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ELECTROMYOGRAPHIC STUDY OF HORIZONTAL AND STAIRS WALKING

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Abstract: The electrical activity of the muscles of lower extremities and trunk during horizontal and stairs walking of healthful subjects has been studied. It has been stated that the innervational stereotype of walking exhibits pronounced stability, it is a combination of activities of two main muscular groups, extensors and flexors, where the first group is active mainly during the stance phase of step, and the second one is activated in the swing phase. A hypothesis is stated that the distribution of muscular activity with cycle time under all the kinds of walking is a display of its central innervational program. Apparently this program in a simplest form reflects the operation of the intraspinal generator of locomotive movements. It has been shown the importance of these findings for the development of the method of muscles functional electrostimulation during the walk.

Key words: horizontal and stairs walking, electrical activity of muscles, central innervation program

Introduction

The subject of the present paper is the investigation of the innervational structure of natural human locomotive acts by means of contemporary computer technique. This study allows to correct the known literature data on human walking along the horizontal path and stairs walking [1, 2], to carry out the complete biomechanical and neurophysiological analysis of different kinds of locomotion, and to develop the algorithm of functional electrostimulation of muscles for patients with pathology of locomotory system.

Methods

The subjects in our study were 10 healthful persons in the age range from 20 to 40 years. All the subjects walked at first along the horizontal track with the length of 14 m, and then they walked up- and downstairs. The stairs had 7 steps with metal contact surface and a platform at the top. Each step was 15 cm in the height.

We registered the electrical activity of ten symmetric muscles of lower extremities and trunk: *tibialis anterior, gastrocnemius medialis, vastus lateralis, rectus femoris, semitendinosus, biceps femoris, gluteus medius, gluteus maximus, adductor longus and sacrospinalis*.

The electrical activity of the muscles was measured by means surface bipolar electrodes in the form of brass cups of 1 cm in diameter, the distance between electrodes was 4 cm. The cups were filled by electroconductive paste and placed on a rubber base.

The biological current was amplified by the UBF-4 biopotentials amplifier. After this the current was transformed by means of a special unit to a form of rectified electromyographic signal with the time constant of 10 ms, and then it was entered into an analogic-digital converter. All the measured parameters were processed at the frequency 200 Hz by means of 12-digit analogic-digital converter with the error of 2 digits.

Concurrently with the electromyogram we registered the podogram and the angular displacements. Usually we recorded horizontal walking 10 times, and stairs walking up and down 20 times each. As a result of the study we calculated for each muscle the following performance data: the mean electrical activity of the muscle within the period of double step, the integral of muscle's electrical activity over the double step time and the distribution of the electrical activity within the gait cycle (electromyographic profile of the muscle). All the electromyographic values were presented in a form of graphs and tables.

Results

Electromyographic profile of muscles during horizontal and stairs walking

The comparative data on the electromyographic profile of the muscles of lower extremities and trunk during walking along horizontal track and walking up- and downstairs are presented in this section. It is expedient to examine these data separately for each muscle, with taking into account the specific features of different kinds of walking (Figs. 1-3).

Musculus tibialis anterior

The electrical activity of this muscle during walking along the horizontal track has two maxima within the period of double step. The first maximum is high, up to $170-180\ \mu\text{V}$. It begins at the time instant $t=95\%$ of the previous step cycle, reaches the peak value during first 10% of the cycle, and terminates by $t=15\%$ of the step cycle. The functional purposes of this maximum are the following: lifting the foot before the support, it smooth coming to the support surface, forward turn of the shin with the fixed foot.

The second lower maximum (it does not exceed $50\ \mu\text{V}$) initiates at the time $t=55\%$ and come to its end by $t=80\%$ of the cycle. This maximum contributes to the foot lifting within the first half of the swing phase.

During upstairs walking the first maximum of activity is absent but there is a wide plateau with the intensity at the level of $50-100\ \mu\text{V}$ up to $t=55\%$ of the cycle. Apparently it sustains the slightly inclined position of the shin during the stance phase. On the contrary, the second maximum is sharply increased up to $150\ \mu\text{V}$. It arises at $t=55\%$ of the cycle, reaches the peak value at $t=80\%$, and terminates by the end of step. The purpose of this maximum is a more complex lifting of the foot during its transfer on the next upper step of the stairs.

While downstairs walking the both maxima of activity are lowered, and the first maximum is flattened. It initiates at $t=90\%$ of the previous cycle and finishes by $t=40\%$ of the next cycle. Probably this maximum is favourable for the forward inclination of the shin during the stance phase. The second short maximum between $t=40\%$ and $t=70\%$ of the cycle controls the fast plantar flexion of the foot.

