by Derek Morrison

You have two shots in the morning to set up your day
With two more mid-morning so that on the pace you stay
In between are the energy gels which are not much to your taste
But they have become essential because they're also caffeine laced.

After one hour the alertness washes over you as the caffeine comes into play
Your thinking is so much faster as out in front you stay
Your endurance has increased, your stamina is high
So you sink another gel as down the road you fly.

At lunch you try to control the slight tremor and restlessness you feel
Just one more coffee will soon bring that to heel
You are really buzzing now as on your bike you get
No one can catch you as back on the road you set.

But you don't feel so good as your system feels the effect
Your pulse is now accelerating as the heart starts to object
Where now is all the strength and stamina you earlier so enjoyed
Perhaps time to reflect on the health with which you've toyed.

That night you cannot sleep because the drive remains too high
So you toss and you turn on the bed where you lie
More time for reflection on the value of what was done
As the dawn light creeps through the curtains, another day begun.

So on your next ride the caffeine fixes have been cropped
Withdrawal headaches were guaranteed as suddenly you stopped
Performance tails right off with fatigue for many weeks
Until your system adjusted to the absence of caffeine tweaks.

Now caffeine is a legal drug and endurance it certainly enhances
But it has diminishing returns for those who choose to take such chances
And *like any drug with overdose it can hit an unexpected spot*

Particularly when you don’t know how much caffeine is in a shot.

As little as one milligram per kilogram of body mass
And physiological effects will still come to pass
At five milligrams per kilogram the effects don’t tend to hide
Which is why some cyclists use it before or during their ride.

Caffeine is a neurostimulant which is why you feel so free
It constricts your brain’s blood vessels and also affects its chemistry
It may strengthen all the muscles which also includes the heart
But it can also raise your blood pressure while along the road you dart.

But like any drug of any type tolerance develops over time
So you increase the dose because with this drug there is never any crime
But in the end it is the withdrawal effects your intake seeks to avoid
So that is why double shots of espresso and gels are then employed.

But how much is is your coffee and how much is in your tea
You are never told this, your barista if asked would flee
The answer of course it varies, but in your 200 ml of filtered bean
It is reasonable to assume there will be at least 100 mg of caffeine.

And if you think you are being real cool
By using coffee instead of Red Bull
But a wrong assumption, best flushed down the pan
Red Bull has 80 mg in a ‘high caffeine’ 250ml can.

Coffee tastes bitter because of alkaloids like caffeine
But the amount contained within depends on the type of coffee bean
Arabica contain 50% less than Robusta which is probably just as well
Because the former has 80% of the world market in its spell.

Consider also how many shots are standard in your refreshing brew
Some shops give you one, whereas others give you two
Get it wrong and you can easily exceed your limit for the day

And at that point you may find where the side effects do lay.

You would also be wrong to think a mild roast will give you a lesser kick
Because less roasting simply leaves the caffeine in much better nick
So when you look at these 1 to 5 numbers on your coffee jar or pack
Lower can mean higher if you get my line of attack.

How much is safe you may want to ask
But that's not so easy, it's definitely a research led task
But for pregnant women it should certainly be low or no
For with more than 200mg per day baby may not grow.

For everyone else an intake of about 400 mg per day
Seems to be pretty average to feed work and play
But caffeine peaks at one hour with effects for three hours more
So b*est take account of this as another coffee you pour.*

For the same reason if you are out for dinner late
And are offered coffee as they clear the plate
It's your call on whether counting sheep
Is preferable to a good night's sleep.

Two shots in the morning may well set up your day
With two more mid-morning so that on the pace you stay
But next time caffeine begins enhancing your coping
Reflect briefly on this tale as you employ this form of doping.

[To listen to this verse select below]

http://www.cyberstanza.com/wp-content/uploads/2015/02/EspressoDelivery.mp3

Postscript

I wrote the above in an attempt to simplify and summarize the messages arising from the extensive and sometimes contradictory studies that have been undertaken on caffeine. Just

to round things off I also offer a few caffeine laced ‘factoids’ which I will try and update from time to time.

Factoid 1

About 3% of caffeine ingested finds it’s way back out into urine as free caffeine. That was the basis of dope testing by the IOC until 2004 where anything above 12mg/litre of urine was an infraction.

