THE INFLUENCE OF THE LEADER ON THE MOVEMENT OF THE HORSE IN WALKING DURING REPEATED HIPPOTHERAPY SESSIONS

Tereza Dvořáková, Miroslav Janura, Zdeněk Svoboda, Milan Elfmark

Faculty of Physical Culture, Palacký University, Olomouc, Czech Republic

Submitted in July, 2009

The movement of a walking horse is utilized as a tool for a therapeutic effect in hippotherapy. The movement impulses of the horse's back are influenced by the movement action of its limbs, morphology, speed of walk, etc.

The aim of the study was to evaluate the influence of the leader on a horse's movement while walking during repeated hippotherapy treatment sessions.

Three dimensional (3D) videography was used for the assessment of the movements of a horse (selected points on the limbs and back) and a human being (reaction to the horse's movement). The study was done with the repeated measurements (n = 6) of the movement of horses (n = 2) and riders (n = 12) during five weeks of hippotherapy intervention (9 sessions in total) by the different leaders (n = 6) of the horses.

There are differences in the range of movement of selected points on the limbs and back of the horse while leading it as done by different leaders ($p < 0.05$, $p < 0.01$). The changes in the kinematics of the horse's limbs are transmitted to the horseback movements of horse H1 only within a limited range. The range of the differences on the limbs and back for horse H2 is similar. The movement responses of healthy riders show differences in the lower part of the spine ($p < 0.05$); in the upper part of the spine the differences are minimal. The horse leader is one of the key factors for adhering to the desired medical effect, which is established on the basis of the intervention of physiotherapy throughout hippotherapy.

As there are a number of factors which could have a negative effect on the movement of the horse (weather, disturbing influences of the environment, low quality surface), the activities of the horse leader in keeping the relevant direction and speed of the horse's movement are decisive factors. This study emphasises the significance of the role of the horse leader in therapy and puts stress on his/her level of professionalism, fitness, motivation and performance.

Keywords: Hippotherapy, leader of a horse, 3D videography, movement response of the rider.

INTRODUCTION

Locomotion of horses

Each gait of a horse has a characteristic sequence of the stepping of the individual limbs onto the ground, which determines the amount of contact of the limbs with the ground and the rhythm and speed of the movement (Pilliner, Elmhurst, & Davies, 2004).

The walking of a horse is a four period gait (four limb contacts). The speed of the movement is at an average of 100 $m \cdot min^{-1}$ (6 $km \cdot h^{-1}$). The ideal situation involves all four limb contacts being in equal periods from each other. This rhythm is described as regular or square (Clayton, 2004). The collective acting of the dorsal and ventral muscles of the horse's torso is very important for the fluency of the rhythm (Nicholson, 2006). The manner of the horse's step is furthermore projected into the three dimensional movement of the horse's back, which becomes the unique balance area for therapy.

The quantitative parameters of the mechanics of the horse's movement are the length of step, speed of movement and step frequency. Dušek et al. (1999) suggests that the more the horse is able to increase its speed through prolonging the length of a step and not through increasing the step frequency, the better it is equipped and disposed to movement.

Hippotherapy – the horse as a variable

A horse trainer takes part in choosing the horse for the purposes of hippotherapy. He or she evaluates the horse as a whole, in collaboration with individual parts, the muscles and the mechanics of movement. A physiotherapist evaluates the horse's height, the width of the back, the length of step along with its softness and fluency. It is necessary to choose the horse with regards to a specific group of patients (Hermannová, 2002). Horses which seem suitable by anatomical appearance, but are unable to become free in movement due to some health problems, should not be considered for therapy (Benetinová, 2000; Hermannová in Kulichová et al., 1995).

We can divide horses into the inhibitive or stimulative categories for the purposes of hippotherapy on the

basis of the biomechanical parameters of movement components in the oscillating of the horse's back. The stimulative category mostly occurs in the bigger intensity of the vertical component of the back movement.

