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THE SENSOMOTOR NATURE OF POSTURAL FUNCTIONS. ITS FUNDAMENTAL ROLE IN REHABILITATION OF THE MOTOR SYSTEM

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SUMMARY

Clinical practice has taught us that changes in function affect the motor system as a whole, forming chains. This requires the existence of a centrally controlled programme. The neurophysiological basis of this programme can only be understood on the basis of developmental neurology, from which it is possible to conclude that in the course of early infancy the original reciprocal muscle activity on a spinal level is replaced by a centrally controlled co-activation pattern, essential for erect bipedal posture. This further determines the sensomotor relations between all sections of the organism, which have so far not been adequately explained. They are fundamental for modern diagnostic and therapeutic approaches in motor rehabilitation. The neurophysiological principles dealt with here are also important for neurology, orthopaedics, even for anatomy.

Key words: postural function, sensomotor relations, co-activation patterns, developmental neurology

Introduction

As clinicians we know that every localised lesion causes reflex changes of function: muscular hypertonus or weakness, restricted or increased joint mobility, increased dermographism, retraction of fascia etc. We find such changes not only in the involved segment, but throughout the motor system. We speak of chain reactions and of functional pathology. In therapy we regularly achieve effects in regions far from the site of treatment. Such functional relations are in no way accidental - they are determined by certain laws; contemporary neurophysiology provides no explanation for these sensomotor relations regularly observed in clinical practice.

The spinal cord and brain stem are the highest control mechanism studied by contemporary physiology for specific stimuli (supporting reaction, crossed extension, automatic gait reaction, tonic deep neck reflexes, segmental cuti-motor reflexes, vestibular reflexes etc.) These reflex mechanisms cannot explain the relationship between movement restriction of joints in distant parts of the motor system, or why we find specific chains of trigger points (TrPs), or why we find predictable reflex changes throughout the organism in cases of visceral disease.

As there seems to be no scientific physiological explanation many diagnostic and therapeutic methods in physical therapy and rehabilitation are either empirical or explained in an esoteric manner.

The Central Programme above Brain Stem level

A central genetically preformed programme is the only explanation of motor function and dysfunction above the segmental level. This central programme matures during the stages of postural development.

This programme comprises *postural activity*, i.e. the development of erect bipedal posture; *postural reactivity*, i.e. motor response to changes of position and *primitive reflexivity*, i.e. reflexes characteristic for a specific developmental stage, e.g. the supporting reaction, automatic gait, the suprapubic reflex, the gripping reflex etc.

Spontaneous motor and postural activity and reflexivity, being of one and the same origin, show corresponding development - no single element is isolated in its development, the common purpose being the maintenance of erect bipedal posture.

The following examples illustrate this thesis: we can predict the motor (postural) response of an infant on lifting him from the supine position into a horizontal position suspended on his arm and leg (Collis's horizontal reaction). We can also foretell what his reflexes will be like, i.e. to which developmental stage they will correspond. If for instnace the infant reacts to suspension by flexion of its free upper extremity by abduction and opens his hand (Fig. 1a), which must not be mistaken for Moro's reflex(!), we can infer that the child will be able to lift his head when prone, propping himself up on his forearms; at the same time the thumb will be outside the palm; also anteflexion of the pelvis and flexion of the hips will have lessened as compared with the neonatal stage (Fig. 2, see Fig. 3). We can also foretell that at this stage it will not be possible to elicit the supporting reaction, nor automatic gait, nor the suprapubic reflex and the other neonatal reflexes.

