METHOD FOR GAIT AIDING AND ANALYSIS

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Abstract: Normal gait is defined as a precisely controlled and coordinated movement of lower limbs and the rest of the body. Walking is basic way of transportation so it is so important to analyse it and if abnormal diagnose it properly. Gait aiding is one of the methods of rehabilitation of the patient. The paper presents both gait analysis and aiding methods, next presents proposition of a new gait aiding method.

Introduction

Research on gait analysis, the basic and natural way of human movement, has been conducted for a long time. Gait is described as an alternating lower limb movement with the contraction of flexor muscles of one limb and extensors of the other, controlled by the spinal cord.

The complex structure and relations between nerve and muscular systems are the cause of many problems.. The gait stereotype may be changed depending on various factors such as the patient's age, weakening of muscle force or pain. The age of the patient causes degeneration changes, disturbances in the coordination of balance and movement, because of which movement characteristics change steadily in order to improve walking efficiency. Pain also has influence on the gait pattern because the patient adapts the gait pattern to minimize pain during movement. However, when the pain goes away, the gait pattern remains.

Every abnormality in gait sequence results in larger energetic consumption which leads to the overloading of the cardiac and respiratory systems. Therefore the process of classification of the walking pattern has key meaning for the length of life. While judging the degree and type of disability, gait is analyzed against the model of normal function. Deviations from the normal pattern define the functional error.

These errors include all segments from toes to trunk and are applicable to all types of pathology.

The walking cycle (stride), described as successive motion phases, is divided into two basic periods: stance and swing, which are further divided depending on their functional tasks into eight phases. Each of these phases has a functional objective which contributes to the accomplishment of three basic tasks. These are Weight Acceptance (WA), Single Limb Support (SLS) and Limb Advancement (LA)[1,2,4]

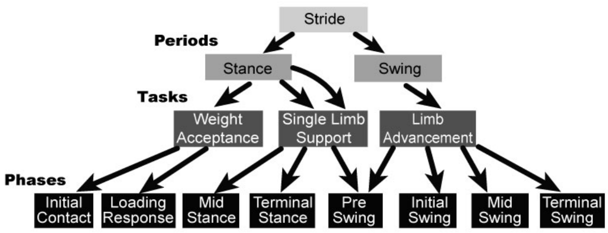

Fig.1 Division of gait phases

Methods of gait analysis

Already having the gait systematic, methods of gait analysis should be described in order to determine whether a patient's movement is correct or how much it deviates from normal gait. There are various methods of gait analyzing, but the most popular and complex are:

- motion analysis
- electromyography
- ground reaction force.

Motion analysis

We are accustomed to observing human motion and we treat it as something natural and simple. We can also determine different types of walk (eg. military, soft, stamping, etc.), but measuring gait is not so obvious and easy. Motion can be measured by 2 different means: electrogoniometers which are attached to limb joints and measure joint flexion.

Fig.2 Electrogoniometer – example of type and fixation

or by a set of cameras recording the patient's movement. Having a record of the patient's walk we can analyse the picture image by image. Identifying anatomic points or markers on the body makes it

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possible to determine the movement of particular limb segments[4]. Systems which do not use markers allow post recording analysis of a patient's gait, which is usually done manually (e.g. Sybar sytem). In some technical solutions the manual defining of anatomical points is aided by picture recognition software. Such a solution allows to assign virtual markers to body segments so it enables measuring limb flexion only in 2D, and afterwards synchronising the video recording with electromyography and ground reaction force plate.
There are other systems which provide more data of a patient's movement. Recording the position of markers attached to limbs gives full (three dimensional) data of the body position during the gait cycle and provides instant visualisation of kinematics and kinetics on a 3D virtual model.(Fig3b).

