minimally, if at all, produced, or the kidneys are not responsive to AVP. This means water that is consumed is urinated out very rapidly rather than absorbed. People with this condition can be chronically underhydrated. When it is completely uncontrolled, the condition can lead to brain damage, but as yet, no one has actually died from the dehydration it causes. Conversely, another condition called syndrome of inappropriate antidiuretic hormone secretion (SIADH; remember that ADH is another name for AVP) causes too much AVP to be produced, so the kidney reabsorbs too much water and the body becomes overhydrated. If left uncontrolled, this can (and has) caused death. It goes without saying that neither of these conditions are healthy and complications in either one are incredibly unpleasant, but they do demonstrate that it is far more dangerous to have too much body water than not enough.

Water is of course an essential nutrient, in that we do need to consume *some* water to live. We produce water ourselves through metabolising energy (Coller & Maddock, 1933), but the amount of water we produce internally is not enough to sustain our needs. In fact, the amount we produce (roughly 300 mL per day) is pretty much cancelled out by what is known as “insensible loss”. Insensible losses are water losses through things like sweating and breathing. So we do need to consume *some* water.

Key message:

Our water needs are easily met and not getting enough fluid is not a legitimate health concern. Contrarily, there are health benefits to consuming far less fluid than is recommended

These ideas may feel very uncomfortable; it certainly did for me, but as a scientist I feel it is important that my views are guided by the evidence, and not long-held beliefs.

1.2 Water myths

The above has hopefully demonstrated that a lack of water is not dangerous, the reverse of which is a myth that is so pervasive, even I, with a PhD focused on hydration, believed it until recently. But there are a few other myths that should be cleared up before we delve into the appetite and health benefits of a low water diet.

Common dogma dictates that we need to drink eight glasses of water per day. The shocking truth about this myth is that it is not only hyperbole, but largely a made-up number completely unrelated to any health outcomes. So where did this number come from? Broadly speaking, the idea of eight glasses of water per day came from the average intake of water in an American cohort that have regular dietary assessments. Why do we need guidelines to tell us to drink what we are already drinking? Plus, as well as being American, this cohort is predominantly white, middle class, and well-educated—in other words, hardly representative of most people.

In this group, researchers looked at the participants' blood (well, technically plasma which is the watery faction of blood) concentration. What was found is that plasma concentration was roughly the same in those who drank a lot compared to those who did not drink very much. From this, the researchers concluded that hydration status is tightly regulated and therefore it does not really matter in the context of daily life how much someone drinks. Alas, the idea to drink eight glasses of water a day came to fruition by simply taking the average fluid intake of the cohort. This logic is full of half-truths and flaws. So why do we need to drink more if it is not affecting our blood (i.e. the transport system for all the nutrients required by the body)? I have never quite understood why their conclusion was to drink more, when drinking more demonstrably did nothing.

Beyond this being an irrational conclusion, the recommendation is also often presented without context; in this case, the contribution of food to our total fluid intake, and the fact that *any* fluid consumed counts towards your "eight glasses". My own research in a representative sample of UK adults showed that about 25-30 % of our total fluid intake is from food, equating to roughly 500-600 mL (roughly 1 pint) per day (Carroll *et al.*, 2016). Since one cup is usually around 240 mL of water, food alone typically accounts for two to two and half of the eight glasses you supposedly need. Now, considering < 2 % of the worlds water supply is made up of drinkable water, the question is whether we do in fact *need* the other five to six glasses per day (of course, this ignores desires such as a morning coffee which serve a different purpose!).

Another central tenet to the "drink more water" campaign is that not drinking enough is bad for the kidneys. Defining "good" and "bad" for the kidneys seems to be a challenge though, and as yet no one has ever given me a clear-cut answer. So at the lack of any particular clarity, I will fall back on some standard markers of kidney function, namely glomerular filtration rate (GFR). This measure represents the volume of fluid filtered by glomerular capillaries in the kidney into the Bowman's capsule (a cup-like sack that performs the first step in the filtration of blood to urine). One by-product the kidneys clear is called creatinine.

Creatinine is formed from normal metabolism of muscle and protein in the body. Creatinine clearance in the kidney therefore measures the volume of blood plasma (the watery part of blood) that is cleared of creatinine per unit of time, and is a useful measure to approximate GFR. It is commonly thought that GFR and creatinine clearance must add more strain to the kidneys if there is less water available to filter through the kidneys. However, this does not stand up to testing. For example, in the study by Papagiannopoulos *et al.* (2013) where participants had no fluid for five days, creatinine clearance increased (!) by 167 %; in other words, the kidneys were working better!

Ok, you might be thinking, but these are healthy participants—what about those with reduced kidney function? This is an excellent question, and a good friend of mine Dr Bill Clark and his team have done, and continue to do, fantastic work in this area. In fact, they conducted the first randomised control trial (gold standard study) of increased water intake on kidney function in those with stage 3 chronic kidney disease (Clark *et al.*, 2018). In this study, participants in the "drink more" group increased their fluid intake by nearly one litre (roughly 2 pints) per day. Their estimated GFR actually *decreased* (which is a not a good thing) compared to the group who kept their water intake the same. Taken together, these and many other studies (e.g. outlined in a review by Rouhani & Azadbakht, 2014) suggest that low fluid intake is at the very least not harmful to the kidneys, but also potentially beneficial.

The next big myth is about thirst; specifically the ongoing debates about whether we should drink before we are thirsty or not. I will start by highlighting that I wrote a rather long paper outlining why I think our commonly accepted notion of thirst is untrue (Carroll, 2020a). To give a brief outline, our dominating idea claims that the increase in plasma concentration we experience when we restrict fluid gets detected by special cells in the brain, and these trigger the sensation of thirst (Armstrong & Kavouras, 2019). This sensation of thirst starts to occur when your blood concentration increases by 1-2 % (Wolf, 1950), and is unignorable and overwhelming (Robertson, 1984).

