Original Article

Effect of physiotherapy and hippotherapy on kinematics of lower limbs during walking in patients with chronic low back pain: A pilot study

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Abstract:

Low back pain (LBP) is a painful disease which results in limitations on normal daily physical activities related to self-care, social contact and communication. Physiotherapy combined with spa treatments and hippotherapy could be a suitable treatment method recommended in patients with LBP. The purpose of the study was to determine the effect of standard physiotherapy with and without hippotherapy on gait kinematic parameters in patients with chronic LBP. A total of 23 patients suffering from LBP with a damage located between L4 and S1 segments were enrolled in the study. Thirteen of them (the experimental group) underwent in addition to standard physiotherapy also hippotherapy. Physiotherapy intervention and hippotherapy units were performed at the Darkov Spa, Czech Republic. The kinematic gait parameters were obtained by the Vicon MX system. The intensity of the pain was determined using the visual analogue pain scale (VAS). After the intervention, we found statistically significant increase in the range of motion the knee joint in the sagittal plane ($P < 0.05$) as well as the flexion in the hip joint ($P < 0.05$) in the experimental group. Similar trends were observed in the control group. Only two significant differences ($P < 0.05$) between lower extremities with and without pain propagation were detected for the experimental group while for the control group the number of differences increased after the intervention. VAS pain score decreased in both groups but significantly ($P < 0.01$) only in the experimental group. Particular physiotherapy protocol had an observable effect on the gait kinematics in the patients with chronic LBP. A significant effect of hippotherapy on the symmetry of gait and VAS pain score was found.

Key words: low back pain, degenerative spinal disorders, hippotherapy, horse, gait analysis, kinematics

Introduction

Painful disease of the lower spine (low back pain, LBP) falls in lifestyle diseases and is one of the most common causes of disability at productive age (Froud et al., 2014). Among others it results in changes in afferent inputs and associated muscle weakness (sensorimotor failures) that are reflected not only in postural changes but also worsen the dynamics of gait. Given the multifactorial causes of LBP, it is important to diagnose precisely underlying pathology and based on it to select evidence-based treatment interventions for each patient (Förster et al., 2013). However, there is still no consensus on how to tailor the best treatment for the patient suffering from a particular type of LBP (Rutten et al., 2014). Physiotherapists who have knowledge of the movement of the horse and its effect on a rider may use also hippotherapy to address impairments, functional limitations, and disabilities in patients with neuromusculoskeletal dysfunction (American Hippotherapy Association, 1996). This neurofacilitation method employs the natural mechanics of the horse's walk and three-dimensional motion pulses (90-110 motion pulses per minute) thereby created (Taufkirchen, 2000; Wheeler, 2003). The rhythmically oscillating back of a horse mainly stimulates rider's postural reflex mechanisms resulting in improvement of balance and coordination (Engel, 2003; Rothaupt, Laser, & Ziegler, 1998; Taufkirchen, 2000). The aim of this pilot study was to determine the effect of standard physiotherapy with and without hippotherapy on gait kinematic parameters in patients with chronic LBP.

Material & methods

Participants

A total of 23 patients with chronic low back pain participated in this study. The experimental group comprised 13 subjects (9 women, 4 men; average age 42.6 ± 13.12 years, height 1.72 ± 0.07 m, weight 72.1 ± 9.69 kg) who underwent hippotherapy sessions three times a week (duration of 15-20 minutes each) under the

guidance of a licensed physiotherapist in addition to standard physiotherapy. A control group consisted of 10 subjects (4 women, 6 men; average age 48.4 ± 12.74 years, height 1.73 ± 0.10 m, weight 82.5 ± 15.63 kg) who underwent the same physiotherapy intervention as the experimental group (individual kinesiotherapy, electrotherapy, exercises in a swimming-pool, re-education of walking using an electric rehabilitation walkway, education of movement stereotypes according to back school and iodine-bromine baths with wraps) but without hippotherapy units (Table 1). Therapy and all measurements were performed at the Darkov Spa, Czech Republic. All procedures were conducted in accordance with the declaration of Helsinki and approved by the Ethics Committee of Faculty of Physical Culture, Palacký University Olomouc, Czech Republic, all participants signed informed consent before participating.

Table 1. Characteristics of patients with LBP enrolled in the study

Variables/Patients		With (n=13)	Without (n=10)
Pain radiating to extremities	Left lower limb	7	6
	Right lower limb	4	3
	Without radiation	2	1
Level of main damage	L4/5	5	6
	L5/S1	7	3
	Multi-level	1	1
Surgery yes*		11	9

* = state after neurosurgical procedure (extirpation of disc herniation, eventually combined with decompression and stabilization).

