**Acta Salus Vitae, Vol 7, No 2 (2019)**
**ISSN 1805-8787** actasalus@palestra.cz

# DOES AN ARTICULATION OF MOVEMENT PATTERNS EXIST?

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***Abstrakt***
*Presented paper aims to introduce a new view on skeletal muscle function. Clinical experience shows that skeletal muscles located around one joint do not behave uniformly. Some of them play probably major role during movement (locomotion), the others take part dominantly in joint stabilization. Literature overview results in following conclusions: a) it is evident from anatomical textbooks that each skeletal muscle moves his joint around all movement axes available during natural (unconscious) movements, b) biomechanical studies show that each joint has its typical pattern of physiological movement. The pattern consists of characteristic simultaneous combination of movements around individual movement axes. Concurrently flexion and extension variant of the pattern can be distinguished. c) EMG studies show that muscles have different electrical activity during voluntary contraction. On the base of foregoing information, we can hypothetically assume that human body does not use all possible joint movement combinations during natural movements but it prefers only some of them. That is why we can divide the skeletal muscles surrounding a joint into two subgroups – pattern and not pattern muscles. The pattern muscles take part mainly in movement (locomotion). They provide either flexion or extension variant of natural movements. Not pattern muscles work in both variants simultaneously. They include movements from both joint patterns. That is why they play their main role in joint stabilization.*

***Keywords***
*skeletal muscle, locomotion, joint stabilization*

## INTRODUCTION

Skeletal muscles play dominant role in holding of body posture (setting of body segment to one another) and in movement of the body in space (locomotion).

Individual muscles differ functionally from each another and it is possible to classify them according to different criteria. The differences regard structure, metabolism connected with energy production, role in movement and communication, in delicate manipulation, in nourishment and in emotional and sexual behavior.

Anatomical textbooks classify skeletal muscles according to different criteria: function (flexors, extensors, …), length (short and long muscles), number of bellies (biceps, triceps, quadriceps), organization of muscle fibers to tendons (pinnation).

The physiologists take into account energy production for contraction of muscle fibers. There are two fundamental muscle fiber types – white and red. The first ones contract quicker but they are more fatigue able. The second ones contract more slowly but they are able to contract a longer time.

Rehabilitation view comes out from previous one. Each skeletal muscle consists of both muscle fiber types. Final functional property is dependent on ratio of both. The muscles containing greater number of white fibers are named phasic muscles, those including greater number of red fiber are termed postural muscles. The phasic muscles serve predominantly to locomotion, the postural ones to holding of body position. Civilized man uses the postural muscles much more than the phasic ones during sedentary life style. It results in muscle imbalances affected for example spine curvatures.

Our clinical experience shows that skeletal muscles located around one joint do not behave uniformly. Some of them play probably major role during movement (locomotion), the others take part dominantly in joint stabilization. This aspect does not correspond to above mentioned classifications of skeletal muscles. The aim of this study is to find out scientific arguments for development of a new hypothesis dealing with a next, more functional criterion for muscle sorting.

## ANATOMICAL FUNCTION OF SKELETAL MUSCLES

Each skeletal muscle of human body holds a position in space with regard to axial system of his joint. No muscle fuses with an axis. That is why we can postulate such a rule: each skeletal muscle provides simultaneously a movement around all axes in his joint. This is valid for natural (unconscious, involuntary, spontaneous) movement.

Anatomical textbooks describe anatomy of individual skeletal muscles including their function. We would expect, that the books describe movements around all axes present in muscle´s joint. Yes, it is so I most muscles. We introduce some examples.

### A) Two axial joints

- Anterior tibial muscle moves the ankle simultaneously in directions of dorsal flexion and supination (inversion). Peroneus long and short muscles provide in the same joint plantar flexion and pronation (eversion).
- All of carpal muscles move the wrist around both axes. For example, extensor carpi ulnaris muscle provides at the same time dorsal flexion and ulnar duction, flexor carpi ulnaris muscle provides palmar flexion and ulnar duction and so on.
- Biceps femoris muscle flexes the knee joint and rotates is externally.

### B) Three axial joints

- Teres major and latissimus dorsi muscles move the shoulder joint in directions of extension, adduction and internal rotation.
- Iliopsoas muscle provides in the hip joint flexion, adduction and external rotation.