However, before you feel thirsty, your body has already taken action to conserve body water. It does this by raising AVP; as discussed above, this will tell the kidneys to stop sending so much water in urine. Because AVP (and other related physiological changes) occur *before* we feel thirsty, many have advocated that we need to beat thirst by drinking before we feel it. In theory, they say, this helps stop the physiological changes (like high AVP), and is therefore better for your health. As described above, both from an evolutionary point of view, and in comparison to other animals, this does not make logical sense. I will discuss the health point of view shortly.

My recent theory suggests that we do not have just one type of thirst, rather we have several subtypes regulated by various psychological and physiological phenomenon (Carroll, 2020a). I dubbed the classical subtype, defined by plasma concentration (as above), "true-thirst", and when this gets strong (i.e. disrupting normal living), this is the signal we need to look out for that the body is struggling. Since previous research has not differentiated subtypes of thirst, it is difficult to know whether they actually measured true-thirst or milder forms of thirst. My own experimental data suggest studies with less than 2 % body mass loss (perhaps even more!) probably have not measured true-thirst (Carroll, 2020b). At lower levels of dehydration, you will likely experience things like a dry mouth, dry lips, a mild desire to drink, and an unpleasant mouthfeel. None of these indicate proper dehydration though; they indicate a reduction in fluid intake and will normalise after a few days when your thirst-related setpoint has been adjusted.

Key message:

When you truly need water, you will absolutely know about it

1.3 Important note

Before going further, I want to discuss some technical aspects of study design to help further explain why there is such a strong belief that drinking more water than necessary is healthy. Much of the work showing water intake or hydration status to be good for various health outcomes is based on what is known as observational data. In observational studies, we measure people's behaviour (e.g. what they are drinking) and we measure a health outcome (e.g. their blood sugar level). Sometimes we do this at one time point, known as cross-sectional, and other times we do this at multiple time points or measure a behaviour at timepoint one and a health outcome at timepoint two, known as longitudinal.

Both cross-sectional and longitudinal observational data suffer with huge problems. For example:

- Reverse causation: in cross-sectional studies in particularly, how do we know whether the behaviour caused the outcome, since we only actually measured one timepoint?
- Residual confounding: these are unmeasured variables that may affect our findings; since they are unmeasured we cannot understand how they relate to either the behaviour or the outcome
- Hypothesising After the Results are Known ("HARKing"): when researchers see the results, and then write a hypothesis, so it looks like their study deliberately was looking at what they report. This is a problem because of…
- …*p*-hacking: in science, we use a statistic called a *p*-value to help us decide whether there was a difference in the outcome we are interested in or not. The more you analyse a dataset though, the more likely you are to come across a significant *p*-value by chance rather than because the difference is true ("false positive"). Some researchers will run lots of statistical tests and then pick the statistically significant findings to report
- Recall bias: this simply describes that people are bad at accurately remembering things. Yet, much of nutritional epidemiology is based on people remembering their diet. Try it for yourself: can you accurately tell me on average over the last year, how often did you eat bread each week? What about drink a sugary drink? Or eat chocolate? Crisps? Sausage? Or drink milk? Water? It is really hard! So the data we get are quite frankly crap and virtually useless. And I say this as someone who has published work using such data!

But beyond all that (yes, there is more!), these studies cannot tell us if a relationship is causal or not. Type into a search engine "spurious correlations" and you will find tonnes of examples of how completely unrelated things have an incredibly convincing relationship with each other. For example, water intake has been *associated* with better blood sugar regulation (Carroll *et al.*, 2015; Carroll *et al.*, 2016; Roussel *et al.*, 2011), but water intake is also associated with higher physical activity (Kant *et al.*, 2009). We know that physical activity *causes* better blood sugar regulation, so maybe water intake is simply a marker of more exercise, and the exercise is the thing that causes the better blood sugar (known as a mediating variable). Unfortunately, whilst these study designs attempt to control for such issues, they cannot do this adequately enough to claim a causal relationship.

Making causal claims from observational data is a well-known problem in the nutrition science literature. Recently, we have seen this occur with breakfast and health outcomes. Observationally, breakfast has been undeniably *associated* with lower body mass (Brown *et al.*, 2013). Yet, when we combine the studies that are designed to infer a *causal* relationship (known as randomised control trials), we see that not only does breakfast not *cause* a lower body mass, but actively increases it (Sievert *et al.*, 2019).

So what are randomised controlled trials? These are beautiful study designs (when done well) because they eliminate nearly all sources of bias. Two key aspects of this study design are important. Firstly, participants are assigned to either a treatment or non-treatment group. The non-treatment ideally would receive what is currently seen as best practice, but may also be a placebo, normal care, or another comparator treatment. The aim here is to try and match the non-treatment/comparator group to the treatment group as much as possible without giving them the thing you are interested in. That way, at the end, you can be confident that any differences you find are solely because of the treatment you were interested in.

Secondly, which group participants will go into is selected at random. This maximises the chance that if these participants were not in your study, they would have the same chance of getting the outcome you are interested in. That way, you increase the likelihood that any final differences are definitely because of the intervention, and not because one group was more likely to end up with the outcome anyway. For example, if you were interested in blood sugar, and everyone in the treatment arm was age 20-25 years, and everyone in the non-treatment arm was 70-75 years, it would be no surprise that you found better outcomes in the treatment group because they were younger and naturally less likely to get ill. Despite observational studies showing positive effects of drinking more water, randomised controlled trials do not, and these are the studies I have based my conclusions on (discussed more below).

