A Practical Guide to the Self-Management of Musculoskeletal Pain in Dental Professionals

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By

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PREFACE

> "What could be better than transforming a person's life?" – this motto inspired me to write this book which advocates a holistic approach to health and fitness.

Over the course of their careers, dental professionals typically spend a huge number of hours working in stressful environments and in awkward postures, with consequential musculoskeletal problems. According to Hayes et al.[1], the prevalence of general musculoskeletal pain ranges from 64% to 93%. The most prevalent regions for pain in dentists have been shown to be the back (36.3–60.1%) and neck (19.8–85%), while the hand and wrist regions were the most prevalent regions for dental hygienists (60–69.5%). Indeed, I have been a victim of such musculoskeletal disorders. After having worked as a dentist for well over two decades, my poor posture has caused me neck and back pain for more than 15 years. When I first started my career in the 1990s, no one took much notice of work posture and ergonomics in dentistry. My interest in posture and musculoskeletal pain only began when I experienced severe episodes of lower back pain. It was truly frightening because my back was so vulnerable that severe episodes of back pain could be triggered by performing minor tasks such as bending down to pick something up.

The problem was exacerbated by the fact that no one was able to offer me any constructive and consistent advice. The information that I obtained was piecemeal, inconsistent and at times contradictory. For instance, my doctor told me to rest or to take painkillers, while although my physiotherapist did eradicate my acute symptoms and recommended certain exercises, he never explained the rationale behind these activities. I was told by a personal trainer at my gym to strengthen my back muscles and core. I followed the advice of my fellow gym-goers by foam rolling my back but I did not really know what I was doing. I was completely bewildered and perplexed by the conflicting advice and simply could not understand why my back problems would recur even though I was complying with the various instructions. I am sure that this frustration is ubiquitous.

I was so fed up that I subsequently decided to take control of my predicament by learning to manage my own back problems. I have since

become a personal trainer, sports massage therapist and NASM corrective exercise specialist. Inspired by my success in reversing my recurrent lower back pain, and fuelled by a vibrant enthusiasm to share my knowledge with those in the profession who suffer from these stubborn musculoskeletal problems, I began to passionately research how to holistically manage musculoskeletal pain and learnt a wealth of information. I have lectured on postural dysfunction and musculoskeletal conditions for many years, helping my fellow colleagues in the dental profession to improve their postures to prevent musculoskeletal pain. I have written numerous articles for various dental magazines including the British Dental Journal (BDJ), BDJ Team, BDJ in Practice, The Dentist, Dentistry, Private Dentistry and The Probe. I have contributed articles to the newsletters of the Dentists' Provident Society and the Medical Defence Union of Scotland, and to a webinar hosted by KaVo Dental.

I am aware that there are many books available on the subjects of neck and lower back pain, core-stability exercises, flexibility training, trigger point management, and cardiovascular and resistance training etc., but there is really no such literature on the holistic approach to the self-management of musculoskeletal conditions specific to dental professionals (dentists, assistants, hygienists, therapists, dental laboratory technicians etc.). A practical guide integrates all the different modalities in one logical and systematic programme, firstly by recognising the possible cause of the predicament and secondly by effectively managing it to prevent recurrence. I have reviewed many articles on the relationships between poor posture, repetitive actions and prolonged static posture on the causation of musculoskeletal pain but none of them mention how such risk factors contribute to neck and back problems, nor do they offer any practical advice on the effective management of these conditions.

You may not be suffering from any musculoskeletal pain at present but prevention is always better than cure and I hope you will find the content of this book beneficial.

Purpose and limitations of this book

We need to be aware that everyone's musculoskeletal pain condition is unique; the cause of such problems is not the same as different muscle groups are implicated. There is therefore no single solution for these ailments.

This is not intended to be a reference or academic textbook and I will endeavour to make this guide as practical and relevant as possible. Furthermore, it is not the intention of this book to offer any diagnoses or

treatments. Although trigger points (Section 5.2.4) are implicated in the majority of cases of muscular pain, there may be underlying conditions which must be addressed by the medical profession. You are therefore advised to consult your doctor, physiotherapist or other relevant professional if you suffer from any form of musculoskeletal pain. You can then use this self-help guide to assist you to understand the treatment protocol and rationale behind the rectification strategies being offered.

