VOLUME TWO

INJURY PREVENTION AND MOVEMENT CONTROL

WARM UP, FLEXIBILITY AND RESISTANCE TRAINING

The Performance Matrix.

BY LINCOLN BLANDFORD AND
THE PERFORMANCE MATRIX TEAM

ymca

HEALTH AND FITNESS GUIDES

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This book is based on the concepts of The Performance Matrix, from Movement Performance Solutions and developed from the work of Mark Comerford and Sarah Mottram. Lincoln Blandford has interpreted these processes for a readership of fitness professionals and those interested in remaining active and injury free.

We are grateful for the contributions of Sarah Mottram, Mark Comerford, Warrick McNeill, Jeanette Hoftijzer, Clare Pedersen, Michael Nicol and Jacqueline Swart, for their input on practical application, their wealth of experience and their painstaking editing.

Central YMCA is the world's founding YMCA. Established in 1844 in Central London, it was the first YMCA to open its doors and, in so doing, launched a movement that has now grown to become the world's biggest youth organisation. Today, Central YMCA is the UK's leading health, fitness and wellbeing charity, committed to helping people from all walks of life – and specifically the young and those with a specific need – to live happier, healthier and more fulfilled lives.

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About the author

Over the past decade I have tutored over a thousand students to become successful personal trainers within the UK fitness industry. Some have remained in the UK, successfully pursuing this career, others have travelled the world. All have hopefully taken the message of the importance of movement quality and applied it to improving their clients' health and fitness, worldwide. This book aims to support both them and their clients in this worthy cause.

In addition to my teaching roles for both YMCAfit and Performance Matrix I regularly contribute to fitness media, writing on injury prevention and performance enhancement through the use of movement screening. I have developed numerous training courses for YMCAfit alongside collaborating with the Performance Matrix team in the development of their personal trainer specific 'Movement Screening Fundamentals' module. I maintain a select personal training client base within London as I continue to develop my own abilities and understanding through on-going study of Strength and Conditioning at St Mary's University College, Pilates, and yoga.

What unite these three apparently distinctly different approaches is the body and its movements. A greater understanding of both, through any chosen discipline, will empower trainers to make better decisions, evaluate questionable claims, and avoid the dogmas that stop us asking 'why?' and 'is there a better way?'.

This is the second volume of my book, looking at the topic of injury prevention and movement control. I'm delighted that you've chosen to read this book and really hope that you enjoy it, applying the ideas in it and answering the questions it may well raise.

Lincoln

Inspirations and contributions

Much of this text has been greatly inspired by the work of Mark Comerford and Sarah Mottram who have made significant contributions to the movement control concept, further developing the application of these ideas with post graduate rehab specialist qualifications, working alongside elite sports teams and contributing to ongoing research. Their movement control testing protocols identify the presence of uncontrolled movement, under a system known as The Performance Matrix. Although movement screening is not included in this text, I'd encourage all of you to have your movement control checked through a qualified source. As a further introduction to the concept see Blandford & Comerford (2013).

Also bringing their sizable experience to the text are other members of the Performance Matrix team. This globally based collective of movement specialists work with elite level movement professionals, employing Comerford and Mottram's movement screening systems. Additionally, the principal author has applied the highly contemporary concepts of 'movement IQ' in a fitness setting and it is from this perspective that the text is primarily composed.

Sarah Mottram

Sarah Mottram is an educator, clinician and researcher who has principally focussed upon the influence of uncontrolled movement on the recurrence of pain and deficits in performance. Over the past 18 years she has lectured nationally and internationally on evidence-based solutions to better understand, prevent and manage musculoskeletal pain and injury related to movement impairments.

Sarah is particularly interested in the integration of differing movement therapies as a means of retraining uncontrolled movement, something evident through her certification in Pilates, GYROTONIC® and the highly contemporary discipline 'Garuda'. She incorporates these valuable tools in her clinical practice based at The Movement Works, in Chichester, UK.

Mark Comerford

In addition to being a director of Movement Performance Solutions, Mark is also world renowned in the field performance and clinical rehab, a reputation enhanced through his role as an educator and author. He delivers consultancy to various sporting and professional organisations which includes 3 NBA teams, West Side Dance and Physical Therapy (New York Ballet), Vermeil Sport & Fitness (USA) and Athletes' Performance (USA).

He has a special interest in the development of clinically relevant models of movement function and dysfunction, understanding the influence of pain on movement and muscle function and the enhancement of performance. He has published papers on movement and muscle function; the integration of local and global muscle training to enhance joint stability; and movement control training. He has frequently been invited to speak at numerous international conferences for movement based professionals around the world.

Jeannette Hoftijzer

Jeannette after graduating as Physiotherapist at the Academy for Sports Studies in The Hague, Holland, Jeanette worked in Switzerland whilst continuing post graduate education culminating with her qualification as a manual therapist. Jeannette currently works in private practice and is aligned with the Johan Cruyff Institute and several other talent programmes of the Dutch Olympic Committee. Several professional track and field, speedskating, ice hockey, basketball, and tennis clubs currently utilise Jeanette as their specialist performance advisor.

Michael Nicol

Originally training in Sports Rehabilitation, Michael completed a Masters in Sports Medicine at Nottingham University. He is now registered with both the Chartered Society of Physiotherapists (CSP) and The British Association of Sport Rehabilitators and Trainers (BASRaT) and clinically works at the St Mary's Clinic in London. He is also a Senior Lecturer in Sport Rehabilitation at St Mary's University College and holds the position of Director of Enterprise within the School of Sport Health and Applied Science. Michael has been involved with Movement Performance Solutions for over 10 years and through that time has both lectured and consulted within professional sport both in the UK and across Europe.

Clare Pedersen

Clare is a chartered physiotherapist with extensive experience in sports medicine and return to sport following injury. She has worked in elite football and handball and was senior physiotherapist for Great Britain's orienteering team 2000-2006. She now works full time at Arena Fysio in Helsingborg, Sweden screening and retraining recreational and elite athletes in many sports. Clare is also a Performance Matrix Accredited Instructor, and delivers Performance Matrix courses In Sweden and throughout Europe.

Warrick McNeill

Warrick is a New Zealand trained physiotherapist, currently running a physiotherapy clinic that operates out of a well-established Pilates studio in Central London. Qualified in Pilates himself, Warrick has a keen interest in treating performers, particularly dancers, which has led to his involvement with the Physiotherapy Advisory Committee to Dance UK, the Royal National Theatre and the Royal Shakespeare Company. He regularly presents to Pilates training organisations, dancers and dance teachers and possesses a keen interest in ergonomics and its use in the workplace. He has taught courses internationally for The Performance Matrix and is an associate editor of the 'Journal of Bodywork and Movement Therapies'.

Jacqueline Swart

Jacqueline lectures on the 'Orthopaedic Manual Therapy' course within a South African university. She has delivered various rehabilitation courses for physiotherapists and presented at movement therapy based symposiums and conferences over the last 15 years. Alongside her role of treating and subsequently training athletes, Jacqueline has a special interest in injury prevention. She teaches courses for both The Performance Matrix and Kinetic Control and has been using The Performance Matrix system for assessment and successfully integrating Pilates exercise in to athletes' rehabilitation. In 2009 she travelled to the world athletics championships in Berlin with the South African athletic team to assist and treat them in their preparation for the event.

Introduction

This, the second volume of Injury Prevention and Movement Control again pursues the desirable goal of remaining injury free through the consideration of movement quality.

Injuries, although often perceived as inevitable for the active, each have a root cause. If the influence of these causes can be limited, injury risk is reduced. Uncontrolled movement, defined as an inability to cognitively control movement to benchmark standards, has been identified as one such risk. It causes repetitive mechanical deformation of body tissues, a process that can eventually lead to injury. The philosophy of this text states 'enhanced movement control reduces injury risk'.

Volume 1 considered the debate that has led to the importance now placed upon movement control within the world of injury prevention research. Volume 1 also sought to make clear that control does not refer to just limiting or preventing movement. Movement is to be embraced. Control refers to the ability to choose how to meet movement challenges of any kind.

The term **movement health** was seen to represent a desired state that was not only injury free and absent of the presence of uncontrolled movement but also a state that allowed the exerciser to choose how to move.

Four basic principles were adhered to in order to remain in movement health;

1- **Awareness:** Develop an awareness of the body, movement, and movement quality.
2- **Control:** Once there is awareness, movement control can be developed so that movement challenges can be met when required. Volume 1 often referred to bodily systems as hardware (structural or strength/endurance related) and software (nervous system or motor control related). This analogy is employed in volume or order to explain differing mechanisms of control.
3- **Varied intensity**: Develop movement control that suits the nature of the challenge. Due to the varying nature of movement performed on a daily basis, numerous layers of movement control are required. Volume 1 touched on exercise intensity of a time under tension (strength/endurance) type or a time under attention (cognitive/brain challenge) level. Movement control can be acquired at both degrees of intensity.
4- **Variability:** Develop multiple ways to solve the same movement challenge. No one strategy is the best – there is not a perfect way to move. The best method is to

possess many movement strategies. This concept is explored in more detail in this volume.

These were collectively described as Movement IQ, a training philosophy now applied to warm ups, resistance training and flexibility.

Chapter 1: Warm up

Boot the computer, load the software

The warm up forms a key role in readying both body and mind – the movement preparation that may seem essential for injury prevention. Pressing the body's on button gets things moving, progressively ramping up the exerciser's abilities and confidence to push harder in whatever comes next.

It sounds essential but unfortunately, in many gyms the warm ups remain anything but; the exercisers move swiftly on to the things they believe really matter. To be fair, this is not surprising as most exercisers do not sit at their work desks bursting with excitement at the prospect of a warm up. So, does the warm up matter?

The sport perspective

The sporting world believes in warm ups. Coaches and players actively endorse warm ups, a perspective backed by other numerous sources revealing the performance-improving qualities of a warm up. To performance, the evidence supports the view that warm ups matter. Less clear is there connection to injury reduction. Professional football (soccer) employs a warm up protocol called "11+," which shows significantly reduced injury occurrence. Its mix of stretching, strengthening, balance exercises, sport-specific agility drills, and landing techniques suggest that a range of components need to be addressed to limit injury, at least for this particular sport.

RAMP up

The RAMP method is another varied component warm up structure that can be adapted to improve movement health and is currently used in the emerging science of strength and conditioning. Raise, activate, mobilise, and potentiate (RAMP) can be adapted for many specialties to offer numerous opportunities to influence movement quality and movement IQ through the development of movement options, allowing us to better adapt to varying movement challenges.

Raise

Raise elevates body temperature, changes blood flow, and quickens heart rate and breathing. Raise will have exercisers performing light but gently increasing intensity

activities, such as a walk that progressively quickens in pace. Because every movement situation is a movement health opportunity, we can also ‘Raise’ while actively developing movement IQ.

Movement puzzles- Control of Direction

Body temperature can be raised when control of movement direction patterns are performed. These non-functional coordination challenges help move one region while limiting movement at another (figure 1). These can be easily interspersed into the walk–run patterns frequently used at this point of an exercise session.

Purpose: Build Control

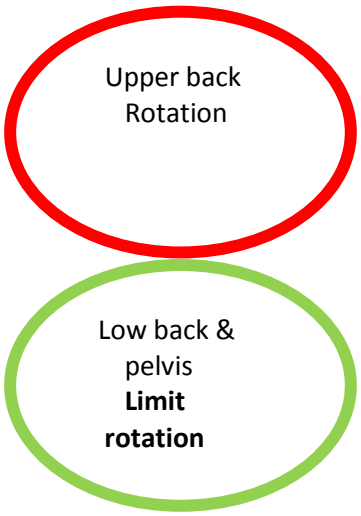


Figure 1. 45-60 degrees

Aim to achieve this amount of rotation in the upper back while keeping the pelvis facing forward. This task is typically performed for spinal mobility because it requires the ribcage part of the spine to rotate on a loosely held, but static pelvis.