Key message:

Much of our diet knowledge, including the dietary guidelines, is based on very weak evidence

1.4 So how much fluid should we drink?

The simple answer to this is that, providing you eat a relatively varied diet (which can be achieved in many different ways depending on your preferences), you get enough fluid from your food. To clarify, as we saw above, we can get about half a litre of fluid a day from our food. This number is based on a representative UK sample (Carroll *et al.*, 2016), which means participants were from all walks of life and so were unlikely to eat a particular kind of diet. High fat and snack foods typically contain low (less than 20 % of their weight) water (e.g. oil, hard cheese, crisps, chocolate), whereas plant foods typically contain high water (more than 90 % of their weight; e.g. fruit and vegetables). Just eating what you normally eat will likely achieve adequate fluid intake!

The reason I emphasise to not drink fluid is that excess fluid gets urinated out, and the most obvious form of excess fluid is from drinks. This was clearly seen in my recent experiment when I rehydrated after three days of no fluid (Carroll, 2020b). The amount of fluid I drank equalled pretty much exactly the amount I urinated out. Even after no fluid for three whole days, my body did not want or need the extra fluid from drinks. So why risk adding strain to my kidneys with worse creatinine clearance and GFR by consuming extra fluid?

Other studies also support this. In Dr Clark's work discussed above, volunteers' urine output increased by pretty much exactly the same amount as they reported consuming extra in fluid. Moreover, you will notice in Table 1 of Dr Clark's paper that urine volume in both groups at baseline (1.9 litres per day) nearly equates to reported fluid intake (2.0-2.1 litres per day). The difference here, if we are being generous, is 200 mL per day. In other words, that 200 mL is the amount of fluid the body stored during the day, and as such, we might consider this "essential" fluid. As we saw earlier, this is easily achieved by eating normally. More likely though, fluid intake was measured by participants reporting what they drank. How accurate do you think that is? Do you think if you were in a study looking at water, you might (even subconsciously) exaggerate how much water consumed?

In another study in healthy adults, another good friend and collaborator Prof Olle Melander and his team asked volunteers to consume three litres extra of water per day (Enhörning *et al.*, 2019a). In doing this, participants appeared to only achieve a net increase of two litres per day, and guess how much extra urine they produced? You guessed it, about two litres (1.95 litres to be precise!). In a similar study by Olle's team, participants were asked to consume 1.5 extra litres per day of water for six weeks (Enhörning *et al.*, 2019b).

Participants again struggled to increase their fluid intake as much as the researchers would like (hmmm, I wonder why…maybe it is not natural to drink that much?), so they reported consuming about 0.9 litres extra per day. That may not be a surprise, but what is a surprise is that they urinated out an extra 1.2 litres per day; in other words, drinking more fluid made them actively lose about 300 millilitres of *extra* water (i.e. 0.9 litres extra consumed minus 1.2 litres extra urination). This is likely due to the excess water being consumed suppressing AVP so the kidneys do not have any instruction to keep fluid in the body. Drinking water actively dehydrated participants!

If you look up the study, you will also notice that before the intervention, participants urinated one litre per day. Their total fluid intake (including fluid from food) was 1.8 litres per day. Only 0.4 litres of fluid was from water and 0.3 litres on top of that was tea/coffee. If we do the maths, that means the water consumed from water, tea, and coffee was urinated out (0.7 litres), plus about another 0.3 litres of the fluid from food (or maybe other beverages unspecified in the paper). This provides evidence that the fluid we get from food is more than adequate to meet our water needs, allowing our kidneys to excrete enough fluid to safely remove waste and metabolic by-products, without the added strain of having to filter excess water.

A more well-known study aimed to quantify the hydrating properties of different drinks, dubbed the Beverage Hydration Index (Maughan *et al.*, 2015). To start, participants consumed one litre of water; quite consistently, participants urinated out 1.3 litres over the next four hours. The index that was created demonstrated that nearly every drink tested led to a similar amount of urine produced when compared to spring water. This once again suggests that drinking itself may be preventing the body from holding onto its own water.

Key message:
Consuming excess fluid actually dehydrates you

Of course, sometimes we drink for reasons other than need, with the most obvious example being caffeinated beverages. I would not object to anyone drinking these on this diet, but perhaps you may wish to consider reducing the amount of these drinks you consume, using a smaller cup so there is less fluid per drink, or substituting a drink for another source of caffeine such as a supplement. I think this is personal preference but ideally for this diet to be effective, reducing excess fluid intake from as many drink sources as possible will lead to maximal effectiveness. If you do really enjoy your caffeinated drinks, avoid drinking these with food, for reasons that should become clear in the next section.

To briefly sum up the key messages from this section, overall so far the evidence shows that:

- ✓ Not drinking enough is far safer than drinking too much;
- ✓ Drinking less than is commonly “recommended” reduces strain on your kidneys
- ✓ Water that you drink just gets urinated out so has no benefit to being consumed

If you are anything like me when I came to this realisation, you will be feeling much discomfort and perhaps even confusion. So before moving on to why drinking less will aid your weight loss and health journey, it is probably worth highlighting that such mistakes have previously been made in nutrition science; in other words, we have been here before, and I am worried we will be making the same mistake again

One example is vitamins. We know vitamins are essential to life, just like water. Because of this, some nutrition scientists proposed that more vitamins must be better; this led to the introduction of vitamin supplements (we can see this happening with water recommendations now, both in the dietary recommendations, and in that a lot of people seem to carry water bottles with them everywhere they go). However, excess intake of certain (water soluble) vitamins leads to them being urinated out (hence you can get brightly coloured urine after taking supplements)—in other words, they serve no physiological purpose. I have just demonstrated above that the same is true for water when consumed beyond our needs. Even worse though, is that excess intake of some vitamins can actually be harmful; for example, too much vitamin E causes prostate cancer (Klein *et al.*, 2011). We can see with kidney function, the potential for harm certainly seems to be the case with water. Considering water is one of the least studied nutrients, I have additional concerns about what we are yet to find out. We also know with vitamins that, assuming we have a reasonable diet, we can adequately meet our needs with food; it seems reasonable therefore that the same is true for water.