The information in this book is provided purely from the perspective of an exercise professional, sports massage therapist and musculoskeletal pain sufferer. The author is not medically qualified and the contents of this book are for general information only and should not be considered as a medical opinion.

This book will help you to understand the common causes and symptoms of musculoskeletal pain and the general principles of self-management that relate to these conditions. The management strategies offered are generalised and are not specific to you. Therefore, the book should not be used to self-diagnose or self-treat any health, medical or physical condition. You can appreciate that unless a thorough examination and postural analysis have been carried out, it is impossible to establish a definitive diagnosis or to offer a bespoke rectification plan. Please therefore consult your healthcare or exercise professional before embarking on the corrective activities recommended in this book.

For example, you should not go ahead and activate underactive tissue until you know which groups of muscles are underactive. Similarly, you should not stretch your tight tissues unless you know what is actually causing the tightness. Let me give you a pertinent example of why professional advice is important: if your hamstrings are tight, this could be due to an anterior tilting of your pelvis, probably as a result of hyperlordosis (Section 8.2.1) pulling on the hamstring thus making it tight. Stretching this muscle without consciously rectifying your anterior pelvic tilt or your hyperlordotic posture may worsen your pelvic misalignment because a stretched hamstring will simply allow the pelvis to tilt forward even further. In this situation, you should first have your anterior pelvic tilt corrected by consciously correcting your hyperlordosis and by strengthening your glutes and abdominal core (Section 5.4.2) before stretching out your hamstrings.

To complicate things further, your anterior pelvic tilt could be caused by problems further down your kinetic chain. For example, flat feet (Chapter 10) may be causing internal rotation of your knees and anterior tilting of your pelvis. In this case, you first need to have your flat feet problems attended to by a podiatrist.

In a nutshell, there is no one-size-fits-all concept for dealing with your musculoskeletal problems. Professional advice must be sought in the first instance if you have any musculoskeletal pain.

Only a limited number of corrective exercises and stretches have been selected as examples and numerous alternatives are available. It is clearly not possible to list every single type of exercise in this book and to go through their detailed execution. You are advised to engage an exercise professional who is experienced in corrective exercises for postural dysfunction as they will be able to design a bespoke rectification protocol for you. Furthermore, it is important to follow the correct execution and progression of these exercises to ensure effectiveness and to avoid injury.

ACKNOWLEDGEMENTS

I feel honoured and privileged to have been able to produce this book. As you can imagine, like most books, it has taken many painstaking hours to put together, and finally it is done.

I am grateful to Cambridge Scholars Publishing for offering to publish this title. My gratitude also extends to my family and medical friends who gave me inspiration and supported me as I embarked on my journey to write a book on musculoskeletal pain. It is my fervent hope that my past experience of pain will help other sufferers.

I am also grateful to my medical friend from church, Dr Jack Neeson, who has kindly agreed to demonstrate some of the corrective exercises in Chapters 5, 7 and 13. I must thank my ex-boss, an eminent dentist for whom I have the greatest respect (although he wishes to remain anonymous, he has spent a lot of time and effort reviewing this book and has provided me with pertinent and invaluable suggestions). My gratitude also goes to Dr Peter Savage, my daughters Jenny and Carey, and Mr Paul Rooney for reviewing the content of the book. Jenny also generously took the majority of the photographs for me while I demonstrated the various corrective exercises. Finally, thanks to David Lloyd Newcastle for allowing me to use its gym and studio for filming.

For regular updates, please visit my website or contact me on www.healthaddiction.co.uk

For regular tips on health and fitness, please follow me on Instagram – james.tang90

Please subscribe to my YouTube channel – 'James Tang Fitness', where I will regularly upload the corrective exercises for postural dysfunction as mentioned in the book.

