Cortisol and exercise – friends or foe?

We've always known that too much of a good thing may become detrimental to us, but current training mentality seems to defy this understanding. From the perspective of cortisol, **Katia Demekhina** eloquently illustrates a balanced view of exercise and of life.

We have all heard the advice that we should exercise to manage stress. However, did you know that exercise can also be perceived as a stressor by the body, adding to the stress load rather than helping manage it? To understand how, why and when this can happen, let us explore the relationship between cortisol – one of the critical human stress hormones – and physical activity.

Cortisol and its many roles

Cortisol is a hormone secreted by the adrenal glands that reside at the top of the kidneys. The daily release of cortisol follows a circadian pattern; the highest level early in the morning stimulates wakefulness, then cortisol supports alertness throughout the day, and gradually decreases to help bring about sleep in the evenings. In addition to its role in the sleep-wake cycle, cortisol is one of the main hormones that help us respond to stress. Stress can be anything that we perceive as a threat – a situation where the demands are perceived to outweigh the available resources to cope successfully. For our ancestors, such stressors used to be the predators that they encountered in their environment. As part of the ancestral survival mechanism, cortisol secretion allowed them to act quickly to protect themselves when faced with a growling tiger. Specifically, to fight or flee – the typical choice they had when faced with a threat.

In an acute stress scenario, such as when encountering a predator, our brain secretes chemical messengers that stimulate the adrenals to release cortisol. Once released, cortisol alters multiple metabolic pathways in tissues, such as skeletal muscle, adipose tissue, the liver and the pancreas, to mobilise the body's energy resources to where they are needed most (e.g. brain and muscles). In skeletal muscles and adipose tissue, cortisol increases amino acid and lipid mobilisation through a catabolic breakdown of tissues. It also stimulates the liver to begin the process of gluconeogenesis, making additional glucose for energy. In the pancreas, cortisol influences the release of insulin and glucagon – hormones that regulate the blood sugar balance – to release more glucose into the circulation. Collectively, these processes increase glucose concentration in the blood, making resources available for crucial systems in the body, needed for fight or flight.