Instrumentation

To obtain kinematic gait parameters, we used the Vicon MX system (ViconMotion Systems, Oxford Metrics Group, London, UK) with seven infrared cameras (200 Hz). All records were processed using Vicon Nexus 1.0 (ViconMotion Systems, Oxford Metrics Group, London, UK); selected gait cycles of all records were processed using Polygon Authoring Tool 3.5 programme (ViconMotion Systems, Oxford Metrics Group, London, UK).

Clinical examinations and gait measurements

The intensity of the pain was determined using the visual analogue pain scale (VAS). Patients marked on the line the point that represented their perception of pain at the beginning and end of the stay. Feelings without pain corresponded to zero value on the scale.

This was followed by kinesiology examination and measurement of basic anthropometric parameters (body height and weight, leg length, ankle and knee width, and the distance between the acromion and the shoulder joint centre), which were used to calculate the centre of the joints. Reflective markers were attached on the subjects' bodies at selected placements according to the Plug In Gait model. Before recorded measurements the patients tried walking barefoot so that they walk at a self-selected speed during the measurements. After this training, each patient completed five recorded trials to walk a distance of about 9 m.

The angular parameters and their changes in the ankle, knee, hip and pelvis during the gait cycle was measured to assess differences between the baseline and after intervention values.

Statistical processing

Given that the data was not normally distributed (Kolmogorov-Smirnov test), we compared the differences between the baseline and after intervention measurement and also between the limb with and without pain using Wilcoxon paired test (STATISTICA version 10, StatSoft, Inc., Tulsa, OK, USA). Level of significance was set at 0.05. The effect size was assessed using Cohen's *d* (Cohen, 1988).

Results

Comparison of pain score in both groups before and after the treatment

The average VAS score in the group with hippotherapy decreased from 4.11 to 2.84 ($P < 0.01$). The difference in the control group (from 5.12 to 4.65) after the treatment was not significant ($P > 0.05$).

Motion characteristics before and after the treatment

The experimental group

After the intervention, we found changes in the knee joint on both limbs; the range of motion in the sagittal plane was greater than at the baseline (Fig. 1). The limb with pain propagation had higher flexion peak in the stance ($P = 0.028$; $d = 1.00$) and swing ($P = 0.016$; $d = 0.65$) phases. This also applies to the extension peak

in the terminal stance ($P = 0.033$; $d = 0.89$) and at the end of the swing phase ($P = 0.039$; $d = 0.69$). Range of motion in the transverse plane increased significantly ($P = 0.006$; $d = 1.0$).

In the limb without pain propagation, we found an increase in the flexion peak in the stance ($P = 0.028$; $d = 0.82$) and the swing ($P = 0.011$; $d = 0.95$) phases; and in the extension peak in the terminal stance ($P = 0.006$; $d = 0.95$) and at the end of the swing phase ($P = 0.028$; $d = 0.78$).

After the intervention, the hip joint on both legs showed a significant increase in the flexion peak (with pain: $P = 0.023$; $d = 0.39$; without pain: $P = 0.039$; $d = 0.50$), and a decrease in the hip extension peak (with pain: $P = 0.046$; $d = 0.32$; without pain: $P = 0.033$; $d = 0.35$) (Fig. 2). In addition, we found a significantly smaller abduction peak ($P = 0.011$; $d = 0.98$) and a greater adduction peak ($P = 0.007$; $d = 1.0$) in the limb without pain propagation (Fig. 2).

We did not find any significant difference for parameters of the ankle joint and pelvis.

Fig. 1. Changes in the range of motion in the sagittal plane of the knee joint before and after the spa treatment

Fig. 2. Changes in the range of motion in the sagittal and frontal plane of the hip joint before and after the spa treatment

The control group

In the knee joint of the limb with pain propagation we found a significant increase in the flexion peak in the stance ($P = 0.005$; $d = 1.84$) and the swing ($P = 0.017$; $d = 1.39$) phase, in the extension peak in the terminal stance ($P = 0.005$; $d = 1.23$) and at the end of the swing phase ($P = 0.013$; $d = 1.08$).

In the limb without pain propagation, we found an increase in the flexion peak in the stance ($P = 0.005$; $d = 2.07$) and the swing ($P = 0.007$; $d = 2.01$) phase, the extension peak in the terminal stance ($P = 0.005$; $d = 1.81$) and at the end of the swing phase ($P = 0.005$; $d = 2.02$) (Fig. 1). The internal rotation peak of the knee joint increased significantly ($P = 0.007$; $d = 1.34$), similarly to the overall range of motion in the transverse plane ($P = 0.028$; $d = 0.83$).