Для рис. 1.

Для рис. 2.

Для рис. 3.

Musculus gastrocnemius

The electrical activity of the muscle during walking along the horizontal track has a maximum between $t = 20\%$ and $t = 60\%$ of the cycle with a peak at $t = 45\%$ of the step cycle. The functions of this activity are the following: regulation of forward motion of the shin (in conditions of negative work up to $t = 50\%$ of the cycle), flexion in the knee joint and plantar flexion in the ankle joint at the end of the stance phase.

While walking upstairs the activity of the muscle is sustained at the level of $50\ \mu\text{V}$ from the beginning of the step. Probably it prevents strong forward inclination of the shin. The maximum of activity is situated between $t = 30\%$ and $t = 70\%$ of the cycle, and the peak value occurs at $t = 50\%$. The functional purpose of the activity is the plantar flexion in the ankle joint. It is favourable to a some measure for the push away of the foot from the lower step of the stairs. Simultaneous flexion in the knee joint is absent because of ongoing contraction of *m. quadriceps femoris*; all this allows to reinforce the vertical component of the support reaction force during the back push phase.

During downstairs walking the electromyogram (EMG)-profile of the muscle is sharply changed. The maximum of activity starts in advance, at $t = 80\%$ of the previous step, and its peak value is reached within the first 10% of the next cycle, when the front section of the foot puts down on the lower step of the stairs. The muscle in this case operates in conditions of negative work, preventing fast back flexion in the ankle joint and creating a certain supportability of the lower extremity.

Musculus vastus lateralis

During walking along the horizontal track the electrical activity of the muscle has one maximum which begins at $t = 85\%$ of the previous step, reaches the peak value of $60 - 70\ \mu\text{V}$ at $t = 10\%$ of the next step and finishes on the whole by $t = 30\%$ of the cycle. The activity of the muscle contributes to extension in the knee joint at the end of the swing phase, prevents the leg bending in the knee joint (in conditions of negative work), and then together with other forces causes the extension in the joint.

During upstairs walking the maximum of activity becomes almost twice as large ($110 - 130\ \mu\text{V}$), its borders are widened from $t = 95\%$ of the previous cycle to $t = 60\%$ of the next cycle. Apparently this powerful wave of activity is the main force factor that gives rise to straightening of the lower extremity during walking upstairs, and the later keeping the leg slightly flexed in the knee joint.

While downstairs walking the EMG-profile of the muscle takes the double top shape: the first maximum of activity has borders from $t = 80\%$ of the previous cycle to $t = 30\%$ of the next cycle, and the second maximum is situated from $t = 30\%$ to $t = 60\%$ of the cycle. The first maximum of activity contributes to keeping the leg with a slightly flexed knee joint (angle up to 20°), and the second maximum prevents bending of the leg during fast flexion in the joint (the muscle work at this time is performed in the negative mode). It attracts the attention that the EMG-profile of this muscle looks like the curve of vertical component R_z of the support reaction force. This likeness is not occasional because it reflects the loading level of the lower extremity during different intervals of the stance phase.

Musculus rectus femoris

The electrical activity of this muscle has two maxima during walking along the horizontal track. The first of them follows the maximum of *m. vastus lateralis*: it originates at the end of the previous step at t = 90% of the cycle and finishes by t = 25% of the next cycle; its peak value is $40\ \mu\text{V}$. The second minor maximum has a projection on the time scale between 55% and 75% of the cycle. The activity of the first maximum prevents the bending of the leg in the knee joint, and the activity of the second maximum contributes to the flexion in the hip joint at the end of the stance phase.

The upstairs walking generates a high maximum of muscular activity with a peak value of $80-90$ μV at $t=10-15\%$ of the previous step. Further at $t=20\%$ the EMG-curve has a point of inflection, and descends with a slighter slope until $t=60\%$ of the cycle. Apparently the highest part of the maximum is connected with straightening of the leg in the knee joint down the angle 10° – 12° (similar to *m. vastus lateralis*). We can notice that the work of other muscles, e.g. hip joint extensors of the ipsilateral leg, and the back push-off of the contralateral extremity may also contribute to the leg straightening in a certain measure The second small maximum at the end of the stance phase contributes to flexion in the hip joint.