The World Anti-Doping Agency says the following:

“Caffeine was removed from the Prohibited List in 2004. Its use in sport is not prohibited. Caffeine is part of WADA’s Monitoring Program. This program includes substances which are not prohibited in sport, but which WADA monitors in order to detect patterns of misuse in sport. The 2010 and 2011 Monitoring Programs did not reveal global specific patterns of misuse of caffeine in sport, though a significant increase in consumption in the athletic population is observed.”

Factoid 2

What’s astounding is that given the known pharmacokinetic effects of caffeine (first isolated from coffee in 1820) even at relatively low doses, e.g. 1-2 mg per Kg of body mass, we just don’t really know with any accuracy how much caffeine we are taking in with our humble cup of coffee. There is a known range of caffeine in different coffee beans but it’s quite a wide range and nowhere on a coffee pack does it specify the level of caffeine per x grams (see also factoids 3 and 4). To that add how much coffee plus how long the brewing time, and so now we are all guessing. Further complexity arises because the variation in the number of many espresso ‘shots’ that are used as the basis of some coffees, e.g. a large americano, latte or cappuccino in one cafe equals 1 ‘shot’ whereas in another there could be two incorporated as standard.

Nevertheless, the UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) gave the following measures for caffeine content in 2001.

Source	Typical caffeine content (mg) per serving
Instant coffee	Approximately 75 mg per 190 ml cup[1]
Brewed coffee (filter or percolated)	Approximately 100-115 mg per 190 ml cup[1]
Decaffeinated coffee (brewed or instant)	Approximately 4 mg per 190 ml cup[1]
Tea	Approximately 50 mg per 190 ml cup[1]
Drinking chocolate	1.1 – 8.2 mg when made up as per manufacturers' instructions in 200 ml water[2]
Energy drinks (containing either added caffeine or guarana)	28 – 87 mg per 250 ml serving[2]
Cola (regular and diet)	11 – 70 mg per 330 ml serving[2]
Chocolate	5.5 – 35.5 mg per 50 g bar[2]

Table 1: Caffeine contents of some commonly consumed beverages and food

Factoid 3

There are a few interesting sources of information about the amounts of caffeine in raw coffee beans (and tea).

"The caffeine content of raw coffee (Arabica type) is 0.8- 2.5%, and may be as high as 4.0% for Robusta varieties.Caffeine accounts for 2.5-5.5% of the dry mass of tea. The xanthines theobromine (0.07-0.17%) and theophylline (0.002-0.013%) are also present in very small amounts. The natural range of variation in caffeine content is very considerable." (Basel State Laboratory)

Normal Arabica beans contain ~12mg caffeine per gram of dried mass although a mutant naturally 'decaffeinated' variety has been found to contain only 0.76g (Nature, June 2004).

The International Coffee Organization indicates that the range of caffeine content is 0.8-1.4% for Arabica beans and 1.7-4% for Robusta varieties. Roasting times progressively reduce the amount of caffeine and so, ironically, a lighter coffee roast is going to contain more caffeine.

N.B. Robusta is considered a lesser quality coffee bean and is much used by the instant coffee manufacturers.

Factoid 4

So what about caffeine labelling? Why is the amount of caffeine in coffee and tea never

specified? Let us just visualise the coffee and tea industry lobby groups rolling their tanks on to politician's lawns if there was even a hint of legislation in this regard.

The UK Food Standards Agency says the following:

"Drinks containing more than 150mg of caffeine per litre (mg/l) must be labelled with the term 'high caffeine content' in the same field of vision as the name of the food, which must be accompanied by an indication of the amount of caffeine per 100ml in the product. No other labelling is currently required by law and this labelling does not apply to drinks such as tea and coffee." (my emphasis)

"New labelling legislation, (The Food Information Regulation (EU) 1169/2011) which will apply from 13 December 2014, will require additional caffeine labelling for high caffeine drinks and foods where caffeine is added for a physiological effect … These rules above do not apply to foods (including drinks) where caffeine is added for a flavouring rather than physiological purpose. For these products the term caffeine must appear after the word 'flavouring(s)' in the ingredients list." (but again coffee/tea are exempt.)