Key message:
Dietary recommendations to drink more water may actually cause harm

1.5 Excess water and health

Now we have established the problems with *drinking* fluid, we can look at the benefits of *avoiding* it. My research focus is cardiometabolic health and appetite. Cardiometabolic health is a fancy phrase encompassing both cardiovascular (i.e. heart and circulatory system) and metabolic (i.e. systems related to how we use energy) health. Whilst the next section will discuss appetite, this section will focus on the two most prominent markers of cardiometabolic health: blood sugar control and blood pressure. Both of these are excellent predictors of diseases like type 2 diabetes, heart disease, and early death (mortality).

Blood sugar regulation is the topic I have published academically most extensively on and where my passion truly lays. This is a really hot topic in the hydration field at the moment; sadly I feel that most people in the field have misdirected their focus. To start, we need to differentiate two aspects of hydration: actual body water (hydration status), and the act of consuming water (drinking), which we will look at sequentially.

There has been huge debate as to whether hydration status affects our blood sugar regulation (Carroll & James, 2019). There is some theoretical, mechanistic, and animal work showing that elevated AVP (which, remember, is a hormone that increases when you stop drinking) might cause your blood sugar to increase (which is bad for metabolic health). This is because AVP is part of the stress response, formally called the hypothalamic-pituitary-adrenal axis. In this axis, AVP is part of a chain that leads to the stress hormone cortisol to be released. Cortisol tells the liver to increase sugar production, and as such is associated with worse blood sugar regulation. However, a recent meta-analysis (a study that looks at the combined effects of lots of studies) suggested that the increase in cortisol that is often seen in dehydration studies, is actually due to the studies using exercise (which is known to increase cortisol) to dehydrate participants (Zaplatosch & Adams, 2020). In fact, the one study that did not use exercise, and instead used a heat-tent and fluid restriction, found no effect of dehydration on cortisol levels despite a huge (up to five-fold) increase in AVP (Carroll *et al.*, 2019a).

Importantly, several studies have shown that neither limiting water intake nor increasing water intake with a view to altering hydration status and hydration physiology affects blood sugar regulation or insulin (a key hormone that helps blood sugar leave the blood and go to cells) (Carroll *et al.*, 2019a; Enhörning *et al.*, 2019a; Zaplatosch & Adams, 2020). Equally, in uncontrolled settings (those 'observational studies' I told you about above), those who drink more water do not seem to have better or worse blood sugar regulation than those who do not drink very much naturally (Carroll *et al.*, 2016; Pan *et al.*, 2012).

Those studies above are either under very controlled settings, or just look at total water intake, disregarding drinking patterns. But we know that most drinking occurs with meals. So does drinking with food make a difference? Rather embarrassingly, I was blissfully unaware of this literature until recently, and to be honest, the findings shocked me.

I initially got interested in this due to my own self-experiment of no fluid for three days (Carroll, 2020b). Based on my previous work (Carroll *et al.*, 2019a; Carroll & James, 2019), I did not expect my blood sugar to change across the three days, though if anything, I expected it to increase a bit. I looked at two measures of blood sugar: fasting (i.e. immediately after waking, and at 3pm where at most I would have eaten a couple of mints by this time), and postprandial (this is another way of saying "after-eating"). These measure slightly different things; fasting blood sugar is a good indicator of how well your liver responds to insulin, whereas post-meal blood sugar is a good indicator of how well your muscles respond to insulin (Nathan *et al.*, 2007).

Both measures were distinctly lower the more days I went without water, but most notable was the after-eating measure. After eating when I was not consuming fluids, my blood sugar barely increased, whereas after eating before starting the study when I had drunk an excessive amount of fluid, and the day after the study when I was rehydrating, my post-meal blood sugar was ~140 % the levels of my fluid-restricted levels. At first I thought this was an anomaly of my data as I used finger prick whole blood glucose. This comes with relatively high error, for example, the temperature of your finger can affect this measure, and it is not as accurate as taking from a vein in the arm.

So, as any good scientists would do, I looked at other literature investigating the effect of drinking water with food. During five days of no food or fluid, Papagiannopoulos *et al.* (2013) found lower blood sugar levels in 10 participants as well. Similar results have been found in those with diabetes (Rouhani & Azadbakht, 2014). However, since these participants were also not eating, it might be reasonable to expect lower blood sugar levels naturally. My journey continued to try and understand what typically happens when participants drink water with their food…

Torsdottir and Andersson (1989) examined this directly by feeding volunteers a standardised meal (meat and potatoes) with or without 300 mL of water. When volunteers had water with their food, their post-meal blood sugar increased by 68 %. Their insulin also increased, suggesting it was harder for insulin to get sugar out of the blood and into cells; if this occurs chronically it is known as insulin resistance which is a precursor to type 2 diabetes. These results were later replicated by Young and Wolever (1998) who additionally showed a dose-response relationship—in other words, the more fluid consumed with food, the higher blood sugar rose after eating! Considering these findings, it is no wonder the hydration community had not been talking about these studies.

The reason for these findings is likely the rate at which food leaves your stomach, known as gastric emptying (Torsdottir & Andersson, 1989; Young & Wolever, 1998). When you drink water, the water leaves your stomach pretty rapidly and takes nutrients like carbohydrates and sugars with it. This means these nutrients enter your blood stream more rapidly, but also means your food does not get properly digested (ever notice how much more bloated you feel when you drink with meals?). It is for these reasons that I recommend only consuming water from food whilst avoiding water from drinking fluids, and equally why I recommend to avoid drinking fluids that you cannot resist (like coffee) with meals (wait at least one hour from eating, though maybe more if you have eaten a large meal).

