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PREVENTION & REHABILITATION: Editorial

Modern disintegration and primal connectivity

1. Introduction

The foot bone's connected to the … ankle bone … and so the song plays out. But what is it that connects the bones of the body? And more than just connecting and moving, what other roles do these connecting tissues serve?

Anyone who has personally experienced, or worked with clients with a connective tissue injury will know that such experiences can be troublesome, persistent, frustrating and sometimes downright disheartening. But there is good reason to be positive about management of such common injuries, as the field of connective tissue research is one of the most vibrant and eagerly explored fields in modern musculoskeletal rehabilitation and performance conditioning circles.

As Robert Schleip recently reminded the 1000-strong delegation at the 2018 Fascia Research Congress in Berlin, connective tissue is not more important than muscles, cardiovascular function, or the nervous system … but it is like their long-lost little sister who had been missing for a while and now is back (Schleip, 2018). In the manual therapies and performance conditioning professions this is not far from the truth, yet from a nutritional perspective, it may actually be that the long-lost little sister has just gone missing.

Included in this edition's Prevention & Rehabilitation section we have selected the following two papers:

- The effectiveness of Biomechanical Taping Technique on visual analogue scale, static maximum handgrip strength, and Patient Rated Tennis Elbow Evaluation of patients with lateral epicondylalgia: A cross-over study, by Dones et al, 2019.
- The effects of passive stretching on the blood glucose levels of patients with type 2 diabetes, by Taheri et al. 2019

In their encouraging paper, Dones et al, 2019 describe how a novel taping approach, called Biomechanical Taping Technique, improved pain levels and hand-grip strength in people with lateral epicondylalgia; providing the potential for an earlier return to sports or work and better quality of life for those experiencing this condition.

In the paper by Taheri's group, a surprising lowering of glycemic levels in Type 2 diabetics was achieved after passive stretching of several muscle groups, which was statistically significant compared with controls. This paper helps to illustrate the interconnected nature of the human myofascial system with far more than just biomechanics; affecting the body's biochemistry, possibly directly, or perhaps indirectly via neural mechanisms.

2. The triad connection

For many decades, practitioners of holistic health have used a model to understand health called the Naturopathic Triad, or Triad of Health (see Fig. 1) (Newman-Turner, 1990). The triad consists of the individual's structure (or biomechanics), their emotions, and their biochemistry. Naturally those involved in musculoskeletal medicine have tended to focus toward the structure of the body, its moving parts, with myriad assessments, tools, and techniques to address them. Conditions such as lateral epicondylitis, tendon, and other connective tissue injuries have tended toward this same bias with various techniques, exercises and mobility approaches focused toward them (see Bisset and Vicenzino, 2015, as an example).

Diabetes, on the other hand, has tended toward being managed via biochemical approaches, such as pharmaceuticals, nutrition and the biochemical effects of exercise (Grady and Gough, 2014).

As we shall see, this specialisation and imbalance toward one aspect of the triad may have been well-intentioned but ill-judged.

3. Evolutionary insights

To understand how a given body system has evolved to function, as seen in glycemic control or the fascial system, one must consider the various selective pressures of the evolutionary environment.

Blood sugar levels, for example, are tightly linked with not only diet, but exposure to daylight and darkness, to exercise, to foods of various types, and to emotional stressors. Similarly, human connective tissues have evolved in response to certain loading characteristics, to certain rest patterns and under variable exposure to nutritional resources.

In primitive times, both blood sugar regulation and connective tissue injury would, by necessity, need to be closely managed by the body's innate homeostatic processes in order to simply survive the environment. If you are reading this paper today, it is because your ancestors were successful in this pursuit; and this means that genetically, you are likely well adapted to those environments (for more on genetics see The Stress Connection below). An Achilles tendinopathy, plantar fasciitis, patella tendinopathy, or even a lateral epicondylitis would likely have been of high risk – potentially catastrophic – to chances of survival. As such, we can be certain that there are in-built mechanisms that mitigate for such circumstances. This notion also helps point to the cause of such injuries as not being unfortunate happenstance vulnerabilities, but a mismatch between how people live today versus how they lived in the 99% of our species' history, known as the Paleolithic Age (Gluckman and Hanson, 2008).

