Reframing the Control Paradigms: Putting Core Stability in its Place

Joanne Elphinston

"Core stability" has been described by Lederman as a myth (8), an understandable position given that the benefits ascribed to the concept have been extrapolated well beyond the scope of the original research upon which it claims to be based.

However, if we separate the assertions of the stability industry from the actual function and behaviour of the human body itself, it is not entirely accurate to dismiss it as a myth. The trunk *does* need to support and withstand the forces acting upon it, however the methods devised to address this and thus feed a hungry commercial industry have evolved without sufficient understanding of the moving functional human.

It is certainly able to be demonstrated that a voluntary contraction in muscles such as transversus abdominis can be provoked by using specific cognitively driven cues, however the evidence for actual transference of such activities to function, or their superiority over other interventions is inconsistent and less convincing than is widely thought (1, 2, 9, 10, 13). Why might this be the case?

Stability versus Robustness

Laboratory-based research, which by necessity narrows its focus in order to examine specific responses, has brought about apparent contradictions. In 2007, Grenier and McGill (6) compared the higher threshold, global "bracing" strategy with the lower threshold "abdominal hollowing" strategy for effectiveness in stiffening and supporting the spine against a load. One of the tasks was to lift a unilateral load by holding a weight in one hand, and as the more global musculature is better positioned to counteract a strong sideways pull, it is unsurprising that they found that a bracing strategy was the more effective technique.

Meanwhile in the same year, Tsao and Hodges (14) found that their low threshold training improved the feedforward response in transversus abdominis in low back pain patients. Two different studies using two different trunk muscle actions achieved positive results for control of the spine. Is there then a contradiction regarding the strategy we should be teaching?

Considering function instead of muscle activation, the first study examined how much lumbar stiffening is achieved in response to a load. The second looked at normalising neuromuscular responses and timing. It is not a question of which technique is "right", as they are measuring different behaviours. Both look at a specific response within a controlled environment, and although they give us useful information about muscular behaviour, neither holds all the answers when considering a patient under normal functional conditions (4).

If we take this one step further, in order to address transference to function we must understand what Reeves et al in their 2007 paper described as the relationship between stability and *robustness* (12). Robustness involves the capacity for a system to cope with a range of tasks, including disturbances and uncertainties.

It is possible for a system to be stable, yet not robust. It simply needs to remain within its functional boundaries to remain uninjured. However, should it be asked to cope with a change in loading, direction, speed or equilibrium beyond those functional boundaries, it is at risk of injury. Clinically, this would be represented by the patient who can maintain a controlled spine during supine tasks in a clinical environment, but whose programme has not been diversified to train a range of relevant responses for the demands of life in general.

Rather than expecting that the activation of a specific set of muscles will bring about globally relevant change, the concept of robustness shifts our thinking to movement performance as a focus for rehabilitation.

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A Dance of Integrated Factors

Movement is the result of a complex interplay of shifting relationships, and its expression involves physical, psychological and emotional factors. Each movement requires that we both create and control forces, which in itself involves the coordination and timing of body parts, posture, proprioception, functional mobility, balance and calibration of muscular tension (4).

The diagram below illustrates just a small number of the elements involved in effective movement, or "Movement Efficacy". The term "stability" is not featured, as stability is not an independent entity, but the result of many interdependent factors.