We must be clear about the purpose of this direction control task. These movement challenges are to be non-fatiguing yet they also supply a means by which to challenge and improve movement IQ. The exerciser is required to think about how to move, promoting awareness, and developing control strategies. The exercise is a cognitive challenge, a workout for the brain that is a ‘time under attention’ drill (see Volume 1 Chapter 2). It is important to be clear we are not suggesting that the region of the body being maintained at a point in range must always be held like this in every other exercise; we are simply improving the ability to make a choice to limit movement or not.

Activate

The Activate phase employs a muscle-specific approach for the warm up. Activate aims to ensure essential control muscles are going to be effectively employed during the workout to follow through the performance of a ‘priming’ exercise. The spotlight of awareness should

be steered towards the body's frequent underachievers of movement control; the global stabilisers.

Global Stabilisers (examples)

- Obliques abdominals
- Serratus anterior and trapezius
- The parts of the gluteus maximus that do not attach to the iliotibal band on the outside of the legs.

Inefficiency in these muscles is often the cause of many movement faults which are linked to injury. The spiral orientation of these structures allows for effective control of the twisting forces and asymmetrical loading placed upon the body during daily, sporting and exercise activities, forces that are frequently linked to injury. Consider the Activate phase as not seeking to exhaust these muscles but simply to awaken them. Within the strength and conditioning domain stimulation of the body's nervous system (analogous to the software) is considered the most important part of the warm up process. The Activate stage can improve the flow of information from the muscle to the brain and brain to muscle; the internal conversation flows and inaccuracies in the body map (See Volume 1) can begin to be corrected. In this way these muscles are picked out for special attention, and are coerced into giving just a little more.

Exercise 1: Single leg bridge

Lie supine with knees bent and the soles of the feet on the floor. Lift the pelvis from the floor into a 'classic' bridge. Keeping focus on maintaining a pelvis that does rotate to the floor slowly lift one foot and then straighten this leg but aim to keep the front of both thighs at the same height. Return the lifted foot to the floor and alternate legs. Initially, aim to keep a neutral training region position around the pelvis. If the hamstring muscles cramp, change the emphasis to the glutes by bringing the heels closer to the pelvis until the hamstrings are felt less.

Exercise 2: 120 degrees arm lift and reach

From a standing position lift and drop the shoulder blades until a mid-position is found between the two extremes (see Chapter 2 for full description of shoulder positioning). Lift both arms as if to perform a side raise shoulder exercise but keep the arms about 20 degrees forward of being completely out to the sides of the body. Keep lifting the arms beyond the usual shoulder height level to about 30 degrees above being parallel to the floor. At this point reach for something you can't quite touch as you allow the shoulder blades to slide in the same direction as the fingers.

Balance

Activate also supplies the chance to employ single leg stance tasks to promote static balance abilities. Once the body shifts to a single leg stance, the exerciser should have the requisite control to align the big toe, navel, and nose. Additionally, these asymmetrical challenges of controlling the center of mass over the base of support also helps bias the global stabilisers.

Mobilise

Mobilisation takes the warmth gained in Raise, combines it with the key muscles awakened in Activation and uses both to produce high-quality, whole-body movement. The aim is to produce movements highly reminiscent of those to be performed in the main workout therefore the movement challenges increase as multiple regions are coordinated. Here is where any significant restrictions in range may limit movement options if they are not appropriately addressed. In Volume 1 range was described as the "currency of movement" and flexibility was the "ease at which this currency was spent". Limitations in this currency may become apparent through the use of functional movements, as typically seen in the Mobilise stage of RAMP (see Flexibility chapter).

Functional movement

For those in a high state of movement health, whole-body movement tasks such as touching the toes from standing can be achieved in numerous ways, displaying good variability (many ways to achieve a movement outcome). This activity requires controlled dynamic lengthening of the structures on the rear of the body. Certain regions can be asked to contribute more or less than others if control is good. Developing a range of strategies to achieve whole-body, functional movements match the movement IQ concept well. If we

have control, options, and awareness we may vary our approach to loading the same structures in different ways throughout exercise and life.

Does functional equal optimal?

Using functional movements with every individual from the start of the 'mobilise' phase may prove to be problematic if their movement options are limited. If certain body regions cannot lengthen, more compliant but not necessarily well controlled regions will have to lengthen in their place. To illustrate the point consider the sit and reach test of flexibility, the common method of testing if you can touch your toes. Through this test we discover how extensible we are through the connected structures on the entire back of our body. Performing the test repeatedly over a period of time would more than likely allow us to achieve a higher score of flexibility because the body will adapt to this regular lengthening. Typically, not all body regions lengthen equally when we pull one end away from the other. Areas that are initially more restricted stay restricted; it is the more compliant regions that lengthen more as the body takes the path of least resistance.

Injury and alignment

During these whole body movements, we adopt strategies that repeatedly place regions of the body into injury-related positions. We may use the same strategy every time we perform the movement. A rigid set of hamstrings (allowing less movement at the hip) will often be accompanied by a greater degree of movement in the lower back. If we lack the ability to choose to control this movement in the back, we risk injury.

Certainly there is evidence of some movement strategies having stronger connections to injury than others. Studies that have considered knee alignment in relationship to knee injury suggest that risk is reduced if knee tracking is controlled to be in line with the second toe as opposed to rolling in toward the body's midline (eg, Mandelbaum et al., 2005; Olsen et al., 2005).

Each individual will possess slightly different strategies to achieve any particular movement outcome because there are many ways to move, yet it appears some strategies and alignments are more injury-prone than others. During functional movements we may compensate for a tighter region by producing more movement somewhere else. This movement compensation, if poorly controlled, just as described with the knee, has an associated injury risk.

A dedicated follower of function

Some health and fitness literature uses the word “functional” with purely positive connotations whereas any activity/exercise described as non-functional appears to be negative. This could be unfair. From a rehabilitation perspective if something is functional it implies it is sufficient, it works, but this does not always equate to optimal. From this perspective, performing functional movement without movement options and control would not be optimal function but merely functional and prone to injury risk.

Fitness functional

The description of functional used with increasing popularity in health and fitness also appears to relate to a perceived utopian state of movement ability that we assume our hunter gatherer predecessors used. This philosophy promotes intent-driven behaviour associated with the phrase “the body knows movement, not muscles.” Functional exercise in this realm involves whole body movements akin to those seen in sport performance such as gymnastics or martial arts. Performed with the requisite control this display of movement represents a truly high level of functional capacity. Although the body’s potential has not changed (some can still reach these movement quality heights) the way most of us live our lives has.

Modern living and the movement lifespan

The harsh daily existence in by-gone days meant humans had a lifespan of around 40, anything past this age would be a bonus. The body needed to function to survive but only long enough to raise the next generation. By the time you had reached your mid-30s, the body had served its purpose. Now, many expect to live to double or more than this age. The movement system evolved in a world that did not support the longevity we now enjoy. If methods to maintain the system in the borrowed time after 40 years of age exist, should these not be used? Recently, research has revealed that the body can pick out (discriminate) individual muscles (Tsao et al., 2011), and this process can be enhanced through what could be considered non-functional training. As research continues to add to our understanding of how best to optimise or prolong movement health we must be cautious of being either instantly dismissive or too accepting of any fashion. Non-functional has its place. Comerford (2013) makes the analogy that it’s hard to fix the car while you are still driving it. The implication is that to improve the body’s functioning we sometimes need to stop and look

and ‘look under the hood’; we now have many more options to maintain optimal movement health throughout our movement lifespan.

Implications for the mobilise phase

Ensuring that our intended movement goal is completed through optimal strategies may require regions to be targeted initially in isolation, increasing controlled compliance/lengthening or controlled stiffening/activation of the relevant part. This idea stands against much current practice of the functional movement school but would provide a more specific, tailored approach to the ‘mobilise’ section. Once greater control can be exerted over the troublesome region the whole system is connected, preventing the loose from becoming looser and the stiff from remaining rigid.

Potentiate

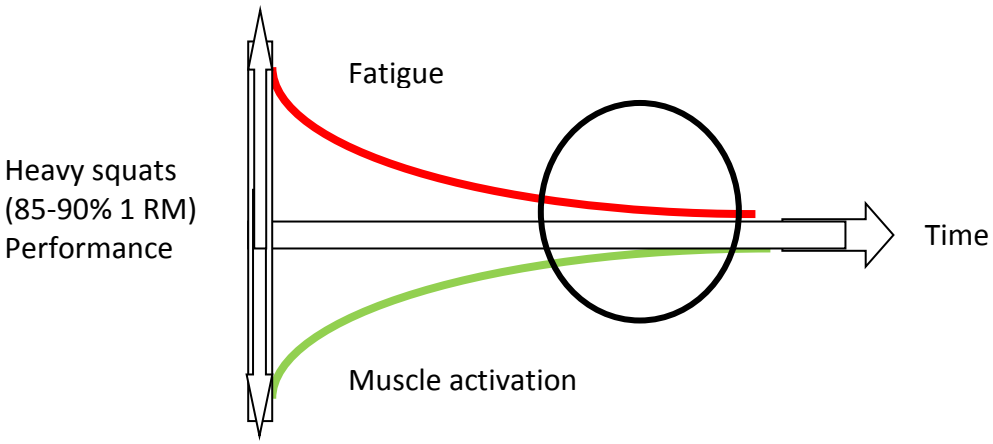
Potentiate takes the intensity of the warm up to the next level, gradually increasing until the workout is just about to begin. It ensures the exerciser can perform at the required intensity for the main session to come. Speed and/or loading demands increase as the systems of the body are increasingly integrated and begin to purr. ‘Potentiate’ offers the chance to manage movement challenges under high but not quite maximal intensity. The body is made fully aware of what to expect, giving it the chance to complain if we discover it is not quite ready.

Post-Activation Potentiation (PAP)

As discussed, the warm up has the potential to affect performance. Generating force within the body quickly, often referred to as power production, is considered the most important characteristic of high-level sports performance. Any acute ergogenic strategy to increase power output for tasks such as jumping and sprinting could directly enhance sport performance. Interest has been diverted toward effective methods of priming the body prior to the performance of these explosive activities. Post-activation potentiation (PAP), defined as an acute enhancement of power following a voluntary contraction at maximal or near maximal intensity (Sale, 2004), is seen to produce these effects.

PAP protocols call for a priming activity such as 3-5 reps of a heavy squat to parallel depth (85-90% 1 RM) to be performed approximately 3-5 minutes before a power-related activity (eg, sprint or vertical jump). Although the general consensus is that PAP exists its underlying mechanisms are yet to be fully determined. It is thought that the priming activity causes an up-regulation of the movement system, subsequently increasing performance. The priming

exercise potentially enhances the PAP effect (facilitation) and also elicits a fatiguing effect on skeletal muscle.



The dual mechanisms of fatigue and facilitation can co-exist; it gives rise to the need for the subsequent period of recovery following the priming activity but not allowing this rest to be excessive so as to still benefit from the potentiation effect.

Cool down: Reset synergy

Finally, at both the end of the chapter and the end of the workout attention can turn to the cool down. During resistance training the rest time between sets can be used for numerous activities including placing bias on the global stabilisers, helping to reset the balance of muscle activation in the region worked (See Chapter 2).