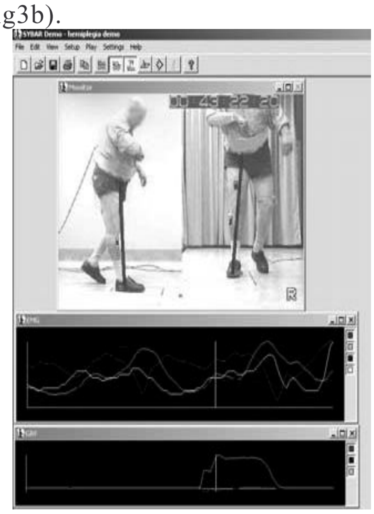

Fig.3a 2D analysis without markers

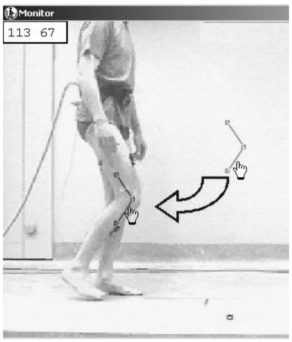

Fig. 3b virtual model created by marker based system

Ground reaction force

As body weight drops onto and moves across the supporting foot, vertical, horizontal and rotatory forces, which can be measured with appropriate instrumentation, are generated on the floor. Such devices are dynamographic plates containing a set of tensometric bridges able to measure component forces in three dimensions, calculating the point of ground contact and angular momentum in three axis. These ground reaction forces are equal in intensity and opposite in direction to those being experienced by the weight-bearing limb. Basing on this information the stress imposed on the joints and the necessary muscle control can be identified. A single vector which sums vertical, sagittal and coronal forces represents changes of the ground reaction force during the gait cycle. (Fig. 4)

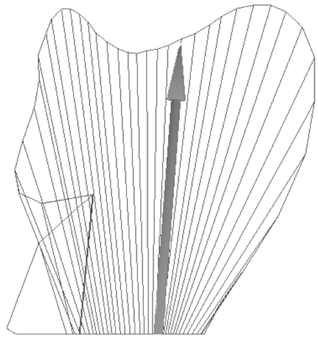

Fig. 4 The ground reaction vector force during the stride cycle

The value of the vector is scaled in the percentage of total body weight in order to be easily comparable.

Electromyography

Electrical signals which accompany the chemical stimulation of muscle fibers travel through the muscles and adjacent soft tissues. With appropriate instrumentation, these myoelectrical signals can be recorded and analyzed to determine the timing and relative intensity of the muscular effort.[1].

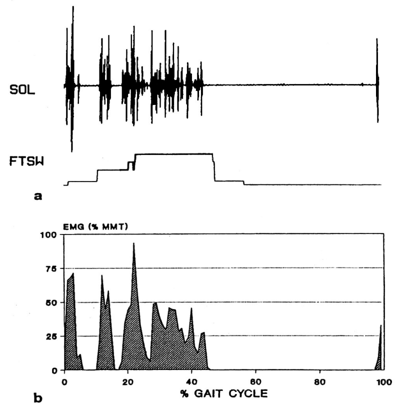

Fig. 5 Comparison of a) Raw EMG b) quantificated EMG

The results have to be filtered and scaled in order to make them usable for clinical use. Data is acquired at a sampling rate of 500 up to 1000Hz, which does not allow for the detection of the whole muscular activity of the limbs, but it is sufficient for gait analysis. The aim of acquiring the muscle stimulation pattern is the correlation with the gait cycle to determine whether the muscles are activated at the appropriate moment.

Gait aiding

As the disability of independent movement is a severe limitation of living functions, the gait aiding of the disabled should be as important a part of rehabilitation

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as the active creation of the gait pattern. All, especially passive, methods of activating motor functions of people differ depending on the rehabilitation centre and are practically unordered. The clinical environment lacks a gait aiding method for disabled people, especially children, because this group especially requires the application of gait pattern.

Gait aiding devices

There have been many gait aiding devices designed and constructed. They can be classified according to the complexity of build. The first device is a useful solution to be applied while the movement system of the patient is fairly impaired, and it is just a support and does not actively influence the development of the patient's gait.

Fig. 6 Device supporting impaired people

More advanced devices are trainers, which motivate and force the patient to develop gait abilities. Such solutions are designed for older people who have passed a stroke or other traumas which impaired the mobility of the patient. Those devices have the ability to measure parameters of gait (velocity, step frequency etc.) and show the expected values so the patient can see what should be practised.

