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Influence of equine conformation on linear and hippotherapeutical kinematic variables in free walk

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ABSTRACT

Fourteen horses with different conformation were used to study the linear and hippotherapeutical kinematics of the free walk. Horses were recorded with two digital video cameras in a sagittal plane at a rate of 25 frames/s. Body proportions, linear and hippotherapeutical data were extracted from the recordings by APAS (Ariel Performance Analysis System). Results of ANOVA and Duncan`s multiple range test indicated that the linear and hippotherapeutical variables of horses were significantly different. Correlation coefficients between the equine conformation and kinematic variables were determinate. The study showed significant correlations (P<0.01) between step-, stride length and body parameters in free walk. It shows that taller and longer horses have longer step and stride length. Correlations were not observed between hippotherapeutical measurements and body parameters.
(Keywords: horse; motion analysis; linear variables; conformation; hippotherapy)

ÖSSZEFOGLALÁS

Lovak testalakulásának hatása a lineáris és hippoterápiás szempontból lényeges kinematikai változókra szabad lépésben
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14, különböző testalakulású lovat vizsgáltunk szabad lépésben a lineáris és hippoterápiás szempontból lényeges kinematikai változók vizsgálata céljából. A lovakat két digitális videó kamerával filmeztük a szagitális síkban 25 képkocka/másodperc sebességgel. A testméreteket, a lineáris és hippoterápiás kinematikai változókat meghatároztuk APAS (Ariel Performance Analysis System) szoftver segítségével. A varianciaanalízis és a Duncan féle teszt eredményei alapján a lineáris és hippoterápiás változók esetén a lovak között szignifikáns különbségeket tapasztaltunk. A lovak testalakulása és a kinematikai változók közötti korrelációs koefficienseket meghatároztuk. A tanulmány erős korrelációt (p<0,01) állapított meg a lépés- és mozgásciklus hossz és a testalakulás között, szabad lépésben. Ezek alapján a magasabb és hosszabb lovaknak nagyobb a lépés és mozgásciklus hossza. A hippoterápiás változók és a testalakulás között szoros korrelációt nem tapasztaltunk.
(Kulcsszavak: ló; mozgás elemzés; lineáris kinematikai változók; testalakulás; hippoterápia)

INTRODUCTION

Horses differ from most other domestic species because their individual value is higher and the objective measurement of their most important production – the quality of the basic movement – run into difficulties. Therefore, the accurate realization of the classical breeding principles is also complicated. Selection of horses is based on the judgment of the experts that carries all the risks that derives from the subjectivity. At present, due to the development of computer technology methods have become wider to increase the objectivity of these measurements. Video analysis is the most frequently used type of motion analysis, which is able to discern many aspects of gait that are not perceived by the judge due to the poor temporal resolution of the human eye.

The exploitation of horses seems to be expanding, besides racing, sport and hobby, due to the recent popularity of hippotherapy. Hippotherapy is a treatment that uses the multidimensional movement of the horse for clients who have movement dysfunction (*American Hippotherapy Association Inc*., 2010). Hippotherapy employs locomotion impulses that are emitted from the back of a horse while the horse is walking. These impulses stimulate the rider's postural reflex mechanisms, resulting in training of balance and coordination (*Janura et al.,* 2009). The horse's walk provides sensory input through movement which is variable, rhythmic and repetitive. (*Trauffkirchen*, 2000).

Hippotherapy as a special utilisation makes several great demands of horses. Hippotherapy requires higher physical and mental strain from a horse. (*Györgypál Z.*, 2002). An essential prerequisite for success of this treatment method is the selection of a suitable horse for a given patient (*Janura et al.,* 2009). The leverage of the horse is affected by its conformation, movement mechanics when walking, its temperament, and other variables (*Hermannova*, 2002). A survey of horse temperament for therapeutic riding has been published by *Anderson et al.* (1999). If a horse's temperament is suitable, the conformation becomes an important selection criterion (*RDA*, 1990).