This is hypothesised as performing the reverse of the PAP method. This theoretical post-activation down-regulation (PAD) would reduce the nervous system input to the major muscles just targeted in the workout and redirect the flow to the muscles of control. The physiological effects of the mechanical damage brought on by the training session would still be apparent in the system yet we could develop the skill of switching attention away from the muscles of power production to those of control. This may increase movement control awareness and options as the exerciser carries on with the rest of their day.

Summary

A warm up supplies numerous opportunities to develop awareness, control, and variability at a progressively increasing range of exercise intensities therefore meeting all the movement IQ criteria. It can employ both functional and non-functional activities to go about this task, sometimes considering the body as both a unit and at others a collection of interrelated sections. Time under attention intensity training meets the profile of the early

part of a warm up, whereas power production can be addressed toward its end though the use of PAP. Warm up clearly matters to performance and through the methods described here the RAMP process can be adapted to enhance movement health and reduce injury risk. Cool down may also call upon the same ideas of placing emphasis on specific muscles so as to assist in movement control once we exit the workout environment.

Chapter 2: Resistance training: Loaded movement health

Much of today's gym-based resistance training is still influenced by bodybuilding. This discipline's focus on the aesthetic resonates with many gym goers' desire to change their body shape. Gaining size through sheer volume of work (lots of sets, reps, exercises) and time under tension (TUT) continues to dominate perceptions of why and how people lift weights. As high amounts of fatigue help drive these adaptations a culture exists in which pain and gain go hand in hand, the burn is still pursued, and typically technique and control are compromised to get that last "killer" rep.

A force for good?

Resistance training reduces injury risk through its positive effect on both muscle and the connective tissue surrounding, binding, and attaching it to the skeleton. The addition of muscle mass to the body cloaks passive structures in a dynamic padding, a useful interface for the contact sport player. Increasing the size of muscles also increases their residual, passive stiffness. This enhanced stiffness produces more robust structures that are better suited to resisting unwanted displacement, thereby assisting control. The passive hardware of the skeleton can also positively adapt to fatiguing load through increased strength of ligaments, supplying greater fidelity to joints, and allowing higher forces to be tolerated before these tissues fail. The evidence that ligament laxity increases the risk of injury is in the literature (eg, Stewart & Burden, 2004). Tendons, the conduit between the passive and active structures of bone and muscle, and common sites of injury, are also thought to positively adapt, thickening and strengthening and therefore becoming more robust.

The magic numbers

To elicit such changes training must be suitably challenging. Any resisted/loaded movement appears to classify as traditional resistance training only at a time when between 1 and 20 repetitions of an exercise can be performed. Typically, the key determinant dictating the number of reps performed is the weight lifted, yet speed of movement also proves fundamental to this. Working at an intensity described as a six repetition maximum (RM) implies a weight that cannot be performed more than six consecutive times, at which point temporary failure occurs. A steady cadence (for example, two seconds up and three down) best describes the reps responsible for this outcome, yet focus on the tempo suggests the

total time the muscle is under tension (time under tension) is an equally valid method by which to prescribe training. The 1-20 rep range can be further classified to identify specific benefits (table 1) stressing different systems of the body to a greater or lesser degree for strength, size, or muscular endurance outcomes.

Table 1. Repetition maximum (RM) continuum (Stone & O'Bryant, 1986)

1 RM	**6 RM**	**8 RM-12 RM**	**13 RM-17 RM**	**18 RM- >20 RM**
Strength	Strength	Strength	Strength	
Power (X)	Power	Power	Power	
Size	Size	Size	Size	
Endurance	Endurance	Endurance	Endurance	

X- *rep range is same as for strength but with approx. 80% of load for multi-joint exercises and these are performed with the intent to move at maximal speed (eg, clean). The key adaptations to the body are shown in larger text.*

This resistance training continuum of global movement control sits at the far end of the complete movement control continuum considered in chapter 3 of volume 1, the opposite end from the local movement control bias of transversus abdominis hollowing. Due to its fatiguing nature bracing is appropriate and the presence of muscle co-contraction is both inevitable and welcome.

Volume equals volume

Performance of multiple sets generally increases the desired outcome of whatever part of the rep range the exerciser employed. Although this is subject to diminishing returns and an optimal volume of work will depend on many factors, the most significant of which is arguably the training status of the individual. If large volumes (many sets of many exercises) of work are performed anywhere between 1-20 reps there is often an associated increase in muscle mass in the target regions. Yet even this may be further differentiated between what is currently, and somewhat derisively referred to as non-functional size gains as opposed to

functional hypertrophy. To some sports performers the latter will have a greater desirability than the other. Mass without strength is a problem if one's body must be carried or projected through the air. To the aesthetic driven exerciser the one most easily achieved is probably the most alluring. With this resistance training outcome guide in hand the conversation must now turn to quality of movement during resistance training.

Gym culture: Weight versus control

Excellent exercise technique in a gym is rare. This, sadly, is a self-perpetuating state of affairs. If the majority of exercisers are seen to perform exercise with questionable technique in a gym, this standard becomes the norm. If this technique is evident even among the gym employees as well as those with the most aesthetically fortunate look, new exercisers will typically follow suit. Sometimes, this observed lack of control is down to inappropriate loading; for some, making the weight lighter just can't be faced, the ego will simply not allow it. To paraphrase Shirley Sahrmann 'although the body chooses the path of least resistance, the ego often chooses the most'. In defense of exercisers, heavy, fatiguing loading is essential to gain the benefits of resistance training. Weight training's visceral approach fatigues and exhausts the body. Its devotees want this and seek it out; but a balance must be found. Simply lightening the load isn't a long-term option. Even in professional sports where the dual paths of performance enhancement and injury reduction must be carefully navigated coaches/trainers must prioritise when and how to focus on skill or heavy fatigue.

Progressive approach: Control to load

A progressive, two-tier strategy is available to achieve the goals of size/strength and performance when control is the exerciser's primary need.

[Box out]

Hoftijzer (2013) states, "I am often working with athletes who need size training for performance enhancement but who are not always able to work with technically demanding lifts to achieve this goal. We go back to fundamental techniques, required for these challenging exercises (weight lifting & plyometrics) but we also target muscles in other, less skill demanding exercises for size and strength changes. This size/strength training is performed in 'safe', conditions; no rotational challenges and lots of support from equipment. This allows the athlete to be trained for parallel goals; strength and size whilst

also working at the technical performance of more skill demanding lifts. Once technique is good the isolated training is stopped and the free weights are now progressed."

High skill, high fatigue exercise can be done but only once control is sufficient, at which point force and mindful attention are united.

From tension to attention

The desired standard of technique may only be possible once loading is significantly reduced for a period of time. This potentially changes the bias of this exercise from one of TUT to that of time under attention (TUA). Filling the exerciser's bandwidth of focus, the cognitive equivalent of a repetition maximum, this exercise now successfully develops the required control. This intensity also suits the profile of a warm up, again adding importance to the need for performance of this preliminary stage. For the experienced exerciser, worries of losing training achievements may be allayed once they identify how quickly positive changes in technique can occur. Importantly, exercises already performed well can be continued and progressed. If technique is good there is no need to hold back on the loading. This two-tier approach also applies to the new exerciser. For those in the initial stages of their gym life, the poor technique cycle can be broken. If a TUA focus is the first port of call, grooving in the patterns of control through mindful training begins to reduce the prevalence of poor technique across the board.

The cost of not paying attention

Some trainers believe there is no such thing as a dangerous exercise, only a dangerous way of doing an exercise. Within the realms of common sense this sounds plausible. Anecdotally, a recipe for injury in the gym is high force and poor control (bad technique), a pairing highly apparent in many fitness settings. Maintaining or restoring precise movement is key to preventing musculoskeletal pain; control matters, the "how" of the exercise, not just the "what." One result of increased force production on the musculature system is how it provides the potential for enhanced control under high force. Simply put, if we train for and achieve control, we improve our control. If control is challenged by a lack of force production within the system this deficit can be addressed. The rules of specificity still apply, but this is a choice that needs to be made consciously and nurtured alongside progressive

gains in strength capacity – a choice which is often contrary to much culture of the gym environment.

How the other half lift

An apparent polar opposite of weight training, Pilates, also attracts those exercisers who desire a change in body appearance. While weights may accrue mass to the body's superstructure (external musculature), the culture of the Pilates studio is one seeking to address the finer control and balanced arrangement of the body's infrastructure. Weights can build the body and its force production; Pilates, through its very particular delivery, seeks to improve control of its architecture. Perhaps something was lost in renaming Mr Pilates original work; 'contrology', his personal title for his own approach said so much.

The best of everything approach

Combining the controlled, mindful movement seen in Pilates with the specific heavy loading protocols of weight training offers an alternative and broader perspective on resistance training. The call for such a blend, a best of both worlds approach, has recently been championed in the literature (McNeill & Blandford, 2013). Adhering too zealously to just one discipline may rule out useful options from other movement professionals. Pilates has long been integrated into the rehabilitative environment; its focus on accuracy suits the precision sought by many therapists to restore movement control. Fatigue producing, TUT-dependent exercises also exist in the Pilates repertoire. Pilates is still subject to universal principles of physiology; size, strength, and endurance adaptations could all be made if intensity is manipulated and progressive programming employed. Biasing the hardware of the body through TUT exercises doesn't have to be devoid of attention to detail. The inclusion of TUA components in a resistance training session allows for intelligent loading strategies, integrating a mindful yet physically fatiguing experience.

Movement lifespan training

Taking a long-term view to the preservation of the body is probably wise in consideration of modern living (see Warm up chapter). Most exercisers choose to exercise for the enjoyment of the experience, the end results, or both. Sustaining this process as the body experiences age-related changes is even more important. Remaining injury-free for as long as possible has an elixir of youth quality about it as does retaining a high quality of movement ability.

Retaining movement choice, key to this state, is desirable throughout the movement lifespan of the body.

Movement variability under load

Movement variability has connections to injury prevention. A system in good movement health has access to numerous strategies to achieve its movement goal. Consciously maintaining a mix of movement options is a means by which to possess this enhanced form of coordination (software). From a mechanical (hardware) viewpoint the same structures may be stressed in different ways, and load may be spread out among different body regions resulting in potential benefits for more tissues.

Gym application

1. **Shoulders**

For the gym goer the painful shoulder has implications, especially if the aim of the session is to train the upper body. Shoulders are complicated and once pain is present diagnostic and rehabilitative input is required from a qualified trainer. Prior to the onset of pain the exerciser should have a great deal of familiarity with the scapula and its numerous movements to develop movement awareness, variability, and control (figure 1).