CHAPTER ONE

INTRODUCTION

1.1 Relevance of musculoskeletal pain in dentistry

Musculoskeletal disorders are defined as muscular pain or injuries to the human movement system (Section 3.8) that can occur after a single event or cumulative trauma (Section 8.2.8), negatively impacting daily activities[2]. Musculoskeletal disorders can range from pain in the upper limbs, such as the forearms and wrists (Chapter 13, tennis elbow), to pain in the back (Chapter 2), neck (Chapter 7), shoulders and lower extremities, such as the hips, thighs, knees and ankles. If they are left untreated, they can evolve into more severe, degenerative and inflammatory conditions.

Dentistry is widely considered to be a demanding profession due to the need for high concentration and precision[3]. Work-related musculoskeletal disorders such as neck and lower back pain have become common amongst dental professionals[4]. For instance, in a survey of Danish dentists, up to 60% reported a one-year prevalence of lower back and neck pain[5]. Mangharam et al.[6] suggested that 60–80% of dentists of various ages and from different parts of the world experience chronic back and neck pain. Furthermore, according to epidemiological studies, the prevalence of musculoskeletal disorders in dental professionals has been increasing and is estimated to range between 64% and 93% worldwide (Hayes et al.[7]). According to Osborn et al.[8], 68% of dental hygienists suffer from musculoskeletal pain. The consequences of such conditions and the time taken off work inevitably have a considerable impact on the finances and goodwill of dental practices.

Due to the restricted work area (the mouth) and the need for dexterity, dentists often need to adopt inflexible work postures, resulting in static activity of the muscles in awkward postures which can predispose dental professionals to musculoskeletal disorders[9]. Furthermore, prolonged sitting and poor postural habits can lead to increased intervertebral disc pressure and spinal hypomobility, factors that may lead to degenerative changes within the lumbar spine and thus lower back pain (Valachi[10]).

The author has presented a lecture on the relationship between posture and musculoskeletal pain to a group of young foundation dentists in Winchester; of the 20 participants, 19 suffer from either recurrent neck or lower back pain, even at such an early stage of their dental careers. This finding is, however, consistent with a study of dentists in Queensland by Leggat et al. in 2006[11] where younger and less experienced dentists were more likely to report musculoskeletal pain of the neck and back. It is possible that experienced dentists are better at adjusting their work positions and techniques to avoid musculoskeletal consequences. The author therefore agrees with Khan and Chew[12] that the theory and practice of ergonomics should be incorporated into the dental undergraduate curriculum.

Despite a widespread awareness of this occupational health burden, Sakzewski et al.[13] found that dental professionals continue to suffer from musculoskeletal disorders at alarming rates. The objective of this book therefore is to raise awareness of the effects of poor posture, immobility, prolonged sitting and repetitive movement on musculoskeletal disorders amongst dental professionals. The author will also explain how these aforementioned factors could contribute to the common musculoskeletal disorders of the neck and lower back, offering preventive and holistic rectification strategies.

1.2 Effects of musculoskeletal pain on dental professionals

There is increasing evidence that musculoskeletal problems commence during undergraduate training[14]. The prevalence of musculoskeletal disorders (MSD) in dentistry has been well established and such problems can have detrimental effects on the profession. Unfortunately, this issue has only recently been given more attention due to the increasing number of dental professionals who have developed painful symptoms. So, what are the effects of musculoskeletal pain on dental professionals?

- Discomfort due to lower back pain and neck pain: it is known that such chronic pain with no means of relief can lead to depression, and according to Sancho et al.[15], back pain may contribute to the high suicide rate amongst dentists.
- Time taken off work causes loss of earnings: according to Rafeemanesh et al.[16], although the most prevalent musculoskeletal complaints are related to the neck and shoulder and these are a major cause of job restriction in dentists, the main reason for job absenteeism is back pain.

- Limitation of movements or disability: for example, difficulty in bending your torso forward or a stiff neck preventing you from turning your head to look over your shoulder, which can be dangerous when driving.
- Careers being ended due to the inability to perform dentistry: Burke et al.[17] studied 393 dentists between 1981 and 1992 and their reasons for early retirement due to illness. The most frequent causes of premature retirement were musculoskeletal disorders (29.5%).

Reasons for Early Retirement Amongst Dentists[18]

- Musculoskeletal disorders (29.5%)
- Cardiovascular disease (21.2%)
- Neurotic symptoms (16.5%)
- Tumours (7.6%)
- Diseases of the nervous system (6.1%).