Johnston et al. (2002) pointed out that the differences in equine oscillation among breeds would originate from differences in equine conformation. The frequencies of rider oscillation both at walk and trot were higher ($P<0.01$) and the vertical ($P<0.01$) and longitudinal ($P<0.05$) amplitudes at trot were smaller, on short horses, than on tall horses. The vertical amplitude at walk was smaller ($P<0.05$) and the lateral amplitude at trot was larger ($P<0.01$) on wide horses than on narrow horses. Short and wide horses should be suitable for therapeutic riding (*Matsuura et al.,* 2008).

The influence of equine conformation on the rider's oscillation needs to be understood to aid selection of horses for therapeutic riding. The aim of this study was to determine the influence of equine conformation on linear and hippotherapeutical kinematic variables in free walk and to use the relationships between these parameters to evaluate horses for hippotherapy.

MATERIALS AND METHODS

Markers

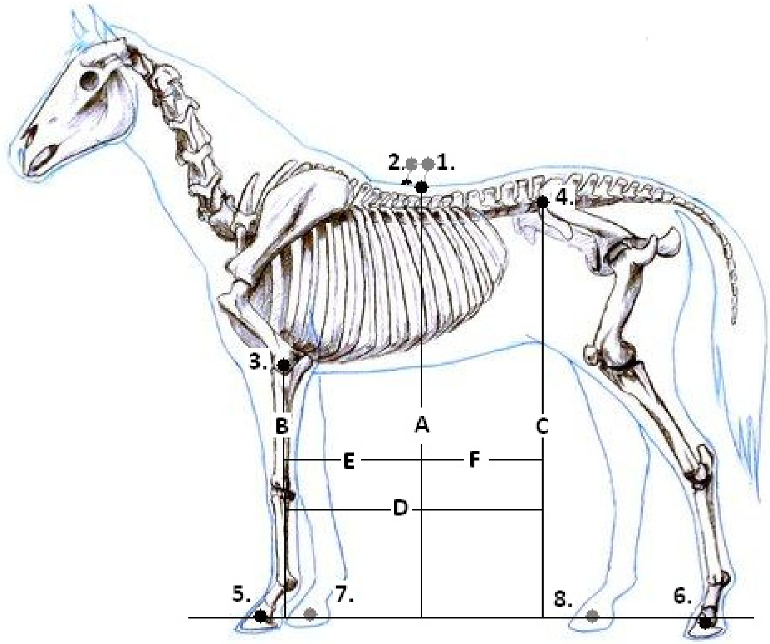
Eight non-active markers of 2 cm diameter were placed on the horses after a thorough warm up. Markers were placed to anatomical locations significant from hippotherapeutical points by the same person each time (*Figure 1.*).The marker points used for the research were:

- left and right sitting points,
- tuber coxae distal part (distal tuber coxae),

- lateral epicondyle of the humerus (elbow),
- midpoint of the periople of the hoof (hoof).

Figure 1.

Body proportions and marker positions



Sitting point height (A), elbow height (B), tuber coxae height (C), elbow – tuber coxae distance (D), elbow – sitting point horizontal distance (E), sitting point – tuber coxae distance (F). 1. expanded left sitting point, 2. expanded right sitting point, 3. lateral epicondyle of the humerus (elbow), 4. tuber coxae distal part (distal tuber coxae), 5–8. midpoints of the periople of the hooves

1. ábra: Testméretek és markerhelyek

Ülőpont magasság (A), könyök magasság (B), külső csípőszöglet magasság (C), könyök-külső csípőszöglet távolsága (D), könyök-ülőpont távolsága (E), ülőpont-külső csípőszöglet távolsága (F). 1. bal ülőpont kinagyított pontja, 2. jobb ülőpont kinagyított pontja, 3. könyök, 4. külső csípőszöglet legalsó pontja, 5-8. a paták szegélyének felezőpontja oldalnézetben

For better observation of the motion characteristics of the sitting points the amplitude was expanded reproducing the human pelvis. To achieve this, we created a trapezoid-frame with four markers (*Figure 2*). The frame was secured on the back of the horse through the pads; the balls directly on the back of the horse representing the sitting points were fixed onto the pads with the nails, pierced through the centreline of the balls. The balls, positioned on the top are the hyperbolism of the sitting points which mark the left and right proximal femur at cranial greater trochanter in an average rider. Due to the boreholes on the balls, they sit on the pad but also can freely rotate around the nails as axels or slide up and down leaving the distance between the four balls constant. The connection between the four points on the frame is rigid making the trapezoid-frame similar to a human pelvis and giving accurate data to study.