This works because water in foods is trapped in a food matrix and will get digested at the same rate as the food, unlike fluid that we drink which as we have seen leaves the stomach rapidly and stresses our metabolism. Providing you eat a varied diet, you will get enough fluid from food to maintain your body water, whilst also not burdening your kidneys with excess fluid, nor strain your pancreas with lots of rapid blood sugar spikes.

Key message:
Dehydration does not affect cortisol or blood sugar (and may even lower blood sugar), but drinking water itself might increase blood sugar and insulin levels, particularly after eating

In terms of heart health, avoiding excess water appears to have profound effects on blood pressure too. Before delving into this research, it is important to acknowledge that a reduction in blood pressure is not entirely unexpected when you reduce your fluid intake. This is because as your body loses excess water that it has been holding on to, eventually some of that water will come from your blood. The result of this is that your blood volume is lower, therefore taking up less room in your blood vessels, causing your blood pressure to be lower. In fact, the most common blood pressure medications work in exactly this way: these are drugs known as diuretics which cause the body to urinate out extra fluid. However, the effects I will show you next are beyond what would be expected through just simple reductions in blood volume. Rather, it is well established that it requires about 10 % of your blood volume to be lost to achieve any notable effect on your blood pressure, particularly if you do not already have high blood pressure (Henry *et al.,* 1968).

I will start with my own data again. During my three days of no fluid both my systolic and diastolic blood pressure reduced by 17 and 7 mmHg, respectively (Carroll, 2020b). To put this in perspective, highly successful interventions that get people to reduce their salt intake have achieved less than this (13/6 mmHg reduction) after two years (He & MacGregor, 2007). More modestly, from a public health point of view, a salt reduction intervention that is deemed successful reduces blood pressure by 4/2 mmHg (He *et al.*, 2013), yet I achieved three to four times this in just three days! Equally, after one day of rehydrating, my blood pressure increased by 12/21 mmHg. This increase is greater than a five day intervention actively giving participants salt (showing an elevation of 4 mmHg for systolic and no change in diastolic blood pressure; Tzemos *et al.*, 2008).

Such an effect on blood pressure has been well-established for decades. Hardy (1944) showed lower blood pressure in patients admitted to hospital (for a variety of reasons) who were dehydrated compared to those who were well-hydrated. Similarly, when patients were infused with fluid, their blood pressure increased notably. Another study taking measures from hospital patients had similar findings; approximately 10 mmHg reduction in blood pressure in those who were dehydrated compared to those who were well-hydrated (Vivanti *et al.*, 2008).

Key message:
Dehydration profoundly reduces blood pressure

Of course, I have only shown you the main benefits of avoiding excess fluid, and I will go into some more technical details in Part II. But there are multiple other benefits too, such as:

- Improved bone health (Bahijri *et al.*, 2015);
- Reduced total cholesterol, triacylglycerol (a type of fat in your blood associated with worth health), and low-density lipoprotein ("bad" cholesterol), and increased high-density lipoprotein ("good" cholesterol) levels (all of these are types of blood fats which predict your risk of things like heart attacks and strokes) (Adawi *et al.*, 2017; Rouhani & Azadbakht, 2014);
- Improvements in several aspects of immune function and reduced inflammation (Adawi *et al.*, 2017; Develioglu *et al.,* 2013; Faris *et al.*, 2012; Rouhani & Azadbakht, 2014)

Key message:
Avoiding excess fluid has a range of health benefits, beyond what is discussed in detail in this book

1.6 Excess water and appetite

The above described the unique properties of avoiding excess fluid on health, but there is another distinct property too: restricting water also dramatically reduces your appetite. With a lower appetite, you will eat less food and this will lead to weight loss. This is critically important on three levels. Firstly, we are amidst an obesity epidemic so anything to reduce this should be taken seriously, yet water restriction is taboo to say the least. Secondly, weight loss does wonders for your cardiometabolic health; combine the benefits of weight loss with the health benefits of avoiding excess fluid described above and that causes an exponentially positive effect on your health. Thirdly, successful weight loss is incredibly difficult and part of the reason is that most diets require some form of restriction that is unsustainable; water restriction will likely be difficult for a day or two, but the diet is flexible and your body adjusts quickly making this a legitimate long-term strategy.

The fundamental key to weight loss is what is known as negative energy balance. Energy balance is when your energy expenditure and losses equal the same amount of calories as you consume and produce. This sounds very simple but has many different aspects to it. You expend or use energy in four different ways (Hall *et al.*, 2012; Kjølbæk *et al.*, 2017; Livesey, 1991; Rigaud *et al.*, 1987; Southgate & Durnin, 1970; Westerterp, 2004):

1. Your basal metabolic rate: how many calories you burn just staying alive (breathing, heart beating, brain functioning, etc); in most people this makes up a large majority of calories burned
2. The thermic effect of food (also known as diet-induced thermogenesis): the extra calories you burn when you metabolise energy from food. Typically, you use about 0-3 % of the energy you consume from fat to get the energy from fat, about 5-10 % of the energy from carbohydrate, and about 20-30 % of the energy from protein (and 10-30 % of energy from alcohol!). So overall, on a standard diet, about 10-15 % of the calories you eat will be expended just getting the energy from your food
3. Physical activity: the amount of energy you use doing any activity above just living. This might be a tiny amount of energy (scratching your head) or a lot of energy (running a marathon)
4. Loss: you also lose some energy in your faecal matter and to a lesser degree urine; these losses are nutrients that essentially did not get absorbed during digestion or used during metabolism, and can be as high as 10 % of the calories you consume

You consume or produce energy in two different ways (Bergman, 1990; Hall *et al.*, 2012; Kasubuchi *et al.*, 2015; LeBlanc *et al.*, 2017):