Factoid 5

The UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) reported on the safety of caffeine in 1984 and the Reproductive Effects of Caffeine in 2001 and 2008 and identified foetal growth restriction as a very real risk from caffeine intake.

"The rate of elimination of caffeine was markedly decreased during pregnancy, the half-life increasing from 4-6 hours in the non-pregnant adult to 18 hours in late pregnancy… As a result, serum caffeine levels may be much higher in pregnant women than in non-pregnant adults for an equal intake." {Source COT 2001}

Factoid 6

A good academic, but accessible, review of caffeine and its effects in sports is provided in Caffeine and Creatine Use in Sport (Mark A Tarnopolsky, Annals of Nutrition & Metabolism, Vol. 57, Suppl. 2, 2010), e.g.

Caffeine has definite positive impact on endurance activities both at the muscular and brain

level. It enhances muscle power and so work output, i.e. it's ergogenic [increases work output] *and increases alertness and so mitigates/ameliorates fatigue. It's doubtful, however, that it has much impact upon activities involving more high intensity work, i.e.Tarnopolsky states that:*

" The evidence for an ergogenic effect of caffeine on high-intensity performance is scant compared to the data with endurance tasks … higher doses of caffeine can be toxic and appear to be ergolytic" [decreases work output].

Factoid 7

Caffeine affects the brain, cardiovascular system, respiratory system and also the muscles. But this extract applies particularly to cyclists.

"It is interesting that the muscle group most affected by caffeine (the knee extensors) plays an important role in the exercise modes most commonly tested (i.e cycling and running). During cycling the knee extensors provide by far the most (>-33%)mechanical energy provided by the body's musculature. Thus, it is possible that small gains in knee extensor strength and endurance after caffeine ingestion could translate into performance improvements commonly observed in endurance and short-term, high-intensity exercise." (Effect of caffeine ingestion on muscular strength and endurance: a meta-analysis.(Warren GLet al, 2010 Medicine & Science in Sports & Exercise. 2010 Jul;42(7):1375-87, p1385)

Factoid 8

So what does caffeine actually once inside our bodies? To begin to grasp that we need an overview of a molecule present in all cells of the body called adenosine. Adenosine play a key role in energy transfer at the cell level. It is also an important messenger (signalling) chemical thus influencing other body chemical processes and pathways.

Caffeine blocks the effect of adenosine and so many (but not all) of caffeine's effects can be understood once we know what role adenosine plays in various parts of the body. For example in the:

Brain – Adenosine is a neurotransmitter which inhibits other neurotransmitters and so reduces arousal and promotes sleep. The level of adenosine rises throughout the day which is

what signals it’s time for you to sleep. Consequently, caffeine intake blocks this natural inhibition which results in an increase in the levels of other neurotransmitters such as adrenaline, noradrenaline, tryptophan, and dopamine. It also impacts other neurotransmitters like GABA, and serotonin. The result? Arousal ++. Cerebral blood vessels are also affected (see below).

Heart and blood vessels – Adenosine dilates the coronary arteries and so improves the heart’s blood flow. It also dilates peripheral blood vessels. It also decreases the heart rate and reduces the tendency of our blood to clot. It inhibits the heart’s sinus node and reduces conduction of the electrical impulse to the atrioventricular node. That’s why adenosine is sometimes used as a treatment for some heart arrhythmias. Caffeine, therefore, can constrict blood vessels with this effect being particularly notable in the blood vessels of the brain, i.e. cerebral vasoconstriction. It’s that phenomenon which lies at the heart of the potentially major headaches that can arise with sudden cessation of caffeine intake. It’s not the vasoconstriction that is causing the headaches but rather the level of temporary vasodilation that occurs sans caffeine until the cerebral blood vessels once again adapt to not having their adenosine receptors blocked. That, plus the potential stamina impact, suggests that it is probably not wise to embark on a draconian caffeine withdrawal process until its possible to regulate athletic or endurance activity during the period of adjustment.