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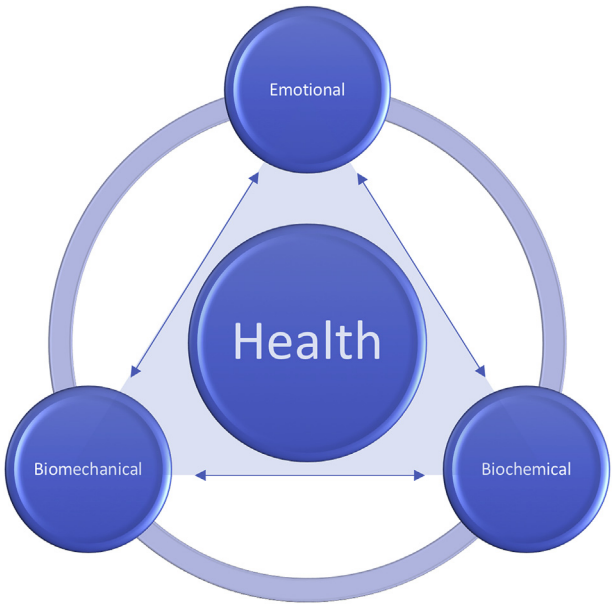

Fig. 1. The Triad of Health (or Naturopathic Triad): For optimal health, good balance should be achieved in each of the 3 components of health. To disregard one may lead to increased risk of injury or illness; and, reciprocally, when people are injured or ill, each of the factors should be assessed and addressed to return to optimal health and function.

4. Primal load

Tendons, it seems, respond very well to loading, both in maintaining their function and in restoring function after injury (Alfredson and Lorentzon, 2000; Stasinopoulos and Stasinopoulos, 2017). Many of the techniques currently used clinically involve increasing, or changing the loading on the tendons relative to how the individual has been using them in sports, work, or activities of daily living (Mascaró et al., 2018). According to Bisset and Vicenzino (2015), some 40% of the population can expect to experience lateral epicondylalgia in their lifetime, with the condition arising most commonly in men and women between 35 and 54 years of age. Critics of the "Paleo" perspective of health, or the "Mismatch Hypothesis," often argue that the average life expectancy for Paleolithic peoples was approximately 40 years; hence, this is why we see a high percentage of such injuries in our modern populations. However, this popular suggestion is a misinterpretation of data and has been reliably refuted by evolutionary biologists. The data actually suggests that among hunter-gatherer (HG) groups who live in the closest environments to our ancestors without modern healthcare, technologies, or mismatch lifestyles, the average lifespan is actually between 68 and 72 years for those who survive beyond childhood (Lieberman, 2013). Moreover, such groups tend to live healthily, leading demanding physical lives for that full period, without developing mismatch diseases or injuries (Lieberman, 2013).

Within such HG existences, activity levels are certainly higher than the general population of industrialised nations. Sisson (2009), a leading proponent of living a primal lifestyle, has developed what he terms the *Primal Fitness Pyramid* to help clarify an approximation of what the human body has evolved to do to retain its physical fitness (see Fig. 2).

Similarly, DeVany (2011), a Professor of Economics and another leading proponent of primal living, noted that the activity curve of HG groups – as well as animals in the wild - follows a "power law" distribution (see Fig. 3). This useful economic concept can be seen to apply to many aspects of natural lifestyles, to include eating patterns, which may be relevant to the high levels of type 2 diabetes in industrialised regions.

As hinted at both by DeVany and Sisson, not only are heavy loads a part of our evolutionary heritage, but so are light loads. In 2008, Wallden proposed a concept termed *biomechanical attractors* synthesised from the work of 3 other thinkers (Wallden, 2008). These biomechanical attractors can be broken down into 3 subgroups:

- Primal Movement Patterns™ (Chek, 1993; 1999, 2001) – alluded to within Sisson's pyramid
- Archetypal Rest Postures (Beach, 1989, 2007, 2010) – alluded to on the base layer of the pyramid (see Fig. 2)
- Instinctive Sleep Postures (Tetley, 2000)

These subgroups can be seen both as foundations, the building blocks of human movement and, as such, the medicine which may serve to balance the human movement system. For a primal human to survive the activity demands of their environment, they must have had equal and opposite repair and recovery mechanisms in place.