According to the Dentists' Provident Society, over a third of the amount paid out in claims was for musculoskeletal issues:

- In 2015, this reached nearly £1.5 million
- In 2016, it was over £1.4 million
- In 2017, it was £1.59 million
- There are approximately 250 new claims for musculoskeletal issues every year.

According to the insurance company Wesleyan, in 2016, 14% of claims made by male dentists were for musculoskeletal conditions (the second highest after mental illness at 38%), while for claims made by female dentists the figure was 11% (the third highest after mental illness and cancer).

The good news is that these problems can be avoided simply by increasing awareness of the postures used during work, redesigning the workstation to promote neutral positions, examining the impact of instrument use on upper extremity pain, and following healthy work practices to reduce the stress of dental work on the practitioner's body (Chapter 9).

CHAPTER TWO

CAUSES OF LOWER BACK PAIN IN GENERAL

Lower back pain is defined as **pain, muscle tension or stiffness localised between the areas covered by the 12th rib and gluteal fold**. Sometimes, lower back pain is accompanied by pain going down the leg, a condition known as **sciatica** (Section 5.3.2.5). Back pain can actually occur in any area of the back, a stack of 26 vertebrae connected by ligaments, muscles and shock-absorbing intervertebral discs. All structures of the spine may contribute to back pain but it is more common to have pain in the lower back as this supports most of the body's weight.

If you have back pain, you are in the majority of the general population. Estimates vary, but approximately 60–80% of us will get at least mild back pain at some time in our lives and this is a significant cause of lost work and productivity. Back pain causes high levels of anxiety and discomfort and it has been linked to depression. There is a great deal of conflicting advice and sufferers are often left confused, in pain and compelled to seek help.

Unlike arthritis where the problem is clear to both patients and surgeons as the pathology can be identified on radiographs, back pain is a problem for sufferers because they often cannot get clear and consistent advice on its cause or the rectification protocols. This is an issue for medical professionals because they cannot identify any definite pathology, establish the exact source of the pain or offer any real cure. This is also a problem for the macroeconomy as lower back pain is one of the most common reasons for lost work, healthcare usage and the payment of sickness benefits. It can affect the morale of dental professionals who suffer from this type of pain, limit their movement and distract them from the effective delivery of service to their patients.

2.1 Common causes of lower back pain

The back is a complex framework and the lumbar spine is a remarkably well-engineered structure of interconnecting bones, nerves, ligaments, tendons, joints and muscles all working in synchrony to provide support, strength and flexibility, allowing the centre of gravity to be

maintained over a constantly changing base of support during functional movements. However, this complex structure also makes the lower back vulnerable and susceptible to injury.

It is quite difficult to make an accurate diagnosis as to the exact nature of back pain; even with the use of the latest imaging and other types of test, doctors are often unable to pinpoint the precise cause. On the other hand, it is possible that imaging tests such as magnetic resonance imaging (MRI) will show problems in the spine of a patient who has no back pain.

Back pain is therefore a symptom rather than a disease on its own. Most back pain is musculoskeletal in origin, although pain that arises from other organs may be felt in the back. Many intra-abdominal disorders, such as appendicitis, aneurysms, kidney disease, bladder infections, pelvic infections, cancer and ovarian disease, can cause pain that is referred to the back, but these rarely present as back pain alone. There are nearly always some associated gastrointestinal, urinary or gynaecological symptoms. For example, a previous dental patient of the author had experienced lower back pain for months and had rightly sought medical advice. Unfortunately, his general practitioner dismissed it as pain which was being caused by muscle overexertion and he simply told him to rest. As expected, the condition persisted and worsened and, months later, his back condition was diagnosed as being caused by pancreatic cancer.

Finding the optimal treatment for lower back pain very much depends on obtaining a correct diagnosis that identifies the underlying cause of the symptoms. Although it is not the intention of this book to offer any diagnoses or treatments, the general consensus is that if you suffer from any form of lower back problem, especially when it is persistent or causes the following symptoms, you must seek immediate medical advice.

