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Review Article

Movement pattern and muscle balance as a source of lumbar spine health according to the concept of Kinetic Control

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ABSTRACT

Introduction: Since the beginning of the 21st century rehabilitation has developed rapidly, however still many patients report problems of the musculoskeletal system.
Aim: The aim of the study was to analyse motor control of the lumbar spine according to different movement patterns and chooses the best exercise for abnormal movement patterns.
Material and methods: The lumbar spine is a region with reference to which patients most often report pain. Pain sensations are most often induced by mechanical overloads. In order to prevent such overloads and treat the pain, it is significant to assess various movement patterns.
Results: The concept of Kinetic Control allows analysing the movement patterns thoroughly, with the use of the assessment of the direction control for flexion, extension and rotation movement.
Discussion: Clinical indication is for people with symptoms and those who still have not reported the lumbar spine pain to work in order to regain correct movement timing during such a global movement. It is often advisable to work at the same time towards controlling the direction of movement, regaining optimal elasticity of multi-joint structures and restoring proper segmental stabilisation. Identifying a dysfunction of the musculoskeletal system early enough, it is possible to avoid pathologies and pain in patients, simultaneously minimising the risk of irreversible structural changes.
Conclusions: The loss of motor control is related to the low back pain, and is a good diagnostic tool. Important is the choice of motor control exercises for a particular direction of motion.

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1. Introduction

Since the beginning of the 21st century rehabilitation has developed rapidly, mainly due to advances in clinical tissue imaging (MRI, ultrasound) and a lot of research undertaken all over the world. Undoubtedly, patients with problems of the skeletal system most often complain about pain, which accompanies certain movements or activities. This is a direct message for a physiotherapist or doctor to perform a thorough movement analysis as well as correlation of conclusions made on such basis and as a result of observing accompanying symptoms. It may seem an easy task, yet a range of studies undertaken in this field shows that there is still a lot to know about movement. Everyday clinical practice is definitely facilitated by the above-mentioned progress in medicine, which provides a lot of opportunities, such as doctor's access to MRI and ultrasound examinations, thanks to which structural diagnosis is complete. Physiotherapists not only diagnose patients but also provide therapy with feedback using more often ultrasound equipment. Still in very few places there is a chance to get access to electromyography equipment (kinesiological EMG), which allows one to assess, among other parameters, muscle activity, timing and coordination. Yet, in such a situation it is even more important to rely on academic reports, which provide essential information about the muscular system. It is worth adding that over the past few years a lot of new information has been provided when it comes to anatomy (structure and function of particular muscles), motion biomechanics, kinesiology and pathology. This scientific progress is effective only when applied by ''practising physiotherapists'' working with their patients.

2. Aim

The aim of this work is to analyse motor control of the lumbar spine and chooses the best exercise for abnormal movement patterns.

3. Material and methods

The present day classification of muscle function was determined and described by Comerford and Mottram[1] in the concept of Kinetic Control. Still a dozen years ago muscles were divided into stabilising and mobilising ones, while another classification included local and global muscles. These divisions were considerably improved when the two classifications merged, enumerating now:

- local stabilisers,
- global stabilisers,
- global mobilisers.[1–3]

Local muscle stabilise the segment locally (Table 1). They are often compared to a deep cylinder,[4] which is built from such muscles as: the transversus abdominis muscle,[5–7] the multifidus muscle,[8] the diaphragm,[9,10] pelvic floor.[11–13] This muscle group is characterised by early activation independent of the performed movement, i.e., the so-called feedforward or early timing. These muscles work mostly isometrically, with no change in their length. Their specific role consists in controlling segmental translation. The training of this muscle group should constitute one of the elements of rehabilitating patients who suffer from pain of the lumbar spine (both those who are treated conservatively as well as surgically).[14]

The group of global stabilisers (Table 1) is able to generate movement but the muscles can also control it. Since these are usually single joint muscles, their task is to control rotational movement irrespectively of the applied loads (low/high). Additionally, these muscles have effect on the assumed static posture.[1–3,15]

The third group, global mobilisers (Table 1), consists of muscles, which are most superficial. They are responsible for generating force to perform a movement and for accelerating the movement concentrically. This group often becomes dominant and ''takes over'' the role of stabilisers, which in turn inhibits movement. Generating compensation, this directly contributes to disturbances in movement patterns.[1–3]