The abduction peak of the hip joint significantly decreased ($P = 0.021$; $d = 0.88$) while the adduction peak significantly increased ($P = 0.021$; $d = 1.03$) (Fig. 2).

Symmetry of movement

The experimental group

Before the treatment, we identified six significant differences in the size of angle parameters on the limbs with and without pain propagation. Range of motion in the ankle joint in the sagittal plane was greater in the leg without pain propagation ($P = 0.019$; $d = 0.75$). The extension peak of the knee joint at the end of the swing phase was greater in the limb with pain propagation ($P = 0.033$; $d = 0.64$). Range of motion in the hip joint in the sagittal plane was greater in the leg without pain propagation ($P = 0.023$; $d = 0.80$), so were the anteversion ($P = 0.011$; $d = 0.99$), retroversion ($P = 0.033$; $d = 0.78$), and the elevation ($P = 0.045$; $d = 0.62$) peaks of the pelvis.

After ending the treatment, the only differences were found in the range of motion of the ankle joint in the sagittal plane ($P = 0.010$; $d = 0.85$) and the pelvic anteversion peak ($P = 0.033$; $d = 0.66$), both remained greater in the limb without pain propagation.

The control group

In the control group we found differences between the limbs with and without pain propagation only for the movement of the pelvis before starting the treatment. Range of pelvic motion in the sagittal plane ($P = 0.036$; $d = 0.75$) and the maximum elevation of the pelvis ($P = 0.012$; $d = 1.12$) were greater on the side of the limb without pain propagation. On the other hand, the pelvic depression peak was greater in the limb with pain propagation ($P = 0.012$; $d = 1.23$).

After completing the intervention, the number of significant differences between the two limbs increased. Internal rotation peak of the knee joint ($P = 0.049$; $d = 0.69$) and the maximum adduction ($P = 0.018$; $d = 0.71$) in the hip joint were greater for the limb without pain propagation. Abduction in the hip joint was greater for the limb with pain propagation ($P = 0.028$; $d = 0.66$). There was still a difference for the maximum elevation ($P = 0.049$; $d = 0.76$) and depression ($P = 0.035$; $d = 0.85$) of pelvis. The total range of pelvic motion in the frontal plane was greater ($P = 0.025$; $d = 0.79$) in the limb with pain propagation.

Discussion

We were able to detect an effect of physiotherapy and hippotherapy on gait kinematics in patients with chronic LBP. On the other hand, we are aware that this issue is highly controversial because it is not easy to interpret data and avoid a number of biases and potential flaws associated with conducting such clinical trials. A hippotherapy effect has been demonstrated in several studies for various diseases (Benda, McGibbon, & Grant, 2003; Casady & Nichols-Larsen, 2004; Glazer, Clark, & Stein, 2004; Hamill, Washington, & White, 2007; Chong, Liao, Leung, & Hwang, 2004; Kwon et al., 2011; Liptak, 2005; Macauley & Gutierrez, 2004). For the group of patients with LBP, however, the number of available studies is minimal. The study by Rothhaupt, Laser, Ziegler, and Liebig (1997) presents a positive effect of hippotherapy on short muscles of the spine which better stabilize motion segment and ensure the neutral zone of the spine in patients with LBP. In these patients as well as in our group, the perception of pain decreased after completion of hippotherapy. Yoo et al. (2014) applied an 8-week rehabilitation programme based on simulator of progressive horse riding in a group of patients with LBP. Upon completion of this program, the trunk flexor and extensor strength significantly enhanced. Lee et al. (2011) reported that a proximal trunk muscle strength, which is critical for postural stability and alignment, was improved during a robo-horseback riding programme. Good proximal stability ensures high-quality distal mobility (Kibler, Press, & Sciascia, 2006) which is also important for basic locomotion – walking.

Comparison of kinematic parameters before and after the treatment

Changes in distal joints of the lower limbs during walking are usually a consequential effect of motor adjustment in the proximal segments of the lower limbs and pelvis (Chuter & Janse de Jonge, 2012), which are subject to the primary therapeutic effect of the horseback movement. In contrast, we did not find significant changes in the range of motion of the ankle joint in any of the study groups.

On the other hand, the maximum values of flexion and extension during the stance phase of gait cycle increased in the knee joint of both limbs after completing the treatment, and achieved the range typical for a healthy population (i.e. 15–20° for flexion and 0–15° for extension) in both investigated groups (Gage, 1991; Kranzl, 2005; Perry, 2004; Seymour, 2002).

