GAIT DIAGNOSTICS DEVICES FOR PEOPLE WITH IMPLANTS

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Abstract: Walking is one of the outstanding characteristics of movement, it is used to achieve the optimal position to perform activity. That is the reason why helping the patients who are the people after different injuries get back to normal movement activity as it was before. This paper presents methods of diagnostic such cases.

Introduction

The standard gait is perceived as precisely controlled activities, based on the periodically coordinated, recurrent leg and trunk (torso) movements, which provide the relocation of the human body from one place to another with the minimal waste of energy. [1,3] Knowing of the gait's model is important for people with implants and other lends of illness the gait's apparatus

Model gait cycles

The granted point from which the diagnosis can be started is the comparison of the propriety of very gait mechanism. Such mechanism presents the gait cycle. [2]

Figure 1: The first double support phase (0 – 15% of the whole gait cycle) [2]

Figure 2: The first single support phase (16 – 40% of the whole gait cycle) [2]

Figure 3: The first single support phase during the foot break off (41 – 50% of the whole gait cycle) [2]

Figure 4: The Second double support phase of the moments asecuration et the moment to transfer body(51 – 60% of the whole gait cycle) [2]

Figure 5: The Second double support phase of the moments to detach from subsoil finger (61 - 75% of the whole gait cycle) [2]

Figure 6: Phase to transfer (76 – 100% of the whole gait cycle) [2]

In case of patients with implants standard gait can be one of phase before implanting. Patient who report to doctor gait problem should have been given thorough basic examination and it helps to describe patient's individual standard gait. Then patient should taken set of examination like getting up/sitting down and walking

(gait phases). This is the best way to gather the larger amount of parameters that can describe patient's original gait. For patients with implants its important to achieve fitness at least the same as before implanting.

Measuring systems and experiments

The main problem for people with long limbs and hips implant are get up and sit down.

Figure 7: The Picture presenting examining to stand – up / sit - down
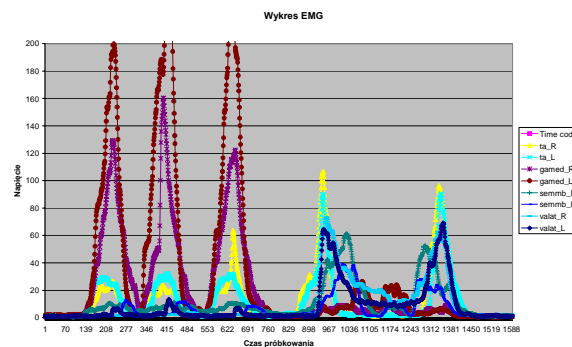
Graph 1: Electromyography EMG – Measurement of muscles electrical activity during stand-up/sit-down.

During the examination we can describe some of the parameter concerning the muscles activity (EMG graph). Above examination is completed by analysis cycle gait. It's similar that patient is taking an examination and there are gathering next gait parameters.

Figure 8: Measurement gait parameter

The gait diagnosis should contain the elements as those included in the gait analysis. The whole diagnostics process should consist of the mathematics, clinic, quantity and subject analysis. The final diagnosis should contain the static, kinetic, kinematic and dynamic research, the measurement of the scope of the joints movements and the measurements, descriptions and evaluations of the features which characterize the human gait.
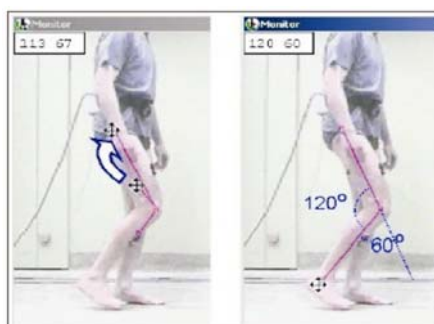

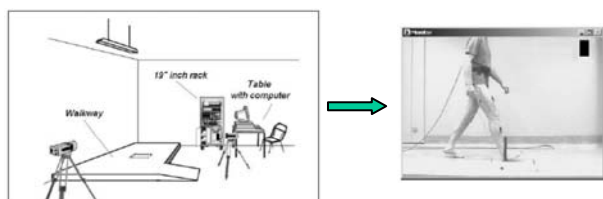Figure 9: Kinematics analysis – measurement angle