But the textbooks describe function of some skeletal muscles incompletely. They stress obviously only so called main muscle function and description of other movements is missing. But we need to know movements around all axes to interpret correctly muscle function and its role in muscle slings. In these cases we can deduce the missing function according to position of the muscle to remnant axis. Two examples for all:

- Supraspinatus muscle works in three axial glenohumeral joint. The anatomical textbooks describe commonly its movements around two axes only and so shoulder abduction and external rotation. The question arises in this case: what movement does provide the muscle around the third axis? Is it flexion or extension? The muscle lies above the axis and passes from behind to the front. That is why it must provide shoulder flexion.
- Subscapularis muscle moves also the shoulder joint. Similarly to the previous muscle, only movements around two axes are introduced in the textbooks and so adduction internal rotation. The muscle is located below the third axis and goes from behind to forward. Its third movement must be extension.

More complicated situation comes in broad and flat muscles which are anatomically described like one structure.

In reality they consist of more functional units with different functions. We introduce two muscles for example.

- Serratus anterior muscle moves the shoulder blade. His one insertion lies on medial margin of the blade. Opposite muscle end inserts by typical teeth on nine cranial rips. Anatomical textbooks describe obviously only one shoulder blade movement – abduction. But this bone moves around three axes: elevation – depression, abduction – adduction and external – internal rotation of caudal angle (Kendall, F. P., McCreary, E. K., Provance, P. G., 1993). But according to muscle relation to remaining two axes, we can subdivide the muscle into upper and lower functional parts. Both of them provide shoulder blade abduction, but they strongly differ in remaining movements. The upper part provides elevation and internal rotation of the caudal angle, the lower part depression and external rotation of the angle.
- Gluteus maximus muscle repeats during its ontogenetic development the phylogenesis of this muscle (Tichý, M., Grim, M., 1985). In position of the definitive human muscle are located three independent muscles in reptiles (iliofemoralis, sacrofemoralis and caudofemoralis muscles). Later on step by step the three muscles fuse together. The muscle covers the hip joint from dorsal side. According to anatomical textbooks moves the muscle his three axial joint in directions of extension and external rotation. One movement around the third axis is missing. Is it abduction or adduction? Upper part of the gluteus maximus muscle lies above and lower part below the femoral head. It is clear from the muscle position that upper muscle part abducts and lower part adducts the hip joint.

We can conclude this chapter as follows: Each skeletal muscle in human body moves his joint simultaneously around all axes available in the joint. Anatomical textbooks confirm this statement in most muscles. But in some muscles they emphasize only main muscle function and movements around other axes are not described. But we need to know them because of better understanding of muscle function and its role in joint kinematics. Another conclusion regards broad and flat muscles. They have a common anatomical name but they may consist of more functional parts with different movement combinations around all joint axes.

## NATURAL JOINT MOVEMENTS, PHYSIOLOGICAL JOINT PATTERNS

Anatomists classify joints according to different points of view. One of the points is a form of articular surfaces which determines another and functionally most important criterion and so number of movement axes. In this chapter we want to answer very important question: Does the central nervous system use during natural (spontaneous, involuntary) movements all possible movement combinations or does it prefer only some of them? We want to introduce some joint like examples.

### The wrist

The wrist is a compound joint which includes several articulations: radiocarpal, mediocarpal, intercarpal and carpometacarpal. Like a functional unit, the wrist moves around two axes and provides two couples of movements: dorsal – palmar flexion and radial – ulnar duction.

Which of the above mentioned movements are combined in the wrist during natural movements? If we follow movement on the wrist during some daily activities (shoe brush, taking a glass and bringing it to mouth and so on), we can conclude that palmar flexion is combined with ulnar and dorsal flexion with radial duction.

The same movement combinations in the wrist are presented for example in Kabat´s method for the second movement diagonal in upper extremity (Voss, D. E., Ionta, M. J., Myers, B. J., 1985). Also biomechanical studies using 3D motion analysis methods support this opinion (Morimoto, H. et al., 2004, Kaufmann, R. et al.,2005).

**The ankle**

Ankle joint consist anatomically of two parts: talocrural (upper part) and subtalar (lower part) joints. Each part moves around another axis. The upper part of the ankle provides dorsal and plantar flexion, the lower part inversion and eversion.

Both ankle parts work like a one functional unit. And now (similarly to the wrist) one typical question follows: which movement combination around both axes is typical for natural movements?

The answer lies in biomechanical studies of the gait (Lundberg, A. et al. 1989). Stand phase of a step starts with initial contact of lateral heel margin. In this moment is the foot in dorsal flexion and inversion. In the next phase the foot falls down with the foot tip and medial (gross toe) margin towards a bottom in direction of plantar flexion and eversion. Just before heel off the shank moves ventrally (dorsal flexion in ankle joint), the foot toes flex and medial (gross toe) margin elevates (inversion) due to plantar muscles contraction.