1. Food and drink: the amount of calories you directly consume from food and drink. Roughly, this can be broken down into four energy-available macronutrients which have different amounts of energy per gram: fat (9 calories per gram), carbohydrates and proteins (both 4 calories per gram), and alcohol (7 calories per gram). Water is of course another macronutrient but does not contain accessible energy
2. Gut bacteria: certain bacteria in your gut produce short chain fatty acids; some of these get absorbed and used as energy by the body. This can be as high as 10 % of the your total energy “intake”

Figure 1 below shows these six energy balance factors:

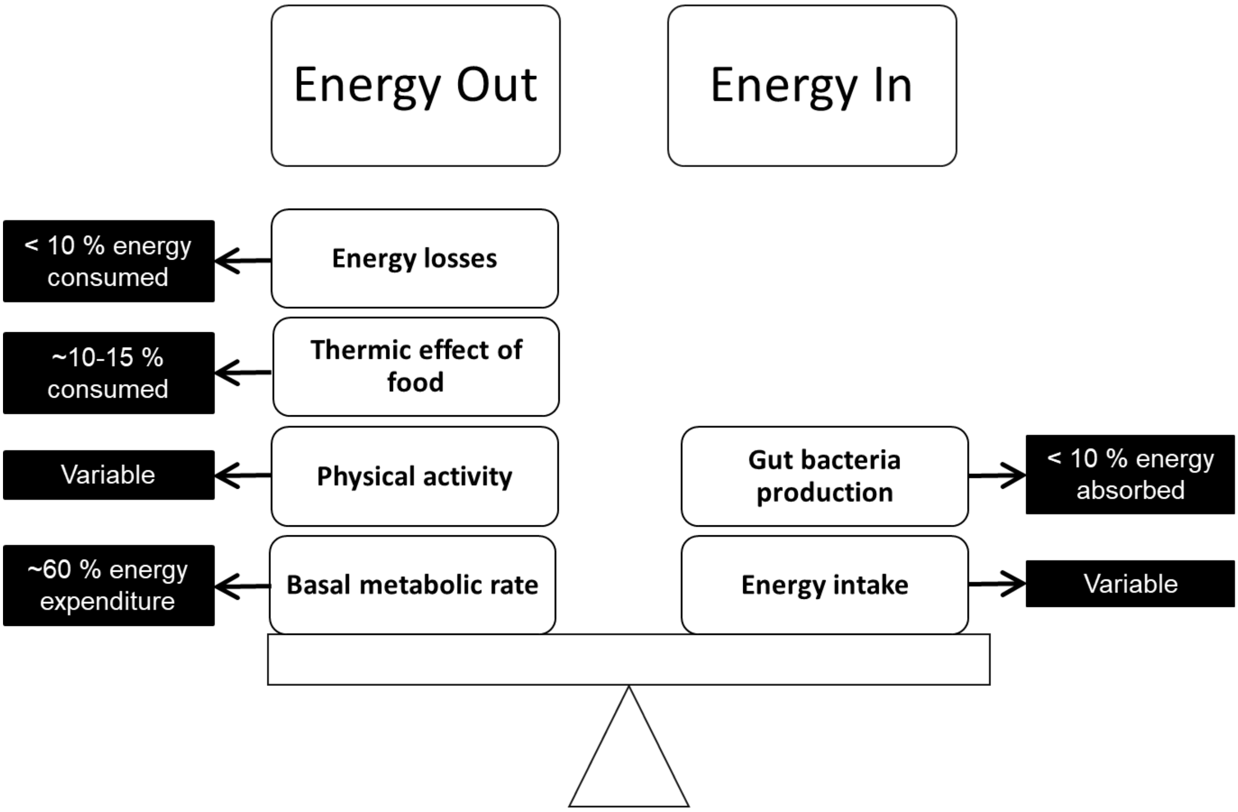

Figure 1. Components of energy balance

As you can see this is very complex already. A successful diet aims to increase energy expenditure and/or reduce energy intake. The regulation of all this fundamentally comes down to your appetite; I say this because exercise increases how hungry you get by more than the calories you burn during exercise, making exercise alone a difficult method to use to lose weight (it is very helpful for weight maintenance though) (Hopkins *et al.*, 2010). If getting people to address their appetite through food-related interventions worked, we would not have an obesity epidemic on our hands. Yet everyone seems to have been ignoring the part of our diet that contains no calories, is very easy to modify, and spontaneously makes you reduce your energy intake with no hunger pangs or cravings to worry about: water!

Key message:

Diets are difficult and energy balance is complex, but avoiding excess fluid reduces appetite effortlessly

How can (lack of) water have such effects though? Water restriction results in a phenomenon known as “dehydration-induced anorexia” (Boyle *et al.*, 2012). Before you worry, anorexia here is simply a term to describe loss of appetite (literally: *an* meaning without, and *orexis* meaning appetite). Dehydration-induced anorexia occurs primarily from losing water from your cells (‘cellular dehydration’); in other words, you cannot cheat this effect easily by using drugs like diuretics as these remove water from outside your cells (extracellular compartments, like your blood). When you stop drinking, you lose water roughly equally from both inside and outside of the cells, so you trigger this rather extraordinary appetite response.

There are many reasons dehydration induces a loss of appetite, mostly relating to the regulation of appetite in the brain. Dehydration increases a hormone called oxytocin (Pretel & Piekut, 1989), and oxytocin decreases food intake (Olson *et al.*, 1991). Oxytocin neurons have been shown to connect to cholecystokinin (CCK) neurons in the in an area of the brain that helps with appetite control, called the nucleus of the solitary tract (Olson *et al.*, 1991). CCK in itself is an appetite hormone that makes you feel full.

What has oxytocin got to do with dehydration though? Oxytocin is more commonly known as the “love hormone” because it increases when parents hug their children (particularly strong immediately after childbirth), and is partly responsible for the feelings people get when they take the party drug ecstasy. The oxytocin molecule is nearly identical to the AVP molecule though, so has key roles in regulating our hydration status too (Conrad *et al.*, 1993; Rhodes *et al.*, 1981; Van Tol *et al.*, 1987; Verbalis *et al.*, 1991; Verty *et al.*, 2004)!