Figure 10: Kinematics analysis – observation of vision of the cameras the VHS
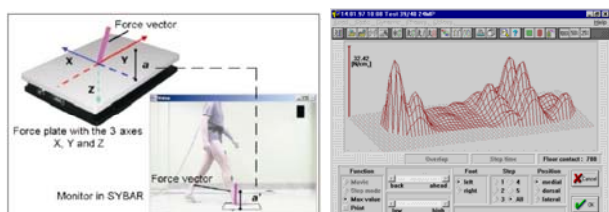

Figure 11: Dynamics analysis – Measurement of reaction force to foot – Ground reaction force vector
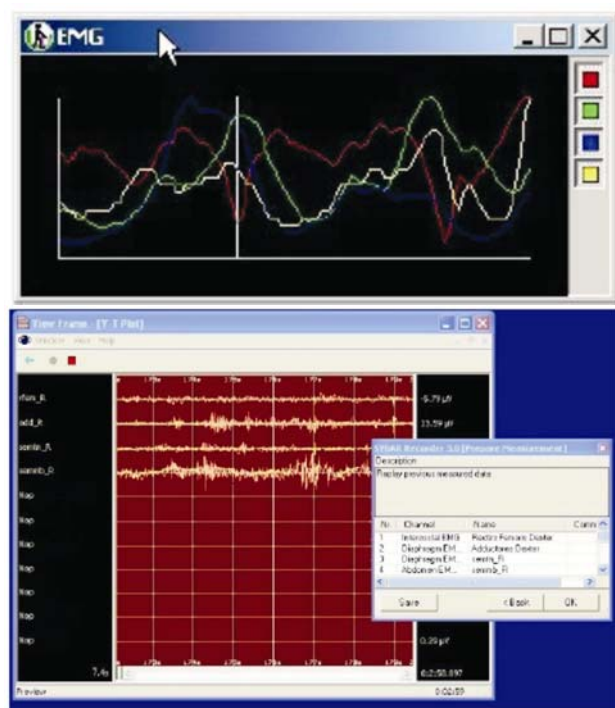

Figure 12: Electromyography EMG – Measurement of muscles electrical activity

By now the construction of such device that would fulfill all the functions at the same time. However there are devices available on the market which in cooperation with other tools give the possibility of the gait diagnosis.

The example of the gait diagnosis can be presented on the basis of CZD in Zalesie. That hospital uses the quantity and object diagnostic tools to analyse the gait.
It is also as all the other well known methods the compilation of the standard clinic and static tests.
It allows to understand the basic mechanisms and strategies of the movement steering, plan the treatment, plan and estimate the results of the surgery treatment,

estimate the quality of the implants, estimate the functional condition of the patient after implanting joints, run the functional diagnostic, observe the treatment progress, distinguish the incorrect movement patterns resulting from the neuropathology.
The classification of the incorrect movement patterns according to the functional disorder allows to the better suiting of the treatment methods to the individual needs of the patient. The basis of the pathological gait pattern can be the deformations, cramp, weakness of the muscle force, incorrect neurosteering or pain.
Even the smallest changes of the gait pattern can cause the increase of the energetic waste and appearing as the secondary disorder.
The laboratory is one of the few places in Poland where this examination is run in the clinic surround. It has the VINCON 460 movement analysis system on its service with 6 cameras, Kistler platform to measure the reaction of the ground forces and dynamic electromyography system and video.
The diagnostics process includes:
- The ground forces reaction during the gait (the average data from the three cycles for each leg) in three directions
- Dynamic electromyography research : EMG signals are registered from the 5 muscles for each leg, all together 10 signals – the possibility to widen to 16 signals).
According to the needs of the patient the signals are registered from different parts of the muscles.

Figure 13: The visualization picture of the gait analysis run in the CZD in Zalesie for system VICOM 460.

- The kinematic parameters measures (concerning the movement)
- The time gait parameters measures: % share of the support phase in the gait cycle, velocity, step frequency, step length

Before starting the measurement the 15 markers folded with a special reflection stick are being located on the patient's body in the precise anatomic points.
The movement of those markers in measurement space is registered by 6 special cameras located in the laboratory. The cameras collect the data in the 60Hz frequency.
The cameras reflect the marker picture in the computer, where the picture is registered and after the examination further processed.

Before the measurement the surface electrodes are being located on the muscles of the patient, so the muscle activity is registered.