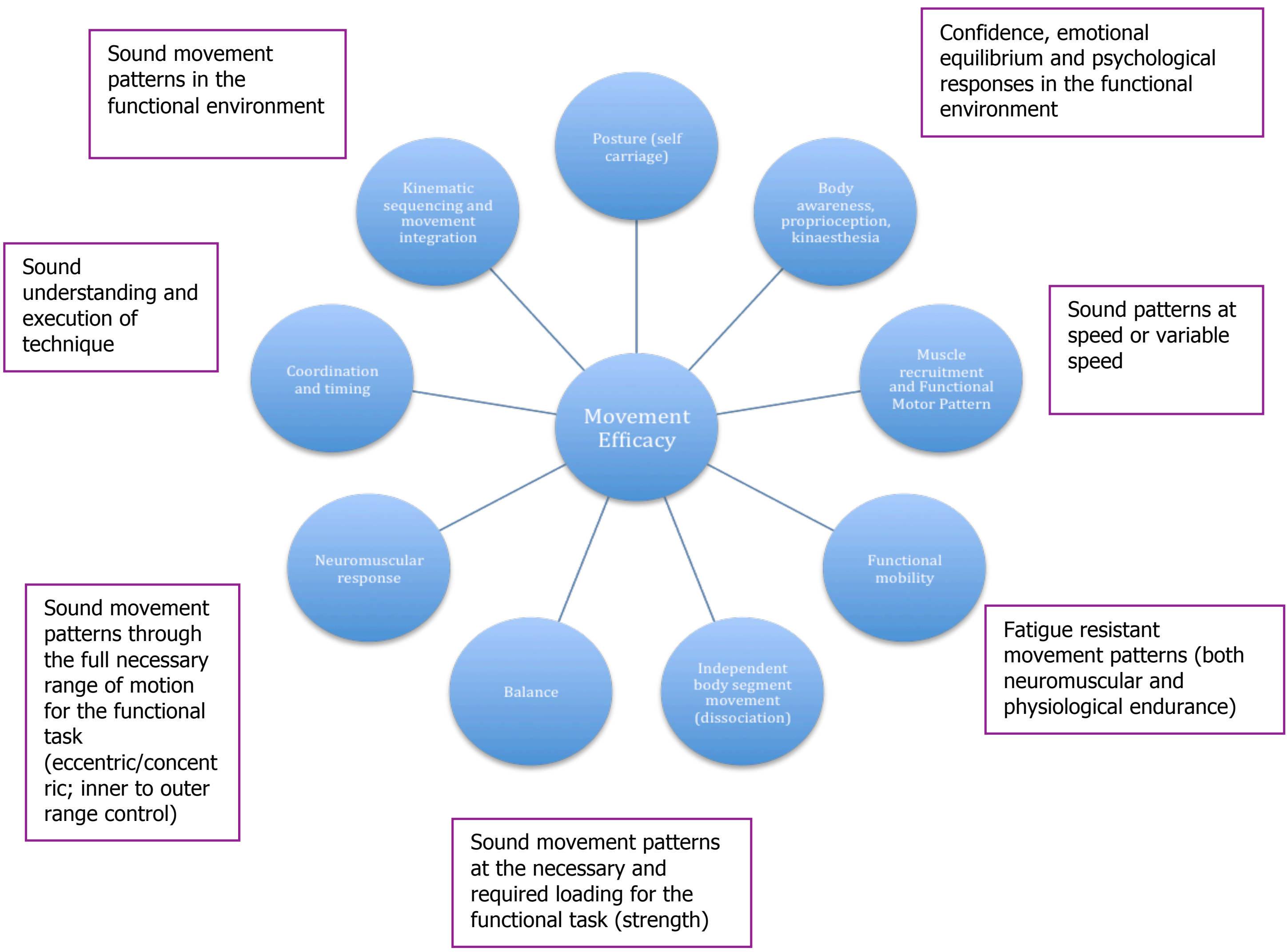


Diagram from Elphinston J 2013 *Stability, Sport and Performance Movement: Practical Biomechanics and Systematic Training for Movement Efficiency and Injury Prevention. Second Ed*. reproduced courtesy of Lotus Publishing, UK.

How can we integrate this idea with existing "control" paradigms?

Firstly, the principle of the "three Vs", variety, variation and variability, can be used to expand and diversify a patient's capabilities, thus ensuring that they achieve a larger functional window.

Variety means that different types of tasks are used to address and develop a single specific objective. For example, for the specific objective of developing trunk control in neutral, a therapist may change the patient's body orientation and angle against gravity, shift the bias from anterior to posterior chain, change the support point, challenge their balance or introduce neuromuscular tasks. The patient is therefore guided into developing a sound sense of spinal position regardless of position, and a range of different control strategies to control it.