The movement dialogue between a person and a horse in hippotherapy

A person and a horse are two independent biological systems with their own wills. The movement "activator" in hippotherapy is the horse and the task of the person (patient) is to adjust to these movements for the collective acting of movements to occur (Wheeler, 2003). The locomotion impulses of the dorsal muscles of the horse's back during walking are three dimensional and are transferred to the rider with a frequency of 90–110 impulses per minute (Tauffkirchen, 2000).

The surrounding elements of both systems most often lead to movement transfer – the pelvis of the patient in the classic therapeutic position in sitting and the horse's back. The mobilisation of individual movement segments of the spine occurs during this transfer, thus leading to the removal of articulatory hyper mobility and, simultaneously, to the eccentric training of the short mono segmental (autochthonic) muscles (Véle, 1997; Rothaupt, Laser, & Ziegler, 1998).

Personal safeguarding of the process of hippotherapy

Hippotherapy is a method of treatment using horses for the purpose of physiotherapy intervention. The patient's doctor must send clients for such treatment. The members of the therapeutical team are the physiotherapist with a special education, a trainer and a horse leader (not always one person), and a helper who ensures the safety of the client on the horse. Due to the degree of progress of the patient with the physical handicap, from 2 to 4 people are necessary to care for one patient.

In practice it is necessary to have the possibility to work gradually with the horse, which the therapist uses through a leader. This mostly involves changing the length of the horse's step and its speed. The therapist modifies the movement behaviour of the animal with the intention of achieving the desired effect within the framework of therapeutical units. This is carried out on the basis of the gradual evaluation of the patient's reactions.

Each leader, just like the horse, is an individual whose movement moves through the horse to the rider. Therefore, it is suitable to use specially trained leaders to lead the horse during hippotherapy to achieve the desired effect (Dvořáková, Janura, Svoboda, & Pavelková, 2004).

The purpose of the study was to find the influence of the leader on the manner of carrying out the movement of the horse in hippotherapy and to determine how these changes affect the reactions of the movement system of the rider.

SUBJECTS AND METHODS

The measurements were taken in cooperation with the equestrian club Théta Chválkovice in Olomouc, where hippotherapy has been taking place for more than 10 years. The study was focused on following the changes in the movement of some selected parameters in the limbs and on the horseback in the repeated performance of hippotherapy for a period of five weeks (nine therapeutical units with a frequency of twice per week). The measurements took place on a large asphalt ring, where hippotherapy regularly takes place.

Characteristics of the observed group of horses

In order to minimise the movement differences, horses of the same breed (thoroughbred) with a similar bodily constitution (Fig. 1) were used in this study.

Fig. 1
Horses H1 and H2 were used for the purposes of our study

Horse H1 – gelding, age 19 years, height 165 cm, length of time in hippotherapy 8 years.

Horse H2 – mare, age 14 years, height 165 cm, length of time in hippotherapy 9 years.

The horses were in good physical condition, i.e. capable of full performance. The Ethical Board of the Faculty of Physical Culture in Olomouc gave their agreement for the use of these horses for the purpose of these studies.

Preparation of the horses

The horses were saddled with a thin mat and stomach strap (sling to stop the mat from slipping). Before they were measured, the horses were lead around outside for around 15 minutes. The bridling of the horses was carried out with a palpation identification of the anatomical structures. The application of contrasting signs was also done. The anatomy of the horse's body surface is relatively simple. Individual anatomical points are identified in relation to the total constitution and are more evident in comparison with other kinds of domestic animals (Černý, 1995). The same person carried out all the measurements of palpation.