As a consequence of this description, we can conclude, that during natural gait the dorsal flexion in talocrural joint combines with inversion in subtalar joint and inversely the plantar flexion goes together with eversion. These movements combination is possible to consider like natural movement combinations in ankle joint.

**Shoulder blade movements**

Shoulder blade is interconnected with trunk only by means of clavicle and its articulations (acromioclavicular and sternoclavicular joints). It means that a major role in shoulder blade fixation and movement play skeletal muscles with one attachment to the blade and second one to the neck and trunk. The muscle structure is described in each anatomical textbook.

Shoulder blade movements are dependent on upper extremity motion. That implies that the muscles interconnecting the blade with neck and trunk play very important role in crossing over of muscle slings (physiological or pathological) from trunk to upper extremity or inversely.

The shoulder blade moves in three axial system (Kenndall, McCreary, Provance 1993). Along vertical axis it moves upwards (elevation) or downwards (depression), along horizontal axis towards the spine (adduction) or towards the flank (abduction) and along ventrodorsal (rotational) axis around which the blade rotates with its lower angle either internally or externally.

In the same manner like in previous joints, we search for natural movement combination of the shoulder blade. From papers by (Kapandji, I. A., 1970, Karduna, A. R., McClure, P. W., Michener, L. A., 2000, Oyama, S., et al., 2010), we can deduce shoulder blade movement from one marginal position (depression + adduction + internal rotation of lower angle) toward an opposite marginal position (elevation + abduction + external rotation of lower angle). The first movement combination is connected with arm flexion, the second one with arm extension.

We can conclude on the base of foregoing information, that each joint has its typical movement pattern which consists of characteristic movement combination simultaneously around all joint axes. The pattern has flexion and extension variants. In clinical praxis, we diagnose so called functional joint blockade exclusively in these directions. It means that the blockade develops only in directions of natural movements.

## PATTERN AND NOT PATTERN MUSCLES

We concluded in previous chapters that each joint of human body uses during natural motion only some of all possible movement combinations around all axes. This statement enables a quite new view on skeletal muscles according to their functions. Some of them provide during their contractions a movement combination which corresponds exactly to a joint pattern. These muscles can be named either flexion or extension "pattern muscles". Remaining muscles work in both patterns. It means that their movement combination consists of individual movements which belong partly to flexion and partly to extension patterns. The muscles can be named "not pattern muscles".

We want now to apply the hypothesis on the same joints we described in previous chapters.

### The wrist

In the previous chapter we derived flexion and extension patterns of the wrist on the base of clinical and biomechanical studies. The flexion pattern involves dorsal flexion + radial duction, the extension one palmar flexion and ulnar duction.

Skeletal muscles belonging functionally to the wrist are named carpal muscles. The following Table 1 introduces their names and functions.

We can now to compare muscle functions with flexion and extension patterns of the wrist. It is evident that flexor carpi ulnaris corresponds to extension pattern and extensores carpi radialis longus et brevis to flexion one. These muscles can be determined as pattern muscles of the wrist. Remaining two muscles belong to not pattern muscles.

### The ankle

In previous text we derived flexion and extension movement patterns of the ankle from scientific information. Flexion pattern includes motion in directions of dorsal flexion + inversion, extension pattern in directions of plantar flexion + eversion. Similarly to previous joint, we will compare now the ankle motion patterns with function of some muscles moving the ankle (see following Table 2).

Comparison of muscle functions in the table with flexion and extension patterns of the ankle leads to the conclusion that tibialis anterior muscle represents flexion pattern muscle and peronei muscles and lateral gastrocnemius represent extension pattern muscles.

### The shoulder blade

We described previously that the shoulder blade moves in three axial system and we deduced flexion (depression + adduction + lateral rotation of lower scapular angle) and extension (elevation + abduction + internal rotation of lower scapular angle) patterns of scapular motion.

Skeletal muscles insert to the trunk on one side and to the shoulder blade on the other. Their names and functions are summarized in following Table 3.

Likewise in foregoing joints we have to sort now the muscles according to their relation to flexion and extension movement patterns of the shoulder blade. We can conclude from this comparison that lower part of trapezius muscle and upper part of serratus anterior muscle belong to pattern muscles.

## HYPOTHETICAL PROPERTIES OF PATTERN AND NOT PATTERN MUSCLES

One question is coming now. What is the difference between pattern and not pattern muscles?