- Pain from your lower back being referred elsewhere such as down your buttocks and legs
- Significant weakness of your leg(s)
- Fever and chills
- History of cancer with unexplained recent weight loss (which is not to do with lifestyle changes, such as a diet)
- Loss of bladder and bowel control
- Severe, continuous abdominal and back pain.

Additionally, if you experience pain after a major trauma, such as a car accident, or if your lower back pain is so severe that it interferes with your

daily activities, mobility and sleep, or if there are any other troubling symptoms, immediate medical attention should be sought.

This book will concentrate only on the most common cause of lower back pain—**musculoskeletal pain**—which is generally caused by **muscle dysfunction** (Section 3.7) when muscles are not contracting properly or applying the right amount of force during contraction, but where there is no specific pathology such as nerve compression or herniation of discs.

2.2 Classification of lower back pain

Besides classifying back pain according to the location of discomfort—upper, middle or lower back—it can usually be classified according to duration and recurrence:

- **Acute back pain** refers to pain that has been felt for less than 6 weeks. Acute symptoms tend to come on suddenly, usually in response to an event such as a slip, awkward twist or injury. They generally last for a few days to a few weeks and often resolve on their own, even without treatment. However, recurrence is common. The initial pain can be so severe that you may not be able to turn or get out of bed with ease, but please be assured that while your current pain is intense and your functional mobility is restricted, you can usually recover in a few days with the correct treatment, activities and advice (Sections 5.1.1 and 5.1.2). But, to avoid recurrence, you need to manage your lower back condition with the holistic approach advocated in Chapter 5.
- **Sub-acute pain** is that which lasts between 6 weeks and 3 months.
- **Chronic pain** is when it lasts for more than 3 months.
- **Frequent episodes of pain** are classified as **recurrent back pain**.

2.3 Typical symptoms of musculoskeletal lower back pain

Back pain has a marked effect on sufferers, as well as on society, due to its prevalence and economic consequences. But, if you are unfortunate enough to suffer from lower back pain, how can you tell if your condition is due to a serious spinal injury (luckily, this accounts for less than 1% of all back pain[19]) or another systemic illness such as a tumour? Generally speaking, if the pain persists for more than 6 weeks, is constantly intense, is getting worse or causes the symptoms mentioned in Section 2.1, it is definitely worthy of medical attention.

Those who have suffered from any form of musculoskeletal back pain may recall these familiar symptoms.

- Generally, the **pain varies with time and physical activity**. The back is usually stiff in the morning and after you have been moving about, it improves. Conversely, for **non-musculoskeletal** causes of lower back pain, the discomfort tends to be constant, rest or exercises do not relieve it and you may not be able to find any position of comfort.
- It does not affect your general health, such as causing sudden and unexplained weight loss.
- It usually presents in people aged between 20 and 55. Patients who present before the age of 20 are more likely to have a serious disease or a structural problem such as spondylolisthesis. Patients who develop new or different back pain after the age of 55 are more likely to have a serious disease, in particular cancer that has spread to the spine, or osteoporosis.
- The majority of sufferers (including the author) tend to have recurrent symptoms because this type of pain is strongly associated with trigger points (Section 5.2.4). Research by Drs Janet Travell and David Simons, authors of *The Trigger Point Manual*, has shown that trigger points are the primary cause of pain in at least 75% of cases and are a factor in nearly every painful condition. Without intervention, trigger points do not disappear; they simply turn latent and can be reactivated with the slightest stress and strain. This explains why although acute episodes generally settle down, even without treatment, after a week or so, the pain may not fully disappear and recurrence is common. It is therefore imperative that you do not simply concentrate on the elimination of pain, even though this may appear to be your most urgent need, but that you also manage the condition effectively (Chapter 5).

CHAPTER THREE

PHYSIOLOGY OF MUSCLE CONTRACTION

3.1 Introduction

In order to understand how muscles become dysfunctional and how trigger points are formed (Section 5.2.4), you need to understand the basic physiology of muscle function; you can then start to help them heal using corrective exercises (Sections 5.2 to 5.5).

3.2 Types of muscle

There are three types of muscle in our bodies: **smooth**, **cardiac** and **skeletal**.