The distances between the markers were 120 mm (down closer the spine of the horse) and 300 mm (top).

Figure 2.

The trapezoid frame markers representing the human pelvis model of the rider

2. ábra: A lovas medencéjét reprezentáló trapéz alakú markerkeret

Calibration, camera positioning, video recording

A calibration frame (developed at the, Department of Large Animal Breeding and Production Technology, Faculty of Animal Science, Kaposvár University, Kaposvár, Hungary) with 12 non-coplanar control points was recorded in the field of view (160 cm x 200 cm x 400 cm) to scale the coordinate rate. Two DV cameras (Sony, DCR TRV 30E) were set up at a distance of 30 m from the horses plane of motion, as a triangle. The horses were filmed as they walked along a track. Each horse performed 10 passes, led at a free walk.

Horses – measurement of equine conformation

In the research we used 14 horses, trained and used for hippotherapy, Hungarian warm blood breeding, and had a mean age of 12 years (range, 9 to 19 years), a mean sitting point height of 145 cm (range 122 to 158 cm). All horses had a minimum of 1 year experience of hippotherapeutic work and they were all used to the testing procedure (placing on markers, moving in the experimental track). The horses were led in free walk by their usual horse leaders (the person who is in charge of the leading of the hippotherapy horse during the treatment session.), and were thoroughly warmed up prior to the start of the study.

APAS (Ariel Performance Analysis System, Semmelweis University, Faculty of Physical Education and Sport Sciences, Budapest.) The body dimension values used in this research differ from the conventional values used in horse breeding (height of the withers, heart girth). In this case we used markers on body points which represent main hippotherapeutic values and can be used in this kinematic system to gain accurate data. The data was taken on the exact frame where the left fore and left hind hooves are in stance phase and close to the vertical (*Figure 1*). The body dimension values used for the research are:

A. sitting point height: vertical distance (cm) between left sitting point and left front hoof,
B. elbow height: vertical distance (cm) between left elbow and fore left hoof,
C. tuber coxae height: vertical distance (cm) between left distal tuber coxae and left fore hoof,
D. elbow – tuber coxae distance: horizontal distance (cm) between left elbow and left distal tuber coxae,
E. elbow – sitting point horizontal distance: horizontal distance (cm) between left elbow and left sitting point,
F. sitting point – tuber coxae distance: horizontal distance (cm) between left sitting point and left distal tuber coxae.

Body proportions are shown in *Table 2*.

Analysis of videographics

Recordings were analyzed with APAS. The marker identification was semi-automated. The marker identification of the first frame is performed by the operator. In the following frames, the cursor automatically jumps in sequence to the location of the points identified in the previous frame by a process known as automatic point prediction. The operator is still responsible for the final adjustments in cursor position and for confirming the locations prior to their acceptance.

Measured variables

Ten strides per horse were analyzed. Initial contact of the hoof with the ground was recognized as the first video frame of the stance phase and the stride as well. The toe off was the first video frame of the swing phase.

Linear stride variables

The linear variables were the *step length* (or *stance phase length)* (cm), the distance between contralateral hoof placements (LH-RH, RH-LH, LF-RF, RF-LF); the *stride length* (cm) was the distance between successive ground contacts of each limb, and the *over-tracking distance* (cm) between the forelimb and the succeeding placement of the ipsilateral hind limb (RF-RH, LF-LH). The *over-tracking distance* was negative if the hindhoof was placed behind the forehoof, zero if the hindhoof stepped into the imprint of the forehoof, and positive if the hindhoof stepped ahead of the forehoof.