Observing points

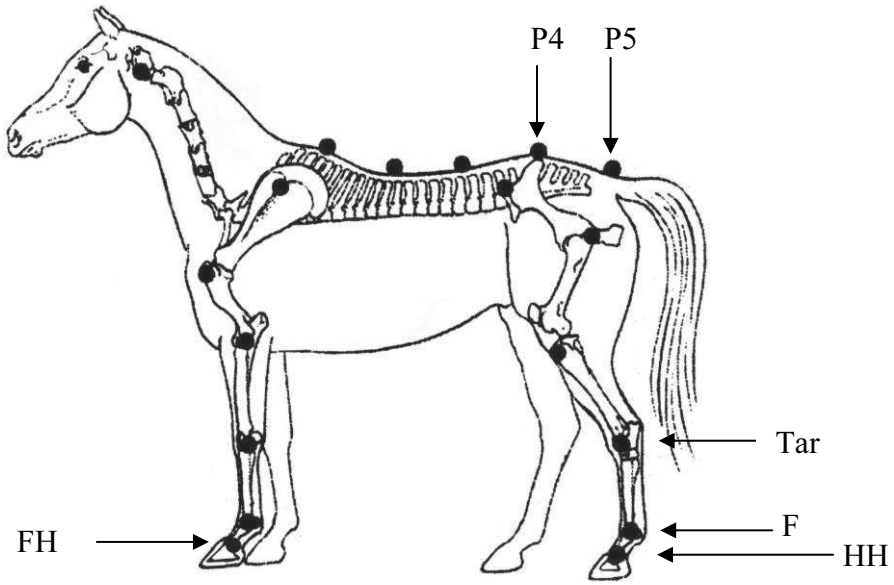
For the purpose of marking the points on the horseback, we used foam semi rounded markings of 0.04 m in diameter and yellow in colour. The labels were fixed onto the horse's skin by using double sided sticky tape. We used crosses from the strips of white sticky tape 0.12 m in length and 0.02 m in width for labelling the horse's limbs, as the labels tended to fall off. The centre of the cross was the observed point.

We used the basic set of anatomic points used for the movement analysis of horses for the purpose of our research. These are presented in the works of Holmström (2002) and Robert, Audigié, Valette, Pourcelot and Denoix (2001). We labelled 8 points on the body in order to fulfil the aims of this work (Fig. 2).

Leaders

Each horse was led by three leaders over the course of the repeated hippotherapy units. They were individuals with varying levels of experience and differing amounts of practice. Each leader, generally an active rider, was acquainted in detail with the method of carrying out these activities and knew all the factors which could negatively influence the movement of the horse. As the research took place over a period of several weeks, it was not possible to find out the concurrent number of therapy units which were carried out with all the participating leaders. This was partially due to the other work responsibilities of the leaders (TABLE 1).

Fig. 2
Observed points on the horse's body



Legend:
P4 – sacral tuber
P5 – root of the tail
F – fetlock (centre of the side projection of the fetlock joint)
Tar – tarsus (lateral edge of the trochlea tali)
FH – centre of the coronet of front hoof
HH – centre of the coronet of hind hoof

TABLE 1
Amount of analysed sequences of horse steps when led by individual rider

Horse H1		Horse H2	
Leader	**Number of sequences**	**Leader**	**Number of sequences**
L1	62	**L4**	98
L2	24	**L5**	68
L3	70	**L6**	24

Legend:
L1–L6 – leaders of horses H1, H2

Records of movement

A flat asphalt area of around 15 m in length was chosen for the recording. Four cameras were placed at the sides of the flat area (JVC GR – DVL9800, SONY DCR – TRV900E, frequency 25 Hz). A central line was marked in the middle of the way indicating the direction of the horse's movement. Perpendicular lines on the determined area with a distance of 2 m were indicated for better orientation when compiling the video recordings. These lines simplified the identification of the double step in synchronising the video recordings from each camera. Three pieces of synchronising equipment were installed into the recording area along with four black and white control points for further video processing.

A calibration device was recorded throughout the measurements in five chosen places. These were created through a cuboid with dimensions of 1 × 1 × 2 m. The points located in the corners of the cuboid and the edges were important for the calibration of the area necessary for the subsequent digitising of the video recordings.

Processing of video recordings and analysis of data

The acquired video sequences were divided into individual strides of the horses and synchronised. They were then processed using APAS software for 3D kinematic analysis (Ariel Dynamics Inc., Trabuco Canyon, CA, USA). The resulting coordinates of points from the synchronised recordings (DLT) were used for determining the basic kinematic parameters (length, speed, and angle).