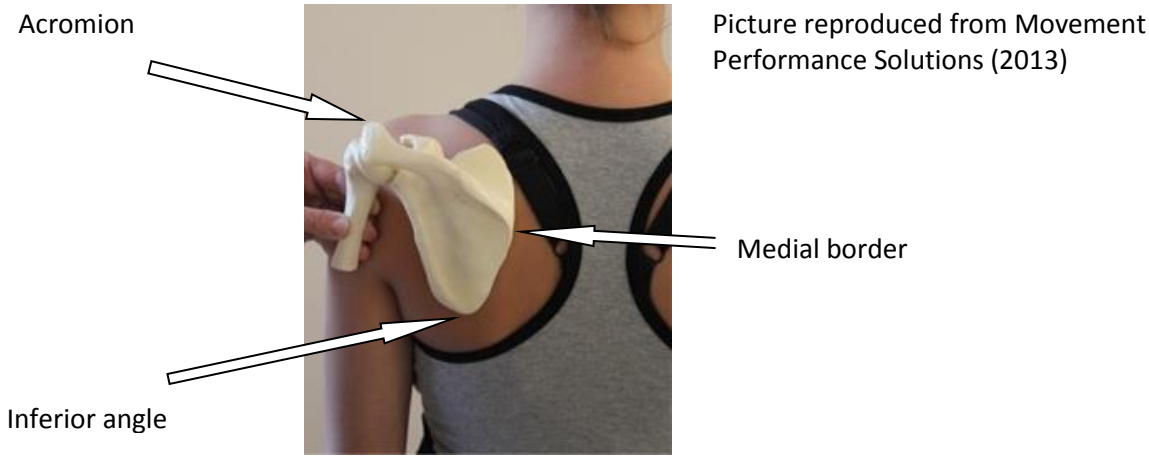


Figure 1. Scapula orientation

The scapula has three rotations that may be emphasised to help limit the occurrence of common movement control faults around the shoulder. These movement faults are:

i. **Issue= Downward rotation**. Strategy - To limit the appearance of a sloping shoulder a lift of the acromion is suggested.

ii. **Issue= Winging**. Strategy- To limit the appearance of the medial border coming away from the rib cage a gentle broadening of the scapula is advised.

iii. **Issue = Forward tilt**. Strategy - To limit the appearance of the inferior angle jutting out a lift up of the acromion combined with a slight backwards pull is suggested. This movement is not pulling the shoulder blades together into a retracted position (see below).

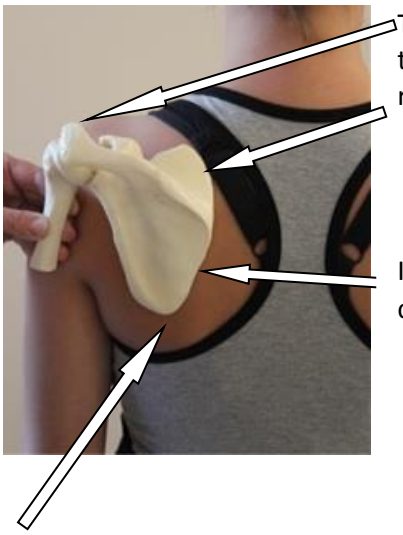


Figure 2. Scapula orientation: The three rotations and finding an 'optimum' starting place

(picture reproduced from Movement Performance Solutions, 2013)

Movements of the clavicle

Adding to the complexity of the shoulder are the possible movements of the collar bone (clavicle).

Scaption

As the rib cage is not flat but round, the scapula positioning must be respectful of this shape. The angle of scaption represents an alignment in which the scapula remains flat

against the ribs and is therefore angled 15-25 degrees off what it would be if the ribcage was flat.

Elevation and depression

The clavicle also allows the scapula to be lifted or dropped. Middling the scapula requires neither an over emphasis of the elevated (lifted) or depressed (dropped) state.

Aligning the scapula in respect to its three rotations, the angle of scaption, and a mid-position between elevation and depression at the start of an upper body resistance exercise has the advantage of maintaining a greater amount of distance between the scapula and the humerus. Some schools of Pilates employ this position as their shoulder set alignment and those conducting research on shoulder movement control also endorse this start position. The take home message, as ever, is improve control through awareness and variability to lessen injury risk.

But what about shoulders back and down?

A frequent teaching point in gyms result in depressing the shoulders and squeezing them together (back and down). This has the effect of reducing the space between the bone of the upper arm (humerus) and the scapula. It also alters the effectiveness of the muscles responsible for allowing the scapula to rotate up and out of the way of the arm as the arm lifts above the head. Repeatedly adding loading to this compressed structure may explain the shoulder issues that often accompany bench press, lat pulldown, and shoulder exercises. As the aim of this is text is to develop movement variability rather than to forbid options, back and down does have its place. The scapula pyramid was constructed to help explain how both movement strategies can be employed.

Scapula ascending pyramid

Exercisers keen to gain the strength, size, and endurance benefits of their training for the upper body but who also wish to be respectful of injury prevention, may want to consider how to organise the shoulder blade.

1. 16 reps then rest for 45 sec.
2. 12 reps then rest for 60 sec.
3. 8 reps then rest for 90 sec.
4. 6 reps then rest for 2 min.

5. 3 reps

For sets 1-5, aim to begin the lift with the shoulders back (not squeezed together) and broad (not depressed down), thereby producing the alignment described above. For the last set – 3 reps – adopt a back and down position which places additional bias towards the pectoralis and latissimus dorsi muscles.

The scapula pyramid serves the purpose of illustrating how control strategies need to adapt to the loading situation and the need for movement options. There is a time for 'back and down', but as loading decreases, exercisers can take advantage of a movement strategy less associated with injury risk. Also, for many gym goers the near maximal loading (3 RM) that requires the locked down position may not fit with goals or current fitness abilities, so only employ it if it fits in with your individual goals.

The aesthetic movement

Finally, perhaps touching upon a little pure and simple vanity may be more persuasive. 'Back and down' slopes the shoulders from the ear to the arm. The suggested alignment shown above, widens the shoulder girdle, broadens the shoulders, lifts and pulls the chest taut, and the focus on the oblique abdominals anchors the ribcage connecting each shoulder to each hip. There is improvement in the aesthetic of bodily architecture through both its infrastructure and superstructure.

Knees and squats

Universal and sometimes controversial, squats allow for force production capacities to be increased through the lower body while demanding multiple coordination challenges around both static and dynamic body regions. The principal joints moving are the ankle, the hip, and the joint that arguably receives the greatest care and attention in a squat – the knee. With regard to injury prevention a one size fits all teaching cue is regularly used: do not let the knees travel forward of your toes.

Dance physiotherapist Warrick McNeill compares a dancer's plié with a gym squat, "A plié differs from a squat as the trunk stays vertically aligned, and the knee bend must travel forward of the toes. The knee should be in good alignment over the centre of the foot and travel forward around 5cm. Less than that gives dancers a problem they call 'short Achilles' which is really a restriction of the calf muscles leading to all sorts of compensations such as:

rolled in feet, poor knee over foot alignment and over arched low backs. Classic gym squats, with their focus on gluteal strengthening and their limited depth of ankle movement, can lead to such restrictions in the calf musculature. Those who squat regularly should be given a plié or its non-dancer equivalent 'the small knee bend' to counter their over conditioned response. Many find it very difficult to perform a small knee bend without sitting back into the hips rather than flexing more at the knee. Being able to perform a range of movement options is important for movement health."

A test of movement IQ

Current movement health status relating to a squat may be qualified by attempting the following:

Exercise 3: Wall slides

Stand with your feet hip width apart and your back against a wall as if to have your height measured. Keeping the same points of contact on the wall slowly begin to slide down the wall allowing the knees to cross the toes as they bend to about 30 degrees. Try to avoid leaning forward. If you can't, it appears that you have lost a movement option. Performance of both the plié and the gym squat allows for variability that once developed as a skill can be loaded to achieve resistance training-focused outcomes. Loaded variations of this approach have been considered in the literature. One group investigated the implications of following the assumed safe squatting (knees behind toes) in comparison to allowing the knees to travel anteriorly (over the toes). Their study reported that limiting movement at one region causes greater stress elsewhere, typically the hips and the lower back. They concluded that loaded squat performance may require the knees to move past the toes, sharing out the load, supplying a movement option and ruling out the 'just one way to squat' idea.

Not just a hinge

From seated on a chair, with the knees bent, rotate the lower leg inward and outward. The knee cap remains pointing ahead as the foot turns. When the knee bends, as in stepping, the whole lower leg can rotate both inward and outward.

When the first wave of group exercise classes touched down in the 1980s a safe, manageable solution was sought for the rise in knee cap-related injuries. Imagine in a step class of 20 people there are 40 knees to look out for. Every time those knees bend and are

then loaded with bodyweight, the muscles of the hip are ideally keeping the thigh bone tracking forward instead of rolling across the body's midline. Simultaneously, the lower leg can be controlled so it doesn't rotate and thus prevents the heel turning in. If control in the lower leg is good it's not so bad if the knee crosses the toes. The loading of the body is shared out between the hip, knee, and ankle. However, if the knee does roll in inward and the heel turns out the knee cap is caught in the middle, stressing its passive structures. Under repetitive loading a knee that crosses the toes can frequently lead to knee pain if combined with these other movements. Addressing the movement issues seen at the knee and the heel is difficult to do in a class situation which is why many trainers put a blanket rule in place of knees behind toes.

During a back squat, keeping the knees behind the toes increases hip flexion. Interestingly, an increase in hip impingement issues has been suggested as the likely outcome of this approach. Just as in the shoulders, having a range of movement (ROM) options throughout the body is a display of movement health. Knees in front of toes increases the loading stresses through the knees; knees behind toes increases loading stresses on the hips and, frequently the spine. Always choosing one begins to limit options and places stress repetitively on the same regions.

Neutral spine and squats

Attention to the alignment of the spine during squats also throws up a point of contention. Should the spine stay in neutral? Does this apply to all squats, under all loading scenarios? The neutral spine philosophy has become widely accepted in the performance of many resistance lifts, such as the squat. The neutral training zone can be considered as a spine aligned so that there is minimal support from passive structures, requiring reliance on control of the muscles of the trunk. It represents the mid region on the movement continuum of a movable body region, the "M/N" position in the range from "A" to "Z."

Squats for the brain

Finding and maintaining this alignment anywhere in the body is a test of coordination, revealing the exerciser's current state of movement health. Squats may be used as a means to improve this ability. During the lowering phase of a squat or any exercise in which the hips begin to close (flexion), the spine is usually tempted to flex (flattening, followed by the

pelvis tucking under). On the lifting phase the hips are opening (extension). This movement at the hips is also teasing the spine to arch. If the pelvis and spine are consciously focused on remaining static as the legs move, a coordination challenge known as direction control is employed (as discussed in the Warm up chapter).

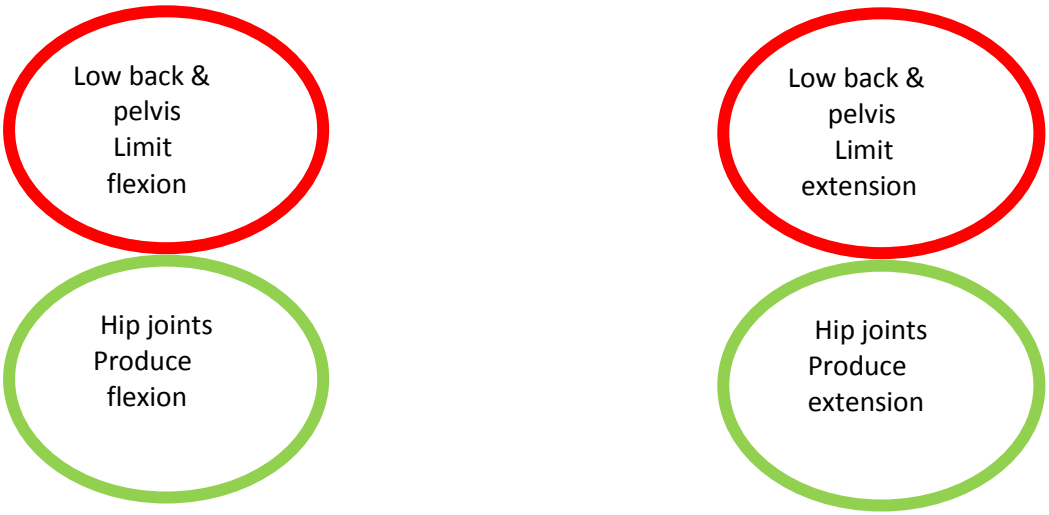


Figure 3. Patterns of direction control at the hip and lower back

The muscles of the trunk must hold the spine and pelvis in position as the legs move below. This would be an effective method to improve movement control of the spine and can be applied to many different exercises as a means to both test and improve the isometric (static contraction) qualities of the musculature that maintain this position. It is important to identify that this is a non-functional task to improve control, movement options, and awareness and not how all movement should be performed. This task employs a mid-range position as a means to improve movement control but it does not state that the spine must always be in the neutral training zone when performing a squat. However, maintaining a mid-position in the spine becomes increasingly important as load increases towards maximal because of how tissues respond to loading.