Beyond their obvious potential to maintain length-tension relationships without the typical isolated stretching practices commonly used before sports (an obvious evolutionary *faux pas*), biomechanical attractors – and specifically the archetypal rest postures (discussed further in the accompanying practical paper) – may offer a primal parallel to the findings of Taheri's group. Could it be that part of the way our ancestors maintained blood sugar control was through the habitual use of such passive stretches? Moreover, could a hidden part of the mismatch equation of why type 2 diabetes is almost exclusively found in industrialised nations be due to a lack of habitual passive stretching?

5. The Stress connection

As well as the potential benefits of relevant biomechanical stressors on the genetic expression of good connective tissue and glycemic health, the effect of stress on epigenetic expression may play a role.

From an emotional perspective, it is well documented that trauma (in the shape of physical, emotional or sexual stressors) can not only affect an individual's future health (Van der Kolk, 2014; Yunus, 2008, 2015), but also the family line, even if experienced in the previous 3 to 4 generations (Wolynn, 2017).

Diabetes has been found to be more prevalent in those with post-traumatic stress disorder (PTSD) (Trief et al., 2006), which may include survivors of 9/11, war veterans, those whose parents or grandparents were war veterans, Holocaust survivors and their offspring, among many other examples. PTSD has been established as contributing to central sensitivity (discussed under Allostatic Load & Central Sensitivity below) and therefore to a series of other persistent health complaints (Yunus, 2008, 2015), as well as to risk of epicondylitis (Shiri et al., 2006; Font et al., 2014). This leads us to question why this would be?

The explanations will certainly be multifactorial. For example, diabetes is well known to contribute to the atherosclerotic process. Since connective tissues are poorly supplied by vasculature, their tolerance for compromise is narrowed (Hegmann et al., 2017). Similarly, type 2 diabetics have an over-abundance of circulating insulin due to cellular resistance to insulin. Insulin is anabolic and its presence in excess may play a role in the neovascularisation (laying down of new blood vessels) process known to be associated with tendinopathies. Certainly, insulin-like growth factor is involved in neovascularisation (Neely and Gardner, 1998). Adiposity, commonly associated with Type 2 Diabetes, is associated with