The observed kinematic parameters on the horse's body

We evaluated the following parameters when analysing the movement of the horse:

- step duration,
- step length,
- step frequency,
- walking speed,
- the vertical displacement of the front and hind hoofs,
- the vertical displacement of the fetlock and tarsus,
- the vertical displacement of points P4 and P5.

The observed kinematic parameters on the rider's spine

We evaluated the following parameters when analysing the recordings of the rider's movements:

- the vertical displacement of point L5,
- the horizontal displacement of point L5 on a sagittal plane,
- the upper spine angle displacement (the angle defined by segments C7–Th5, Th5–Th12) on a sagittal plane,
- the lower spine angle displacement (the angle defined by segments Th5–Th12, Th12–L5) on a sagittal plane.

Statistical analysis

The acquired data was processed by the STATISTICA 6.0 programme. Basic descriptive statistics were calculated for the evaluated parameters. An analysis of variance was used for the comparison of the data derived from all lectures involving different leaders. We used the LSD post hoc test for determining the differences between individual leaders.

RESULTS AND DISCUSSION

The basic statistical values of the observed parameters are in TABLE 2.

Horse H1

Movement of the horse

There were significant differences between the individual leaders ($p < 0.01$; $p < 0.05$) in terms of the majority of the observed parameters (TABLE 3). The length of each step was between 1.69 m and 1.80 m; the speed of each step was between 1.39 $m.s^{-1}$ and 1.49 $m.s^{-1}$. The highest step speed in leading done by leader L3 was achieved through a combination of the highest length of a step and a higher frequency.

The maximal displacement for the front hoof differed by 0.019 m, whereas it is 0.012 m for the hind hoof. The differences in the lifting of the leg are also transferred to further segments of the hind limbs and the size among individual leaders decreases. In the case of leader L3, this height is at its lowest and the trajectory of the limb is at its flattest.

We found a further decrease in differences for the points on the horseback. The differences we found were statistically significant on the level $p < 0.01$ i.e. $p < 0.05$, and the absolute difference is less than 0.01 m.

Parameters of the riders

We found statistically significant differences in the body of the rider, especially for the movement of point L5 in a vertical direction. The tendency of changes is similar to those in the case of point P4 on the horse's

TABLE 2
The basic statistical characteristics of selected parameters on the bodies of the horse and rider while working with different leaders

Horse	Leader	Tstep [s]		Lstep [m]		Speed [m.s^{-1}]		Freq [Hz]		FH [m]		HH [m]		F [m]	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
H1	L1	1.26	0.113	1.74	0.047	1.39	0.128	0.80	0.065	0.073	0.016	0.092	0.024	0.126	0.015
	L2	1.19	0.088	1.69	0.058	1.43	0.133	0.84	0.064	0.086	0.017	0.105	0.017	0.146	0.015
	L3	1.22	0.098	1.80	0.042	1.49	0.120	0.83	0.063	0.067	0.017	0.093	0.017	0.124	0.015
H2	L4	1.32	0.064	1.78	0.042	1.35	0.076	0.76	0.037	0.061	0.013	0.091	0.014	0.129	0.011
	L5	1.28	0.115	1.81	0.058	1.43	0.139	0.79	0.067	0.068	0.012	0.090	0.013	0.126	0.011
	L6	1.32	0.079	1.79	0.027	1.36	0.090	0.76	0.045	0.076	0.017	0.091	0.015	0.124	0.012

Horse	Leader	Tar [m]		P4 [m]		P5 [m]		L5y [m]		L5z [m]		A1 [°]		A2 [°]	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
H1	L1	0.154	0.023	0.059	0.011	0.074	0.009	0.078	0.041	0.030	0.011	21.00	11.18	18.41	7.69
	L2	0.165	0.017	0.054	0.008	0.070	0.010	0.069	0.027	0.021	0.009	21.64	14.93	17.84	10.91
	L3	0.160	0.018	0.062	0.009	0.079	0.009	0.066	0.023	0.034	0.010	18.13	7.39	17.62	7.17
H2	L4	0.128	0.014	0.055	0.007	0.068	0.007	0.064	0.055	0.028	0.009	12.13	4.43	11.18	4.21
	L5	0.135	0.010	0.064	0.008	0.074	0.009	0.062	0.056	0.027	0.008	14.69	5.60	12.35	3.87
	L6	0.130	0.013	0.052	0.006	0.065	0.005	0.074	0.059	0.025	0.008	13.59	4.92	10.86	3.50