We observed similar trends also for the value of flexion peak in the swing phase; the increase in the motion shifts the values to the range of normal population (60–70°). The extension peak in the terminal swing phase decreased in both limbs and in both groups. In the experimental group, the measured values are in the range of 0–5°, typical for a healthy population (Gage, 1991; Kranzl, 2005; Perry, 2004; Seymour, 2002).

At foot contact, the knee joint did not achieve adequate extension which is necessary for the limb stability (Perry, 1992) and also for minimizing the energy requirements to maintain the centre of gravity of the body in the phase of weight acceptance. The main function of ensuring the stability of the knee joint at the end of the swing phase is controlled by quadriceps muscle (Gage, 1991; Perry, 1992; Seymour, 2002; Whittle, 2007). A weakening of the quadriceps muscle, which may impair the stability of the knee joint at the end of the swing phase, is typical for L4 root syndrome as well as for a group of other conditions (Callaghan, Parkes, Hutchinson, & Felson, 2014).

The similarity of pelvic movements while walking with the movements in hippotherapy has been observed (Fleck, 1997; Rigby, Garner, & Skurla, 2011). Several studies report that the pelvis position and improvements in the dynamic postural stability may also affect the movements in the joints of the lower limbs (Encheff, Armstrong, Masterson, Fox, & Gribble, 2012) and thus the walking performance (Quint & Toomey, 1998; Rigby, 2009). Improvement in the stability of the pelvis and changes in its motion in the frontal plane allow removing alternative pattern of motion in the hip joint. Minor changes in the position of the pelvis compared to the hip joint measured in our study are in line with the conclusions of Encheff et al. (2012). Absolute differences in the position of the pelvis in different planes are small, ranging usually around 1–2°. On the other hand, the effect size of the found differences is large for most parameters.

In the hip joint, we found a change only in the experimental group. Flexion peak in the stance phase of the gait cycle increased in both legs, with a small effect in the limb with pain propagation and moderate effect in the

limb without pain propagation. Its size for both legs was about 31° after completing the treatment, therefore, in the range of 25–35° which is typical for a healthy population (Kranzl, 2005; Perry, 2004). The average value of maximum extension in the swing phase decreased for both limbs. Despite that only small effect size for both limb, this parameter shifted also into the range of 0–10° which is typical for a healthy population (Kranzl, 2005; Perry, 2004).

Symmetry of movement in the limb with and without pain propagation

Walking of healthy persons is characterized by a certain degree of symmetry; a mild asymmetry may be associated with limb dominance for propulsion and stability control (Sadeghi, 2003). Asymmetry assessment is often used as an indicator in clinical practice (Gouwanda & Arosha Senanayake, 2011; Zifchock, Davis, Higginson, & Royer, 2008). Hannah, Morrison, and Chapman (1984) found symmetry of limb movement during walking in all three planes for the hip joint and in the sagittal plane for the knee joint. The differences in the evaluation of gait asymmetry in the ankle and knee joint were found by Gundersen et al. (1989). In our study, we observed different trends after completing the procedures. In the experimental group, the number of differences between measured parameters decreased for both limbs; in the control group, we observed an increase in the number of parameters with different values for the limb with and without pain propagation. When evaluating the asymmetry, it is necessary to take into account not only biomechanical parameters but also neurophysiological regulations that strongly affect the observed motion performance (McClay, 1995).

Limitations of the study

The observed findings might be biased by wide heterogeneity in the group of patients with LBP. Division into groups was not done at random. Hippotherapy was indicated for patients who consented to the inclusion of this form of therapy. Within a comprehensive rehabilitation, the patients had the same composition of basic procedures. However, it was not possible to ensure the same physiotherapist could lead the treatment in all patients in the study. Duration of the treatment either with or without hippotherapy was only three weeks. It would also be advisable to carry out follow-up measurements after a certain time interval since the end of the stay.

Conclusions

Both groups of patients with LBP demonstrated improvement in kinematic gait parameters after the spa treatment. The maximum values of flexion and extension in the knee joint of both limbs increased and achieved the range typical for a healthy population. In the hip joint such changes were found only in the flexion peak in the stance phase of the gait cycle in the hippotherapy group. We did not find any significant changes in the range of motion of the ankle joint in either group.

Only the group of patients with LBP additionally participating in hippotherapy showed an improvement in the symmetry of movement between the limb with and without pain propagation. The number of differences between measured parameters for both limbs decreased after spa treatment. The average VAS score in the group with hippotherapy significantly decreased.

The positive effect of the spa treatment as well as the additional effect of hippotherapy on gait execution was confirmed. However, further studies are needed to prove clinical significance of the observed changes.

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Conflict of interest

No competing financial interests exist.

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