If at that stage the infant supports himself using the free upper extremity with his whole palm with fingers extended,

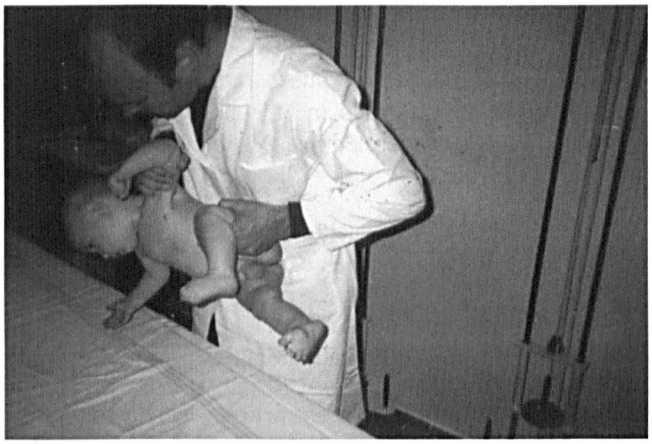

Fig. 1a: Horizontal suspension producing Collis' reaction.

we know that he is also able to grip objects, that he can erect himself prone supporting himself on his palms with fingers abducted, that he can also turn from supine to prone and that we shall not be able to elicit either the gripping or the suprapubic reflex.

It is equally important that the response to a change in position (e.g. Collis's reaction) is in no way accidental, but if repeated under standard conditions, the response will be the same each time, although the infant has never been instructed. It is particularly important that if this reaction is carried out under conditions of a change in afferent signalisation (e.g. if a lower extremity is immobilised) this response will be different in each segment of the motor system (Figure lb). Even then this response will be the same each time.

This is further proof of a centrally controlled programme which must be distinguished from the well known spinal and brain stem reflex responses.

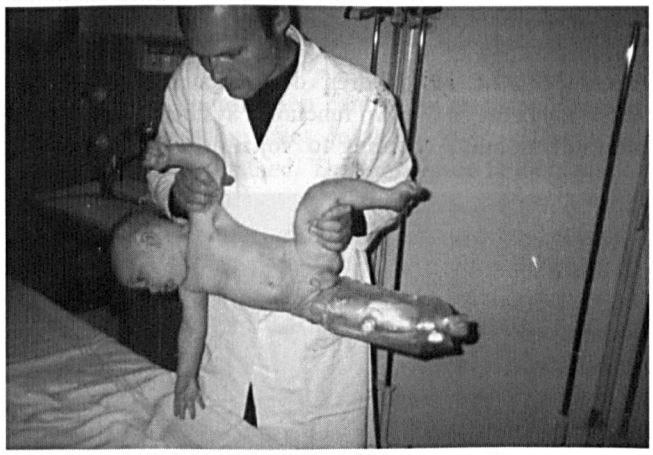

Fig. 1b: Collis' reaction with a passively altered position of one lower extremity: the motor response of each section of the motor system is changed.

THE APPEARANCE OF SYNERGY BETWEEN AGONISTS AND ANTAGONISTS (CO-ACTIVATION) DURING POSTURAL DEVELOPMENT

This synergy develops in the newborn when orientation in space appears, i.e. at the age of 4-6 weeks. At this stage the infant is capable of optic fixation and begins to use his head for orientation, and to aim at targets. In this way motor behaviour patterns (posture) automatically develop, making these functions possible. Motor control is thus established on a higher level. Changes in posture and the active support function develop (Figure 2).

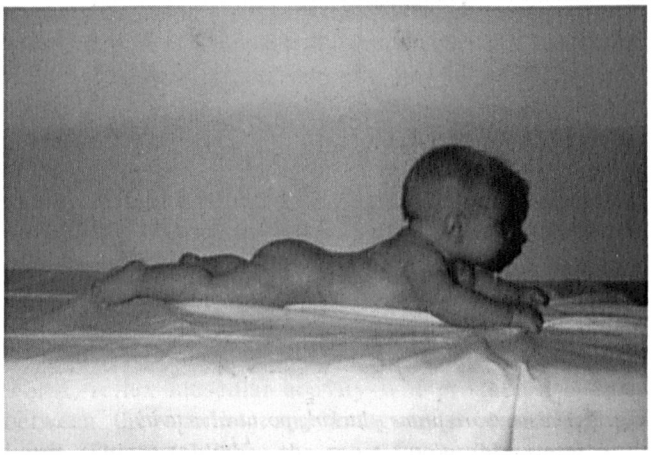

Fig. 2: Co-activation pattern prone at 6 weeks making visual fixation possible.