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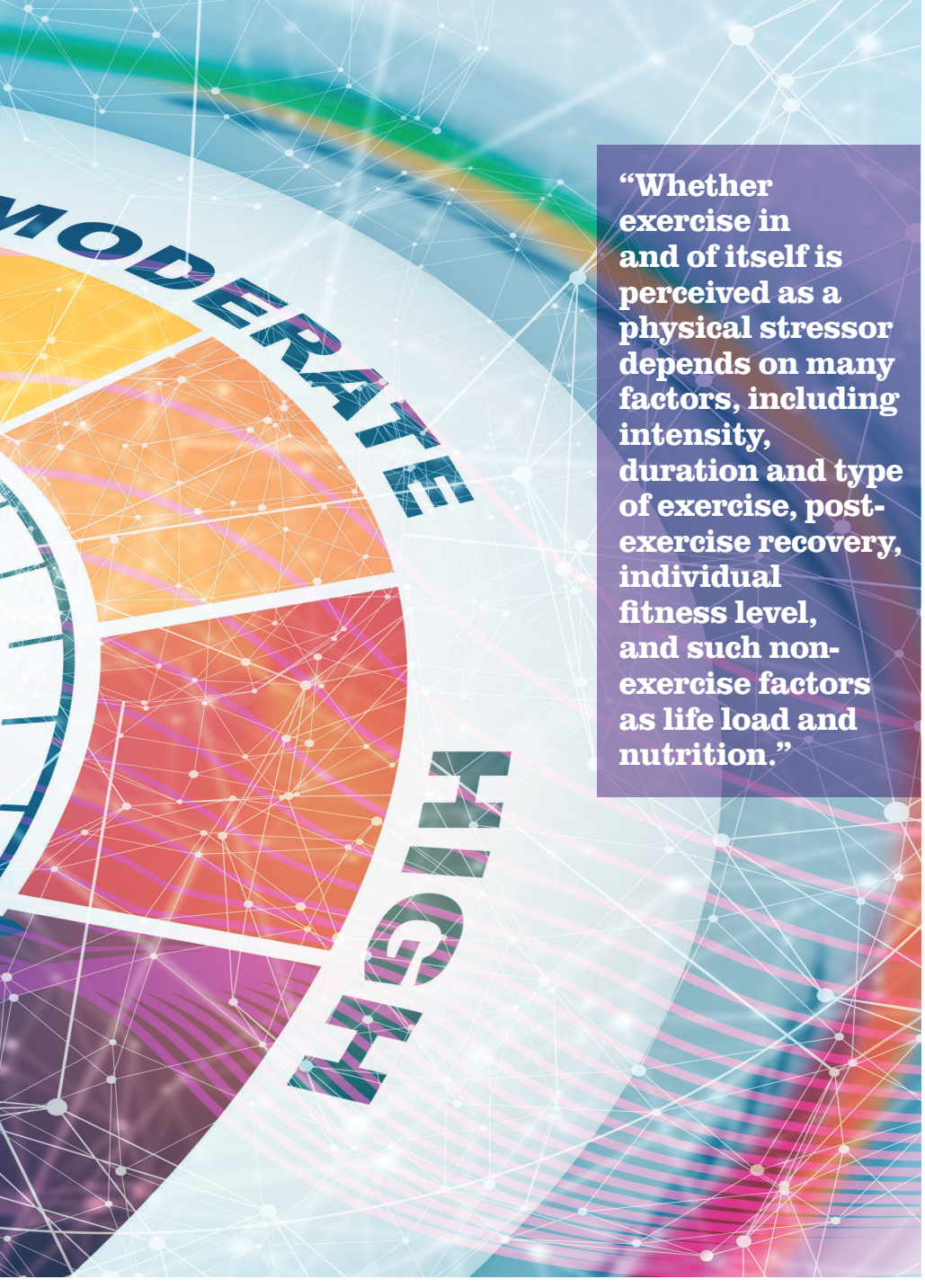
Glucose is an essential substrate for skeletal muscles during exercise. Once glucose stores in the body are depleted, cortisol release is triggered to provide the energy needed for working muscles to operate at peak capacity. Animal studies clearly show the importance of cortisol as the controller of energy needs. Removing the adrenal glands in rats (with an ensuing absence of cortisol secretion) results in low blood sugar levels during exercise, with subsequent rapid onset of fatigue and muscular exhaustion (1).

However, if we secrete just a little too much cortisol too often, this hormone can start having a degenerative effect on the body. Excess cortisol will switch from fuelling the body for the high-intensity exercise to increasing muscle loss, elevating blood sugar, and inducing insulin resistance, accelerating abdominal fat accumulation, contributing to fatigue and depression, and more (2). In addition, cortisol also weakens one's immunity, shuts down less critical functions like reproduction and digestion,



"Whether exercise in and of itself is perceived as a physical stressor depends on many factors, including intensity, duration and type of exercise, post-exercise recovery, individual fitness level, and such non-exercise factors as life load and nutrition."

and interferes with other endocrine functions like the activities of the thyroid gland. Too much cortisol for too long leads from merely "bad" to outright "ugly" aspects of cortisol overexposure, characterised by immune suppression and widespread tissue destruction – ranging from muscle and bone loss to organ damage.

Moderating cortisol levels is therefore vital for maintaining physical performance, health, and wellbeing. So how can we manage our training regimen in such a way as to reduce the excess load on the adrenal glands and optimise performance?

Not all exercise is created equal

In an attempt to enhance performance, professional and recreational athletes typically undertake a tremendous amount of training. Structuring the training programme correctly is therefore critical to avoid inappropriate neuroendocrine stress responses and to sustain an athlete's ability to perform. Whether exercise in and of itself is perceived as a physical stressor depends on many factors, including intensity, duration and type of exercise, post-exercise recovery, individual fitness level, and such non-exercise factors as life load and nutrition.