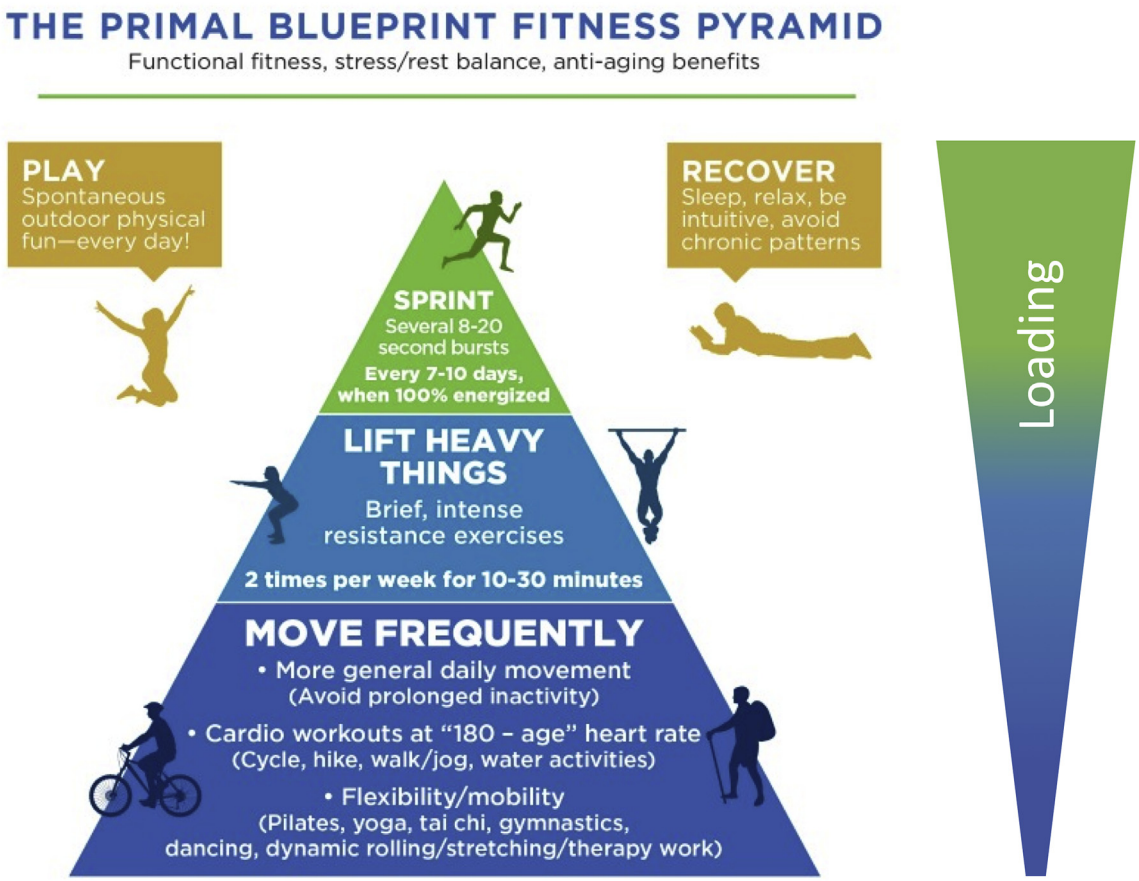

Fig. 2. The Primal Fitness Pyramid: Sisson (2009) recognised that to mimic the environment the body evolved to function optimally in, individuals should partake in very high intensity activities, such as sprinting, infrequently; they should life heavy things or perform resistance training for relatively short periods; and should move for more prolonged periods daily, including stretching and flexibility. In this paper, and the accompanying practical paper, we propose using "Archetypal Rest Postures" as one way to build stretching into the daily routine – to optimize length-tension relationships, support fluid dynamics, aid recovery and relaxation, and to even support blood sugar management. Loading goes from high at the top, to low at the bottom, but there is never complete respite from loading.