As the programme develops, concurrent activity of agonists and antagonists is established and reciprocal inhibition no longer ocurs; we speak of muscular co-contraction or co-activation.

In the newborn (Fig. 3) no such programme as yet exists (there is no co-activation of antagonists). At this stage we can only evoke motor programmes (reflexes) at lower levels of the CNS. The reflex response is characterised by the reciprocal reaction of agonists and antagonists. The support reaction stimulates the extensors alone, while automatic gait only affects the extremity flexors on the side of stimulation. Once automatic control of posture and co-activation are established, these antagonistic reflexes are abolished.

The development of co-activation (4th - 6th week) affects not only the head and neck, but the posture of the body as a whole, involving the deep neck flexors, the lower fixators of the scapula, the external rotators of the shoulder joint, the trunk extensors, the supinators of the forearm, the wrist and finger extensors, the abdominal muscles and the muscles of the pelvic diaphragm, the external rotators of the hip joints, the abductors, the pronators and extensors of the feet and toes. All these muscles are activated as a functional unit.

As posture changes from predominantly flexion to extension, the (upper) neck extensors are relaxed as are the upper fixators of the scapula, the internal rotators and

adductors of the shoulder joint, the pronators of the forearm, the finger flexors, the adductors and internal rotators of the hip joint, the knee flexors and the plantar flexors of the foot and toes.

This development results in equilibrium between two groups of muscles, forming a pattern of correlation between the mainly tonic system which predominates in early infancy, and the mainly phasic system determining posture, which comes into play as the the optic system matures.