When it comes to resistance exercise, research shows that training intensities exceeding 75 per cent of maximal strength capacity produce a 68 per cent larger cortisol response than moderate-intensity training (which does not cause a significant change in cortisol secretion). However, recovery time within a session is also a crucial modulator since the cortisol response is reduced when low repetition sets are combined with more extended rest periods between sets. On the other hand, high repetitions with short rest periods result in increased heart rate and subsequent greater cortisol response (3).

Compared to similar duration and intensities of resistance training, aerobic exercise may have a greater impact on cortisol concentrations. The perception of the difficulty of aerobic exercise is linked to the cardiovascular response and is expressed as a percentage of maximal oxygen uptake (VO_2max). Most exercise physiologists suggest that aerobic exercise needs to be performed at intensities at or above 50-60 per cent of VO_2max for circulating cortisol levels to start to rise. On the other hand, the exercise of low intensity (at or below 40 per cent of VO_2max) may result in a reduction in the circulating cortisol (4).

The length of time spent exercising appears to be the primary modulator of cortisol production (3). The longer the amount of time the body is under physical stress and in a state of hypoglycaemia, the higher the plasma cortisol concentrations and the more significant the metabolic and immune activity disturbances (5). In 2012, a team of researchers assessed cortisol levels in 370 amateur endurance athletes (such as long-distance runners, triathletes and cyclists). They found a dose-response association between training volume and cortisol levels, such that repeated stress of intensive training and competitive races was associated with elevated cortisol exposure among endurance athletes (6). Even with low-intensity endurance exercise, the stress response becomes similar to that in high-intensity training if there is a lot of it. A 2021 study of healthy recreational athletes who had to walk a distance of 100km in under 24 hours found that stress parameter changes among the competitors were comparable to triathlons or ultramarathons of much higher intensity (7). With duration being such a significant modifier of a cortisol response, endurance athletes are one of the athletic populations most at risk for cortisol imbalances, regardless of exercise intensity.

The exercise training status can also influence one's hormonal exercise response. In resistance and endurance exercise, training programmes can lead to adaptations that allow the body to increase the capacity to handle a higher workload with less stress axis activation proportional to the degree of physical training (3). It has been proposed that cortisol responds less to continuous exercise in higher trained individuals as they develop a reduced cortisol sensitivity to protect muscle and other tissues against increased cortisol secretion during (and after) training (8).

Additionally, recovery is critical to allow the cortisol to return to normal. As cortisol concentrations increase linearly with exercise intensity, a longer time is needed for cortisol to return to baseline values after high-intensity exercise. A 2021 meta-analysis of 900 participants in high-intensity interval training found that 24 hours may be required for cortisol to return to baseline after a single intense training session. More extended recovery periods may be necessary for those undertaking multiple sessions as part of their training regimen (8).

Total life load

Both professional and recreational athletes alike may push their training volume and intensity to the limits to maximise their performance.

However, many athletes don't realise that in addition to their training regimen, other factors such as mental stress, daily hassles, lack of sleep, and inadequate nutrition also place demands on the body's resources, impacting their ability to train, recover and perform. As such, athletes need to consider the 'total life load' when assessing an appropriate training level to avoid maladaptation (9). In fact, for all but the most elite (full-time) professional athletes, training is not the most important source of stress on the body. Factors such as work stress, inadequate nutrition, and sleep deprivation represent significant sources of stress for many athletes with busy lives.

Cortisol is a great way to respond to stress, but it needs to end so that the body's functions can return to normal. However, many of us do not have an off switch, resulting in a permanently activated stress response. Chronically elevated cortisol is implicated in overreaching and overtraining scenarios – a result of an accumulation of training and non-training stress, leading to a short- or long-term decrease in athletic performance capacity, with possible physiological and psychological ailments (10).