The electromyography signals, the ground force reactions during the gait from the dynamographic platforms and the video picture from the two cameras located in the face and parallel surfaces are registered together with the camera picture recording the marker movement.

After data registration during the patient's gait there is processing and calculation phase. The 6 properly registered gaits of the patient and one static cycle are analysed. In case of the patients, who move not easily the number of gaits is lower.

The result is forwarded in a form of a report with diagrams, tables and description.

If it is the next examination the results are compared with the last one (before treatment to the situation after treatment etc..).

Another place, where the gait can be analyzed is Clinic Hospital in Zagorze. The quantity and object analysis system is used here as well as in CZD in Zalesie. The lab is also a place where the clinic surround examinations are being made.

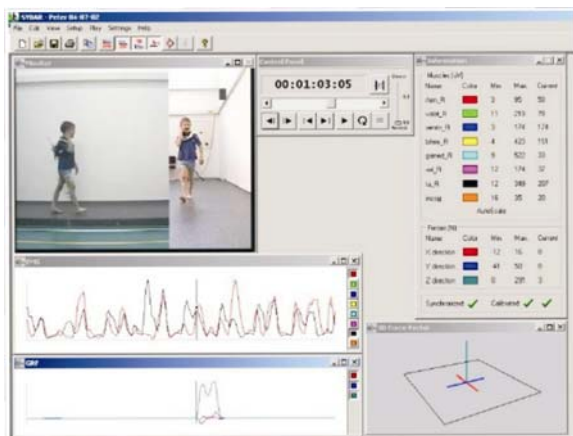It has the Sybar gait analysis system with two VHS cameras, which cooperates with Kistler platform.

Figure 14: The visualization picture of the gait analysis run in the Clinic Hospital in Zagorze –SYBAR 2.0.

Conclusions

In the medical literature there are many gait patterns, practically adequate to the concrete health and rehabilitation problems.

All the human gait diagnostics tools available on the market, have usually the appliance in the medicine, rarely in sports and work together with the experienced observer. Even the smallest deviations from the correct gait pattern are relatively easy to notice by the observer who doesn't have an access to the specialist equipment. That's why the analysis of the gait is mostly based on the observation where in the first phase all the disorders are caught and verified. It is unfortunately a very subjective method and it is very easy to make a mistake while using it.

Human gait diagnostics for patients with the pathologies does not considerably differ from the analysis of the healthy people. There are however the certain stereotypes which describe the values of the particular gait parameters and point out the pathology with a huge probability. The problem of the patients with implants is much more complicated. It is connected with the fact the patient with an implant is a person who learns how to walk again from the very beginning.

In the psyche of the healthy person the information about how he should walk is already saved very deeply that is why the gait is for him a certainty. The gait diagnostics of such people is also a bit complicated. During the analysis and diagnostics the ability of the gait should be matched with the comparable group.

Examining of the patients with implants does not differ from the research made on the healthy patients or even the patients with different kinds of pathologies. The problem in most cases of the patients with implants the previous gait pattern, is that characterized the patient before implanting, hasn't been known.

At the patients with implants during the research and later on during the analyzing of the results there are still ambiguities. Discovering the certain disorders can be caused by the previous pathology, or can also be the reason of the incorrect implant placing or its incorrect work.

In most cases the patients who have an implant surgery are the people who have been suffering from osteoporosis and there is no original correct gait pattern to reference.

The big percentage of the patients are the people after different accidents and injuries, who were not forced to make the analysis of their gait before. After implanting the patient must be rehabilitated while is being taught how to get up, sit and walk again from the very beginning and in some cases even how to run or lay down. However the gait pattern of such patient after making the rehabilitation exercises will always differ from the gait pattern of the healthy people. It is all about the remaining the basic rules included in the gait definition, where it is perceived as fully controlled activity based on the cyclic coordinated, repeatable leg and trunk movements aiming to move the human body from one place to another with a parallel minimal waste of energy. The research to solve that problem are in progress.

References

[1] NAŁĘCZ M. and others, (2004): *Biocybernetics end Biomedical Engineering* , PAN 2004 Warsaw
[2] MARCINIAK W., SZULC A., (2003): Wiktor Dega - Orthopaedic and Rehabiltation. PZWL 2003 Warsaw
[3] PERRY J., (1992):'Gait Analysis Normal and Pathological Function', Slack Incorporated, 1992