The pattern muscles provide natural movements. That is why they have dominant role in locomotion. Their hypertonus develops a set of signs which are typical for so called functional joint blockade. Pathological chains in locomotive apparatus consist of only just functional joint blockades. That is why the pattern muscles take part in the chaining and form pathological muscle slings. Furthermore, clinical experience shows that the pattern muscles make much more problems during therapeutic process than the others muscles.

Not pattern muscles work in both flexion and extension movement patterns. That is why we predict for them dominant role in joint stabilization. They protect a joint from destabilization and greater excursions.

## CONCLUSION AND DISCUSSION

Conclusions of the paper may be formulated as follows:

1) Each skeletal muscle of human body provides in his joint movements around all axes available in the joint. Concurrently we have to respect the fact that different parts of large and flat muscles can have distinct functions.

This statement is supported by anatomical textbooks describing structure and function of skeletal muscles. But description of a movement is missing in some muscles. We can deduce this movement according to space position of the muscle to individual movement axes.

2) Each joint of human body has his characteristic motion pattern. The pattern has flexion and extension variant. It consists of movement combination simultaneously around all joint axes.

This hypothesis is supported by scientific literature introduced above in the text describing natural joint movements. Next literature data regard anatomical structure of articular surfaces predicting joint motion pattern. We introduce here some examples.

Elbow and forearm are anatomically two independent structures but they work like a one functional unit. There are two movement axes for providing flexion and extension in elbow joint and supination and pronation in proximal and distal radio – ulnar joints. During natural movements elbow extension is combined with forearm pronation (taking a food from table) and elbow flexion with forearm supination (bringing a food to mouth) (Buchanan, T. S., Rovai, G. P., Rymer, W. Z., 1989). This natural motion combination is predicted by a form of articular surfaces in trochlear humero – ulnar joint (Johnson, D., 2008). Movement between trochlea humeri and incissura ulnae is dictated by a leading crista. The crista does not form a ring but a slight spiral. That is why elbow extension is connected with ulnar pronation and elbow flexion with ulnar supination.

Knee joint moves around two joint axes. Two pairs of movements are possible provide in this articulation: flexion + extension and outer + inner rotations. During natural motion is flexion combined with outer and extension with inner rotation (Hirokawa, S. et al., 1992, More, R. C. et al., 1993, Aagaard, P. et al., 2000). Similarly like in previous joint, these natural knee joint patterns are predicted by anatomical structure. Femoral condyles are of different size. Their curvatures do not correspond also. There is why tibia must rotate during flexion and extension movements in the knee.

3) Skeletal muscles around each joint can be subdivided into pattern and not pattern muscles. The pattern muscles provide flexion or extension variant of joint motion pattern.

Hypothetically, they should be more active during movement than not pattern muscles. We argued in previous point that knee joint flexion combines with external rotation and joint extension with internal rotation during natural movements. In this case, the pattern flexion muscles is biceps femoris and pattern extension muscle vastus medialis. It is supported for example by EMG studies on the knee joint (Schüldt et al., 1983). They recorded EMG activity in vastus medialis and lateralis, biceps femoris and semitendinosus/semimemranosus during rising exercise. They discovered that the vastus medialis is more active than vastus lateralis during extension and biceps femoris is more active than semitendinosus/semimembranosus during knee flexion.

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***Table 1: Muscles of the wrist and their function***

| Muscle name | Muscle function |
|---|---|
| flexor carpi radialis | palmar flexion + radial duction |
| **flexor carpi ulnaris** | **palmar flexion + ulnar duction** |
| **extensores carpi radialis longus et brevis** | **dorsal flexion + radial duction** |
| extensor carpi ulnaris | dorsal duction + ulnar duction |

***Table 2: Muscles of the ankle and their function***

| Muscle name | Muscle function |
|---|---|
| **tibialis anterior** | **doral flexion + inversion** |
| tibialis posterior | plantar flexion + inversion |
| **peronei longus et brevis** | **plantar flexion + eversion** |
| gastrocnemius medialis | plantar flexion + inversion |
| **gastrocnemius lateralis** | **plantar flexion + eversion** |

***Table 3: Muscles of the shoulder blade and their function***

| Muscle name | Muscle function |
|---|---|
| levator scapulae | elevation + adduction + internal rotation of lower angle |
| rhomboideus minor | elevation + adduction + external rotation of lower angle |
| rhomboideus major | elevation + adduction + internal rotation of lower angle |
| trapezius – upper part | elevation + adduction + external rotation of lower angle |
| **trapezius – lower part** | **depression + adduction + external rotation of lower angle** |
| **serratus anterior – upper part** | **elevation + abduction + internal rotation of lower angle** |
| serratus anterior – lower part | depression + abduction + external rotation of lower angle |

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