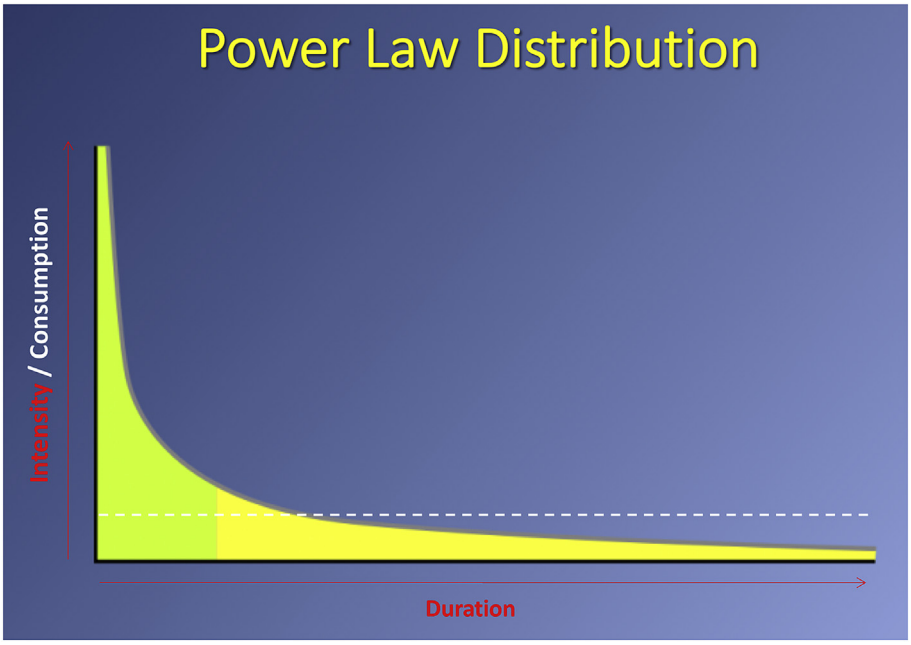

Fig. 3. Power Law: DeVany (2011) recognised that both movement (biomechanical stress) and nutrition (biochemical stress) in nature, follows the "Power Law" distribution, with very short durations of very high intensity movement, moderate durations of moderate intensity movement and very long durations of very low intensity movement. This same pattern in recapitulated in most popular sports. Similarly, consumption of food stuffs would go through bouts of gorging (high levels of consumption for short durations) and long periods of little of no sustenance (fasting).

increased levels of tendon injury. One theory here is that increased weight due to adiposity may be causative in the higher incidence of tendon injuries found in this group. However, one issue with this hypothesis is that those with increased adiposity exhibit increased tendinopathy in all tendons; not just weightbearing tendons, suggesting that the driver of this predisposition may be metabolic in nature (Abate et al., 2013).

Looking through the limbic-emotional lens of the triad of health, it is known that persistent stress to the HPA (hypothalamic-pituitary axis) creates significant demand on the body's ascorbic acid resources (Pizzorno and Murray, 2013; Murad et al., 1981) and inhibits collagen synthesis. Humans are unusual amongst mammals as their ability to produce vitamin C endogenously has been lost due to our ancestry as frugivores (Pauling, 2006; Chatterjee, 1973). Hence, a lack of dietary vitamin C, excessive persistent stress levels, or a combination of the two may contribute to connective tissue injury.

As such, management of emotional stressors through movement, breathing, play, and mindfulness practices is key to minimizing risk of blood sugar dysregulation and optimising connective tissue health. Even high-intensity exercise, which may be seen as catabolic, when done with relevant acute exercise parameters (see Wallden, 2008, 2015), will stimulate an anabolic/parasympathetic rebound.

For people with either diabetes or connective tissue injuries, minimizing exposure to inflammation (which acute cortisol exposure reduces, but chronic cortisol exposure compounds) is a key strategy. Working with not only appropriate exercise parameters, but also with effective nutrition, lifestyle, and rest strategies is important. Nutritionally speaking, avoiding foods which create or facilitate sympathetic drives, such as foods with high allergenicity (grains, soy, or dairy are good examples) or processed, high sugar foods, can help minimize systemic inflammation (Sisson, 2009; McAuliffe et al., 2018). An inappropriate balance between omega-6 and omega-3 fatty acids in the diet, which ancestrally would have been consumed at a ratio of between 1:1 and 4:1 respectively, is also a likely contributor to excessive levels of inflammation in 21st Century living (Siano et al., 2019). The modern diet is far higher in omega 6's leading some authors to suggest the ratio may be between 10:1 or even 20:1 (Sisson, 2009).

For many years, red meats were vilified as a primary cause of inflammation due to their higher levels of omega 6 to omega 3, compared to fish, for example, with higher levels of omega 3 to omega 6. However, it has emerged that this finger pointing was at least partially misdirected, and that grass-fed, free-ranging animal meats are actually much higher in omega 3's, while reciprocally farmed fish are higher in omega 6's (Hebeisen et al., 1993, Hegmann et al., 2017; McAuliffe et al., 2018). The conclusion: when feeding an animal on foods that it did not evolve to metabolize and keeping it in close confinement (which requires high antibiotic use), the end result is a stressed, inflamed, sick animal, high in omega 6's. One cannot avoid noting the striking resemblance between this pattern of animal husbandry, and the human condition in industrialised nations where these meats are not only consumed as a mainstay, but these same practices of mis-feeding, close-confining and over-medicating are common amongst the human population itself.

However, this is not the whole picture, as consumption of even "healthy" muscle meats from healthy animals, which is now the predominant habit in industrialised areas, may still be contributing to persistent inflammation.