Getting to know the functions of particular muscle groups and having knowledge as to which muscles belong to which groups enable to localise precisely muscular dysfunctions (which may cause movement dysfunctions). It is an essential diagnostic stage that allows one to provide a correct diagnosis and plan rehabilitation in an appropriate way. Correct muscular balance is essential in eliminating dysfunctions within the musculoskeletal system.[16] According to the concept of Kinetic Control there are a few diagnostic levels, which are related, among other factors, to the fact that there are three

Table 1 – Functional classification of muscles.[1–3]

Local stabilisers	Global stabilisers	Global mobilisers
1. Early activation (feedforward) 2. Activation independent of the direction of movement 3. Segmental translation control 4. No or minimal change in their length during movement	1. Functional ability to: – shorten in the full inner range of movement – maintain the position isometrically – eccentrically control returning to the initial position 2. Generating force to control range of movement and limit it 3. The eccentric work is responsible for inhibiting the rotation movements 4. The activity is not constant and depends on the direction of movement	1. Generate power to perform a range of motion 2. Concentrically accelerate movement (sagittal plane generates power) 3. Absorb loads 4. Their activity depends on the plane and direction of movement

muscle groups fulfilling different functional tasks. Moreover, tests are performed in low and high loads, depending on the clinical indications for a given patient (e.g. high load in athletes). The foundations of the concept include four levels of evaluation of movement control: translation, direction, range and control of extensibility. During assessment of translation the system of locally stabilising muscles will verify in relation to appropriate tonic activation. Evaluating the control through the range it should first verify the system of global stabilisers and then global mobilisers (control of extensibility). Assessing the control of movement direction it must validate the appropriateness of the performed movement patterns and evaluate integration of the local and global systems in the performed movements.[1–3] In the clinical approach it is worth determining the character and direction of both diagnostic procedures and therapy in order to see clearly the work to be done. In the present study, the lumbar spine is analysed with reference to multidirectional assessment (flexion, extension, rotation). The lumbar spine is a segment with reference to which patients most often report pain. The pain concerns people in almost all ages, and at least once in their life about 75% of any population suffer from pain in this region.[17,18] As a result, the problem is relatively often compared to a civilization disease. The above pain sensations are induced by mechanical overloads, which most often constitute a primary factor contributing to secondary structural changes.

In order to prevent such overloads and treat the pain, it is essential to assess a movement pattern or various movement patterns performed during everyday activities. The concept of Kinetic Control allows one to analyse the movement patterns thoroughly, with the use of the assessment of the movement direction control and muscle balance. The correct movement, described as a movement pattern, is one that is performed effectively and allows controlling and minimising physiological loads at the level of joints and tissues. The movement should be generated maintaining appropriate muscular stability, which will protect the spine and stabilise it during movement, yet at the same time providing mobility (of the right range at the right joints). Thus, it is particularly significant to understand timing, sequence and range of performed movement. In addition, observations concerning the assessment of the musculoskeletal system should be confronted with the assessment of the muscle balance and control of particular movement.

4. Results

4.1. *Control of direction – forward and backward bending*

Bending the trunk forward – is one of the most functional movements performed during the day. Through this movement, apart from the lumbar spine, also the pelvis and hip joint move, thus it is defined with reference to the whole chain as a lumbo-pelvic rhythm. Assessing the above-mentioned rhythm, one must recognise which of the levels initiates the movement, and how much of the movement is seen in a given time and how subsequent spine segments join in the movement. In the correct movement pattern, flexion is initiated by anterior pelvic tilt (flexion at the hip joint), with neutral alignment of the lumbar spine. This movement should be conducted until 25° up to 30°, and then the remaining movement of the pelvis is aligned with the movement of the lumbar spine, until reaching optimal hip flexion approximately 70°–80°. Continuing the analysis of forward bend, after the phase of flexion there comes the phase of return, i.e. extension. Again, one needs to analyse the lumbo-pelvic rhythm, in which the movement is initiated from the pelvis, which is later accompanied by the movement of the lumbar spine.

4.2. *Diagnostic tests according to Kinetic Control concept*

Among tests used to assess the control of flexion, there is a test of knee extension in sitting (Fig. 1). The patient assumes a sitting position and aligns their lumbar spine in the neutral

Fig. 1 – Knee extension in sitting.
***Source*: Adapted Sahrmann.**

Fig. 2 – Knee flexion in prone lying.
***Source*: Adapted Sahrmann.**

position. Their task is to perform extension at the knee joint to the position of −10° (10° to the full extension) simultaneously for both lower extremities, with control of the neutral position of the lumbar spine. A shift in the position of the pelvis and spine towards flexion during the performed test reveals lack of control of the lumbar spine into flexion. Such lack may result from disturbed muscular balance between global stabilisers and mobilisers, which should also undergo further diagnostic procedures.[1,19]

