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Miroslav Janura, Christian Peham, Tereza Dvorakova, Milan Elfmark. An assessment of the pressure distribution exerted by a rider on the back of a horse during hippotherapy. *Human Movement Science*, 2009, 28 (3), pp.387. 10.1016/j.humov.2009.04.001 . hal-00538157

HAL Id: hal-00538157

<https://hal.science/hal-00538157>

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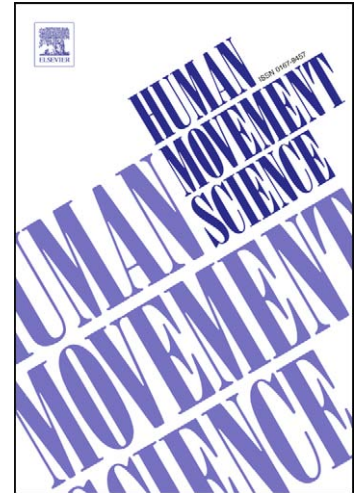
Accepted Manuscript

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PII: S0167-9457(09)00037-2
DOI: [10.1016/j.humov.2009.04.001](https://doi.org/10.1016/j.humov.2009.04.001)
Reference: HUMOV 1146

To appear in: *Human Movement Science*



Please cite this article as: Janura, M., Peham, C., Dvorakova, T., Elfmark, M., An assessment of the pressure distribution exerted by a rider on the back of a horse during hippotherapy, *Human Movement Science* (2009), doi: [10.1016/j.humov.2009.04.001](https://doi.org/10.1016/j.humov.2009.04.001)

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**AN ASSESSMENT OF THE PRESSURE DISTRIBUTION EXERTED BY A RIDER
ON THE BACK OF A HORSE DURING HIPPO THERAPY**

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Abstract

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. The aim of the present study was to assess the changes in magnitude and distribution of the contact pressure between the rider and the horse during a series of hippotherapeutic lessons. The monitored group, consisting of four healthy women (mean age 22.75 years, mean body weight 59.75 kg, mean height 167.25 cm) without any previous horse riding experience, received five 20 minute-lessons lessons in a three-week period. Hippotherapy was given on a 15-year-old thoroughbred mare. An elastic pad (Novel Pliance System, 30 Hz, 224 sensors) was used for pressure magnitude evaluation. The maximum pressure value was increased ($p < .05$) in the event of a second measurement (5th lesson). The pressure exerted on the rider upon contact of the rear limbs was higher than upon contact of the front limbs ($p < .01$). The size of the COP deviations in the anteroposterior direction reduced ($p < .05$) with the number of lessons received. With the growing experience of the participant, an increase in pressure occurred on contact of her body and the horse's back as well as in the stability of the COP movement.

Keywords: Physical Therapy, Horse, Pressure

PsycINFO Classification: 3357

1.0 Introduction

Hippotherapy is usually ranked among the proprioceptive neuro-muscular facilitation methods (Benetinova, 2000; Engel, 2003; Holly & Hornacek, 2005; Künzle, 2000). It involves four general principles of facilitation: integration of motor afference, activation of one muscle facilitating other muscles in a given locomotion chain, activation of the lumbar system as a fundamental exercise in its own right, and activation of the responsible muscle groups on the contralateral side of the body. Hippotherapy employs locomotion impulses that are emitted from the horse's back while the horse is walking and that induce a therapeutic effect. The rhythmically oscillating back of a horse mainly stimulates a rider's postural reflex mechanisms, resulting in training of balance and coordination (Engel, 2003; Künzle, 2000; Rothaupt, Laser, & Ziegler, 1998; Strauss, 2000). The patient is positioned on the horse according to the degree of his or her kinetic development, from the most stable lying down positions to a sitting position.