Elastic and plastic zones

The passive hardware of the spine can initially stretch because of its elastic properties (see figure 4), and then recover from this deformation soon after the mechanical loading is removed. As loading increases, tissues enter a plastic phase of deformation. At this point, tissues yield to the load and will not return to their original condition once the load is

removed. Tissue failure will occur at some point when the tissue can no longer continue to deform and the end result is usually an acute injury.

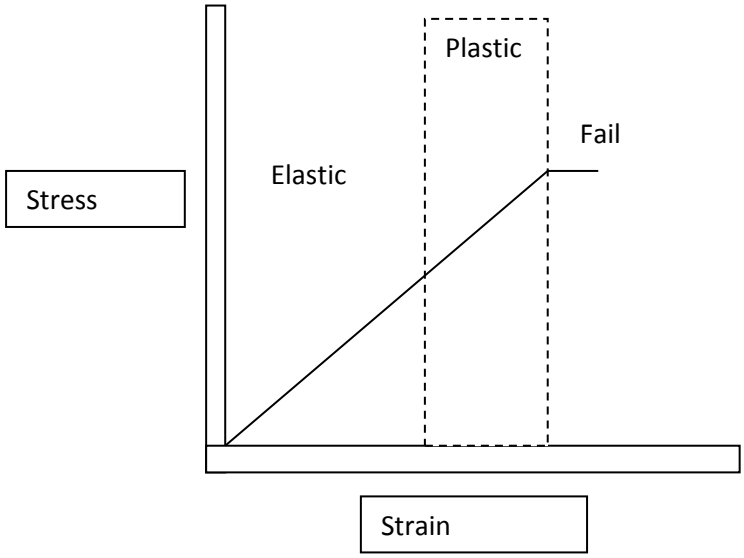


Figure 4. Plastic and elastic

In a squat, as shown in the direction control patterns in figure 4, as the hips are flexed and the body lowers there is an increased chance the spine will begin and then continue to flex, moving away from the mid position of neutral and toward a position more reliant on passive structures. As movement continues closer to the end range of flexion in the spine the **elastic** zone is entered. Comerford (2013) states “sometimes training into the elastic zone is OK as this is required in day to day life but training into the plastic zone under high load is pathological.” This means that if the squat continues until the end ROM in the spine under heavy loading (1-6 RM), tissue tolerance may be exceeded and cause injury. Although flexion is a common movement that exercisers find difficult to control, the same control issues may be seen during extension of the spine. No one movement should be avoided; it would be overly dogmatic to become flexion-phobic.

Finally, even the plastic range is not to be avoided in all scenarios. If the aim is to stretch tissue, training in the plastic zone is acceptable if the loading is low and slow as opposed to plastic and loaded. This is one way in which flexibility is enhanced.

Rest periods

Performing multiple sets during resistance training requires a period of rest between them. Dependent on the loading, the time between sets can vary. A simple rule is the heavier the

weight, the longer the wait. When rest periods of 60 seconds or more are used, a window of movement control opportunity opens. If the upper body is worked during the set, a lower body TUA movement control task can be performed because the physiological effects of fatigue of the TUT exercise diminish elsewhere.

The knee that rolls inward

For the knee that rolls in across the midline during squats or lunges or for the foot that has an arch that flattens on its big toe side try this:

Perform the plié style exercise described earlier (small knee bends) with resistance tubing pulling the problem knee in, toward the problem movement. The added resistance strangely makes the action easier to control as the exerciser can now more easily sense what is happening to the knee and take evasive action. The muscles required to perform the role "shout out" that bit louder to the brain, which on hearing them employs them more effectively. So, yes, sometimes adding load can make an exercise easier to perform correctly. The addition of such a strategy to a weights workout is most effectively achieved once there is a familiarity with the TUA exercise. Attempting to learn this in a fatigued state would be needlessly challenging and likely cause error.

Summary

Awareness of movement control under loaded situations is beneficial to tissue health, force production qualities, aesthetics, and injury prevention. Differing applications of movement control from a range of disciplines can be adopted and applied with good effect in a resistance training scenario. The resistance training recipes can be effectively combined with the movement health principles of control, awareness, and variability at this most fatiguing end of the movement control continuum.

Chapter 3: Flexibility

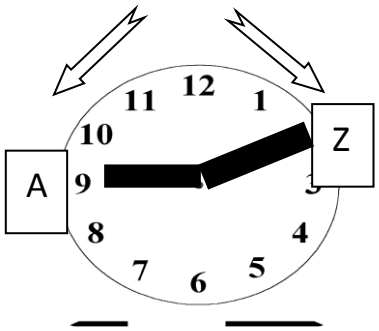
How to spend the movement currency

A belief in the benefits of possessing good flexibility has endured in the minds of many exercisers; a belief that recently has had to contend with the possibility that stretching may not confer any injury prevention (eg, Shehab et al., 2006; Witrouw et al., 2004). Importantly, we must be clear, stretching and flexibility are the not the same thing. Flexibility has implications for movement health across the whole body whereas stretching techniques may prove more or less effective depending on the nature of the problem they seek to address.

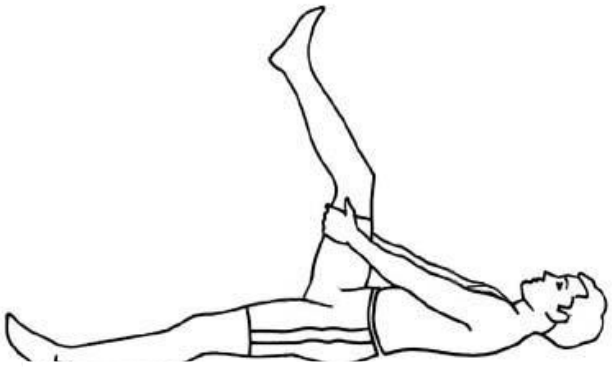
Defining moments

If range of movement (ROM) is the possible distance a joint can move between fully closed and fully open (A or Z), flexibility is the ease of lengthening of the structures crossing these joints. The elongation of this hardware depends on both passive/structural and dynamic/active factors, making flexibility a complex mix of the mechanical and the neural.

Figure 1.



Range available at a joint



Elongation of the hardware

(the ease of travel)

This chapter explores the relationship between limitations in range, both real and relative, and the compensatory movement strategies the body adopts to manage them.

Accounting for the movement currency

Range could be considered the currency of movement. How much any one body region or one individual has to spend varies; more can be earned through numerous methods of elongation. How individuals choose to spend their currency also varies; there is no one way

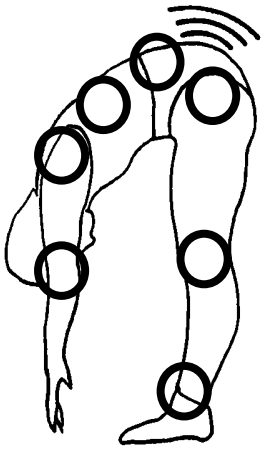
to move; tasks can be achieved in a multitude of ways. Possession of sufficient funds is something routinely assessed in many movement-based disciplines. Testing may consider the ease of transition between points A and Z (flexibility) and the point at which movements become stuck (range), possibly prior to reaching a predetermined benchmark, known as a restriction. These testing protocols may be functional, considering the body as an integrated unit, or may investigate the available range at specific joints in isolation.

Common causes of movement restriction

- Injury and increased scar tissue
- Guarding responses
- Postural shortening due to habitual use of structures at a particular point in range
- Degenerative changes over time (age related)
- Overuse
- Hypertrophy (increases passive stiffness/hardware, see Resistance Training chapter)
- Recruitment dominance (overuse of certain hardware but an issue of the software)
- Psychosocial factors

Movement 'variability'

The task shown below is a functional activity that may also act as a test of range of motion (ROM). Touching the toes can be attempted in numerous ways. For those in good movement health each body region contributing to the task's achievement could do so to varying degrees, depending on the choices the exerciser makes. This would demonstrate good variability, one of the four components of movement IQ.



Regions that can contribute

Regions can contribute in differing amounts

Tasks can be achieved through differing sequences eg, 'first, next, last'

Figure 2.

The musculature of different regions could be actively stiffened (recruited) or made compliant (flexible) to achieve the task multiple times with good control yet in different ways. This requires control of sequencing and contribution. Sequencing considers which body region initiated the movement, which region followed, and finally which was the last region to move in the task. Contribution considers 'how much' movement comes from each region. It could be we can choose to achieve our movement goal from just one or two regions or allow all to contribute evenly. For those with good control, both sequencing and contribution can be varied reinforcing that good movement health is rooted in employing options rather than adhering to a single, repetitive strategy.

Patterns and losing variability

If the same sequence and pattern of contribution is used every time, variability becomes compromised. The region that typically initiates the task frequently becomes overused. The last region to contribute is used much less, leaving this region prone to the effects of atrophy and restriction. To illustrate how altered sequencing/contribution can become engrained, patterns of movement are predictable within certain sporting/movement disciplines. To touch their toes, dancers and gymnasts typically move first from their hips while maintaining a relatively fixed lower back. In direct contrast, sedentary individuals accustomed to spending long hours in an office chair, will achieve the same outcome in the reverse sequence. Their lower backs will lengthen first as the hips, usually tethered by less flexible hamstrings, contribute minimally and last. A martial artist typically has excellent ROM through the hips. In this instance, the high volumes of conditioning work performed on the abdominals will cause martial artists to flex in the trunk, lengthening the lower back to reproduce the "ducking" pattern required in their sport. All three groups have developed domain-specific movement patterns and as a result may have lost a degree of variability.

Functional test limitations

Functional task testing has its place, possibly revealing sequencing/contribution strategies representative of exercise history, yet used in isolation its limitations are clear. If this particular functional test was employed as a one-time method of assessment it would reveal little difference between those able to touch their toes in a variety of ways and those only

able to achieve this in one way. For those who cannot achieve the task at all it is clear that a function limitation is present, yet questions of control remain unasked and location of restrictions unanswered. Illustrating this point are two scenarios resulting from this test.

Can the toes be touched?

1. No. The exerciser cannot achieve the task; regions are too stiff to elongate sufficiently; there is insufficient ROM in the system. However, where this limitation lies is not revealed in this test. Additionally, with regards to the regions that did lengthen, the functional test fails to investigate whether these compliant regions are controlled: Could these more flexible regions be cognitively managed or is there an injury risk associated with uncontrolled movement?
2. Yes, but... The individual may employ a strategy that always calls on the same structures to elongate while others always remain stiffer in comparison. The answer to the question is “yes” but neither the “how” (with control?) or in “what other way” (with variability?) is revealed. Again, the control of the flexible regions is not tested and injury risk may also be present in this case, just as in the case above. Variability may be diminished, leaving only one movement option.