Legend:
Tstep – step duration
Lstep – step length
Speed – walking speed
Freq – step frequency
FH – centre of the coronet of front hoof
HH – centre of the coronet of hind hoof
F – fetlock (centre of the side projection of the fetlock joint)
Tar – tarsus (lateral edge of the trochlea tali)
P4 – sacral tuber
P5 – root of the tail
L5y – the horizontal displacement of point L5 on a sagittal plane
L5z – the vertical displacement of point L5 on a frontal plane
A1 – the angle defined by segments C7–Th5, Th5–Th12 on a sagittal plane
A2 – the angle defined by segments Th5–Th12, Th12–L5 on a sagittal plane
** – $p < 0.01$
* – $p < 0.05$
LA × LB – difference between leader A and leader B

TABLE 3
Statistically significant differences of measured parameters when horses H1 and H2 are led by different leaders

		Horse 1			Horse 2		
	Parameter	L1 × L2	L1 × L3	L2 × L3	L4 × L5	L4 × L6	L5 × L6
Body – horse	Tstep	*					
	Lstep	**	**	**	**		
	Speed		**		**		
	Freq	*			**		
	FH	**	*	**	**	**	*
	HH	**		**			
	F	**		**			
	Tar	**	*		**		
	P4	**		**	**	*	**
	P5	*	**	**	**		**
Body – rider	L5y		*				
	L5z	**	*	**			
	A1		*		*		

Legend:
Tstep – step duration
Lstep – step length
Speed – walking speed
Freq – step frequency
FH – centre of the coronet of front hoof
HH – centre of the coronet of hind hoof
F – fetlock (centre of the side projection of the fetlock joint)
Tar – tarsus (lateral edge of the trochlea tali)
P4 – sacral tuber
P5 – root of the tail
L5y – the horizontal displacement of point L5 on a sagittal plane
L5z – the vertical displacement of point L5 on a frontal plane
A1 – the angle defined by segments C7–Th5, Th5–Th12 on a sagittal plane
A2 – the angle defined by segments Th5–Th12, Th12–L5 on a sagittal plane
** – $p < 0.01$
* – $p < 0.05$
LA × LB – difference between leader A and leader B

back and the size of the differences increases to the value of 0.013 m when leaders L2 and L3 lead the horses. There are lesser differences in the segments in the upper parts of the spine. The angle displacement with the top in Th12 differs from leader to leader by less than 1°. The average value for the angle with the top in Th5 in terms of differences between leaders L2 and L3 is 3.5°. The extent of the interindividual differences between individual riders is great.

Horse H2

Movement of the horse

In the movement of the horse we found significant differences ($p < 0.01$) when the horses were led by leaders L4 and L5. The length of the step of the horse ranged between 1.28 m and 1.32 m and the walking speed between 1.35 $m.s^{-1}$ and 1.43 $m.s^{-1}$. The increase in the walking speed when the horse was led by leader L5 was caused by a combination of the longest step and the highest frequency.

The maximal displacement of the front hoof differs by 0.015 m, the differences between the individual leaders were significant ($p < 0.01$). We found differences for the points on the hind limb, which were smaller and did not exceed 0.005 m. With the exception of the difference for the tarsus displacement, when the horses were led by leaders L4 and L5, there were no significant differences between the remaining leaders on the level of $p < 0.05$.

In terms of the points on the horseback, the amount of statistically significant differences increases. For point P4 we found this difference in three different leaders. The absolute size difference is 0.012 m for point P4 and 0.009 m for point P5.