Hippotherapeutical stride variables

The hippotherapeutical variables are described the *kinematics of sitting points* which are the clue of the therapy. Measured sitting point motion characteristic show the character of the therapeutical effect of each horse.

The hippotherapeutical variables are compared in the explanatory *Table 1.*

Table 1.

The hippotherapeutical variables

Measured parameter (1)	Sitting points (2)	Directions (3)
(HT1): sitting point velocity differences, cm/s (4)	Accelereation–deceleration (8)	Horizontal, strightaway (12)
(HT2): velocity difference between the left and right sitting points at maximum speed of left sitting point, cm/s (5)	Transverse plain movement (9)	Horizontal, transverse (13)
(HT3): the common vertical displacements of the sittingpoints, cm (6)	Lift–drop (10)	Vertical, dorsal-ventral (14)
(HT4): maximum distance difference between vertical amplitude of sitting points, cm (7)	Left–right, lift–drop (11)	Vertical, dorsal-ventral (15)

1. táblázat: Hippoterápiás változók

Vizsgált paraméterek (1), Ülőpontok (2), Irányok (3), Ülőpont sebességkülönbség (4), Sebességkülönbség a bal és job oldali ülőpont között, a bol ülőpont maximális sebességénél (5), Az ülőpontok együttes közös, függőleges elmozdulása (6), Az ülőpontok közötti maximális vertikális távolság (7), Gyorsulás-lassulás (8), Mozgás a transzverzális síkban (9), Emelkedés - sűllyedés (10), Bal-jobb, emelkedés- sűllyedés (11), Horizontális, előre irányuló (12), Horizontális, transzverzális (13), Vertikális, dorsoventrális (14), Vertikális, dorsoventralis (15)

HT1 (sitting point velocity differences, cm/s)
From the aspect of hippotherapy, HT1 is one of the most significant kinematic parameters. The continuous straightaway fluctuation *in the mid-sagittal plane* is a successive acceleration and deceleration (in the direction of the movement) caused by alternation of the swing and stance phases of limbs of the horse. In the meanwhile it enhaces the forward and backward movements of the rider's human pelvis including the flexion and extension of the hip, the sacroiliac joint and the erection of the veretebral column. Horses with the lowest straightforward speed difference of the sitting points (low HT1) are better for riders having balance issues. These horses are suitable for first time riders or patients with spasticity. The higher HT1 values have positive effects on training the rider's trunk. Furthermore, the higher HT1 in free walk enables the therapist to collect the movement of the horse according to the needs of the patient.

HT2 (velocity difference between the left and right sitting points at the maximum speed of left sitting point, cm/s)
The degree of lateral torsion of the vertebral column of the horse determine the velocity of the sittingpoint *in the transversal plane*. This is measured quite accurately on the basis the velocity difference between sittingpoints (cm/s) at the maximum speed of one of the sitting points. The alternating acceleration and deceleration of the sitting points result backward and forward swinging in the patient's pelvis which stimulate the erection of the spine and intensely influence the control of balance.

HT3 (The common vertical displacements of the sittingpoints, cm)
Due to the phases of walk the up and down movement of the flexible vertebral column of the horse lifts and drops the patient in his upright position. This effect makes the rider coordinate the muscles of the hip and the proximal thigh. These vertical movements are important in hippotherapy. The higher common vertical displacements of the sittingpoints the more favourable because it lifts and drops the patient forcing the erected position.

HT4 (maximum distance difference between vertical amplitude of sitting points, cm)
The axial rotation of the vertebral column of the horse can be demonstrated by the vertical displacement differences of sitting points. The higher axial rotation movement of the vertebral column of the horse is also favourable which transforms to lateralflexion of the vertebral column of the patient relaxing the muscles.

Analysis of data
Statistical analyses were made on ten strides in each horse. Means (SD) were computed for the spatial, temporal and the hippoterapeutical variables with SAS software (SAS Institute Inc., SAS Campus Drive, Cary, NC, USA). The group means were analyzed for normality of distribution. Than one-way ANOVA and Duncan`s multiple range test were used to investigate the effects of the change of the horse on measured variables. A probability value of $\alpha = 0.05$ was chosen for all the statistical tests. Pearson's correlation coefficient analyses were used to asses the relationships between the equine conformation and kinematic variables.

