1. Introduction

Whole body vibration (WBV) represents a concept that was applied in several studies to confirm benefits for astronauts, athletes, and wellness of healthy population [1 - 3]. Positive results were obtained also in clinical studies in patients with various diseases [4 - 7]. WBV has been also studied for its dangerous effects on humans, especially when exposed as occupational vibration at high amplitudes and specific frequencies [8 - 10].

Recent clinical works suggest that low amplitude and low frequency of mechanical stimulation of the human body is a safe and effective way to exercise musculoskeletal structures [11].

The studies realized during past decade indicate that WBV may increase muscle strength, neuromuscular function, bone mass and mineral density [12], can be useful in improving physical capacity, cardiorespiratory functions, hormonal production, proprioception, and balance [13 - 14]. Despite of WBV positive effects presented in almost all related research studies, the authors interpret their results with caution. Also, the underlying mechanisms by which WBV enhance neuromuscular performance vary between studies and are still unclear. Inconsistency in presented results is caused by various training protocols and heterogeneity in study designs.

Because of both the positive and the negative effects of WBV on human body and its systems, it is important to consider all loading parameters that may affect WBV benefits. These parameters include type of vibration, frequency, amplitude, direction and exposure time, but also the position and activity of the subject on the WBV platform. The effect of vibration may be also tested using various modelling techniques [15 - 19].

The aim of this study was to investigate whether the single WBV session has any positive effects on gait kinematics in children patients. This was based on assumption that the WBV may stimulate muscle activation and that application of WBV will result in improvement of human gait quality.

2. Material and methods

A group of five children patients (age 4.10 ± 1.75 years, 1 male and 4 females) with hemiparesis or paraparesis of lower extremities were included in this pilot study. No of the patients had prior experience in WBV training. All patients and their parents or legal representatives were informed about the WBV training, tests to be realized and possible risks and benefits of the research. Prior to participation they gave written informed consent approved together with the study design by the local Ethics Committee.

All participants attended a familiarization session before the study was realized. No other physical treatment or intervention was realized at least 24 hour before WBV session. The anthropometric measures were also taken and registered in patients' experimental
interval followed after this WBV exposure. Then, the patient’s gait was captured and analysed again.

Gait assessment was performed using our marker-free motion analysis system MAFRAN. Here, the patient’s gait in sagittal plane is captured using any commercial video camera. Then, the raw record is used in the system to reconstruct motion trajectories of human body anatomical landmarks, i.e. the trajectories of all lower extremity joints and adjacent segments. These trajectories are consequently used to calculate other kinematical parameters for detailed description of patient’s gait. Here analysed parameters include positions, velocities and accelerations of individual joints, hip flexion/extension, knee flexion/extension, and ankle plantar/dorsal flexion angles, gait cycle length, gait cycle time, gait cycle velocity, cadence (cycles per minute), stance phase and swing phase of the gait cycle.

All the parameters were analysed individually within the subject and then within the group of here included patients. The kinematical characteristics of the patients were evaluated as differences between right and left side. The hypothesis was based on assumption that these differences should be smaller after WBV training comparing values obtained before WBV training. Otherwise, the WBV will probably have no immediate benefits for gait kinematics. Statistical methods included descriptive statistics and Student’s paired t-test and were used to ascertain specific and significant differences. The significance level was set to P > 0.05.

3. Results

All children patients accepted here realized WBV sessions very well. No one reported any pain or expressed any problems during WBV exposure. A first analysis was performed with anatomical joint angles of lower extremities in sagittal plane. Individually, no of the patients had the same curves of all tree
The second analysis was performed in spatio-temporal parameters. Here, the symmetry of all characteristics was examined and summarized. The mean differences between right and left side and standard deviations of these parameters are listed in Table 1.

None of here analysed parameters had significantly either positive or negative changes. Nevertheless, some of the parameters had positive and another negative tendency. The positive trends were shown in decreasing differences between right and left side in gait cycle length (2.276 ± 9.837), velocity (0.008 ± 0.121) and cadence (0.416 ± 3.565). Gait cycle time remained almost unchanged (0.000 ± 0.057). Negative trends were registered in gait cycle phases (stance: -1.200 ± 3.626, swing -1.188 ± 3.630).

4. Conclusions

The effect of single WBV training unit was tested in the group of children patients with hemiparesis or paraparesis in lower extremities. The results of this pilot study proved that WBV influences kinematics of human gait. Significant improvements were also confirmed in some of the here analysed parameters. On the other hand, changes in anatomical joint angles and in spatio-temporal characteristics, even if not significant had both the positive and the negative trends. To confirm the long-term effect the individually planned training should be designed. First of all, this training should respect limitations given by patient’s disease. Then, the amplitude, frequency, duration and repetition of WBV during training unit will be adopted to the particular patient. The usage of WBV in patients’ therapy, especially in patients with neurological disorders, has to be managed by physicians to avoid serious injuries, physical harms and/or other health related damages.

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|                | Pre           | Post          | Delta pre/post |
|----------------|---------------|---------------|----------------|
| GC length (cm) | 8.560 ± 8.362 | 6.284 ± 4.595 | 2.276 ± 9.837  |
| GC time (s)    | 0.088 ± 0.072 | 0.088 ± 0.018 | 0.000 ± 0.057  |
| GC velocity (m/s) | 0.112 ± 0.084 | 0.104 ± 0.043 | 0.008 ± 0.121  |
| Cadence (GC/min) | 7.258 ± 5.147 | 6.842 ± 2.945 | 0.416 ± 3.565  |
| Stance phase (%) | 2.784 ± 0.756 | 3.984 ± 2.983 | -1.200 ± 3.626 |
| Swing phase (%) | 2.784 ± 0.756 | 3.972 ± 2.990 | -1.188 ± 3.630 |
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