For the restricted individual more information is required about the nature and location of the restriction. For those individuals who can achieve the task through only a single strategy this reduced variability goes unchecked. For both, any potential uncontrolled movements and associated injury risks remains present, unqualified and therefore unaddressed.

It’s all relative

The topic of control calls into question perceptions of the relationship between stiffness (perceived as bad) and flexibility (perceived as good). In daily life the body operates as a unit, made up of relatively stiff and relatively flexible regions. This is normal. The more flexible regions compensate for the shortfall of the stiffer ones so that function can be maintained. Of note, a particular muscle may not actually be restricted (it can still attain A or Z when tested in isolation); it could just be relatively stiffer than neighbouring muscles. Alternatively, this stiffer region does possess a real physical restriction. This means that this particular region cannot achieve benchmarks of range when tested in isolation. In day to day life these real restrictions can also be adequately compensated for as the body finds another movement option; sufficient variability allows the system to cope.

If compensations (evident as the flexible regions) for either these real or relative restrictions are well controlled, a higher state of movement health is preserved. However, once numerous restrictions are present the body begins to struggle. Variability may be reduced to such an extent that only one option may remain. The limited movement options seen in those with pain, is then replicated, loading the same tissues, in the same way, every time.

But it's the control that counts

Uncontrolled movement frequently develops to compensate for restrictions in an attempt to maintain function and it is here where the injury risks reside; not necessarily at the stiffer/restricted region but more typically at the flexible areas. Simply put, stiffness can be good if it is dynamic and controlled. Contrary to blind belief, flexible is not good if it is uncontrolled; therefore to say that stretching reduces injury is oversimplifying the issue.

Functional task testing leaves many questions unanswered

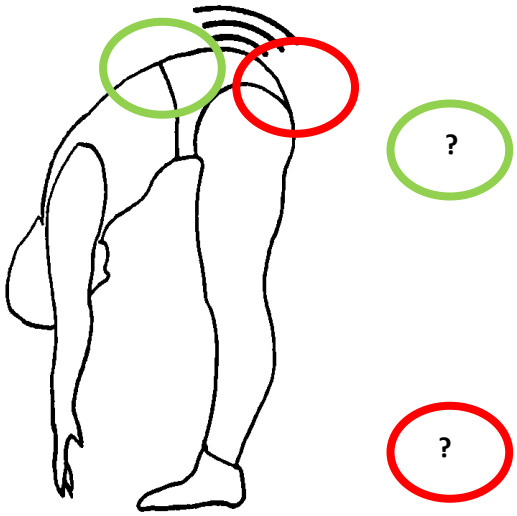


Figure 3.

Flexible; controlled or uncontrolled?

Is this region relatively more flexible than the region below and therefore it contributes more to the task or is it also uncontrolled?

Uncontrolled = it cannot be cognitively controlled if required.

Stiffness; real, relative or controlled?

Is this region relatively stiff in comparison to the region above or does it possess a real restriction?

Is this just the exerciser's strategy and could they display good control of this region and vary task achievement?

Nature of restriction

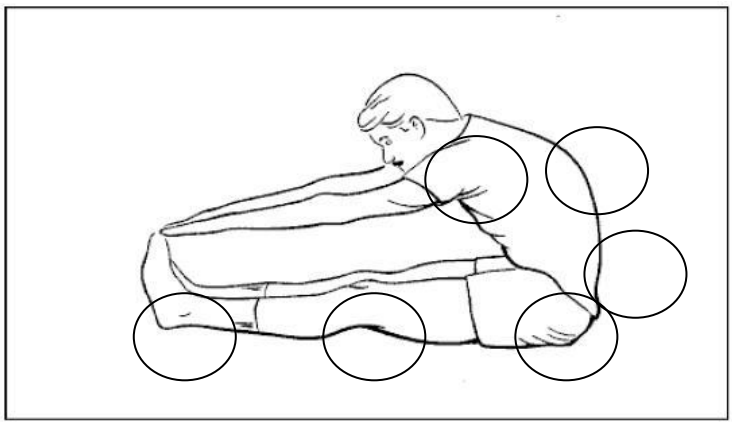
In order to address restrictions their underlying nature needs to be revealed. The causes of restriction are numerous, as seen above, and may be classified under the headings of either dynamic (software) or passive (hardware/structural). To explore the nature of restriction in

the body, both as a unit and at regions in isolation, a battery of tests is required. A suggested route of assessment is supplied below. In addition to identifying the presence of and qualifying restrictions, the following guide may also act as a process of potential referral if the movement-related issues that arise go beyond the comfort zone of the tester.

1. **Specific task achievement (Functional ROM)**

Sit and reach – the classic flexibility test, is also an assessment of a specific, functional ability. Just as in the standing toe touch task above it also asks if the benchmark of touching the toes can be achieved. Due to the dual factors of relative stiffness and relative flexibility the body lengthens at multiple regions in this test, although each region does not necessarily contribute in equal amounts, and different regions may initiate or complete the task (**sequencing**).

Figure 4. The give and take of sit and reach



If a restriction is present at one point, another more flexible region can make up for this deficit; the toes may still be reached, an effective strategy has been found (contribution). Although the exact location of any restriction is not pinpointed, the test reveals if the unit as a whole can achieve the task.

The recent interest in functional movement and intent-driven rather than muscle-specific training has relevance here. The concepts and images used by Myers (2009) and others not only attractively illustrate the clearly integrated nature of the body's anatomy but could be employed to initially help reveal restrictions or stiff/flexible relationships in the same manner as sit and reach. In fact, sit and reach closely replicates the superficial back line as seen in Myers' 'Anatomy Trains' sequence (figure 5).

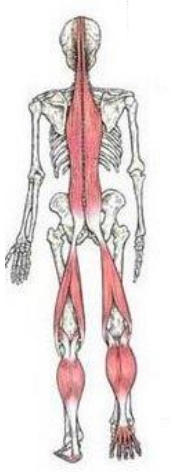


Figure 5. Superficial back line

(Myers, 2009)

Although of use it is vital to make clear that functional tests only identify what they look for: is the task achievable? But *how* the task was achieved or not, fails to be ascertained if this is the only form of testing. The root cause of this lack of functional ability needs further investigation as to whether any limitation is due to a real structural restriction or is an issue of relative flexibility and stiffness and where this restriction/stiffness actually lies.

Neuro-dynamic sensitivity

As identified above, ROM assessment may highlight the need to refer clients on to diagnostic specialists. Testing may find restrictions that are accompanied by pain during a whole body lengthening task like sit and reach. This combination of pain and restriction reveals that hardware along which the software travels is becoming compressed by direct pressure (compressing a nerve). As a safety measure the body's controller (the CNS) increases the tension of muscles in this region (such as the hamstrings) to protect the nerve from further abuse. Not only will this guarding response restrict ROM but it is a sign that the system is compromised. Additional guidance should be sought from a suitably qualified professional at this point because an issue of neuro-dynamic sensitivity is present.

Identifying restrictions in joints

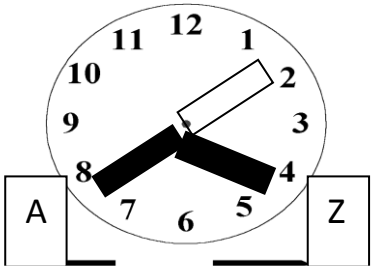
Having identified the presence of a restriction, ideally in the absence of pain, its location can be pinpointed through deduction. Attention can turn to establishing whether this restriction originates in the passive hardware of the joints or the dynamic or passive hardware of the muscles. Joint assessment does typically lie in the hands of clinicians due to the specific nature of the handling required, such as the feel of how the joint moves and the potential for causing pain. Tests do exist which allow some joints to be identified as the cause of restriction without the need for the subtle skills of a clinician.

2. Multi-joint muscles

Frequently it is not the joint but the multi-joint muscles of the body that are to blame for restriction, especially in cases of relative stiffness. This needs to be qualified through assessment in both a passive and an active working state, revealing whether restriction is related to the muscle's passive structural/hardware or if it is software/dynamic driven. Once this is established a strategy can be implemented to resolve the limitation.

Passive range: Hardware restrictions

Here the exerciser being tested remains passive (no active involvement) during the testing. It is the tester who moves the exerciser's body part toward the benchmark (eg, "Z"), similar to moving the clock hands when the clock is not actively ticking.



Passive restriction

Figure 6.

In the example the clock hand becomes "stuck" at "1" and cannot reach the "4," which for this exerciser is identified as the desirable ROM. The tester cannot move the passive exerciser beyond this point. A structural, real, hardware restriction is present in the myofascia (muscle/connective tissue) or articular (joint) structures.

Passive test example

A highly revealing example of a passive ROM assessment is the Modified Thomas test to consider the flexibility of the multi-joint muscles on the front of the hip joint (figure 7). Using deduction to pinpoint the offending structure, this test identifies restrictions typically found in the following muscles:

- **Tensor fascia latae.** Produces hip flexion, medial rotation, and abduction
- **Rectus femoris**. Produces hip flexion and knee extension
- **Sartorius.** Produces hip flexion, lateral rotation, and knee extension

All of these structures also anteriorly tilt the pelvis and therefore place the lower back into extension. The test also demonstrates whether a restriction may be present in the hip joint itself.

Start position

Figure 7. Modified Thomas test protocol (Harvey, 1998; Sahrmann, 2002)

1. Use a sturdy bench/table/plinth set on an even surface.
2. The exerciser should lie supine on the table.
3. The exerciser holds one knee in toward the trunk. The other leg is also initially supported in the same position but is held by the tester.
4. The pelvis should be straight and square to the trunk so that an imaginary line drawn between both hip bones is perpendicular to the length of the spine.
5. The exerciser ensures the lower back is fully flattened against the surface as opposed to remaining in a neutral alignment.

Test execution (Sahrmann, 2002)

1. The tester-supported leg (right) is gently drawn toward the left and with the knee remaining bent at 90 degrees is slowly moved toward the surface.
2. If ROM is good in this position the leg should remain 10-15 degrees above the horizontal if the back has stayed flat (benchmark).
3. If the leg remains higher than this point a restriction is present.

Figure 8.

Benchmark: can the leg get within 10-15 degrees of horizontal?

If the answer is "no" which structure is restricted?

1. If the leg is kept at 90 degrees of flexion and moved away from the exerciser's mid-line (abducted) and now the exerciser achieves the benchmark, the tensor fascia latae muscle, which inserts into the iliotibial band on the lateral part of the leg, is restricted.
2. If the leg is straightened and the leg achieves the benchmark, restrictions are present in the rectus femoris and the sartorius muscles.
3. If the tested leg is taken away from the still bent non-tested leg and then straightened, a restriction is present in the hip joint if the benchmark still cannot be achieved.

On seeing this last outcome, the restricted hip joint will require mobilization from a qualified practitioner. It may also be that the multi-joint muscles are restricted but the hip joint itself is hyper-mobile. This would be apparent if the leg is kept straight, moved away from the body's midline and then fell below the horizontal after seeing a restriction in both of the first two sections of the test. This makes the hip vulnerable to the translational issues discussed in Chapter 3 of Volume 1.

The passive test might reveal no passive restriction yet a limitation was evident during the functional test. This implies a dynamic restriction (software tightness) is present. Also, even though the exerciser is primarily passive during the passive testing, there could be piece of software running in the background that is providing a dynamic component of restriction. Identifying the presence of software-influenced restrictions provides greater clarity on the exerciser's movement qualities.