A horse's walk involves a delicate coordination of neck, trunk, and limb muscles. The locomotor impulses from the horse's back are transferred to the rider at a frequency of 90-110 impulses per minute (1.5-1.8 Hz) in three movement planes (Taufkirchen, 2000). An essential prerequisite for success of this treatment method is the selection of a suitable horse for a given patient. The leverage of the horse is affected by its conformation, movement mechanics when walking, its temperament, and other variables (Hermannova, 2002). The physiotherapist's task involves evoking optimal conditions for the fastest possible creation of a "locomotion dialogue." The horse leader has a significant share in the final outcome, which can be significantly affected by any inappropriate intervention (Strauss, 1995).

Thus far, research on hippotherapy has been mainly focused on its therapeutic benefit. Lechner, Kakebeeke, Hegemann, and Baumberger (2007) analyzed the effect of hippotherapy on spasticity and on the mental well-being of persons with spinal cord injury. Other studies

examined the effect of therapeutic riding in children with cerebral palsy (Bertoti, 1988; Sterba, Rogers, France, & Vokes, 2002). Kubota et al. (2006) found that in elder diabetic patients, mechanical horseback riding enhances the insulin-induced glucose uptake.

In equine studies biomechanical methods such as pressure measurement have been used to evaluate the force acting upon the back of a horse with various saddles (Fruehwirth, Peham, Scheidl, & Schobesberger, 2004; Winkelmayr, Peham, Fruehwirth, Licka, & Scheidl, 2006). The influence of the width of the saddle tree on the forces and the pressure distribution under the saddle was analyzed by Meschan, Peham, Schobesberger, and Licka (2007). One of the objects of other studies that used a pressure measurement mat was saddle fit (de Cocq, van Weeren, & Back, 2006).

In hippotherapy, the effect of equine motion and its transfer to the rider's body is of main interest. Quantification of the dynamic parameters defining the interaction between both contact surfaces is essential to validate theoretical models that form the basis for clinical hippotherapy. The tools developed in various equine studies can be of great help in achieving this goal.

The aim of the present study was to examine the changes in magnitude and distribution of the contact pressure between the rider and the horse during a series of hippotherapy lessons.

2.0 Methods

2.1 Participants

Four healthy women (mean age 22.75 years, mean body weight 59.75 kg, mean height 167.25 cm) without any previous horse riding experience volunteered to participate in the study. All participants were familiarized with the possible risks, the course, and the conditions of measurement, and gave their unreserved consent before the actual lessons and measurements.

2.2 Therapeutic horse characteristics

Hippotherapy was conducted on a 15-year-old thoroughbred mare (withers height 165 cm, weight 487 kg). The horse had been used for hippotherapy since 1995. It was thus prepared in a long and systematic manner for handling unusual situations and tolerating strangers and unusual objects. At the time of measurement, the horse was in a good state of health. One week prior to the first measurement, a test-session using the measuring equipment was conducted in the presence of a hippologist. The horse did not show any signs of restlessness and thus was considered apt for the study.

2.3 Measuring equipment

The pressure forces on the saddle were measured with a double elastic pressure pad (Pliance System, Novel Company, Munich, Germany) at a sample frequency of 30 Hz. The pressure pad comprised 224 sensors (3.2 cm × 2.5 cm), configured in 16 rows and 14 columns. The pad was divided in two halves, which were bound together with adhesive tape. The entire pad was covered in neoprene with a total thickness of 2.6 mm, thus enabling direct measurement of the pressure forces exerted on the saddle during hippotherapy.

2.4 Measuring process

All participants underwent, for the purpose of the study, a series of five hippotherapy lessons, held twice a week for a period of 20 minutes. During the first and the fifth lesson, force pressure measurements were conducted on the premises of a riding club on a horizontal asphalt surface. The recordings were made during the first five minutes of the lesson in question. Forty-eight cycles were measured for each participant. The saddle mat was placed on the horse's back in such a manner that its central region was situated directly above the

center of the horse's back. Before the actual measurement, the pad was initialized to zero after placing the pad on the horse. The horse was led by a leader from the front.

During each lesson, a physiotherapist, who had completed a specialized hippotherapy course, would accompany the horse with a participant. She actively corrected the participant when necessary and insured that hippotherapy was strictly applied in accordance with standard guidelines.