During downstairs walking the EMG-profile of *m. rectus femoris* follows the activity pattern of *m. vastus lateralis*. It contains two maxima, the first of them contributes to straightening of the lower extremity being slightly flexed in knee and hip joints, and the second maximum prevents its bending during fast flexion under the load. In this case the EMG-profile of the muscle also looks like the curve of vertical component R_z of the support reaction force.

Musculus semitendinosus

During walking along the horizontal path the electrical activity of the muscle forms a high maximum which extends from $t=85\%$ of the previous cycle to $t=40\%$ of the next cycle. The peak value of this maximum falls at $t=90-92\%$ of the previous cycle. The functional purposes of the activity of this muscle consist in retardation of the shin extension at the end of the swing phase, creation of a small angle of flexion at the beginning of the step, and extension of hip joint in the first two thirds of the stance phase.

During upstairs walking this muscle generates three maxima of activity: the first at $t=0-30\%$, the second at $t=40-75\%$, and the third at $t=75-100\%$ of the cycle. The role of the first maximum reduces to extension in the hip joint, when the foot is situated on the next upper step of the stairs under the load. The second maximum of activity contributes to flexion in the knee joint, as the back push-off created by m. gastrocnemius is not efficient enough for execution of this task. The third maximum favours to retardation of the extension in the joint, and as a result of this the lower extremity is placed on the next step of the stairs with a lesser angle in the knee joint.

While walking downstairs the activity of m. semitendinosus is decreased. A well-defined maximum of activity is revealed only during the swing phase ($t=65-100\%$ of the cycle). Probably it is intended for retardation of the fast extension in the knee joint during the swing phase.

Musculus biceps femoris

During walking along the horizontal track EMG-profile of this muscle nearly checks with the activity pattern of *m. semitendinosus*. The difference is only in lesser electrical activity of this muscle.

During upstairs walking the first maximum of this muscle is less pronounced but the second and the third maximum are remained. This muscle has the same function as *m. semitendinosus*.

The electrical activity during downstairs walking within the stance phase generates a plateau, since $t=65\%$ this plateau is changed by a small maximum which is intended for retardation of shin extension.

Musculus gluteus medius

During walking along the horizontal path the EMG-profile of this muscle is characterized by a high maximum from the beginning of the cycle to $t=20\%$, then it is followed by a small plateau at $t=20-45\%$ of the cycle. The activity of the muscle is intended for the retardation of frontal displacements of the pelvis in the direction of the carried extremity, and for ensuring the media-lateral stability.

During upstairs walking this function is not only preserved but somewhat exaggerated. The first maximum becomes higher, and the plateau is extended nearly to the end of the stance phase ($t = 60\%$).

While walking downstairs *m. gluteus medius*, like the heads of *m. quadriceps femoris*, creates two maxima within the stance phase ($t = 90 - 30\%$ and $t = 30 - 55\%$). They serve for ensuring the media-lateral stability, as the decreasing of the activity between these maxima corresponds to minimum of vertical component R_z of the support reaction force.

Musculus gluteus maximus

The electrical activity of this muscle during walking along the horizontal track generates a small maximum extended from $t = 90\%$ of the previous cycle by $t = 25\%$ of the next cycle. The activity of this muscle serves for extension in the hip joint at the beginning of the step.

During the upstairs walking the activity of the muscle increases, and the maximum is prolonged to $t = 0 - 55\%$ of the cycle. This activity contributes to leg straightening in the hip joint during the stance phase.

During downstairs walking the activity decreases, and the EMG-profile looks like the horizontal walking one.

Musculus adductor longus

During horizontal walking the EMG-profile of this muscle exhibits two small maxima of activity, $t = 85 - 20\%$ of the cycle and $t = 50 - 70\%$ of the cycle. The main purpose of the muscle consists in prevention of pelvic rotation in the direction of supporting extremity, when it is abducted in the hip joint.

During upstairs walking the growth and the time interval of activity maxima are sharply increased. Apparently it is concerned with the necessity of increased stability during the rotational motion of the pelvis.

While downstairs walking the EMG-profile of the muscle looks like the pattern of its activity during horizontal walking.

Musculus sacrospinalis

The EMG-profile of this muscle has two maxima of activity at the beginning and at the end of the stance phase, $t = 85 - 15\%$ of the cycle and $t = 45 - 65\%$ of the cycle. The contraction of the muscle at the end of the stance phase counteracts the inclination of the spinal column in the direction of the carried leg and on.

The same activity maxima there are during upstairs walking, but they equate in the height. Moreover, the second maximum shifts to the right ($t = 50 - 70\%$).

While downstairs walking the activities of the both maxima are decreased but their locations on the time scale are the same.