Smooth muscles

Smooth muscles are involuntary due to our inability to control their movements. They are found in the walls of hollow organs such as the stomach, oesophagus and bronchi, and in the walls of blood vessels.

Cardiac muscle (heart muscle)

This type of muscle is found solely in the walls of the heart. It is under the control of our **autonomic nervous system**, but even without a nervous input, contractions can take place due to the pacemaker cells. The cardiac muscle is highly resistant to fatigue due to the presence of a large number of **mitochondria** and **myoglobin**, and a good blood supply allowing continuous aerobic metabolism.

Skeletal muscles

Skeletal muscles attach to bones and contract to facilitate movement of our skeleton. They are also known as striated muscles due to the stripy appearance of bands of actin and myosin forming the sarcomere within the muscle cells, the myofibrils. These muscles are voluntary because we have

direct control over them through our nervous system. They consist of 70% water, 23% protein (actin, myosin and collagen) and 7% minerals.

Within skeletal muscles, there are three types of fibre (Section 3.3).

3.3 Types of fibre in skeletal muscles

Slow-twitch (type 1) fibres (the local muscular system – for stabilisation)

Stabiliser muscles: they are not confined to the spine and are not movement specific. They provide stability to allow movement of a joint. An example of this is the rotator cuff muscles of the shoulder that provide dynamic stabilisation for the humeral head in the glenoid fossa.

Postural muscles: examples include the core musculatures such as the transversus abdominis, multifidus, internal oblique, diaphragm and the pelvic floor muscles (Section 4.3.2.2). These postural muscles are primarily composed of type 1 aerobic fibres that are used for endurance-type activities. They are loaded with myoglobin (which gives them their red appearance) and mitochondria. They therefore use oxygen and fat as their main fuel source for contraction (Section 6.3.3). The myoglobin is able to increase the rate of oxygen diffusion so red slow-twitch fibres are able to contract for longer periods. These fibres do not generate as much force as type 2 fibres but are more resistant to fatigue. For this reason, the muscles containing primarily type 1 fibres are often postural muscles. These types of muscle are commonly found in the neck and spine and, due to their endurance capabilities, they have an antigravity role and are heavily involved in the maintenance of posture. In addition, athletes such as marathon runners have a high number of this type of fibre, partly through genetics, partly through training.

Most problems with muscle shortening occur in postural muscles because, with the correct posture, these muscles are fairly inactive and only respond to disruptions in the balance to maintain an upright position. Therefore, when you move away from ideal alignment, postural muscle tone is increased (Chapter 7).

Fast-twitch (type 2) fibres (A&B) (the global muscular system: the movement system)

These consist of more superficial musculatures, are larger and are associated with movements of the torso and limbs. They primarily consist

of two main types of fast-contracting muscle fibre—**type 2a** and **type 2b**; they are both able to produce fast, strong muscle contractions, but are quick to fatigue.

Fast-twitch 2a fibres have a fast contraction speed and can use aerobic (Section 6.3.3) as well as anaerobic (Sections 6.3.1 and 6.3.2) energy sources. These are "white fibres" as they are low in myoglobin and less reliant on oxygen supplied by the blood for energy, and therefore they fatigue faster than slow-twitch fibres.

Fast-twitch 2a fibres are suited to speed, strength and power activities, such as moderate/heavy weight training (8–12 reps, Section 6.6.2) and fast running events such as the 400 metres. Fast-twitch and slow-twitch fibres cannot be converted into each other. However, type 2a fibres (intermediate fibres) can adapt in different ways depending on the type of training performed. In response to endurance training, they will adopt the characteristics of slow-twitch fibres, and in response to resistance training, they can turn from type 2a fibres into type 2b fibres.

Type 2b (muscles that are composed primarily of this type of fibre are called global muscles)

Often known as fast glycolytic fibres, they are white in colour due to the low level of myoglobin, and a relative lack of mitochondria. They produce ATP (Chapter 6) at a slow rate by anaerobic metabolism and they break it down very quickly. This results in short, fast bursts of power and rapid fatigue.