RESULTS

Body proportions are shown in *Table 2*. The data shows the horses in the study are quite varied that can expectedly help to picture the kinematic differences between the individuals.

Table 2.

Body proportions

Body parameters (1) Horse (2)	Sitting point height (cm)(3)	Tuber coxae height (cm)(4)	Elbow height (cm)(5)	Elbow – tuber coxae distance (cm)(6)	Elbow – sitting point horizontal distance (cm)(7)	Sitting point – tuber coxae distance (cm)(8)
1.	152.8	141.3	91.1	87.9	42.5	45.4
2.	149.2	128.4	91.0	88.5	39.4	49.1
3.	153.6	136.7	87.0	98.9	50.4	48.4
4.	157.9	136.1	93.6	93.0	47.8	48.3
5.	148.5	133.7	81.6	99.5	47.3	52.2
6.	123.6	104.9	57.5	80.3	41.8	38.5
7.	152.5	141.5	79.0	100.7	47.2	53.5
8.	150.6	135.8	75.3	102.8	57.9	44.8
9.	140.3	123.9	68.3	79.0	33.1	45.8

10.	137.6	124.4	77.6	88.6	48.6	39.9
11.	149.0	133.5	75.1	101.6	49.4	52.2
12.	156.0	136.4	82.0	108.2	54.2	54.0
13.	131.5	120.2	64.6	85.0	38.8	46.2
14.	122.1	108.7	59.9	85.4	43.0	42.4
Mean±SD (9)	144.7±11.8	129.0±11.4	77.4±11.5	92.8±9.1	45.8±6.5	47.2±4.9

2. táblázat: Testméretek

Testméretek (1), Ló (2), Ülőpont magasság (3), Külső csípőszöglet magasság (4), Könyök magasság (5), Könyök-külső csípőszöglet távolsága (6), Könyök-ülőpont távolsága (7), Ülőpont-külső csípőszöglet távolsága (8), Átlag±szórás (9)

Statistics for the linear stride variables at free walk were determined (*Table 3*). Results of ANOVA and Duncan`s multiple range test indicate that the kinematics variables of horses were significantly different.

Linear stride variables
Means (SD) of the linear stride variables are summarized in *Table 3*.

Table 3.

Means and SD of the linear variables in the 14 horses in free walk. Accentuatation indicates the extreme values in the examined population

Variable (1) **Horse (2)**	**Step lenght (cm) ± SD (3)**	**Stride length (cm) ± SD (4)**	**Over-tracking distance (cm) ± SD (5)**
1.	85.9± 3	169.2 ± 7.0	8.5 ± 2.6
2.	84.7± 2.1	166.2 ± 10.3	7.7 ± 3.7
3.	83 ± 2	161 ± 2.2	9 ± 3.1
4.	95.5 ± 2.4	187 ± 7.3	19.9 ± 4.2
5.	98.1 ± 2.8	196.4 ± 4.3	27.2 ± 2.7
6.	65.3 ± 1.3	128.9 ± 2	3.8 ± 1.8
7.	91.9 ± 1.7	184.3 ± 4	26.8 ± 3
8.	84.8 ± 1.6	172.2 ± 3	10.8 ± 1
9.	89.8 ± 1.7	177.7 ± 3.4	18.4 ± 2.5
10.	74.5 ± 1	148.8 ± 2	3.6 ± 0.5
11.	91.1 ± 1.1	181.6 ± 1.8	17.8 ± 3.1
12.	89.5 ± 1.8	179.7 ± 2.7	11.1 ± 3.6
13.	84.6 ± 1.6	168.7 ± 3.5	25.8 ± 3.4
14.	70 ± 2.5	139.1 ± 3.2	13.7 ± 2.9
Mean±SD (6)	84.9 ± 9.4	168.6 ± 18.9	14.6 ± 8.2

3. táblázat: 14 ló lineáris változóinak átlagai és szórása szabad lépésben. A félkövér kiemelések a vizsgált populáció kiugró értékeit szemléltetik

Változók (1), Ló (2), Lépéshossz (3), Mozgásciklus hossz (4), Túllépés mértéke (5), Átlag±szórás (6).