It can be supposed that the activity variations of *m. sacrospinalis* during stairs walking are closely connected with trunk's inclinations with respect to sagittal plane. During lifting upstairs the trunk is inclined on, and during descent downstairs it has a small back inclination.

The quantitative variations of electrical activity of muscles during horizontal and stairs walking

The data on the magnitudes of the electrical activity of different muscles of lower extremities and the trunk during horizontal and stairs walking are presented in Tables 1 and 2. There are considered two parameters, the mean amplitude within the step duration (measured in μV) and the total integral over the step period (measured in $\mu\text{V} \cdot \text{sec}$). The first parameter is equivalent to muscle's power, and the second one is equivalent to its work.

Для таблицы 1

Для таблицы 2

It can be seen from the tables that during walking along the horizontal track the average value of mean amplitudes of all analyzed muscles of lower extremities is equal to $23.0\ \mu\text{V}$ (100%). During walking upstairs this value is $34.5\ \mu\text{V}$ (150%), and while downstairs walking it is $24.3\ \mu\text{V}$ (105%).

The average value of the total integral of all muscles of lower extremity is equal to $25.5\ \mu\text{V}\cdot\text{sec}$ (100%) during walking along the horizontal track. This value is equal to $50.0\ \mu\text{V}\cdot\text{sec}$ (170%) during upstairs walking and $29.0\ \mu\text{V}\cdot\text{sec}$ (113%) during downstairs walking.

Thus, the obvious outcome of these calculations is that during upstairs walking the power and the work of the muscles are increased, and during downstairs walking these parameters also exceed (but in a significantly less degree) the similar characteristics of horizontal walking.

It should be noted that during upstairs walking it is observed the most sharply activity increases of the following muscles: *vastus lateralis* (190% for mean amplitude and 222% for total integral)*, *rectus femoris* (190% and 221%), and *adductor longus* (180% and 197%). The activity of the rest muscles increases in a least degree, e.g. the activity of the shank muscles does not exceed 130-140% for mean amplitude and 160-170% for total integral. This all testifies that during upstairs walking the predominant is the work of the femoral muscles.

During downstairs walking the both parameters of electrical activity of muscles come nearer to the muscular activity during walking along horizontal path. Nevertheless, it is observed an activity increase of *m. vastus lateralis* (170% for mean amplitude and 180% for total integral), and *m. rectus femoris* (192% and 206%, respectively).

At the same time the shank muscles have approximately the same activities as during horizontal walking, and such muscles as *semitendinosus*, *biceps femoris*, *gluteus maximus* and *sacrospinalis* are characterized by the lowered level of electrical activity.

The explanation of this phenomenon is the following: during upstairs walking a person has to work against the load (the weight of own body) but during walking downstairs this external force, on the contrary, contributes to the locomotive act.

Discussion

The biomechanical aspect

The following questions can be discussed in more detail:

- What is the basic organization of the investigated locomotive acts? What their features are common, and which of them are specific?
- How much is stable the structure of each act?
- What biomechanical conditions determine either kind of locomotion?

The findings of this paper permit to answer a number of similar questions.

Each investigated locomotor act is biomechanically advantageous as it is intended on the execution of strictly determined motional tasks.

At the same time, the execution of these tasks is somewhat stereotyped since a construction of movements from two phases with different physical substance: the stance phase and the swing phase lies in its basis. The first of them ensures the stability during walking and forms the forces that are necessary for the movement of the human body in the space, and the second phase implements only the transfer of the lower extremity. During the stance phase the activity of the muscles extensors is mainly mobilized, and in the swing phase the muscles flexors are active. Thus, the locomotive synergy in its simplest form is composed of two parts - the extension and the flexion.

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*The average activity values of the right and the left symmetric muscles are considered.

Therewith it appears that the structure of each locomotive act is very stable.

Different biomechanical factors are involved in this comparatively simple scheme of the main muscular forces of the human body. These factors after N.A. Bernstein [3] are included in the construction of any locomotive act: inertial forces dependent on the motion rate, weight, air resistance and other forces. These forces determine the distinguishing features of different locomotive acts.

For example, the horizontal walking widely employs the vibratory characteristics of lower extremities and resonance phenomena connected with them. It contributes to concentration of muscular activity during the specific phases of the locomotion cycle [4].

While the upstairs walking the possibility of the employment of resonance phenomena is sharply reduced due to limitation of the step length and rate of motion. What is more, the walking upstairs being connected with the moving against the body weight is a slower and on the whole an involving strength process. It anticipates the increase and prolongation of the activity maxima of muscles extensors, first of all the muscles of proximal articulations of the lower extremities.