As well as the above quite immediate appetite-reducing effects (within a day), after a few days of dehydration, other appetite-blocking mechanisms occur. The most fascinating change in my opinion is an increase in a hormone called glucagon-like peptide-1 (GLP-1); the increase is again is caused by oxytocin (Rinaman & Rothe, 2002). Admittedly, I am a bit biased as my PhD thesis included quite a lot of work on GLP-1. The reason I am so enthused by GLP-1 is that it has a three-fold effect on health: (i) it makes you feel full; (ii) it reduces the reward value of food, so you crave foods less; (iii) it is known as an incretin hormone because it works with your pancreas to produce insulin and keep your blood sugar in check and your pancreas healthy. So anything that increases GLP-1 has two thumbs up in my book!

Moreover, in the brain, there are two key signalling molecules (‘peptides’) that tell you that you are hungry: neuropeptide Y (NPY), and agouti-related protein (AgRP). When you stop drinking, you will likely continue to eat meals when you normally would, but you will probably find that you eat less at each occasion; this is from lower NPY activity! In other words, hunger signals in your brain become weaker (Boyle *et al*., 2012; Salter-Venzon & Watts, 2009). The final appetite hormone that is affected by avoiding excess fluid intake which I want to highlight is ghrelin. High ghrelin levels make you hungry, but it is most strongly suppressed by intestinal osmolality (remember, osmolality is how concentrated things are, but this time in your intestine rather than your blood) (Cummings, 2006; Overduin *et al.*, 2005). Therefore, by not drinking, you allow your gut concentration to increase and this stops you feeling hungry.

Key message:
Avoiding fluid increases hormones that make you feel full, and decreases those that make you feel hungry

It makes sense for appetite to be lessened during times of fluid restriction (Bankir *et al.*, 2017). If you remember earlier I mentioned that when you stop drinking, your blood concentration increases? Well, this also happens when you consume solutes, such as salt. When you eat salt, this gets absorbed into your blood stream, and water then follows because of osmosis. As water moves into your blood stream (and anywhere else the salt has been distributed), your blood concentration stays roughly the same. But if you are dehydrated already and you do not drink with your food, your blood concentration will end up taking water from other areas of the body. As I hopefully demonstrated above, this is not dangerous; the fact your appetite goes away helps prevent it being dangerous! It therefore creates a negative feedback loop (Figure 2) (negative feedback loops, despite sounding bad, are actually good as they stop things getting out of control): not drinking increases your blood concentration and this reduces your appetite and stops your concentration getting too high:

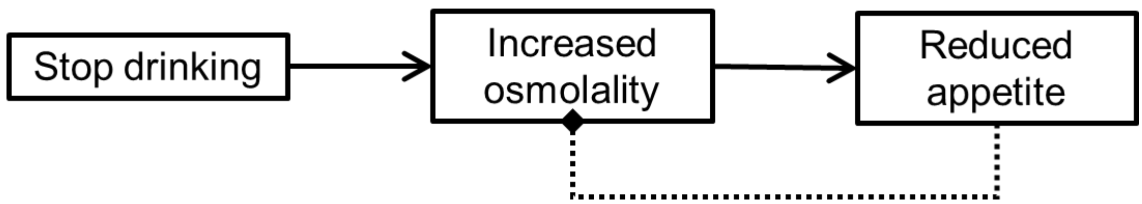

Figure 2. Negative feedback loop showing how high osmolality (concentration) reduces appetite and this maintains balance. Filled line shows how one things causes another thing; dotted line shows how one thing stops another thing

Of course, anything in excess will be dangerous including too much salt in your blood. So listen to your body and the appetite signals it is giving you—these will tell you when you should eat, and because this is so tightly regulated, your eating will occur at optimal times for your body to handle the salt you consume.

It therefore makes sense that when we dramatically reduce our fluid intake, our appetite reduces as this prevents the salts in our blood getting too concentrated, and our body cleverly regulates this by altering our appetite hormones and how our brain responds to appetite signals. But all that is quite theoretical, and what happens in a lab does not always work outside the lab. So what does more 'real life' research show?

Let us go back to my three day study of no fluid (Carroll, 2020b). When I stopped drinking my hunger decreased, and had all but vanished by the third day. Similarly, my fullness was consistently high every day when I was not drinking. By the end of day 1, I also noticed something quite peculiar: my desire to eat was basically gone. I have participated in lots of nutrition studies over the years, and even when I have not been hungry, I have still in some way *wanted* to eat. I imagine this lack of wanting to eat might be related to my GLP-1 increasing (though I did not measure this, it just seems likely). Equally, before the study started (when I was pre-loading with lots of water) and when I was rehydrating after the three days of no fluid, my hunger was much higher, as was my *want* to eat. Part of this was probably an increase in ghrelin from diluting my gut with all this excess fluid, but regardless of reasons, this rapid reversal of the appetite loss when reintroducing fluids is well documented so not unexpected (Watts, 1998). I ran some correlations on the data too, and found strong relationships showing that the longer I went without fluid, the lower my hunger was, the higher my fullness was, and the less I wanted to eat. I also desired fatty and savoury food much less too.

It is all well and good that I *felt* this way, but how did any of that change my eating? Well the day before and the day after the fluid restriction when I was consuming ample fluid, my energy intake averaged 1731 calories per day. But during fluid restriction, my energy intake averaged just 1012 calories per day. That is a difference of over 700 calories per day, and honestly this was without any effort at all.