6. Traditional sustenance

Until about a century ago, human nutrition was characterised by being omnivorous, and with the *waste-not want-not* mantra generally being applied, the carnivory component of human nutrition meant eating "nose to tail". Broths made from otherwise undigestible - or perhaps unsavoury - parts of the animal were commonplace until only recently on the evolutionary scale. Stews and slow-cooking methods that allowed the "lower quality" cuts of meat with higher densities of connective tissue to be tenderised and made palatable, were a standard component of traditional cooking (Fallon, 1999). Consumption of high-nutrient density organ meats was also common practice, and such consumption of what is termed "the lion's share" was both seen as showing respect to the animal whose life had been taken, as well as providing much needed nutriment (Hines, 2009). The result has been a decrease in the overall levels of glycine consumed (the primary amino acid found in connective tissues), relative to methionine (found in abundance in muscle meats). This imbalance can cause a rise in homocysteine which is a marker not only of inflammation, but also of cardiovascular risk (Minger, 2013, Nygård et al., 1995). As these types of cooking practices and meat cuts became a shrinking rarity, the use of gelatin in desserts and confectionery became increasingly popular, which may have served as some level of compensation, at least from a glycine consumption perspective. Nevertheless, recent campaigns to decrease animal product use in confectionery has swung the pendulum back toward a decrease in overall gelatin and glycine consumption.

So, as Schleip (2018) described, the long-lost little sister may have returned into the fold of the manual therapies, but she seems to have only recently been lost from the world of our nutritional intake. An interesting, albeit anecdotal, observation from John Beck, Orthopaedic Surgeon, is that across the course of his 48-year career, he has observed the connective tissues of patients appearing to get weaker and weaker – tissues that used to take more time and effort to incise have become easier and easier to cut, like a hot knife through butter (Chek, 2001, Personal Communication). If this is a more common finding – and not just due to "sharper scalpels" – it may well be that a combination of nutritional compromise and lack of appropriate loading across recent decades have been contributory to this intriguing observation.

7. Treating like with like

For some time it has been suggested that when it comes to nutritional medicine, it is easier to make connective tissue out of connective tissue than it is to make a connective tissue out of sunflower seeds (or, indeed, muscle meats), for example.

Nutritional data shows that of the top 100 dietary sources of glycine, only 2 are plant-based, with seaweed spirulina listed at 50th best source, and soy protein isolate at 87th (nutritiondata.self.com). Standard nutritional science suggests that dietary proteins are broken down to constituent amino acids in the digestive system before being absorbed; so, if we need the amino acid glycine to synthesise collagen, it does not matter where it originates from. However, there may be some challenges to this way of thinking as firstly, getting glycine from eating connective tissue means it arrives in the body with the exact correct ratio of other amino acids with which to build connective tissue. Secondly, there is evidence that the large breakdown products of protein can be absorbed directly through the gut wall without being catabolised into their constituent amino acids (Hemmings and Williams, 1978).

In this latter instance, it would be reasonable to suggest that the resonant frequency of a (connective) tissue and its constituent molecules will attract to it molecules or proteins of a similar resonance or composition; but what does the research have to say on this front? One study found that oral consumption of collagen peptide supplements resulted in increased uptake of collagen in the skin of test subjects (Yazaki et al., 2017). Another study by Trc and

Bohmová (2011) found that supplementation with collagen in osteoarthritic patients had a significantly superior effect in reducing pain, osteoarthritic symptom levels, and improving perceived health (via the SF-36 questionnaire) compared to supplementation with glucosamine sulphate.

Another double-blind, placebo-controlled, randomised controlled study testing the effectiveness of collagen supplementation for osteoarthritis, found a reduction in pain, improvement in quality of life and improvement in WOMAC scores (a questionnaire specifically designed to measure symptoms of osteoarthritis), all of which were statistically significant compared to the placebo group, over the 13-week duration of the study (Kumar et al., 2014).

Similarly, when collagen supplementation was used in conjunction with resistance training in a group of sarcopenic men (men with age-related decline in muscle-mass and performance) across 12 weeks, their muscle strength increased, as did fat free mass and fat loss at a significant level compared to those using resistance training alone and placebo supplements (Zdzieblik et al., 2015).