2.5 Data processing – evaluated parameters

Recordings from the pad were related to stride cycles using kinematic data of the left fore hoof using a dedicated soft-ware package (MATLAB, Version 7.0.1, The Mathworks, Inc., Natick, Massachusetts, USA), and expressed in relative time as a percentage of the stride cycle. From the measured pressure data the average and the maximum pressure were determined. In addition, the location of the center of pressure (COP) was calculated for significant moments in the stride cycle (i.e., impact of the horse's limbs) (Fig. 1). The maximum pressure and its variability were complemented with the COP deviation in anteroposterior and mediolateral directions. A one-way ANOVA for repeated measurements with an LSD Fisher's post-hoc test were performed using a dedicated soft-ware package (STATISTICA, Version 6.0, Stat-Soft, Inc., Tulsa, Oklahoma, USA). In all tests and comparisons, p -values less than .05 were deemed significant.

Fig. 1. Graphic representation of COP deviations in anteroposterior direction of a selected individual (thick line represents average value)

3.0 Results

3.1 Maximum pressure size

Comparison of the maximum pressure sizes (see Table 1) revealed that in the event of a second measurement (5th lesson of hippotherapy) an increase in pressure at all monitored points of the curve occurred (see Fig. 2). The differences of the maximum pressure between the first and the fifth lesson were statistically significant ($p < .05$) upon the impact of the horse's rear limbs. The pressure upon contact of the rear limbs was higher than upon contact of the front limbs ($p < .01$).

Table 1. Maximum pressure values (N/cm^2) as monitored during the first and the fifth hippotherapy lesson (Lesson = received hippotherapy lesson; RR = contact of rear right limb, FR = contact of front right limb, RL = contact of rear left limb, FL = contact of front left limb, p = probability level).

Limb	Lesson 1		Lesson 5		p
	Mean	SD	Mean	SD	
RR	1.568	0.150	1.937	0.380	.044
FR	1.331	0.154	1.575	0.339	.227
RL	1.548	0.149	1.962	0.388	.047
FL	1.382	0.130	1.630	0.285	.218

Fig. 2. Comparison of maximum pressure of monitored individuals during the first and fifth hippotherapy lesson.

With the growing experience of the participant, an increase in pressure at the contact of her body and the horse's back occurred. The pressure difference between the first and fifth hippotherapy lesson was greater than in the course of any given lesson.

3.2 Maximum pressure stability

The stability of the maximum pressure was assessed for all participants by establishing the intraclass correlation coefficient (ICC) based on 48 motion cycles values in each lesson. In the first lesson the ICC fell within the range of .84-.90 for all participants. In the fifth lesson the ICC increased significantly ($p = .082$) to the range of .90-.97. Thus, with increasing time spent on the horse's back, the stability of the postural reaction to the horse's motion increased.

A reduction in pressure variation occurred within a relatively short period of time at the beginning of both the first and the fifth hippotherapy lesson. The stability did not differ within a single lesson.

3.3 COP deviations at contact of the rider's body with the horse's back

The COP deviations in mediolateral direction and in anteroposterior direction reduced with an increasing number of hippotherapy lessons. The standard deviation, which indexes the extent of the movement in the anteroposterior direction, changed from 1.19 cm in the first lesson to 0.977 cm in the fifth lesson ($p < .05$). In the mediolateral direction a reduction of 0.650 cm to 0.551 cm occurred.

3.4 Stability of COP deviations at the contact of rider's body with the horse's back

The COP movement was characterized by a tendency to higher stability for sway at the contact of the rear left limb with increasing experience of the participants (see Table 2, see Fig. 3).

Table 2. Stability of COP movement (cm) in mediolateral (Swayx) and anteroposterior directions (Swayy) at selected points of the stride for the monitored group during the first and fifth hippotherapy lesson. Lesson –underwent hippotherapy lesson; RR –contact of rear right

limb, FR –contact of front right limb, RL –contact of rear left limb, FL –contact of front left limb, p – significance level.