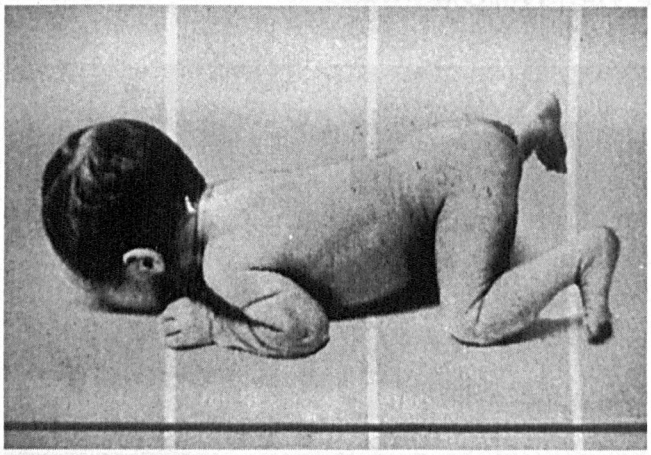

Fig. 3: The newborn prone - lacking postural activity

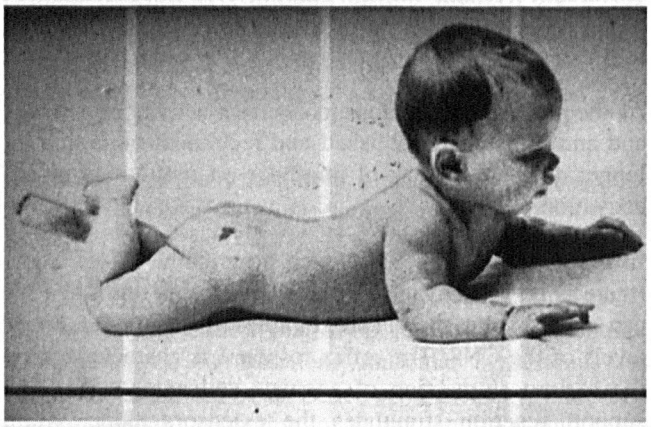

Fig. 4a above *Fig. 4b below*

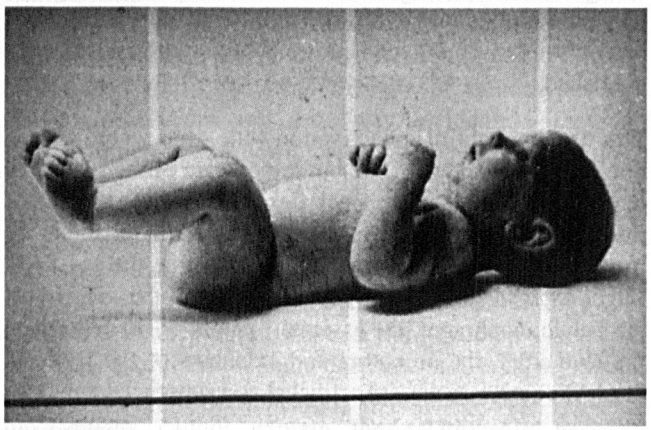

Fig. 4: Fully developed co-activation of flexors and extensors at the end of 3 months (a) prone supported on the elbows and symphysis, (b) supine supporting himself on his trapezius

This co-activity pattern is achieved by the end of the first three months; it can be demonstrated prone, using as supports the elbow and the pubic symphysis, and supine making use of the trapezius and the sacrum (Fig 4a,b). At this stage an exactly defined postural model controlled by the CNS is the rule.

Trunk extension is thus achieved by well balanced co-activation of the entire intersegmental back musculature from the occiput to the sacrum and the trunk flexors. A similar balanced co-activation pattern is also established between the antagonists at the extremities.

As a result of balanced co-contraction of antagonists, the joints of the spinal column and of the extremities are held in a position of optimum weight bearing, i.e. of maximum contact between the joint facets. This can be called functional centration. This pattern is specific only for the erect posture of the human race.

The specific basic postural function determines the shape of the anatomical structures of the human motor system. It is of great interest that this function can be evoked during the neonatal period by Vojta's method of reflex locomotion, although the anatomical structures do not yet correspond to that function. The correlation and interplay of the kinesiological programme and the anatomical structures enables us to understand their structure: the interplay of fascia with muscles, the course of muscle fibres, the close relationship between muscles, joints and connective tissue structures etc. It also explains chain reactions between anatomical structures.

The posture of the trunk and the extremities, i.e. the model of well balanced muscular co-activity, guaranteeing optimum load for joints, is attained at the end of the third month and remains the basic model for the entire future postural development. At each phase of this development we distinguish differences only in respect of different points of support (Figure 5a-c).

About 30% of all children do not attain normal co-activation between the two functional systems by the end of the third month. According to Vojta such children suffer