Fig.7 Gait trainer

The most advanced rehabilitation devices used in gait training are fully automated and computerised systems which permanently observe and analyse the patient's movement and use it as feedback to mechanically help the patient make proper movements similar to the gait standard. The supporting force is calculated to relieve the patient when it is really needed. The patient is also suspended in a harness to support the weight of the body which makes training possible for impaired people.

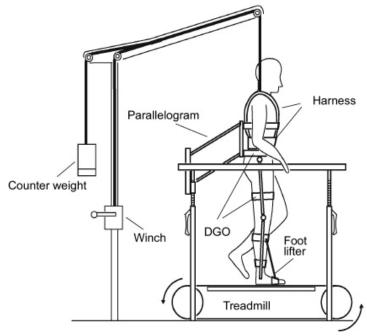

Fig.8 The system of active gait aiding

However all those devices are supposed to help patients in the struggle to move independently, their technical advancement is different and group of patients is different. The simpler solutions are designed for children and the more sophisticated for adults.

Proposition of the gait aiding method

This method assumes the possibility of conducting exercises suitable for the patient's physical abilities, which have been determined by the methods described earlier. While performing exercises there is a possibility of gait analysis so if the progress is ascertained, parameters of exercise may be changed or the character of the exercise modified in order to adjust it to the motion abilities of the patient.[3]
A different approach to the methods of gait aiding and developing the ability of walking is needed because of the varied origins of disabilities of movement. – beginning with a basic rehabilitation device forcing proper gait kinematics and finishing with a system teaching the patient overall gait sequence, monitoring progress and making gait pattern similar to normal gait sequence.

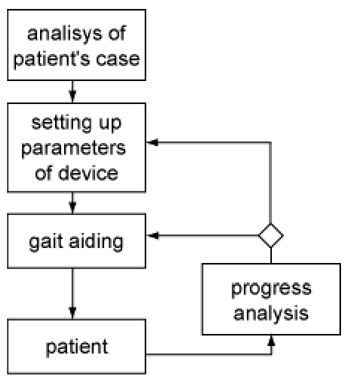

Fig. 9 diagram of functional scheme

The above block diagram (Fig. 9) shows the method of functioning and feedback loop of the gait aiding and supporting system. One of the elements of this method (visible in the diagram) is the gait aiding device, the

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settings of which depend on the type of impairment and its advancement. The analysis of the impairment is determined by the use of neural networks.

Conclusions

Designing and constructing such a gait aiding system for children seems to be complicated. The reason of such an opinion is the great variety of development of patients with cerebral palsy. A person of 8 may reach the level of physical and mental development of a 5-year-old child. This phenomenon creates two problems to overcome. The first problem is the range of device settings, because if they are too big it makes the construction too complicated for the technical staff to operate the device. The second problem is the result of mental deficiency what makes patients afraid of many strange looking devices, so using of such a device might have limited appliance if few patients were not scared enough to use such a device. Another problem is considerable spasticity of a large population of children with cerebral palsy. Spasticity appears in adult patients but symptoms are notably weaker, so in this group such exercises are more efficient.

As a result of the foregoing problems only a progress analysis module can be developed. Such a module may be useful as an independent diagnostic tool which helps clinician to analyse the patient's problem. This element may become a basis which can later be developed into a gait training device if constructional problems are overcome.

References

[1] Perry J.”Gait Analysis. Normal and Pathological Function”, Slack Incorporated, 1992
[2] Collective work. W. Marciniaka and A. Szulc: ”Wiktor Dega orthopedic and rehabilitation. Wyd. 1, PZWL, Warszawa, 2003
[3] Jasińska-Choromańska D., Kabziński B.:”Methods for analyzing human motion functions”, Elektronika, Nr 8-9, SIGMA, Warszawa, 2004
[4] Levitt S. „Rehabilitation In cerebral palsy and movement impairment”, PZWL Warszawa 2000

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