Another test that is performed in order to assess control of extension is a test of knee flexion in prone lying position (Fig. 2). The patient assumes a prone position and aligns their lumbar spine in the neutral position. Their task is to perform flexion at the knee up to 120° simultaneously for both lower extremities, with the lumbar spine position unchanged. If the neutral position is disturbed before the required 120° range, it means that there is no control of the lumbar spine extension. The lack of such control may result from disturbed muscular balance between global stabilisers and mobilisers, which should also undergo further diagnostic procedures.[1,19]

Rotation is related to asymmetric work, thus to control of rotation is possible to apply the two above presented tests in modified forms (Fig. 3). During the tests, the patient has to perform asymmetric work of extension or flexion of one knee joint at a time. The researcher has to observe the activity and notice a rotation error of the lumbar spine and pelvis, which will confirm a possible lack of control of the rotation. It is also necessary to compare the left and the right side.[1,19]

4.3. *Therapy*

A negative result of the above tests reveals lack of movement control in particular directions and constitutes a clinical indication to undertake neuromuscular re-education therapy. One of the proposals in such a therapy consists in applying 20–30 slow repetitions of the presented tests. An exercise, which binds together training control of both flexion and extension of

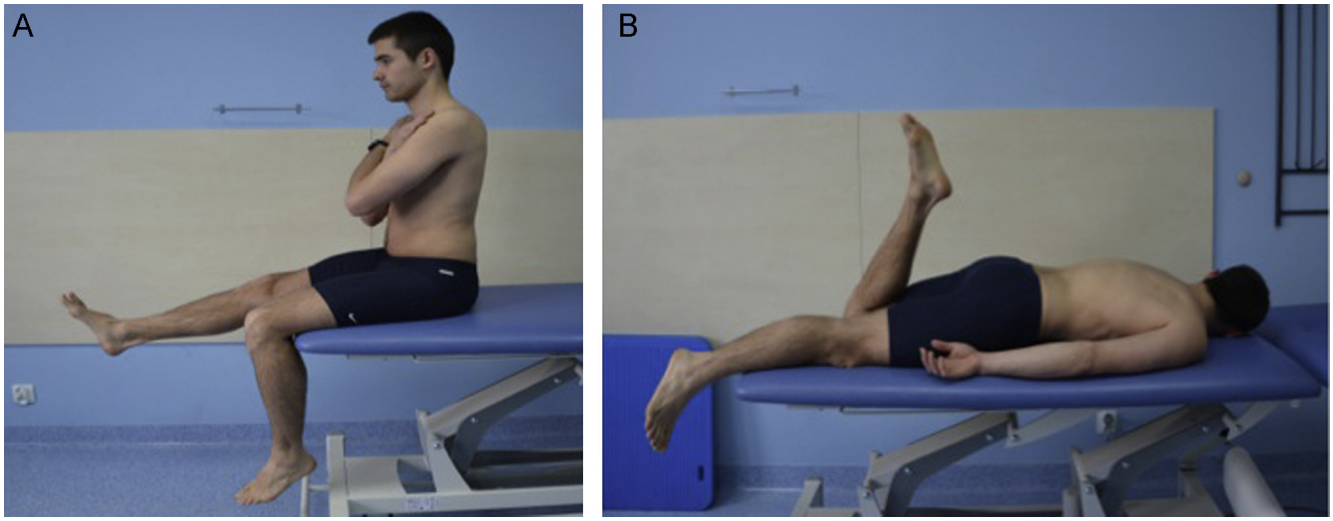

Fig. 3 – Asymmetric knee movement: (A) extension in sitting and (B) flexion in prone lying.[1,19]