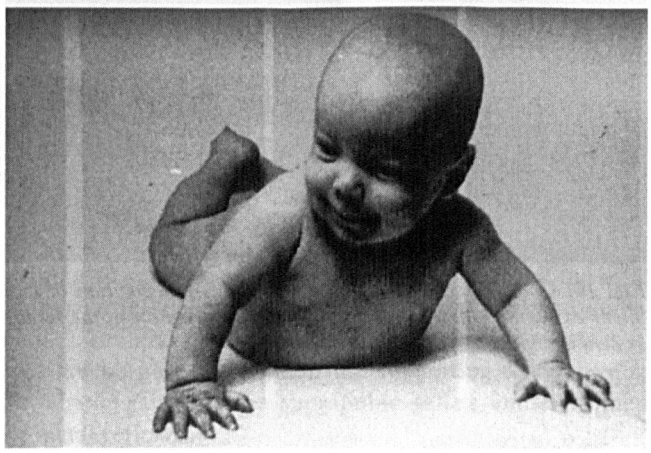

Fig. 5a

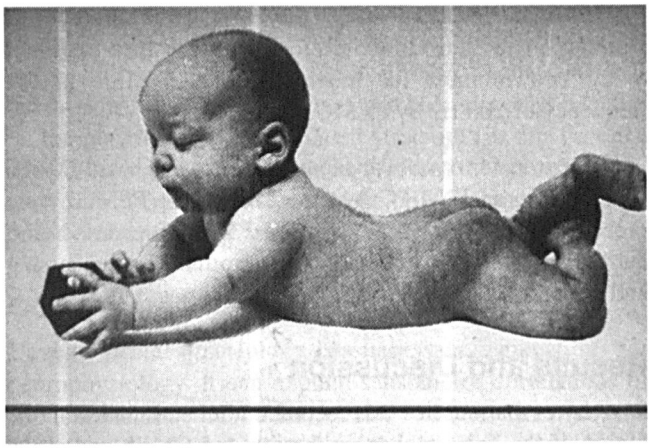

Fig. 5b above *Fig. 5c below*

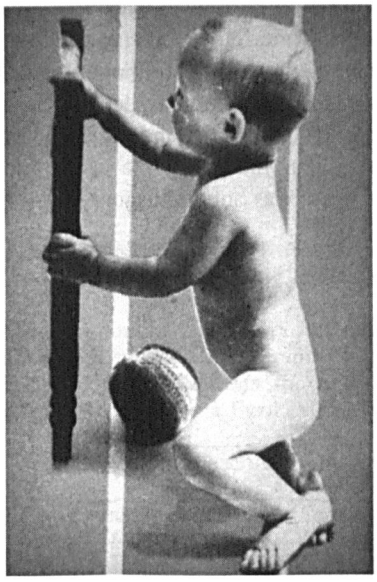

Figure 5a-c: The co-activation pattern reached at 3 months which determines posture, remains unaltered throughout further development: in (a) at 6 months the infant can support himself on his hands; in (b) he can grip a ball with one hand, supporting himself on the other; in (cc) he can reach the upright position at 9 months.

from disturbed coordination control. In these children the tonic system predominates in their co-activation when upright posture is attained. This imbalance is the cause of future faulty posture.

Good posture requires maturity of balanced co-activation of the tonic and phasic systems of muscles. If any disturbance is observed treatment must begin at the initial stage.

THE ROLE OF THE POSTURAL PROGRAMME IN SENSOMOTOR CORRELATIONS

The central programme is characterised by:

- its precedence over the spinal and brain stem level of control;
- it is specific for the human species and cannot be studied in animals;
- it develops in the course of postural ontogenesis as the CNS matures (not as the result of motor learning);
- its purpose is the automatic control of posture.

This postural programme forms a functional diagnostic and therapeutic unit in rehabilitation medicine. It specifies sensomotor correlations between muscles, joints and other systems. It reveals entirely new sensomotor correlations. It will be shown that it leads to a better understanding of functional relationships above the segmental level.

It has become possible to demonstrate these programs and sensomotor correlations by stimulating this basic posture even in the adult. This can be demonstrated by the Vojta technique. The position of any part of the body is exactly determined in relation to the pattern as a whole.

This reaction is provoked by gentle pressure on trigger zones (not painful) in certain initial positions (supine, lying on the side prone). It is exactly predictable and depends on the initial position.

If one part of the motor system (e.g. the cervical spine) is in an initial position in which agonists and antagonists are balanced, i.e. the joints are fully aligned, and if this position is not changed during stimulation, stimulation will produce a fully determined muscular response. The result will be optimum load bearing of all joints. In other words, reflex muscular activity will produce a balance between the agonists and antagonists controlling the joints. This establishes the most favourable static joint function.

If, however, this part of the motor system (the cervical spine) is in a position in which agonists and antagonists are not balanced during stimulation of the same points, e.g. in a position in which the extensors predominate, this imbalance will be evident throughout the entire motor system. The result will be predominance of internal rotation and adduction in the shoulder joints, of the upper fixators of the shoulderblades, of the adductors and internal rotators of the hip joint etc. This produces imbalance of the entire postural pattern. The result is the disturbance of posture known as the upper and lower crossed syndromes

The study

We used polyelectromyography (PEMG) to demonstrate such disturbance of the whole motor program following reflex stimulation.