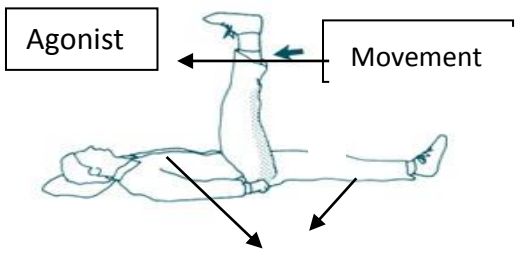
Dynamic range: Software restrictions

Dynamic ROM relates to the amount of movement the exerciser is able to produce when they consciously move a body part toward the "Z" position. This task is now subject to the influence of the body's software on the active hardware of muscle. The muscle tested must lengthen, yet excessive, ongoing activation of this structure may limit elongation. This restriction represents a software tightness issue.

This software tightness also has implications for other muscles in the same region, both on the same and opposite sides of the body. To explore the impact of altered software on these relationships it is necessary to identify the roles that muscles play in any given movement task.

Agonists and antagonists

Muscles operate in groups on opposite sides of the body. Agonists are responsible for producing observable, physiological movements. The opposing muscles are called antagonists.



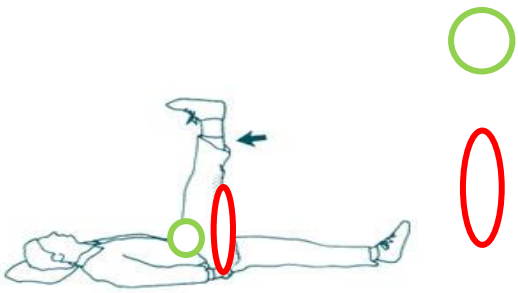
Agonists contract to produce the observed physiological movement. These will include global stabilisers and global mobilisers.

In non-fatiguing activities the global stabilisers are required to be the major contributors to the task.

Antagonists must typically lengthen in order for the body region to move. These will include global stabilisers and global mobilisers.

Certain techniques may be used to inhibit (reduce activation) the restricted muscles. If these are used and an increase in ROM is seen there is a strong suggestion that the restriction possesses a dynamic/software component. Contraction of the agonists (the working muscles) on one side of the limb causes reflexive actions to occur in the software, reciprocally inhibiting the antagonist. This limits the ability of the antagonists to contract and allows the limb to move.

Reciprocal inhibition: Simple (reflex) software loop



The software producing the contraction of the agonist also reciprocally inhibits the antagonists on the opposite side of the limb/joint.

The software that flows to the antagonist is reduced allowing the antagonist to lengthen.

This is an inhibitory technique that if shown to immediately increase range reveals there is a software component to the restriction.

Figure 10. Good movement health

Before inhibitory technique

After inhibitory technique

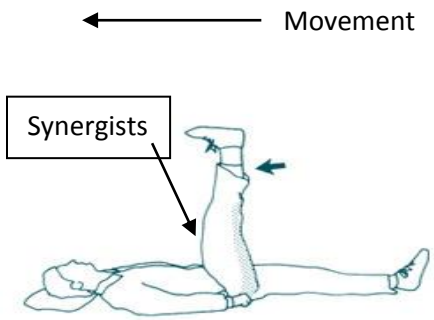
Figure 11. Inhibitory techniques as a test

It may be that a restriction was also evidence during passive ROM testing. This does not mean there might not be a dynamic component also present. If the restriction is not dynamic the inhibitory techniques will not alter the ROM. This result strongly implicates the structural, passive hardware as the root cause.

Synergists

When a group of muscles operate together at a body region and play the same movement role they are described as synergists.

Synergists: Team effort



Agonists can also be broken down into different synergists. This is a group of muscles that may bring about the same observed physiological movement.

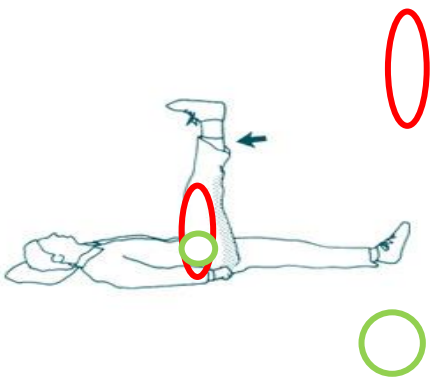
This will include single joint, global stabilisers, and multi-joint global mobilisers.

Depending on where the task lies on the movement control continuum, stabilisers and mobilisers will contribute in differing proportions.

In good movement health stabilisers are dominant in non-fatiguing tasks.

As intensity becomes fatiguing or speed increases all

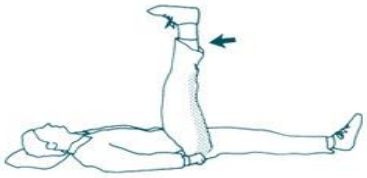
In some cases one synergist may become dominant to another, resulting in uncontrolled movement and injury risk. To move a limb takes a certain amount of force. If one muscle in a group of synergists contributes less (down-regulated) to this task another muscle must contribute more (up-regulated). It is routinely observed that the mobiliser muscles become dominant to their stabiliser synergists in these patterns. This may then lead to a software related restriction in this mobiliser.



The muscles on the front of the leg (two joint hip flexors) may become so highly activated/up-regulated during shortening as to synergistically down-regulate (synergistic dominance) the single joint hip flexors.

The muscles on the same side of the body (single joint hip flexors) may become down-regulated from excessive activation of the two joint hip flexors. This may mean that these single joint muscles, ideally responsible for producing the movement during low intensity activities, may prevent the desirable lengthening in the hamstrings without excessive contributions from the two joint hip flexors.

Figure 13. Synergist dominance



Two joint synergist up-regulation may be accompanied by single joint synergist down-regulation.

Down-regulation of the single global stabiliser will frequently be accompanied by an associated uncontrolled movement and its injury risk.

Examples

Up-regulated rectus femoris will be seen with down-regulated iliacus.

Up-regulated hamstrings will be seen with down-regulated glutes.

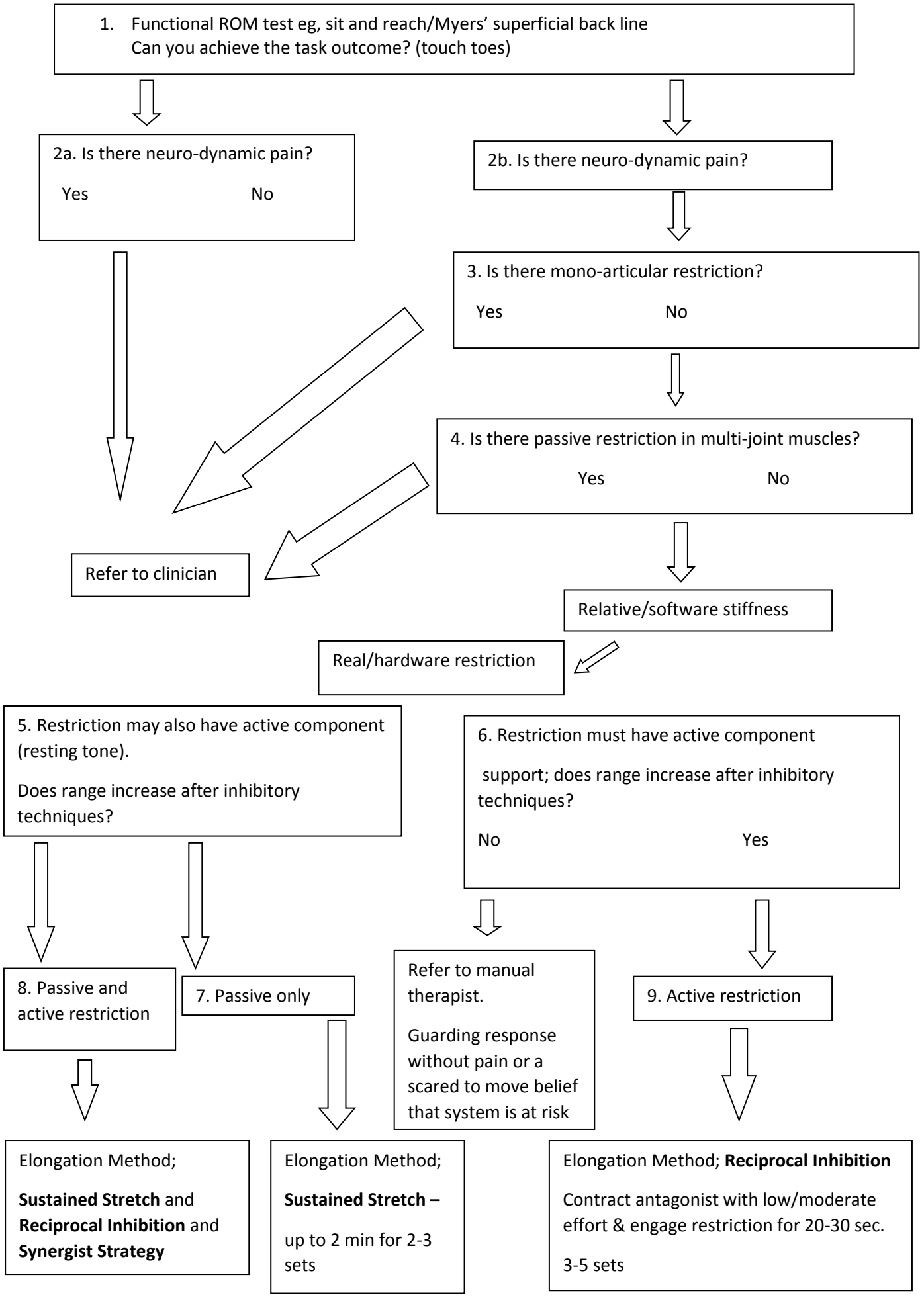
Figure 14. Movement health implications of stabiliser mobiliser dominance (up-regulated)

If such a pattern of movement was apparent, these multi-joint structures could be inhibited through the use of reciprocal inhibition. Working their single joint stabiliser antagonists would aid the down-regulation of the mobilisers in addition to improving the efficiency of the global stabilisers. We could also employ a synergist strategy, biasing the mobiliser's stabiliser synergist so as to reduce activation of the mobiliser itself.

Contract–relax

Another inhibitory technique in the hands of movement professionals is that of contraction followed by an immediate relaxation (contract/relax) and ideally subsequent elongation of the targeted structure. Of note, the performance of such a protocol on an up-regulated, multi-joint muscle frequently causes further recruitment of this muscle and therefore prevents lengthening. This technique is not suited to this cause of restriction.

Figure 15. Range of movement assessment and referral route



The usual suspects

Progressively working through this ROM assessment identifies which structures to target with techniques of elongation, whose protocols are listed above. Typically, the multi-joint muscles, identified as the global mobilisers, lose extensibility and begin to bring about deficits in movement control due to restriction. In the lower body, restrictions in the global mobilisers found on the front and rear of the hip commonly contribute to compensatory movement strategies. Although sometimes referred to as two joint muscles these structures actually impact on three regions directly: the hip, the knee, and the pelvis. This also implicates the lower back in movement control issues related to limitations in range.

Restricted ROM in the muscles that cross the hip and the knee on both the front and back of the body can affect the regions above and below. Just as with the sit and reach, if one region can't get there, another more flexible region will help.