Parameters of the riders

In contrast to leading horse H1, the number of statistically significant differences is smaller. The size of the difference in leading horse H2 through leader L4 and L6 is 0.012 m for the movement of point L5 in the horizontal direction. The differences found in the movement of point L5 in the vertical direction were minimal, less than 0.005 m. The range of the movement of the angle with top in Th12 differed between individual leaders by 1.5°. The size of the difference between leaders L4 and L5 for the angle with top on Th5 was 2.56° ($p < 0.05$).

When evaluating the differences in the performance of the movement of the horse and rider in hippotherapy, a number of factors must be taken into account, sharing the influence in these changes. As the horse's movement is, to a certain degree, determined by the activity of the leader, it is necessary to judge the situation from a systematic point of view, where there is an interaction between two (three in the case of observing changes to the body of the rider) biological subsystems (Wheeler, 2003), which are both extremely complicated. It is therefore necessary to define the basic factors which influence the activity of individual subsystems and which also have a say in the quality of the measured data.

Weather and wind conditions

During the measurements, the weather changed from cold and rainy to sunny, with the temperature reaching 30° C. This was, of course, an influencing factor in the carrying out of the movement, especially in terms of the speed and length of the steps. It is possible to say that rain and cold weather lead to a tendency to spend less time in unsheltered areas. Being in a fixed area (on a course) may lead to the movement becoming faster. This is evident in the length of the steps and in the size of the absorbtion of impulses in the stepping of the front limbs (Harris, 1993). Furthermore, these changes are evident in the size of the deviations of the horse's back (Dvořáková, Janura, Vyjídáková, & Svoboda, 2004).

Influence of tiredness

It is difficult to presume that the leader is not affected by physical or psychological tiredness in his/her maximum professional approach. This may have a significant effect on the basic parameters of his/her gait (Straus, 2001). Furthermore, the relatively simple and stereotyped activities required by the leader may in turn cause tiredness.

Moreover, the work of the horse in hippotherapy is very demanding, not only due to the intensive stress put on the back by the patient, with a frequent erroneous control over his/her own posture, yet more from a psychological point of view. "Hippotherapy is not a relaxing activity for sport horses nor renting stables, nor is it an outing for old used up horses" (Casková, 2003, 7).

Errors in measurement

When comparing the measured differences, it is necessary to take the size of the measurement errors into account. In this case, it is a combination of the accuracy of the technical equipment and its influence on a living and moving entity. The error grows in the process of evaluating records, during the calibration of the space and the transformation of coordinates (Allard, Stokes, & Blanchi, 1995). If we are dealing with mistakes caused by the palpation of the bone structure, placement of markers, or movement of tissue, then this influence cannot be totally eliminated. A certain advantage in the analysis of the movement of a horse is that the anatomic points on its body are more evident in comparison with other domestic animals due to the total constitution (thin skin, thinner fascia, a smaller amount of ligament in the fat tissue) (Černý, 1995).

The above mentioned sizes of errors touch particularly on the cases where the analysis of the movement is carried out in one attempt. Our study focuses on com-

paring the effect of leaders, when the amount of analysed attempts for the given leader was from 24 to 98. The determination of the average values from the high amount of sequences leads to a decrease in the errors in measurement (Smith, 1993).

When evaluating the size of differences, we must also take the segment or place on the horse's body (rider) into account, for which the difference was established. In the case of horse H1, the differences in movement of the points on the horseback are smaller than the differences on the limbs. Their size, which approaches 1 cm in the vertical direction, is to be considered to be objectively important. This is also valid for the movement of points on the rider's body, as there is an increase in the differences in comparing the movement of points on the horse's back. The number of differences is smaller in terms of the movements of horse H2. The sizes of differences on the limbs and on the horse's back were similar. These changes were not transferred to the points on the rider's spine.

CONCLUSIONS

The horse leader is one of the important factors contributing to the quality of a hippotherapy course. As there are a number of factors which could have a negative effect on the movement of the horse (weather, disturbing influences of the environment, low quality surface), the activity of the horse leader in keeping to the relevant direction and speed of the horse's movement are decisive factors. These are essential conditions for adhering to the medical effect which is established on the basis of the intervention of physiotherapy throughout hippotherapy.