Muscular activity was studied supine with the upper extremity in an asymmetrical initial position. One upper extremity was in 90 degrees abduction, the other was in adduction parallel with the trunk. The cervical spine was held erect, i.e. in a position of balance between neck flexors and extensors. The head was rotated 30 degrees towards the adducted upper extremity. PEMG was recorded from the lower extremity towards which the head was turned.

A. At 45 degrees abduction and external rotation of the hip joint.
B. At adduction of the hip joint with the extremity across the midline.

Gentle pressure was applied to the linea nuchae lateral to the midline, to the thorax close to the costo-sternal junction of the 5th and 6th rib and the elbow at the medial epicondyle. Reflex motion was resisted after stimulation in each initial position (Fig. 6).

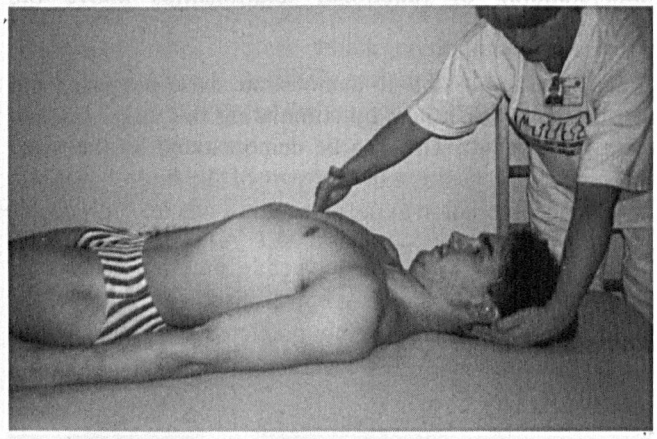

Fig. 6: Reflex stimulation at the left linea nuchae and between the costosternal junctions Th 5 and 6 according to Vojta: note correct positioning of the neck.

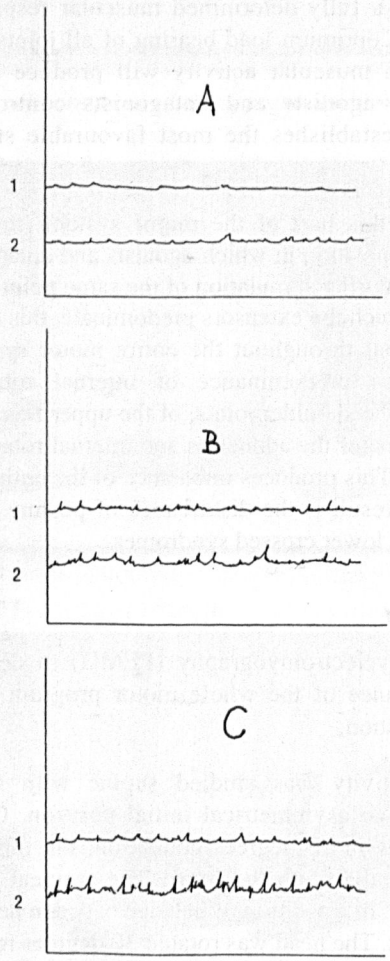

Fig. 7a-c: EMG activity in the gluteus medius (lst channel) and adductor longus (2nd channel) after stimulation at the linea nuchae, the medial epicondyle and between the 5th and 6th rib close to the sternum with the lower extremity in abduction: at the start (A) no activity, after 2 minutes (B) moderate activity more pronounced in the adductors, after 4 minutes (C) further increased activity, mainly in the adductors.

PEMG was recorded after the first two minutes of stimulation for ten seconds; recording was then repeated every two minutes for ten seconds each time at the frequency of 200 Hz by PEMG.