The linear variables of horses were significantly different. The system recorded and processed data determining individual kinematic characters.

Hippoterapeutic stride variables
Statistics (mean, SD) of the hippoterapeutic stride variables are summarized in *Table 4*.

Table 4.

Statistics for the hippoterapeutic variables in the 14 horses in free walk. Values are mean and SD. Accentuatation indicates the extreme values in the population examined

Variable (1) Horse (2)	HT1 (cm/s) ± SD	HT2 (cm/s) ± SD	HT3 (cm) ± SD	HT4 (cm) ± SD
1.	25.3± 7.3	6.4± 1.0	4.6± 1.2	1.6± 0.7
2.	43.3± 7.4	7.1± 0.8	1.6± 0.3	1.5± 0.6
3.	8.6± 6.1	4.3± 1.6	3.5± 0.7	2.2± 0.4
4.	34.3± 11.9	10.9± 1.5	3.8± 0.7	1.4± 0.8
5.	67.7± 15.0	11± 1.2	3.2± 0.4	2.3± 0.4
6.	6.8± 2.1	2.8± 1.4	2.9± 0.3	2.3± 0.6
7.	38.2± 2.9	2.7± 1.1	3.3± 0.4	1.3± 0.4
8.	28.3± 5.1	6± 1.2	3.4± 0.6	2.9± 0.7
9.	41.9± 5.0	3.2± 1.8	3.9± 0.6	2.2± 0.5
10.	25.2± 5.6	3.6± 0.8	2.3± 0.5	2± 0.5
11.	32.3± 4.1	3± 1.0	4.6± 0.4	4± 0.4
12.	36.9± 8.4	8.3± 2.1	3.8± 0.6	2.2± 0.7
13.	57.2± 11.1	7.7± 1.7	2.7± 0.5	3.4± 1.0
14.	35.8± 8.4	10± 2.2	4.1± 0.4	2.1± 0.7
Mean±SD (3)	34±16	6±3	3±1	2±1

4. táblázat: 14 ló hippoterápiás változóinak statisztikája szabad lépésben. A félkövér kiemelések a vizsgált populáció kiugró értékeit szemléltetik

Változók (1), Ló (2), Átlag±szórás (3).

Correlation coefficients between the equine conformation and kinematic variables are shown in *Table 5*.

Table 5.

Correlation coefficients between the equine conformation and kinematic variables (P<0.01)

Body parameters (1) / **Linear variable (2)**	**Sitting point height (3)**	**Elbow height (4)**	**Tuber coxae height (5)**	**Sitting point – tuber coxae distance (6)**
step length (7)	r=0.77	r=0.59	r=0.77	r=0.81
stride length (8)	r=0.75	r=0.54	r=0.77	r=0.81
over-tracking distance (9)	r=0.15	r=-0.04	r=0.23	r=0.54
HT1	r=0.05	r=0.02	r=0.1	r=0.4
HT2	r=0.09	r=0.22	r=0.03	r=0.15
HT3	r=0.17	r=0.01	r=0.21	r=0.19
HT4	r=-0.17	r=-0.35	r=-0.14	r=0.03

5. táblázat: Testalakulás és a kinematikai változók közötti korrelációs koefficiensek (P<0,01)

Testméretek (1), Lineáris változók (2), Ülőpont magasság (3), Könyök magasság (4), Külső csípőszöglet magasság (5), Ülőpont-külső csípőszöglet távolsága (6), Lépés hossz (7), Mozgás ciklus hossz (8), Túllépés mértéke (9)

Significant correlations were observed between sitting point height and step- and stride length and we found the same correlation with sitting point – tuber coxae distance.