There are considerable differences found between different leaders when comparing the movement of points on the limbs and on the horse's back (P4, P5). These differences also have a logical significance for the vertical movement of the L5 point on the rider's spine.

This study should serve as a source of information for those engaged in this therapeutic method. It emphasises the significance of the role of the horse leader in therapy and puts stress on his/her level of professionalism, fitness, motivation and performance.

ACKNOWLEDGEMENT

The study has been supported by the research grant from the Ministry of Education, Youth and Sports of the Czech Republic (No. MSM 6198959221) "Physical Activity and Inactivity of the Inhabitants of the Czech Republic in the Context of Behavioral Changes".

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VLIV VODIČE NA POHYB KONĚ V KROKU V OPAKOVANÝCH LEKCÍCH HIPOTERAPIE

(Souhrn anglického textu)

Pohyb koně v kroku je prostředkem k léčebnému působení hipoterapie. Pohybové impulzy hřbetu koně jsou ovlivněny mechanikou pohybu končetin, morfologií, rychlostí kroku atd. Vzhledem k tomu, že pohyb koně je do určité míry determinován činností vodiče, je nezbytné posuzovat situaci ze systémového hlediska, kde v rámci systému dochází k interakci mezi dvěma (třemi, v případě sledování změn na těle jezdce) biologickými subsystémy.

Cílem práce bylo určit vliv vodiče na pohyb koně v kroku při opakovaných jednotkách hipoterapie.

Pro hodnocení pohybu koně v kroku (vybrané body na končetinách a na hřbetu) a jezdce (reakce na pohyb koně) byla použita 3D videografická metoda. Studie byla provedena jako opakovaná měření (n = 6) pohybu koní (n = 2) a jezdců (n = 12) v průběhu pěti týdnů probíhající intervence formou hipoterapie (celkem 9 lekcí) při vedení koní s využitím různých vodičů (n = 6). Data získaná ve všech lekcích při vedení různými vodiči byla pro každého koně porovnána použitím analýzy rozptylu (program STATISTICA v 6.0). Pro určení rozdílů mezi jednotlivými vodiči jsme použili LSD post hoc test.

V rozsahu pohybu vybraných bodů na končetinách a na hřbetu koně existují významné diference při využití různých vodičů ($p < 0,05$, $p < 0,01$). Při vedení koně H1 se změny v kinematice končetin koně přenáší do pohybu hřbetu pouze v omezeném rozsahu. Pro koně H2 je rozsah diferencí v pohybu bodů na končetinách a na hřbetu koně podobný. Reakce zdravých jezdců na rozdíly v pohybu koní v horních úsecích páteře se při vedení různými vodiči vyznačuje pouze minimálními diferencemi. V oblasti bederní páteře je změna ve vertikálním posunu bodu L5 významná ($p < 0,05$).

Vzhledem k množství faktorů, které mohou negativně působit na pohyb koně (počasí, rušivé vlivy prostředí, nekvalitní povrch), rozhoduje aktivita vodiče o dodržení odpovídajícího směru a rychlosti pohybu koně a tím o naplnění léčebného efektu, stanoveného na základě intervence fyzioterapeuta v průběhu hipoterapie. Tato studie zdůrazňuje význam role vodiče v terapii a klade důraz na jeho profesionalitu, kondici, motivaci a standardní výkon.

Klíčová slova: hipoterapie, vodič koně, 3D videografická metoda, motorická reakce jezdce.

Mgr. Tereza Dvořáková, Ph.D.

Palacký University
Faculty of Physical Culture
tř. Míru 115
771 11 Olomouc
Czech Republic

Education and previous work experience

2002 – Master (Mgr.) in physiotherapy – Palacký University in Olomouc.

2009 – Ph.D. in kinantropology – Palacký University in Olomouc.

Member of the Execution committee of the Czech Therapeutic Riding Association.

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