Spine flexion exercise: Myths, Truths and Issues affecting health and performance

Professor Stuart McGill, PhD

University of Waterloo, Canada, and Backfitpro Inc. (www.backfitpro.com)

This short article is intended to address the confusion regarding the issue of spine flexion and the misquoting of our work on this topic. First, some general thoughts are addressed, followed with discussion of the mechanisms of athletic performance, injury resilience, and suggestions for designing training sessions.

There is confusion between the terms flexion “movement” and flexion “moment”. Flexion movement defines the act of bending the spine forward, flexing the spine. This is the kinematic term. Flexion moment refers to the act of creating flexion moment or torque. This is the kinetic term. This is independent of whether movement occurs. Standing, and pushing a load requires the spine to stiffen with anterior muscle activation, hence flexion moment occurs requiring abdominal muscle strength but not movement.

I was shown a quote recently from a trainer who stated, “I followed McGill and avoided flexion and got so weak I could hardly do a situp”. Apart from a terrible misunderstanding and misquote of what we do, this person did not understand the difference between flexion movement and moment. It would appear he avoided moment training. He caused his outcome.

Flexion movement of the spine strains the layers of collagen in the spinal discs. When loads on the spine are small, movement is healthy. We often recommend the cat-camel motion exercise taking the spine through an unloaded range of motion. Thus, there is a time and place for flexion motion. When the spine loads are high in magnitude with repeated flexion motion, the collagen fibres delaminate in a cumulative fashion. Slowly the nucleus of the disc will work through the delaminations and create a disc bulge. The greater the load, and the greater the repetitions, the faster this will occur (Tampier et al, 2007, Veres et al, 2009). Several other events occur depending on the amount of stretch on the spine ligaments at the end-range of flexion. For example, cytokines linked to acute and chronic inflammation accumulate with repeated full-flexion motion exposure (D’Ambrosia et al, 2010).

I have been misquoted along the lines, “McGill states that XXXXX bending cycles cause disc herniation”. There is not a single number – it is a variable. Many variables influence the rate of the herniation process. For example, the shape of the persons disc influences whether the herniation will be focal (Yates and McGill, 2010) and responsive to McKenzie types of rehabilitative exercises, or not (Scannell and McGill, 2009). These responsive discs are predominantly limacon-shaped. In contrast, ovoid discs survive twisting cycles better. The thickness of the spine also influences the rate of gradual herniation – thicker spines have higher bending stress and herniate faster with flexion cycles. For example, a NFL linebacker must have larger diameter discs to survive the compressive loading, but these same discs will not do well performing a 1000 situps. In contrast, it has been pointed out to me that there is a fellow in Brazil on Youtube who does 1000 situps everyday, implying by logical extension that I must be in error. But you will notice that he has a very slender spine so the bending stresses are small.

But his thin spine would not survive the loading of a single NFL game. These elements of biological variability preclude the recommending of an exercise approach simply because it was tolerable by another individual. Further, time of day influences the rate of herniation. After rising from bed, the disc nucleus' are fully hydrated and have much higher stresses during flexion. It is more risky to train repeated bending earlier in the morning. Occupational studies have shown avoiding flexion motion in the morning reduced disabling workplace backpain (eg Snook et al, 1998). Different spines mean different injury mechanisms, different resiliencies to motion, and different training approaches. Choose your parents (disc geometry and thus stress patterns came from your parents), then choose your best way to train!

I have been shown quotes, "McGill uses pig spines" to dismiss our work. These quotes must come from kids who live in their basements. They may have seen a single study but do not know our body of work. We have published hundreds of experiments in medical publications over 30 years with about 10% of them using animals. These are essential studies where we can test 40 identical spines to establish the interaction and influence of some of the variables introduced above. Of course these mechanisms are calibrated back to human mechanisms (eg Yingling et al, 1999).

Why is "flexion exercise" such a passionate issue? Core training, training the abdominals, core stiffness and stability are all essential components for pain control, performance enhancement, and injury resilience. But the specific issue here is whether the spine needs flexion movement or flexion moment training. The following section explains the foundation for athletic performance that has 4 components: 1) Proximal stiffness (meaning the lumbar spine and core) enhances distal athleticism and limb speed; 2) A muscular guy wire system is essential for the flexible spine to successfully bear load; 3) Muscular co-activation creates stiffness to eliminate micro-movements in the joints that lead to pain and tissue degeneration; 4) Abdominal armor is necessary for some occupational, combative and impact athletes. Logically, we must now discuss the priority for flexion movement or moment.