Variation means that a single task is diversified in order to increase adaptability. Changing a plane of movement, moving one body part from another, altering speed or range of motion involved in the task, or modifying the base of support are all methods for incorporating variation.

Variability introduces a degree of unpredictability, sudden change and the possibility of the unexpected. This is where we randomise and diversify the skills, mixing up speed, load, direction, intensity and task. Variability in the rehabilitation programme encourages the patient to rapidly respond and organise themselves under changeable conditions, and to gain confidence in their capability. The patient does not have to be a high performance athlete to benefit from the introduction of variability into their programme. A low back pain patient will widen their functional window and increase their chance of regaining spontaneous, unselfconscious movement if they are able to confidently cope with variable speed, direction and movement tasks.

It is therefore possible to quite simply provide a patient with a cocktail of motor learning opportunities.

Secondly, in order for training to meet a patient's functional requirements, it is helpful to understand movement in terms of the functional force management strategies that the patient uses.

Functional Force Management

Functional Force Management is the manner in which we create and control forces, and represents our capacity for physical *expression* through qualities such as power, speed or balance, and for physical *conservation*, or protection, through strategies such as shock absorption and force sharing to divert pressure from body structures (3).

There are four key elements to Functional Force Management:

1. How effectively force is generated and directed.

Example: The throwing action represents a good illustration of force generation. A good thrower will initiate their action from the lower body, first stepping into the motion, and then rotating the pelvis to create torque through the body which both supports and facilitates the shoulder. A poor thrower initiates the action from the arm, increasing loading on the shoulder and elbow and reducing potential power. The poor thrower may present with shoulder pain, but for effective transference to function, isolated scapular and rotator cuff work is insufficient to normalise the loading on the shoulder. The patient requires a more effective force generation strategy, so they will benefit from experiencing forward weight transference and rotational motion of the pelvis, as well as integration of the shoulder with the trunk as a part of their rehabilitation.

2. How effectively forces are transmitted throughout the body.

For optimal efficiency, the body transmits forces up, down and across the body. A key "stability" training error is the blocking of these forces by over-controlling certain body parts. If forces are blocked from moving through the body, overload will result somewhere in the system.

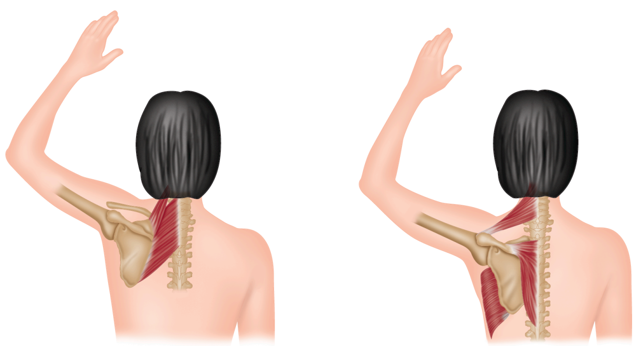
Example: Normal walking and running use counter body rotation, Gracovetsky's "spinal engine" (5), to achieve biomechanical efficiency. Force flows diagonally up and across the body in diagonal patterns, utilising the elastic potential of the myofascial slings, dispersing excessive load across multiple joints, and lengthening the stride. The thorax must be able to rotate independently of the pelvis, but it cannot do this if the patient has been trained to maintain a constant fixed relationship between these body segments. Excessive fixing in "the core" prevents this central zone from effectively transmitting force between the upper and lower body, thereby diminishing efficiency and increasing loading on the lower body propulsive structures.

3. How effectively forces are dispersed or shared across a large surface area in the body.

Stress = Force/Area is a fundamental engineering principle. To decrease structural stress, you must increase the area across which that force is borne. Whether referring to bridges, buildings or bodies, the effect is the same.