A further study which combined ascorbic acid with collagen in a supplement, found that higher levels of supplementation (15g versus 5g) with these substrates increased collagen synthesis incrementally (Shaw et al., 2017).

In short, it seems the data suggests there is plenty of scope for benefit in preventing or treating connective tissue injury through increasing connective tissue consumption via alteration of nutritional and cooking practices, or by supplementation.

8. Central sensitivity & allostatic load

Beyond a focus on just the effect of dietary increases in collagen and stretching practices on connective tissue health, there are also broader considerations of nutrition and lifestyle in the treatment and prevention of these pervasive health challenges. For example, Hegmann et al. (2017) found an association between cardiovascular risk factors (CVD risks) and epicondylitis.

In their study of 1824 workers across multiple domains, Hegmann et al. (2017) not only found that those with CVD risk factors had 6 times higher risk of epicondylitis, but also identified literature showing similar risk levels for other musculoskeletal conditions, such as carpal tunnel syndrome (5 times higher in those with CVD markers), median nerve entrapment (8 times higher in those with CVD risk factors) and rotator cuff tendinopathy. The presence of diabetes in workers was also found to increase likelihood of epicondylalgia.

These figures provide insights into potential mechanisms being not just biomechanical, but also metabolic or biochemical in nature. In considering the etiological pathway, one possibility is the notion that central sensitivity – a sensitization at the spinal cord causing decreased threshold to pain and reduction in descending pain inhibition – may be contributory. This may be especially relevant when it is recognised that CVD risk factors imply stress on the heart, which shares common regional innervation with the shoulder and upper limb.

However, CVD risk factors do not only describe stress on the heart, but also on the vascular system. As such, it may come as little surprise that Achilles tendinopathy is also more common in those with CVD markers (Hegmann et al., 2017). The innervation of the Achilles (or triceps surae) is not close to the heart's innervation, so this would seem to reduce likelihood of central sensitivity from cardiac stress playing a role in Achilles tendinopathies. Font et al. (2014) point to lateral epicondylitis being driven by the diabetes and peripheral vascular disease, so this may well be a feature in other connective tissue compromise. Nevertheless, it does pose the question: if central sensitivity or metabolic changes are involved in connective tissue and other musculoskeletal pain conditions, which comes first?

Research into allostatic load (sometimes termed “physiological load”) may provide insights, as allostasis is the body's response to accumulated physiological stressors. In short, an individual must engage in an ongoing process of maintaining physiological stability – or homeostasis - by adapting to stressors (minor, major and ongoing/repetitive), whether biomechanical, biochemical or psycho-emotional (Read and Grundy, 2012).

However, there is a cost to such adaptation, with compensations being overlaid by new compensations which, while “functional” does not usually mean “optimal”. The end-result of such compensation (sometimes termed *decompensation*) is usually compromise of various bodily systems and functions, ultimately presenting with symptoms as diverse as digestive complaints, headaches, blood sugar dysregulation, sleep disturbance, persistent pain, or recurrent injury. The logical conclusion, then, is that allostatic load is a precursor to central sensitivity, which may, in isolation or together, drive decompensation and symptomatic states (See Fig. 4). Indeed, in his review on central sensitivity syndromes, Yunus (2015) concludes that lateral epicondylalgia, patella tendinopathy, and other connective tissue pathologies may all be driven by and/or contribute to central sensitivity.

As with the proverbial unpeeling of the layers of an onion, it can be argued that the skill of a holistic physician is to help the individual sequentially address each layer of compensation to move them back from their allostatic state toward a state of greater balance and homeostasis. As such, balancing stressors in the individual's life,