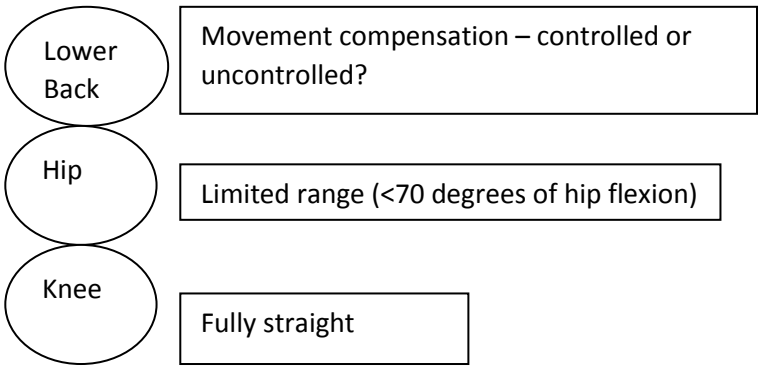
Range and control strategies

While regaining elongation in dynamically or structurally restricted mobilisers is fundamental to maintaining/attaining movement health restoring movement control through increasing dynamic stiffness of global stabilisers is the obverse of this same coin. The following recommendations address issues of both restriction and control.

Hamstrings and low back

Because the hamstrings attach both below the knee and on the rear, central region of the pelvis, a restriction in these structures during leg straightening may well be accompanied by flexing of the lower back.

Figure 16.



Movement health is maintained if this compensation is controlled. If the movement is uncontrolled, the injury risk is heightened.

Hamstrings range of motion strategy

Passive restriction – move slowly into a hamstring stretch to allow the stretch reflex to ease off and allow lengthening of the connective tissue, aiming to limit low back flexion. The stretch reflex can be considered like a radar that will detect a rapid change in the muscle length and subsequently cause the muscle to contract. We must 'sneak under this radar' to address passive restrictions.

Dynamic restriction

Synergist strategy

Target the glutes to allow the hamstrings to down-regulate. Perform a bridge but voluntarily contract the glutes before lifting. Start the exercise with the heels close to the hips so as to take emphasis off the hamstrings. Two minutes of work without fatigue and with lots of conscious attention on the recruitment of the gluteal muscles recruitment is required.

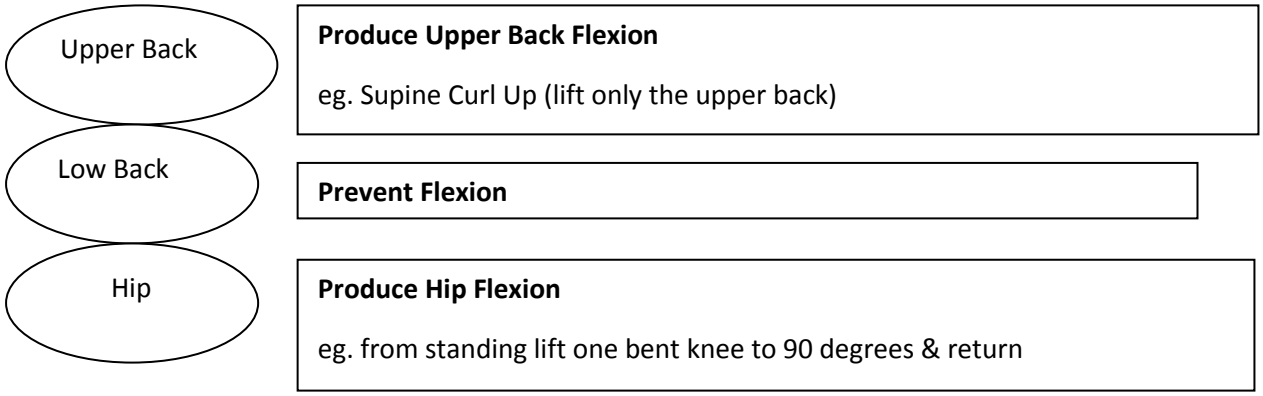
Reciprocal strategy

From seated in a chair keep one leg straight and resting on the floor in front of the body. Lean forwards from the hip but also tilt the pelvis anteriorly so that the low back is arched and the muscles of extension are activated. Ensure the upper back is not also excessively arching during this stretch.

Related control issue exercise 'generator'

Improve control of lumbar flexion employing 'Direction Control' exercise

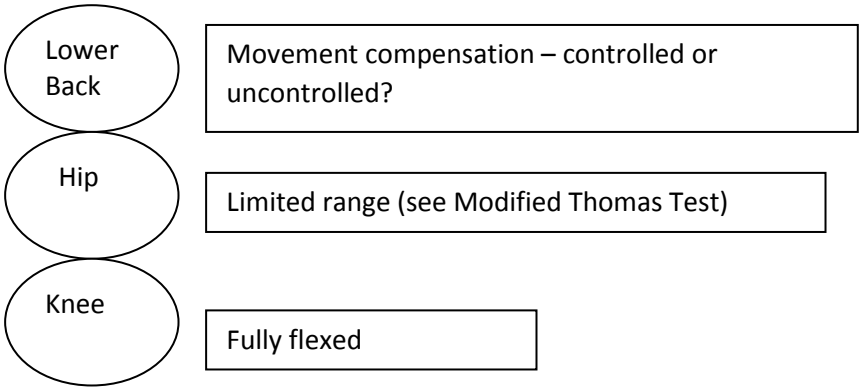
Figure. 17



Two joint hip flexors and low back

If the anterior hip is stiff (as tested in the Modified Thomas test) and prevents the leg from traveling behind the trunk, the lower back will often move instead. This is especially prevalent when the knee is fully bent.

Figure 18.



The lower back is then relatively flexible in comparison to the hip. In the case of an exercise such as the lunge or split squat a restriction of the rectus femoris, attaching above the hip joint and inserting through the knee cap onto the lower leg, may cause the pelvis to rock forward (anterior tilt of the pelvis). This alteration in pelvic alignment will be accompanied by an increased arch in the lower back. This performance lacks the attention to detail and the specificity required to bring about changes to the desired structures; however, the structures on the opposite side of the body from the lower back are held in a lengthened position. Ideally, controlling an overarched lower back is a role for the abdominals and the gluteals. Activating both of these muscle groups will go some way to improving the quality of the lengthening on the desired structures.

Two joint hip flexor range of motion strategy

Passive restriction

In yoga there is a posture called the pigeon/swan. Although this position is often used as a stretch for the glutes on the front leg it can be adapted for the rectus femoris on the rear leg. Once in the posture, flex the rear knee so that the front of the thigh is put on a stretch. Bring the chest as low to the floor as possible and allow the lower back to fully flex so as to pull one end of the muscle away from the other. If the hamstrings in the stretched leg begins to cramp, there may be a need to use a yoga strap, positioned around the ankle of the rear leg, to gently pull the leg into a flexed position.

Dynamic restriction

Synergist strategy

Lie supine with the heel of one leg on a stability ball and the hip flexed to 90 degrees. Place one hand on the region where the leg meets the trunk on this leg. Slowly roll the ball away and towards the hip whilst aiming to feel minimal muscle activation. The aim is to reduce activation of the muscles that are dynamically tight and if they cannot be felt it suggests we must be using something else (the favoured synergist). This should be performed for two minutes without fatigue.

Reciprocal strategy

Assume a lunge/split squat position but allow the rear knee to rest on a mat below the body. Recruit the glutes and perform a full posterior tilt of the pelvis so that the low back flattens. Ease the hips gently forwards until a stretch is felt. Increase this opening by placing the foot of the rear leg of a chair so that this leg can be closer to a fully flexed position. Aim to avoid compromising the low back position and gluteal recruitment to achieve this.

Related Control Issue Exercise Generator

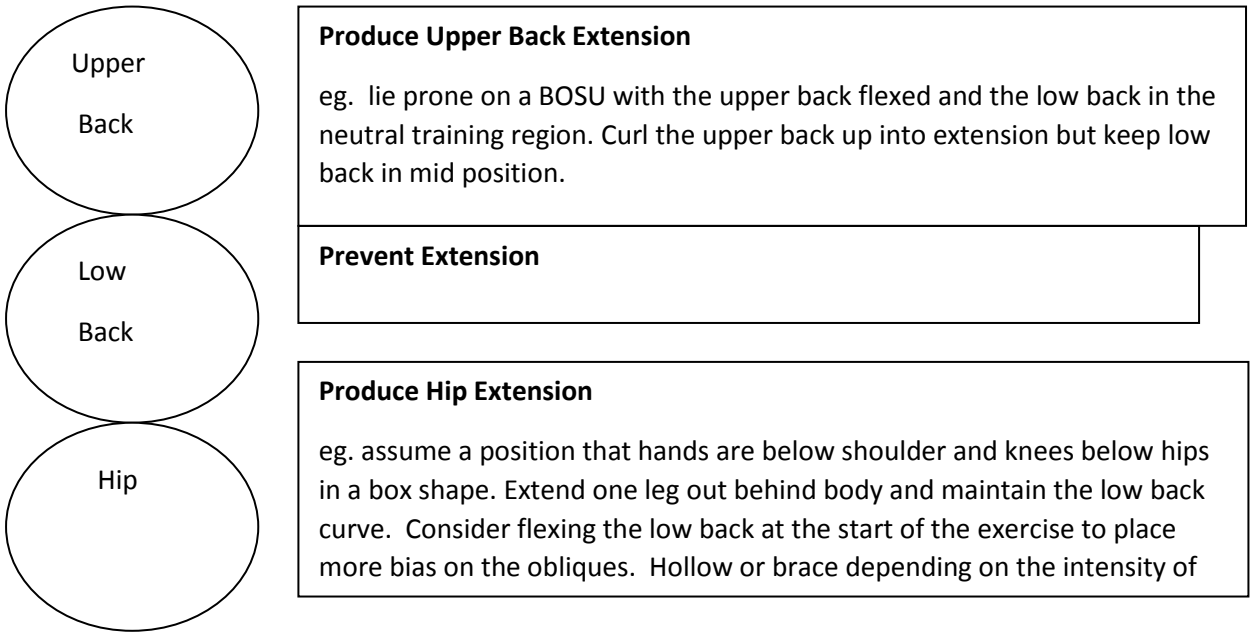


Fig. 19

Summary

The body's mix of relatively stiff and compliant regions is subject to the influence of both passive/structural and active/dynamic components. The interplay between all of these factors allows the body to achieve daily tasks, spending the movement currency of range subject to the ease of movement that is flexibility. Effectively controlled stiff and flexible regions preserve movement health. Restrictions can be found, classified and managed through several elongation techniques yet

it is the areas of compensation – the flexible but possibly uncontrolled regions – in which the injury risk must likely reside. These must also be addressed through the use of exercises that promote awareness, control and variability at all intensities along the movement control continuum.

Volume 2 Summary

This volume has considered the components of the warm up, the workout and the cool down, viewing these through a filter of the movement control concepts presented in volume 1. Both the 'RAMP' warm up and the performance of gym based resistance training are considered as opportunities to develop movement health alongside gaining the traditional benefits typically derived from these parts of an exercise session. The consideration of flexibility as both a passive, structural entity and a dynamically innervated machine allows for a route of assessment to emerge and pinpoint the risks associated with a lack of movement range. Ultimately, whether range is optimal or deficient it is the control of this currency of movement that matters.

Final thoughts

Movement is everywhere; an essential of life, essential to health. With regards to the bigger picture of health, movement/activity must be embraced. Physical activity is often perceived as the answer to many health issues that plague modern society. Yet, even this 'wonder drug' comes with its own particular side effect; injury risk. Effective injury prevention can keep those engaged in health-related activity active for longer, reducing the associated personal and economic burden of both injury and long term inactivity. Developing awareness, control and possessing variability at varying intensities all limit the common injury risk – uncontrolled movement. Although not the only cause of injury a reduction in its presence may allow our most complex and ever present possession to remain in all types of good health.

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