What to do about this?

The key to making the cortisol work for you rather than against you is balance. In addition to managing training load, life load, and recovery, two critical modifiers that can tip this balance are stress management practices and nutrition.

Stress management techniques, such as yoga and meditation, can change the negative cortisol narrative. A 2017 review of 42 studies found that yoga practice can reduce waking, afternoon and evening cortisol levels (11). In the same year, Pascoe and colleagues synthesised the results of seven randomised control trials (the current gold standard of research) and determined that meditation also consistently reduces cortisol levels (12). The most recent meta-analysis of 21 studies completed in 2021 found that the effect of meditation on cortisol levels was particularly significant for those with persistent activation of the fight-or-flight response. Authors also established that more extended meditation programmes were more effective in stress reduction, highlighting that stress management practices work best if you can put them into regular practice (13).

The nutrition status of an athlete before and following the exercise stimulus also influences the endocrine response. Since the role of cortisol during strenuous exercise is to mobilise energy, starting exercise with low circulating glucose, such as during a fasted morning session, can significantly increase the cortisol response (3). If the adrenals are already overwhelmed by day-to-day life, we don't want to stress the body further by limiting easily accessible energy sources for exercise.

In general, a diet that provides sufficient carbohydrates for the exercise load can help provide adequate energy substrate for optimal hepatic and muscle glycogen synthesis in-between training bouts. This replenishment of glucose stores allows optimal levels of blood glucose to be maintained longer during exercise, attenuating cortisol release. Conversely, a low carbohydrate diet may increase plasma cortisol concentration during exercise (5).

In addition to a diet that provides sufficient complex carbohydrates during periods of increased exercise workload, carbohydrate ingestion immediately before physical exertion, or during prolonged exercise, may also attenuate cortisol rise by supporting steady blood glucose concentration. To supply muscle fuel needs, support blood glucose concentration, attenuate cortisol rise, lessen protein breakdown, reduce the rate of perceived exertion, and improve exercise capacity and performance, a drink proving around 60 grams of carbohydrates per hour is ideal (14). The box below shows an example of such a drink.

A SIMPLE WAY TO SUPPORT BLOOD GLUCOSE LEVELS DURING EXERCISE

- 1 litre green or rooibos tea (high in antioxidants)
- 75g raw honey
- A pinch sea salt
- 1 tsp glutamine powder

Dilute honey in lukewarm tea, mix in salt and glutamine (optional) and sip on the drink in the run-up to and during the exercise session. These proportions have been designed to sustain blood glucose levels during an hour-long intensive exercise session.

It is also essential to fuel the body with correct nutrients for recovery to dampen the cortisol levels and prevent its catabolic effects. The thing is that when you stop exercising, cortisol levels remain high, and the breakdown of muscle protein continues. A recovery drink containing carbohydrates and protein can facilitate muscle glycogen replenishment, modulate cortisol levels and turn on the cellular pathways that rebuild and repair muscle (15). The post-exercise smoothie recipe below also adds berries and other superfoods that boost the recovery potential.

A POST-EXERCISE RECOVERY SMOOTHIE

- 1 banana
- ½ cup frozen cauliflower florets
- ½ cup frozen berries
- 1 tbsp cocoa powder
- 30g protein powder
- 1 scoop of red superfoods powder
- 1 glass of coconut water

Blend all the ingredients and enjoy. A looser consistency can be achieved by adding more water.

Conclusion

Cortisol is a perfect example of when too much of a good thing can get it working against you. The key to embracing cortisol's good, while keeping the bad and the ugly at bay is life balance... A balanced life means a wholesome diet, adequate recovery, healthy sleep patterns, stress management and adequate physical activity. And remember, when it comes to exercise, more may not be better. **fsn**

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SEPTEMBER/OCTOBER 2022

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