Kidneys – Adenosine decreases renal blood flow which stimulate specialised cells in the kidneys to produce a hormone called renin (not rennin). By antagonising adenosine’s influences in the kidneys caffeine can, therefore, both reduce reabsorption of water and sodium (resulting in a transient diuretic effect). The renin starts a chain of chemical processes that result in a rise in the blood pressure by constricting blood vessels. This process also stimulates the adrenal glands to release the hormone aldosterone. The aldosterone causes the kidneys to reabsorb sodium and water and this further increases the blood pressure.

Lungs – Adenosine constricts the airways and so caffeine enables them to dilate.

Liver – Adenosine constricts blood vessels and increases the breakdown of glycogen to glucose. It also inhibits fat breakdown (lipolysis) and increases the uptake of glucose.

Adrenal glands – Adenosine increases productions of steroids and other secretions. Caffeine

pushes up the secretion of adrenaline and noradrenaline and that will further impact on arousal, heart action and blood pressure.

Immune system – Adenosine has a small immune suppressant effect.

The sometimes contradictory effects of adenosine are a result of two different types of adenosine receptors in the human body. Heart muscle cells contain a different type of adenosine receptor from that found in the endothelial (lining) and smooth muscle cells which are found in blood vessels. Adenosine is very short acting and our red blood cells as well as the lining of blood vessels produces an enzyme which deactivates it. That is part of the human body's checks and balances, i.e. homeostasis.

In summary, caffeine, just as an adenosine antagonist can have widespread and quite complex effects on arousal levels, heart activity, blood vessels, kidneys, respiration, endocrine function, and energy metabolism.

Factoid 9

Caffeine also influences calcium, sodium, and potassium metabolism at a cellular level and that in turn can have widespread effects on many physiological processes, notably muscle performance in endurance activities.

But why just endurance activities?

Tarnopolsky offers us a very detailed physiological explanation which I have attempted to simplify and summarise below.

Calcium and Potassium affect muscle electrical conductivity. Muscles fatigue during endurance activities because insufficient calcium ions are being released. Caffeine stimulates calcium release and so increases electrical activity of muscle. In high intensity exercise with bursts of power, e.g. weights, sprints, time trials etc blood potassium rises and that blocks the electrical conduction necessary for skeletal muscles to function and caffeine has no effect on that. But caffeine can attenuate the effects of the lower level of increase of blood potassium that arises during endurance exercise (in Caffeine and Creatine Use in Sport, Mark A Tarnopolsky, Annals of Nutrition & Metabolism, Vol. 57, Suppl. 2, 2010).

Further support for caffeine's specific influence on endurance rather than anaerobic activity is offered by Simmonds et al who have studied whether if improved supramaximal exercise performance in trained cyclists following caffeine ingestion was associated with enhanced oxygen uptake, increased anaerobic energy provision and whether slow twitch muscle fibres were more sensitive to caffeine. They suggested that muscle fatigue arises because of disturbances to ion balances and ion pump activity at the cell level, e.g. Sodium (Na+), Potassium (K+). For example potassium levels fall within muscle cells and rise in the plasma just before muscle fatigue. Caffeine, therefore, could be exerting its effect by increasing Na+ – K+ pump activity. In the submaximal warmup phase of their study the blood potassium of the caffeinated cyclists was reduced by 13.4% which left more headroom before reaching the peak level of potassium at exhaustion. Their time to exhaustion was also increased by 14.8%. Such submaximal warmup results are very relevant for endurance sports. Submaximal means the cyclist's activity is at a level consistent with endurance riding. This is lower than their individual functional threshold so that they always remain in their aerobic zone (MJ Simmonds, CL Minahan, S Sabapathy, Caffeine improves supramaximal cycling but not the rate of anaerobic energy release, European journal of applied Physiology, 2010 – Springer.)

Factoid 10

Partial tolerance to caffeine occurs which may mitigate some of the effects on blood pressure, neurostimulation, and kidney function. The partial tolerance may develop because the number of adenosine receptors in the body increases thus reducing the impact of caffeine's adenosine blockage effect. Because of the increased number of receptors sudden withdrawal of caffeine can lead to an increased response to adenosine within 12-24 hours, e.g headache due to a rebound increase in cerebral blood flow, loss of concentration, and fatigue. Some withdrawal signs and symptoms can be anticipated even with as little as 100 mg of caffeine intake per day on a regular basis, i.e. a modest coffee drinker.