Significant correlations were not observed between hippotherapeutical measurements and body parameters, but we found significant correlation between the vertical amplitude of the tuber coxae and the sitting point height (r=0.72) and the elbow height (r=0.75) and tuber coxae height (r=0.68). We also find significant correlation between the maximum speed of the sitting point and elbow height (r=0.74). *Table 6.* shows correlation coefficients between all linear and hippotherapeutical variables.

Table 6.

Correlation between linear and hippotherapeutical variables (P<0.01)

	Step length (1)	**Stride length (2)**	**Over tracking distance (3)**	**HT1**	**HT2**	**HT3**	**HT4**
step length (1)	r=1.00	r=0.98	r=0.66	r=0.50	r=0.24	r=0.20	r=0.01

stride length (2)	r=0.98	r=1.00	r=0.67	r=0.53	r=0.23	r=0.22	r=0.04
over tracking distance (3)	r=0.66	r=0.67	r=1.00	r=0.65	r=0.25	r=0.17	r=0.12
HT1	r=0.50	r=0.53	r=0.65	r=-1.00	r=0.47	r=-0.10	r=0.13
HT2	r=0.24	r=0.23	r=0.25	r=0.47	r=1.00	r=0.05	r=-0.06
HT3	r=0.20	r=0.22	r=0.17	r=-0.10	r=0.05	r=1.00	r=0.18
HT4	r=0.01	r=0.04	r=0.12	r=0.13	r=-0.06	r=0.18	r=1.00

6. táblázat: A lineáris és hippoterápiás változók közötti korreláció (P<0,01)

Lépés hossz (1), Mozgás ciklus hossz (2), Túllépés mértéke (3)

Significant correlations were observed between all linear stride variables. We also find medium correlation between HT1 and the over tracking distance. There also was a tendency (r=0.47) between HT1 and HT2.

DISCUSSION

In our study the kinematics variables of horses were significantly different, so the method we used is suitable for assessing and comparing horses used in hippotherapy.

Horse nr.3 is ideal for the first hippotherapeutic training, due to the extremely low speed differences the riders can find their balance much easier, furthermore, it is also ideal choice for spastic patients. Horses nr.4 and nr.5 have excellent axial rotation effects on an experienced well-postured rider, this also results the most effective muscle relaxation. Horses nr.1 and nr.2 are ideal as hippotherapeutic horses as in motion characteristics they provided medium results suitable for patients multiple impairments.

Little work has been published on the effect of equine conformation on rider oscillation. This study showed significant correlations between step-, stride length and body parameters in free walk. It shows that taller and longer horses have longer step and stride length. Correlations were not observed between hippotherapeutical measurements and body parameters. We suppose that there are too many factors (body parameter) effect the movement of the sitting point of the horse.

We found significant correlation between the vertical amplitude of the tuber coxae and body parameters. It shows that tuber coxae of taller horses move on a bigger vertical range. *Barrey et al*. (2002) showed that Andalusia horses whose withers height, back length and forelimbs were smaller than German horses had smaller vertical amplitude.

There was a strong tendency (r=0.65) between sitting point velocity differences (HT1) and the over tracking distance. From the aspect of hippotherapy, HT1 is one of the most informative kinematic parameter. The continually forward fluctuation in acceleration and deceleration (in the direction of the movement) caused by changing the swing and stance phases of limbs of the horse enhances the forward and backward movement of the human pelvis, flexion-extension the hip and sacral pelvic joint and erection of the vertebral column. Horses low HT1 are better for riders having balance issues. These horses are suitable for first time riders or patients with spasticity. The higher HT1 values have positive effects on training the rider’s trunk. The over tracking distance is measurable easily, without any special equipment, so this is a useful information for the hippotherapeutists.

There also was a tendency (r=0.47) between HT1 and HT2 (velocity difference between the left and right sitting points at maximum speed of left sitting point). The lateralflexion of the equine vertebral column causes transverse movements of the sitting points. This results a rotation of the vertebral column of the patient relaxing the muscles of the trunk. The longest step length and over-tracking distance were noticed at individuals with high average HT2, because the lateral flexion of the vertebral column is determinate mostly by the step length of hindlimbs.

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