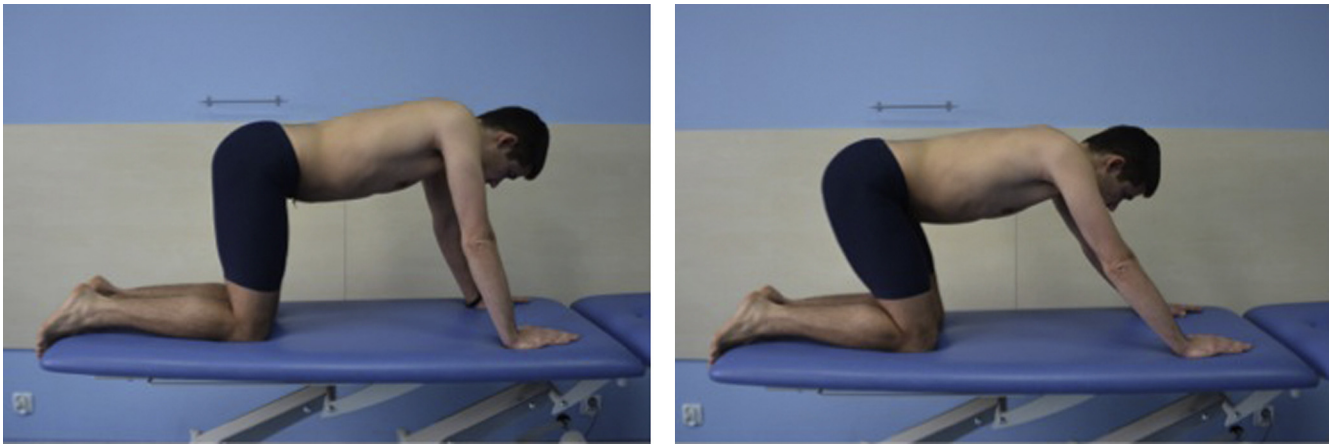

Fig. 4 – Training of flexion and extension in quadruped position.

the lumbar spine, is performed in kneeling with front support. The patient's starts the movement from the position in which hip joints are flexed at 90° and shifts the weight of the body backwards, until flexion at the hip joints is at the level of 120°. The movement has to be performed with the lumbar spine in the neutral position. During the shift backwards, special attention should be paid to the control of flexion in the lumbar spine, while during return extension control should be in focus (Fig. 4). It is recommended to repeat the sequence slowly 20–30 times. The exercise can be modified with the application of regression (e.g. feedback in the form of taping or work within the range of 60°–90° at hip joints) and progression (e.g. work within the range of 60°–150° at hip joints or adding external resistance, or lowering the number of support points).

Obviously, the presented proposals do not amount to a complete therapeutic programme. They only show an example, which is based on the training of movement in three different directions.

5. Discussion

Although people lead increasingly sedentary lives, ''movement'' is still an indispensable element of everyday life. In the diagnostic process, the body posture should be assessed, and incorrectly performed movement patterns should be localised at the level of a movement chain.[1–3,15,19] This can be done with the use of motor tests that assess ''control of the direction of movement.''[1–3] Hamilton and Richardson[20] analysed the ability to perform selective activity of the pelvis during forward bending (in sitting), with the lumbar spine in the neutral position. She compared two groups of people, with and without low back pain (LBP). It appeared that people with the pain were not capable of controlling the alignment of their lumbar spine while performing flexion.[21] Thus, it is a clinical indication for both people with symptoms and those who still have not reported the lumbar spine pain to work in order to regain correct movement timing during such a global movement as trunk flexion.[22]

With control of the movement pattern, one needs to assess the system of global stabilisers. In the case of flexion of the lumbar spine, the multifidus muscle is one of the key structures.[1,20] Functionally, it is divided into the surface portion and deep portion, which ensues from its structure (the presence of tonic and phasic fibres). It is mainly the surface portion of the muscle that is responsible for controlling the direction of movement.[23] It is worth remarking that the pain appears at the level of the lumbar spine inhibits this muscle and even leads to appearance of fat tissue.[24–27]

Gluteus maximus is one of the muscles, which guarantee correct movement of extension in the lumbar spine. Nelson-Wong et al.[28] conducted tests in which he assessed the activity of the gluteus maximus muscles and the erector spinae muscles during return from flexion. Study included both groups of people with LBP and free from symptoms. It appeared that people with LBP show disturbed timing of muscular activation, with erector spinae muscles activated sooner than gluteus maximus muscles. One of the conclusions of this analysis showed that biomechanical changes at the level of the musculoskeletal system are important also in order to prevent LBP in the future.

It needs adding that most often disturbances of movement patterns appear in more than one direction.[1–3,19,29,30] The proposed work towards controlling the direction of movement has to be complemented with specific muscle retraining. Further diagnostic procedures should also include assessment of multi-joint muscles.

6. Conclusions

Information reported from the tests establishes a foundation of rehabilitation programme to regain optimal neuromuscular control. Early identification of the musculoskeletal dysfunction avoids pathologies and pain, minimising the risk of irreversible structural changes. The loss of motor control is related to the LBP, and is a good diagnostic tool. Important is the choice of motor control exercises for a particular direction of motion.

Conflict of interest

None declared.

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