Like type 2a fibres, the fast-twitch type 2b fibres are also suited to speed, strength and power activities. Heavy weight training (1–3 reps), powerlifting and 100 metre sprints are examples of activities that predominantly require 2b fibres.

Movement is the main function of global muscles; they are more superficial, tend to span several joints and are composed primarily of type 2b fibres. A tight postural muscle often results in inhibition (Section 4.5, reciprocal inhibition) of these global muscles, whose function becomes weakened as a result. A typical example of this is the tight hip flexors inhibiting the function of the glutes. When trying to correct a musculoskeletal imbalance, you would encourage lengthening (Section 5.3) of an overactive muscle prior to attempting to strengthen a weak elongated muscle (Section 5.4).

We are genetically programmed to have a certain percentage of each muscle fibre type. It is thought that the average person is born with around 60% fast-twitch and 40% slow-twitch fibres; those born with a larger

amount of fast-twitch fibres are more suited to power activities while those with a higher percentage of slow-twitch fibres are more suited to long endurance activities such as marathons and triathlons.

Furthermore, the proportion of slow- and fast-twitch fibres in each muscle is determined by its role. The muscles of the neck and back have a key role in the maintenance of posture and so have a high proportion of slow-twitch fibres which are slow to fatigue. The muscles of the shoulders and arms are often used to generate force and they have a higher proportion of fast-twitch fibres. Although there is a distinction between postural and global muscles, many muscles can exhibit characteristics of both and contain a mixture of type 1 and type 2 fibres; for instance, leg muscles (quadriceps, hamstrings and the calf muscles) often have large numbers of both fast- and slow-twitch fibres since they must both continually support the body and play a role in movement. The hamstring muscles, for example, have a postural role and are notoriously prone to shortening. Generally speaking, muscles that have a stabilising role (postural) have a tendency to shorten when stressed. Muscles that play a more active/moving role (global) have a tendency to lengthen and become inhibited (e.g., the gluteus maximus).

3.4 Motor unit recruitment and the "all-or-none law"

A motor unit consists of a single motor neuron and all the muscle fibres it innervates. When a nerve impulse travels down a neuron, all the muscle fibres within that motor unit are activated. So, the motor unit either activates all of its fibres or none at all (the **all-or-none law**).

The number and size of motor units in specific areas of the body depend upon their functional roles. For example, postural muscles have fewer motor units supplying more fibres and those muscles that are involved in more intricate movements (such as those of the hands) have more motor units supplying fewer fibres.

Effect of exercise on motor unit recruitment: one of the long-term adaptations to resistance training (Section 6.6.5) is the enhancement of neuromuscular connections by recruitment of more motor units. This adaptation will enable the muscle to generate more strength during contractions.

3.5 The sliding filament theory

The most basic unit of a muscle is the muscle cell, the **myofibril**.

Muscle contraction begins when a nervous impulse arrives at the **neuromuscular junction**, causing a release of a neurotransmitter called **acetylcholine**, which in turn causes the depolarisation of the motor endplate, which leads to the release of calcium (Ca+) from the **sarcoplasmic reticulum**.

Within each myofibril are strands of myofilaments called **actin** and **myosin**. They are arranged in a series of compartments called **sarcomeres** that run the length of the myofibril (Diagram 3.5). The actin is anchored to the end of the sarcomere and the myosin sits within the middle of the sarcomere. These filaments slide in and out between each other to form muscle contractions. Millions of sarcomeres have to contract in your muscles to make even the smallest movement. In the presence of high concentrations of Ca+, the Ca+ binds to troponin, changing its shape and so moving tropomyosin from the active site of the actin. The myosin filaments can now attach to the actin, forming a cross-bridge.

The breakdown of ATP releases energy (Section 6.3), enabling the myosin heads to attach themselves to the actin filament and rotate, pulling the actin filaments inward towards the middle to generate tension. This occurs along the entire length of every myofibril in the muscle.

This process of muscular contraction can last for as long as there is adequate ATP and Ca+ stores. Once the impulse stops, the Ca+ is pumped back to the sarcoplasmic reticulum and the actin returns to its resting position causing the muscle to lengthen and relax. It is worth noting that an increased release of calcium ion is postulated to be an essential part of trigger point formation (Section 5.2.4). A trigger point exists when overstimulated sarcomeres become unable to release their contracted state.