The *Noraxon Myosystem* apparatus with an ADC card DT280 connected to an IBM PC was used for EMG. PEMGs were processed by *Myosoft 2000* (version 1,2). and recorded on a hard disc. The Myosoft system was also used for processing and evaluation of the recordings. A videofilm was made.

Results and Discussion

Activity in the muscles was recorded after stimulation in the region of the linea nuchae, at the 5th and 6th rib and at the medial epicondyle. Activity differed greatly according to the initial position. First - in abduction and external rotation of the lower extremity we found tonic activity in the adductor longus; this increased as stimulation continued (Figure 7a-c). In the gluteus medius only some twitches of individual fibres could be seen. On the other hand, in adduction there was activity in the gluteus medius, while in the adductors i.e. in its antagonists, there was only minimum activity (Fig.8 a-c).

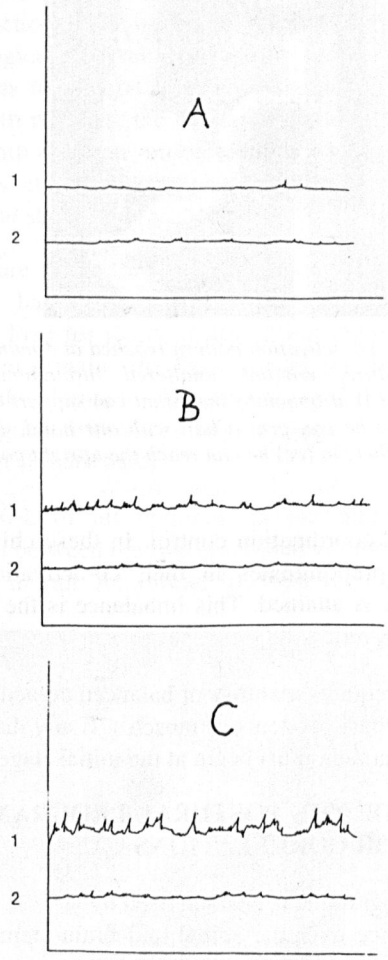

Fig. 8a-c: EMG activity in the gluteus medius (lst channel) and in the adductor longus (2nd channel) after stimulation at the linea nuchae, the medial epicondyle and between the 5th and 6th rib with the lower extremity in adduction: at the start (A) no activity, after 2 minutes moderate activity mainly in the glutei, after 4 minutes even more activity in the glutei (abductors).

The most important point to be made is that after stimulation of exactly the same points (zones) the results differed according to the initial position A (abduction) or B (adduction). It is also important that this response depends on the position of the stimulated structure (in this case the cervical spine) which is situated far from the site of PEMG recording. Stimulation seems to help in attaining a position of maximum stability at the hip joint for good function.

CONCLUSION

Developmental kinesiology has important implications for neurophysiology. It can explain sensomotor correlations of one section of the motor system with the rest of the organism, by central control mechanisms acquired during the first three months of normal infancy. It can thus explain the chain rections in disturbance of function described by several authors. It is particularly important in rehabilitation medicine. It is, however, no less important for other branches of medicine, e.g. neurology, orthopaedic surgery (and medicine), even for anatomy.

REFERENCES

1 Brügger, A. Das sternale Syndrom. Huber, Bern 1971
2 Janda, V. Muscle Function Testing. Butterworth, London 1983
3 Kolář, P. Sensomotorická podstata posturálních funkcí jako základ pro nové prístupy ve fyzioterapii (Sensomotor origin of postural functions as a basis for new approaches in physiotherapy). Rehabilitace a Fyzikální Lékařství 1998; 4: 142 - 147
4 Lewit, K. The functional approach. J. Orthop. Med. 1994; 16: 74-75
5 Lewit, K. Chain reactions in disturbed function of the motor system. J. Manual Med. 1987; 3: 27
6 Vojta, V. Mozkové hybné poruchy v kojeneckém věku. Avicenum, Praha, 1993
7 Vojta, V. Peters, A. Das Vojta Prinzip. Springer, Heidelberg, 1992

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