First, how does core stiffness enhance limb speed and strength? Consider an example with the shoulder and the pectoralis major muscle – it attaches the rib cage at its proximal end, crosses the shoulder joint, and attaches to the humerus of the upper arm at its distal end. When muscles contract they try to shorten. Consider the specific action here – pectoralis muscle contraction flexes the arm around the shoulder joint moving the arm from muscle shortening at the distal end. But the same shortening also bends the rib cage towards the arm at the proximal end of the muscle – in other words bending the core. Thus simply using the pec muscle would not result in a fast nor forceful push or punch. Now stiffen the proximal end of the pectoralis muscle attachment – meaning stiffen the core and ribcage so it can't move. Now 100% of pectoralis muscle shortening is directed to action at its distal end producing fast and forceful motion in the arm. In the same way a stiffened core locks down the proximal ends of the hip muscles producing faster leg motion. A loss of core stiffness causes the torso to bend when sprinting, and a loss of speed - some force was robbed that should have been expressed in leg velocity. Thus, a universal law of human movement is illustrated – "proximal stiffness enhances distal mobility and athleticism". This requires flexion moment training (core stiffness), not movement.

Second, the spine is a stack of vertebrae that is called upon to bear loads, yet it is flexible. An engineer cannot design a structure to be good at both. A steel beam that is straight and stood on its end is stiff, and can bear loads that try to compress, shear and twist it. So the beam can bear load but it can't move. A flexible rod that allows movement will bend and buckle under load, but absorbs shock. Our spines do it all - they bend and allow the lungs to fill with air, and even allow us to dance. The spine is this beautiful structure that is flexible and allows flowing movement, but requires a 3-dimensional guy wire system to stiffen and stabilize it when it is required to bear loads. Analysis of the muscular system, together with its associated fascia sheets reveals a clever guy wire system that creates balanced stiffness eliminating the possibility of buckling and injury. The concern is that modern living does not "tune" and train this guy wire system. In many people it lapses into complacency. This requires flexion moment training (core stiffness), not movement.

Third, back injury causes joint laxity. For example, injury to the disc causes it to loose height allowing aberrant joint micro-movements. The micro-movements irritate sensory nerves resulting in back pain and radiating pains. Spine stiffness from co-contracted torso muscles minimise the micro-movements and control pain. Note this co-contraction is "tuned" to create sufficient stiffness. This requires flexion moment training (core stiffness), not movement.

Fourth, athletes who require abdominal armor to survive kicks and blows need abdominal training. Top combative athletes seek my consulting expertise for back pain. Typically, they have trained high repetition situps to build armor, but eventually develop back pain ending their careers. I change the flexion movement approach to flexion moment (core stiffness) by having them perform exercises such as "stir the pot". No motion occurs in their spine. Their strike speed is enhanced (Lee and McGill, in press), and their training tolerance has been restored. Their careers have been salvaged.

Finally there is practical/applied evidence from group trials. For example, military groups have made speed situps a mandatory component for annual fitness tests. Soldiers train the test. Recognizing the US military unacceptable low back injury statistics, Childs et al, (2009) tested the substituting of situp training with planks and "stir the pot" consistent with flexion moment training (core stiffness, not movement). The group of soldiers with moment training performed better in the situp tests even though they did not train them. They had healthier backs.

The "big 3" exercises (McGill, 1998 and McGill, 2014) have been proven to enhance stiffness that lasts after the session has finished (Lee and McGill, in press), tuning the guy wire support of loads. For those with back injury, and unstable spine joints, enhancing stiffness with flexion moment training together with flexion movement avoidance are essential to control and eliminate the micro-movements that cause pain (Ikeda and McGill, 2012). These exercises should be performed every day. They are the foundation from which larger exercise progressions can be designed to optimally reduce pain, and enhance athleticism. These progressions will include the objectives of endurance, strength and power while building resilience, reaction time and whatever else they need to be their best.

There are those who claim that their sport is flexion movement-based and they must train flexion movement – such as jiu-jitsu athletes. But again I have consulted with several top jiu-jitsu players. They were not able to train because of the back pain they induced over time training flexion movement cycles. With no pain-free capacity to train they were finished. We changed the training from a flexion movement to a flexion moment approach, thus regaining pain-free spine flexion ability but saving the spine flexion for the ring and octagon. Their capacity to train was restored. Again some careers were salvaged and indeed flourished.