Example: When a patient presents with neck pain and can be observed using a shoulder elevation strategy every time they load their upper limbs, they are bearing maximum load over a small surface area, in this case the relatively small structures of the neck. If instead they shared the forces of the upper limb across the broad surface of their thorax, as they would if they accessed serratus anterior and lower/middle trapezius, the stress on specific structures would be reduced. By understanding the patient's force management strategy for the upper limb, it is possible to identify a mechanism for the neck pain. Training a more sustainable upper limb strategy will be the foundation for the rehabilitation plan.

Elevation Force sharing



4. How effectively force is dispersed and released from the body.

Example: When landing from a jump, a coordinated sagittal plane action between hips, knees and ankles helps to disperse vertical force. Many athletes can be observed blocking their landing through excessive co-contraction around the knee. If the knee is effectively immobilised, it can no longer contribute to the shock absorption and force dispersal mechanism in the lower body. However, those forces must be managed somewhere, and the body has a number of possibilities. It can divert the forces from the sagittal plane which is blocked at the knee, into the frontal and transverse planes by adducting or internally rotating the hips. It can try to disperse the force in the sagittal plane by tipping the trunk forward. It can also jam the force into a spine which has collapsed into extension, creating high lumbar stress. In all of these scenarios, force pools within focal areas in the body instead of moving safely through the kinetic chain.

Conceptualising movement through the generation and transmission of force allows us to appreciate the biomechanical interactions throughout the body, and the integration necessary for fluency and efficiency. It also gives us a means for understanding movement dysfunction in a practical way.

Strategies for managing forces are dictated by the task being performed, and a number of different strategies are available for different situations. This will vary the muscle actions used. Withstanding a rugby tackle for example will involve a different trunk control strategy to running a marathon.

The examples below illustrate just some of the possibilities:

The "Suit of Armour" strategy.

Suit of Armour, otherwise known as the *compression* strategy, involves stiffening of the large trunk muscles. It is primarily a protective behaviour which constrains the shoulders and hips, and locks the trunk to the pelvis using high muscle force. In terms of force flow, the impulse is compressive and directed centrally into the body. In essence it halts force transmission through the body and eliminates independent motion between zones. This strategy would be extremely useful when withstanding an impact such as a rugby tackle, for example.

This strategy, however, has a high energy cost, and is not a sustainable strategy to use continuously. Neither is it helpful when fluent, efficient dynamic movement is necessary, because its role is to restrict and constrain motion. Training for this strategy will involve higher threshold global activation.

The "Elastic Support" strategy.

The "Elastic Support" strategy funnels forces between the upper and lower body via the central musculature of the trunk while maintaining freedom of motion of hips and shoulders. Running would be a good example of this strategy. The Elastic Support strategy allows the body to lengthen while remaining connected and controlled. Training will involve low effort control through full shoulder and hip range.

The "Neuromuscular Response" strategy.

A Functional Force Management discussion must also include the "Neuromuscular Response" strategy. This is the body's capability to cope with the unexpected, to be able to respond instantly to an external challenge, minimise potential body stress and regain control and balance. It is a stabilising response that must be instant, adaptable and above all, not rigid, in order to be able to successfully cope with the unpredictable. Whether slipping on ice, being bumped in a crowd or contacting an opposing player on a netball court, this strategy is essential. It can be trained at all levels and from very early stages of rehabilitation (3).

It can therefore be seen that more than one control strategy is required to cope with the wide range of functional possibilities that we may encounter.

Towards a Model of Movement Efficacy

Movement efficacy, which is the expression of effective force management, integration of whole body systems, coordination, adaptability and spontaneity, is a phenomenon applicable from childhood throughout the life span. With sufficient understanding of normal movement and the range of strategies through which we cope with our functional demands, it is possible for practitioners to transcend localised, prescriptive models of stability to create balanced, progressive exercise programmes relevant to the patient as an individual and to their functional requirements.

Concepts and text excerpts from the newly updated edition of Stability, Sport and Performance Movement: Practical Biomechanics and Systematic Training for Movement Efficiency and Injury Prevention. Second Ed. Lotus, UK, and from JEMS Movement A.R.T. (Analysis, Rehabilitation and Treatment) courses.

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