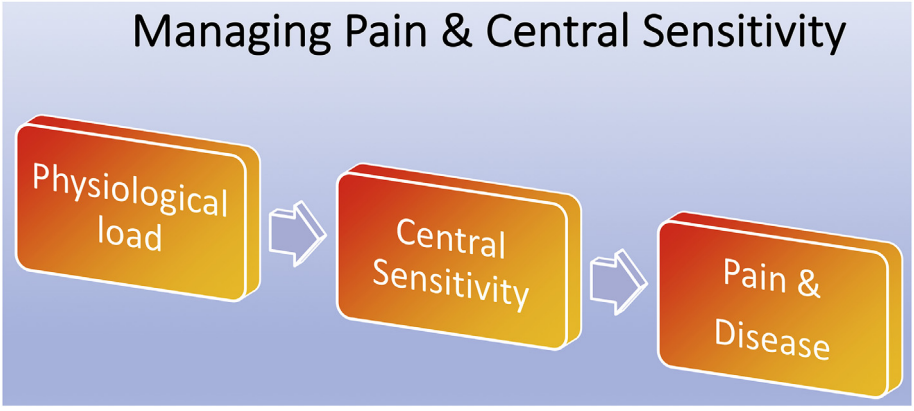

Fig. 4. Managing Pain & Central Sensitivity: The likely sequence of events leading to persistent pain or lifestyle diseases moves from, initially, physiological (or “allostatic”) load, which progresses to central sensitivity, leading on to pain and, in some cases, disease.

facilitating optimal nutrition and lifestyle habits to bring the individual into closer alignment with the environment their physiology evolved to thrive within, and helping the individual to identify purpose in their life, are all strategies that enable this process (Zilioli et al., 2015; Wallden and Chek, 2018).

If the goal of the therapeutic encounter is to identify and address the root cause of pain or illness, to allow both optimal interventions and preventive strategies, then it would seem that beyond tools such as supplementation and taping, the development of health-supporting habits, such as regular stretching and optimised nutrition and lifestyle, is a foundational aim. If this is correct and supported by the literature, then the objective must be to identify what challenges an individual may face in making these shifts in habit.

Perhaps three of the most common challenges to individuals effectively making lifestyle changes include ignorance, finances, and time. Ignorance – in both the "not knowing" sense of the word, and in the lack of willingness – the tendency to ignore or overlook what is known, may be the most pervasive challenge for people with pain or illness. How many people in the general population might know, for example, that their diet is somewhat deficient in glycine from connective tissues? And if or when they become aware, what percentage of this group would act on it? If the health professional is able to convey the importance and provide education for the individual to understand the ramifications of their choices and commitments, this is a beginning; the impetus is set.

Time pressures and the challenges of a modern lifestyle are often cited as real and present reasons that individuals struggle to follow recommended advice. As such, developing both a sense of purpose and ways for the individual to build such advice into their lifestyle are critical (Zilioli et al., 2015). The archetypal rest postures are a good example of a means by which most individuals may help to manage such physiological and time pressures (see the accompanying practical paper) as these can be built into both the working and the home environment without encroaching on other commitments. Establishing movement activities that are fun, that involve true play -not necessarily competitive- may also facilitate this process; alongside recognising the benefits of simple movement. Parking the car a little further from the shops, enjoying what used to be seen as chores and reframing them as valuable contributions to the individual's movement portfolio which move them closer to their movement goals, are important forms of re-contextualising what may previously have been seen as a negative, stressful "to-do" on the list of life.

Finances may also be posed by symptomatic individuals as a blocking factor to making positive change, but movement does not need a gym membership. Going to bed a little earlier, or eating a little closer to our ancestral norms can be even less costly than staying up late or buying the prime cuts. For these kinds of changes there is abundant information available online and free of charge from reputable advisors.

9. Conclusion

In concluding, we stress the importance of a rounded or, perhaps, *triangulated* (nutritional, biomechanical, emotional) view of health coaching in addressing connective tissue injuries, blood sugar regulation and a wide range of other health challenges. Additionally, as we have illustrated, a primal view helps provide context and insight into how our modern lifestyles may be mismatched with our genetic inheritance. Understanding the primal blueprint that supports our optimal genetic and epigenetic expression is of great value in optimising clinical results; as Dobzhansky (1973) famously stated "nothing in biology makes sense, except in the light of evolution". Perhaps, then, we may do well to remember that sometimes to move forward, we have to look backward.

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