How are these thoughts put into practice? It depends! The answer depends on history – does the person have episodic back pain, or chronic pain or perhaps has never had pain. If they are a grand master of powerlifting and have never had back pain I suggest keeping their style. But if they have a pain history, the answer is different. First, if the spine is under load, it is best to not move it – keep it stiff. This principle is not contestable. The second best is, if the spine must flex such as a strongman event competitor lifting an atlas stone, the spine is stiffened in an isometrically flexed spine posture. The stone is hooked by the thighs, arms and pectoralis muscles as the spine curls over the stone. The spine does not move as the motion is focussed about the hip joints until the final "hoik". So the spine is flexed while under load but it does not move. The worst technique would be to move the spine into flexion, over and over, so the combination of load with motion would slowly and cumulatively delaminate the disc collagen. Here the spine is fatigued before the muscles. Training volume is compromised. It would be more effective to build training volume by reducing the spine movement, truly train the muscles to perform, and spare the spine. My consulting with this approach has taken many injured athletes back to function sufficient to compete at the Olympics, and in the UFC, NBA, NHL, NFL etc. and win.

Other considerations besides pain history would include findings from an assessment. I would assess the geometry of their hip joints, their function, and look for opportunity to enhance the mechanics through the linkage to the pelvis and spine. Then I would perform provocative testing to identify the mechanism of pain generation. If the pain is resulting from flexion motion, or flexion motion when combined with a specific compressive load, there is no option regarding the training strategy that will allow the continuation of pain-free training – flexion must be avoided. Then I examine lifestyle and the rest of the training program. For example if the individual sits at a computer as an occupation, most likely the training program will need to address the consequences of long duration spine flexion first. Then, together we identify the training goals of the individual, assess their current status, and decide on the best exercise tools to take them to the goal.

The reader appreciates that the issue of "spine flexion", from the perspective of injury mechanics and exercise prescription, is complex. The most justifiable approach will not be guided by a single study, not one on pigs, humans, or within institutions like the military. But together, all of these studies are important. Interpretation of this collection of work requires much time and expertise. While I have injected a few references, they are sparse so as to not burden the reader. I have synthesized these many papers to guide training in my textbook "Ultimate back fitness and performance" (fifth edition 2014, www.backfitpro.com). Many of the original scientific papers are listed in my CV on the university website (https://uwaterloo.ca/kinesiology/people-profiles/stuart-mcgill).

References:

Callaghan, J.P., and McGill, S.M. (2001) Intervertebral disc herniation: Studies on a porcine model exposed to highly repetitive flexion/extension motion with compressive force. Clin. Biom. 16(1): 28-37.

Childs, J.D., George, S.Z., Wright, A., Dugan, J.L., Benedict, T., Bush, J., Fortenberry, A., Preston, J., McQueen, R., Teyhen, D.S., (2009) The effects of traditional sit-up training versus core stabilization exercises on sit-up performance in US Army Soldiers: A cluster randomized trial, J. Orthop. Sports Phys. Ther., 39(1): A18.

D'Ambrosia, P., King, K., Davidson, B., Zhou, B., Lu, Y., Solomonow, M., (2010) Pro-inflammatory cytokines expression increases following low and high magnitude cyclic loading of lumbar ligaments, Eur. Spine J., doi 10.1007/s00586-010-1371-4.

Ikeda, D., McGill, S.M. (2012) Can altering motions, postures and loads provide immediate low back pain relief: A study of four cases investigating spine load, posture and stability. SPINE. 37 (23): E1469-E1475

Lee, B., and McGill, S.M., (in press) The “Big 3” stabilization exercises enhance spine stiffness.

McGill, S.M. Invited Paper. (1998) Low back exercises: Evidence for improving exercise regimens. Physical Therapy 78(7): 754-765.

McGill, S.M. Ultimate back fitness and performance, Backfitpro Inc., Waterloo, Canada, ISBN 0-9736018-0-4 (www.backfitpro.com). Fifth edition 2014.

Scannell, J.P., McGill, S.M. (2009) Disc prolapse: Evidence of reversal with repeated extension. SPINE, 34(4): 344-350.

Snook, S.H., Webster, B.S., McGarry, R.W., Fogleman, D.T., McCann, K.B., (1998) The reduction of chronic non-specific low back pain through the control of early morning lumbar flexion: A randomized controlled trial, SPINE, 23(23):2601-2607.

Tampier, C., Drake, J., Callaghan, J., McGill, S.M. (2007) Progressive disc herniation: An investigation of the mechanism using radiologic, histochemical and microscopic dissection techniques. SPINE, 32(25): 2869-2874.

Veres, S.P., Robertson, P.A., Broom, N.D., (2009) The morphology of acute disc herniation: A clinically relevant model defining the role of flexion. SPINE: 34(21):2288-2296.

Yates, J.P., Giangregorio, L. and McGill, S.M. (2010) The influence of intervertebral disc shape on the pathway of posterior/posterior lateral partial herniation. SPINE. 35 (7):734-739.

Yingling, V.R., Callaghan, J.P., and McGill, S.M. (1999) The porcine cervical spine as a reasonable model of the human lumbar spine: An anatomical, geometrical and functional comparison. J. Spinal Disorders 12(5): 415-423.