Now, admittedly, the food I ate was very low water content too, so each day my total fluid (water from foods and drinks) was less than 50 grams. It is perfectly safe for most (healthy) people to do this for a few days, but you do need a bit of extra fluid than that longer term. Hence why I recommend eating normally, and avoiding excess fluid intake by not drinking. Of course, you may want to eat low water content foods (e.g. toast, oil, nuts, flapjacks, dried fruit) so you can drink more fluid (e.g. coffee!), and I would leave that decision up to you. But aiming for a total fluid intake of less than 800 mL (about 1.5 pints) a day if you are a man and less than 600 mL (about 1 pint) a day if you are a women should provide you with the benefits I described above.

I will finish this section by highlighting that the above is not just my experience in terms of appetite; plenty of research has shown similar rather extraordinary effects. To give some examples, above I described a study by Vivanti *et al.* (2008); within this study they looked at body mass index. Body mass index can be used as a proxy for appetite regulation as if you are eating the right amount relative to what you are burning through activity, you will have a healthy-range body mass index. Vivanti *et al.* (2008) found that those with dehydration had on average a body mass index that was seven points lower—their body mass index was 20.0 kg/m^2 (at the lower end of the healthy range) compared to those with normal hydration who had an index of 27.5 kg/m^2 (which is well within the overweight category).

Similarly, Salari-Moghaddam *et al.* (2020) found those who drink less than two cups of water per day reduced their risk of having obesity by 78 % compared to those who drank more than eight cups per day. Thinking back to the above, two cups per day is roughly in line with my recommendations set out above. In a very early study, Nadal *et al.* (1941) experimented with different methods of dehydrating people, and also found dehydration-induced anorexia though they did not give details on how much calorie intake was reduced by. This is such an interesting but completely ignored topic, and I could go on and on but want to save some of the details for Part II. So for now, I just want to emphasise that this is a well-established phenomenon (Bruno & Hall, 1982; Callahan & Rinaman, 1998; de Gortari *et al.*, 2009; García-Luna *et al.*, 2010; Jaimes-Hoy *et al.*, 2008; Reyes-Haro *et al.*, 2015; Rinaman *et al.*, 2005; Watts, 2000; Watts *et al.,* 1999).

Key message:
Losing your appetite when avoiding excess fluid is an incredibly well-established phenomenon

I also want to add a couple of extra points to this section. Firstly, I am sure you are aware of the success people have on the low carb diet. A lot of people attribute this to the metabolic switch from carbohydrates to ketones. But with the low carb (or ketogenic) diet, comes body water loss. This is because to store carbohydrates, you need three times as much water as there are carbohydrate, so when you consume carbohydrates, you also encourage your body to store excess fluid (Carroll *et al.*, 2019a). When carbohydrates are dropped from the diet, there is an initial rapid weight loss from losing this excess fluid. There also appears to be a rather rapid reduction in appetite. I cannot help but feel that this is exactly what I have described above, particularly considering the water loss is directly from cells which is the driver of dehydration-induced anorexia. Low carbohydrate diets also reduce how much water can be absorbed, so often people experience mild dehydration and more urination than usual. This suggests the dehydration is prolonged during such a diet, but due to its controversial nature has not even been considered as a reason for the success of the diet.

Further, in terms of how your metabolic response might aid your weight loss, my research showed that even at low levels of dehydration, such as those you will likely experience after one or two days of avoiding excess fluid; the amount of fat you burn increases after eating, compared to when you are well hydrated (Carroll *et al.*, 2019a). This means that behaviourally, you will eat less, whilst metabolically you will also be burning more fat! To add to that, if you remember back to when we discussed blood sugar, you will recall that when we drink with food, we get a higher blood sugar response. This was attributed to water drawing nutrients out of the stomach prematurely. But this lower blood sugar level when we stop drinking might also represent that we are actually absorbing fewer calories too. This means that gram for gram, you absorb less energy when you stop drinking excess fluid, which of course is another helping hand to your weight loss success.

Finally, I want to clarify that I am not advising that anyone does anything as extreme as permanently living in a state of extreme thirst. If you want to experience that, it is perfectly safe to do for a few days (assuming you are generally healthy), then you can move onto the diet I am suggesting. I am actually not suggesting anything extreme; just avoid excess fluid. By that I mean you can get more than enough fluid from your foods (perhaps be a bit selective, a diet of soup would be somewhat counterproductive!). I also recommend that you listen to your body through this. You will feel things like a dry mouth but these are just whilst you adjust and will get better over time. You may want every week or so to have a “cheat” day to enjoy fluids that you miss. I think it is important to make this work for you, safely and comfortably. You know the science now, so you can make it happen! Hopefully the next sections will help with some of the finer details of this diet and empower you to make evidence-based, science-backed decisions on your health.

Key message:

Avoiding excess fluid is a flexible diet, reduces your appetite, and helps you burn fat

1.7 Summary

To sum, the key messages you should have picked up from Part I are as follows:

1. Our water needs for survival are vastly exaggerated
2. Our water needs are easily met and not getting enough fluid is not a legitimate health concern. Contrarily, there are health benefits to consuming far less fluid than is recommended
3. When you truly need water, you will absolutely know about it
4. Much of our diet knowledge, including the dietary guidelines, is based on very weak evidence
5. Consuming excess fluid actually dehydrates you
6. Dietary recommendations to drink more water may actually cause harm

7. Dehydration does not affect cortisol or blood sugar (and may even lower blood sugar), but drinking water itself might increase blood sugar and insulin levels, particularly after eating
8. Dehydration profoundly reduces blood pressure
9. Avoiding excess fluid has a range of health benefits, beyond what is discussed in detail in this book
10. Diets are difficult and energy balance is complex, but water restriction reduces appetite effortlessly
11. Avoiding fluid increases hormones that make you feel full, and decreases those that make you feel hungry
12. Losing your appetite when restricting fluid is an incredibly well-established phenomenon
13. Avoiding excess fluid is a flexible diet, reduces your appetite, and helps you burn fat

Once you have digested (sorry for the pun!) that, you are ready for Part II where we will delve into the details…