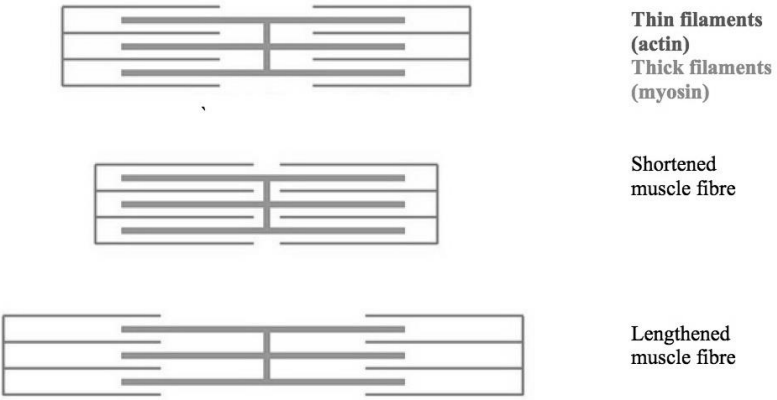

Diagram 3.5 – Sliding filament theory of muscle contraction

3.6 Length-tension relationships of muscles

Muscle length-tension is the relationship between the length of a muscle fibre and the force that it produces at that length. When a muscle fibre is stretched to the point of minimal overlap of contractile protein actin and myosin, the contraction force will be weakened. Similarly, when a muscle is shortened, contractile force will also be weakened.

Therefore, muscles can become weak because they are stretched or are too tight. Muscles are more prone to injury, fatigue and damage when they are weak.

As we will be able to see in subsequent chapters, spending an excessive amount of time in a seated position will not only affect the length-tension relationships of muscles that are attached to the lumbo-pelvic-hip complex, it can ultimately lead to reduction in core muscle activation (Section 4.3) due to a lack of neural stimulation. Therefore, even relatively light loads placed upon these muscles exceed their ability to cope as they have been “inactive” for so long.

3.7 Muscle dysfunction

Muscle dysfunction essentially means abnormality in muscle function, either not contracting properly or not applying the right amount of force during contraction, but there is no pathology.

- Muscles are “dysfunctional” if they are stretched for a prolonged period of time so they are weak.
- Muscles are “dysfunctional” if they are contracted for a prolonged period of time, causing muscle tightness. When these muscles are tight, there is a reduction in blood flow, making it difficult for them to accomplish their basic physiological functions, including the removal of waste that would naturally be carried away in the blood circulation. Additionally, there is a deprivation of oxygen, which is essential for tissues to remain healthy; thus, a lack of oxygenated blood being delivered to the muscle will exacerbate its dysfunction, result in increased muscle fatigue and impede the muscle repair process and the ability to recover from exercises. All these factors can greatly increase the chance of injury.

Essentially, **muscle adaptation** means that tightened muscles can, over time, become structurally short and mechanically incapable of lengthening to an appropriate level. Overstretched muscles can become structurally long and incapable of shortening to an appropriate level.

When muscles are incapable of firing correctly, compensation occurs, and this will alter joint motion from its normal path resulting in the **cumulative injury cycle** (Section 8.2.8).

3.8 An introduction to the human movement system (HMS)

The **human movement system** (HMS) is a complex, well-orchestrated system of interrelated and interdependent myofascial, neuromuscular and articular components[20]. The functional integration of each system enables efficient neuromuscular performance in our daily activities. Optimal alignment and functioning of all components results in an ideal length-tension relationship and neuromuscular control. The HMS consists of the muscular system, the skeletal system and the nervous system, and the functioning of the body is an integrated and multidimensional system. For example, during functional movements, the body must maintain its centre of gravity aligned over a constantly changing base of support; if change in alignment occurs at one joint, changes in alignment at another joint must occur in order to compensate. Consequently, impairment in one system or a component of each system can lead to compensation and adaptation in other systems, initiating the **cumulative injury cycle** (Section 8.2.8), the repair process that our body goes through to heal an injury, causing decreased performance and musculoskeletal pain.