On the contrary, the downstairs motion being connected with the downward displacement of the body weight reduces the muscular load but at the same time results in the necessity of the compensatory muscular efforts.

Therefore, as our findings and the data known from the literature show, the most economical is the walking along the horizontal path, see [1, 2].

At the same time, if we divert attention from different levels of electrical activity, we can see that the EMG-profiles of many muscles during different kinds of walking are extremely similar. The deviations from the customary activity pattern are observed only in comparatively small number of the cases in forms of origin, disappearance or shift of its maxima. Such transformation of activity pattern is usual for shank muscles during stairs walking.

All this points to the generality of the central innervational program that is varied during different kinds of locomotion under the influence of motional tasks of a specific biomechanical situation.

The neurophysiological aspect

In accordance with modern ideas [4-6] in the basis of the central innervational program, despite the multilevel nature of locomotive act control, lies the activity of intraspinal generator of walking movements. It is a system of interneurones and motoneurones of muscles antagonists with reciprocal brake connections.

On this basis, we can expect the reciprocal character of the organization of the work of muscles antagonists during walking. Such a form of muscular interaction really exists but there is a number of exclusions.

The alternating activity is observed in the work of the shank muscles (*m. tibialis anterior* and *m. gastrocnemius*) during horizontal walking, and in the work of extensors and flexors during upstairs and downstairs walking.

At the same time there are the cases of collaboration of the muscles-antagonists. They may be presented in two categories. In one of them we can say about the coincident activity of *m. quadriceps femoris*, *m. semitendinosus* and *m. biceps femoris* at the beginning of the stance phase while horizontal walking. Many authors interpret this electromyographical fact as an example of violation of the reciprocity principle. But really it is not true as the both muscular groups in this step phase are the extensors of knee and hip joints.

Only at the swing step phase *m. semitendinosus* and *m. biceps femoris* are the real shank flexors. Hence, we can judge the belonging of the biarticular muscles to either antagonistic group only with reference to the phase of the locomotor act. The neurophysiological substratum of this phenomenon consists in the possibility of the biarticular muscles to receive the innervational commands either from the flexion semicenter of the generator of locomotions or from the extension one [5].

The other real cause of the violation of the reciprocity principle may be in a particular behavior of muscles flexors, as a lesser rigidity of their central innervational program allows the appearance of the activity of these muscles in any phase of the step cycle [4].

The analysis of muscular EMG profiles during different kinds of locomotion also has to take into account the influences of the proprioreceptive reflexes on the central innervational program. These influences may display in two forms: as a maintenance of the program itself and as its adaptation to rapidly changing biomechanical situation.

The first form is implemented mainly in the condition of positive work of the muscles connected with their shortening. To smooth out the negative influence of this factor*, the system of co-activation of alpha- and gamma-motoneurones is energized. The main role in the reflex activation of alpha-motoneurones probably is played by the responses of the muscular spindles controlled by the static gamma-motoneurones. The reflexes influenced by the muscular shortening arise during all kinds of locomotion, but they are the most distinct while upstairs walking.

On the contrary, during horizontal and downstairs walking, when the instant response on the change of the rate of motion or the load is required, it is observed the second form of the proprioreceptive reflexes that hypothetically may be connected with the work of muscular spindles controlled by the dynamic gamma-motoneurones. The exhibitions of these reflexes are the following: the concentration of electrical activity of the muscles within the cycle duration influenced by resonance phenomena, the fragmentation of the activity maxima owing to sharp load decrease during downstairs walking, and some other phenomena.

The noted effects that are intended for adaptation of the central innervational program of walking to the real biomechanical conditions, probably give rise to a more advantageous execution of the locomotive act.

The practical consequences of the study

The presented data are not only of theoretical but also of practical importance. The investigations of muscular EMG-profiles in different kinds of walking allow to develop a judicious program of functional muscular electrical stimulation for patients with pathologic state of their locomotory system.

This program is based on the idea that the phases of artificial excitation and contraction of the muscles have to be in adequate correspondence with the phases of their natural excitation and contraction [7].

The following reasons attach great significance to the given thesis.

- The phasic electrical stimulation maintains the biomechanical expediency of the motion correction as it does not violate the natural performance of the locomotive act but only corrects those of its elements which turned out to be disturbed due to the functional deficit of individual muscles.
- That kind of electrical stimulation creates the possibility of immediate effect on the locomotory centres as in the phases of muscular activation these centres become free of brake influences and become perceptive («become open») for the afferent signals that accompany the motions and the electrical stimulation [5].
- The similar electrical stimulation allows to maintain the smoothness of the resulting movement due to superimposition of the synchronous contraction of the motor units induced by the electrical stimulus on their natural asynchronous activity.

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* During the contraction of the muscle connected with its shortening a pause arises in discharges of muscular spindles, if their activation from the gamma-motor system is absent.

Another fundamental thesis followed from the given study is concerned with the purposeful selection of the corrected movements and the stimulated muscles in different kinds of locomotion.

In according with our ideas and findings [7], the correction of extension motions of lower extremities and trunk during the stance phase of step is a paramount task of the functional electrical stimulation, and the next task is the correction of the flexion motions during the swing step phase.

Indeed, during the horizontal and upstairs walking the locomotory function is implemented on the whole due to the work of the muscles extensors of the lower extremities. Therefore, the muscles implementing the extension in the hip and knee joints may be the subjects of electrical stimulation, namely *m. gluteus medius*, *m. gluteus maximus*, *m. adductor magnus*, proximal portions of *m. semitendinosus* and *m. biceps femoris*, and the short and straight heads of *m. quadriceps femoris* in the first half or two thirds of the stance phase.

During downstairs walking, in addition to this muscular group the following muscles may be exposed to electrical stimulation at the beginning of the stance phase: *m. gastrocnemius* and *m. soleus*, these muscles maintain the rigid plantar flexion during the support on the lower step of the stairs.

If it is necessary, e.g. in the cases of drooped foot or weak muscles flexors of shin and femur, the electrical simulation of the mentioned muscles has to be combined with the artificial contraction of *m. tibialis anterior*, distal portions of *m. semitendinosus*, *m. biceps femoris*, and other flexors at the end of the stance phase and at the first half of the swing step phase. In order to achieve the necessary correctional effect in different kinds of the walking, the intensity of electrical stimulation of the muscle has to be complied with the principle of sufficiency.

Conclusions

1. The horizontal and stairs walking is characterised by the stable innervational stereotype that makes possible the advantageous performance of the motions which are peculiar to the given kind of locomotion.
2. The innervational stereotype of the walking is added on the whole from activities of two main muscular groups, extensors and flexors. The first group is activated predominantly in the stance phase, and the second one - in the swing phase of the step. In the investigated kinds of the walking both the alternate work of muscles antagonists and their cooperative work are observed.
3. The functioning of the muscles extensors maintains mainly the stability of the body during walking and its movement in the space, and the operation of muscles flexors ensures the transfer of the lower extremity and its correction.
4. The operation of the muscles during upstairs walking is mainly in the nature of involving strength but during downstairs walking its nature is mainly correctional. The most economical kind of walking is the walking along a horizontal path, and the least economical is the upstairs walking, the downstairs walking occupies an intermediate place.
5. The distribution of the electrical activity of muscles within the step cycle under all the kinds of walking is a display of its central innervational program that apparently in the simplest form reflects the operation of the intraspinal generator of walking movements.
6. The functional purpose of the proprioreceptive reflexes consists in the maintenance and correction of the central innervational program in accordance with the biomechanical conditions of walking.
7. The findings of the given study may be used for the justification of the selection of the motions under correction and for the development of the algorithm of time amplitude program of the functional electrical stimulation of the muscles during horizontal and stairs walking.

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ЭЛЕКТРОМИОГРАФИЧЕСКОЕ ИССЛЕДОВАНИЕ ХОДЬБЫ ПО ГОРИЗОНТАЛЬНОЙ ПОВЕРХНОСТИ И ПО ЛЕСТНИЦЕ

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Исследована электрическая активность мышц нижних конечностей и туловища при ходьбе здоровых испытуемых по горизонтальной поверхности и по лестнице. Установлено, что иннервационный стереотип ходьбы характеризуется значительной устойчивостью и складывается из деятельности двух главных мышечных групп – разгибателей и сгибателей, из которых первые активируются преимущественно в опорную фазу, а вторые – в переносную фазу. Высказана гипотеза, что распределение активности мышц в течение цикла при всех видах ходьбы является проявлением ее центральной иннервационной программы, которая в элементарном виде, по-видимому, отражает работу интраспинального генератора локомоторных движений. Показано значение полученных данных для разработки метода функциональной электростимуляции мышц при ходьбе. Библ. 7.

Ключевые слова: ходьба, лестница, биомеханические параметры

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