Limb	Swayx				p	Swayy				p
	Lesson 1		Lesson 5			Lesson 1		Lesson 5		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
RR	1.027	0.646	0.630	0.306	.378	0.328	0.084	0.281	0.077	.497
FR	1.449	0.543	0.783	0.266	.145	0.340	0.117	0.240	0.081	.158
RL	1.013	0.724	0.740	0.547	.542	0.372	0.154	0.238	0.068	.064
FL	0.816	0.344	0.824	0.399	.986	0.289	0.051	0.231	0.070	.407

Fig. 3. Graphic comparison of the stability of COP movement in the anteroposterior direction for the monitored participants during the first and fifth hippotherapy lessons.

4.0 Discussion

The use of a pressure-measuring pad is an effective means to quantify the contact forces between the rider's body and the horse's back. By evaluating the magnitude and distribution of the forces and the COP trajectory, the effects of the rider on the equine back can be assessed (Fruehwirth et al., 2004). Several previous studies have investigated the force transmission under the saddle (Harman, 1994; Jeffcott, Holmes, & Townsend, 1999; Meschan et al., 2007). Nevertheless, the present authors could not find any report on the use of this system in hippotherapy where the contact is accomplished without a saddle.

The basic change connected with the increase of the client's or participant's riding experience (14 days, 5 hippotherapy lessons) was an increase in pressure values at the points of contact between his or her body and the horse's back. There is a correlation between the skill of the rider and the consistency of motion of the ridden horse (Peham, Licka, Girtler, & Scheidl, 2001). We attribute this fact mainly to the gradual mastering of the new locomotor activity and a corresponding relaxation at the physical as well as the mental level. It is known

that at the beginning of riding sessions, similar to learning any new locomotor activity, there is an accompanying higher tension (muscle tone) with changes in the physiological functions of the individual. In the case of equitation increased muscle tone appears mainly in the area of the lower trunk, pelvis, and the thighs. It causes a certain amount of redistribution of load away from the area of the ischium and thus also an initial reduction of pressure values. Gradual relaxation leads to adjusting to the horse's movement when fully "seated" on its back. These changes show considerable variation depending upon the rider in question, which can be attributed to various levels of mastering the given locomotor activity. Changes in the patient's movement pattern, which appear during hippotherapy, present themselves relatively early. Since hippotherapy engenders a potent emotional experience, we can also expect better memory fixation if the induced emotions are tuned in a positive manner (Ionatamishvili, Tsverava, & Avaliani, 2001).

There exists a linear relationship between the rider's body mass and the pressure under the saddle (Jeffcott et al., 1999). The total force (pressure) transmitted via the pad is closely correlated to the rider's body weight (de Cocq et al., 2006; Fruehwirth et al., 2004).

Analyses of the COP distributions revealed how the rider exerts a stabilizing effect on the load of the back (Fruehwirth et al., 2004). Larger (excessive) muscle activity results in a higher position of the center of gravity above the horse's back at the beginning of therapy. In that case, impulses generated by the horse's movement will become manifest as a greater amplitude of motion of the participant. At the same time, due to a certain degree of disharmony between the movement of the horse's back and the participant's body, a higher variability in the position of the point of application of a reaction force will occur.

The lateral movement of the horse's abdomen produces COP deviations in a medio-lateral direction. It is followed by the rider's pelvic movement. In this direction, the center of gravity of the rider's body deviates from the expected direction of wilful locomotion. COP

deviation values are higher here in comparison to the anteroposterior movement and the movement is characterized by less stability. Jeffcott et al. (1999) reported that the combination of an unbalanced horse and rider caused large lateral deviation of the COP.

In hippotherapy, we utilize the horse's ability to deviate in medio-lateral direction for patients with cerebellar function disorders. On the other hand, for generally unstable to hypotonic patients, we utilize a tolerant horse that is balance-wise unexacting for the participant. We must always take into consideration that input information from the periphery (step frequency, step length) has to be supplied in adequate doses and in sufficient intervals (Hermannova, 2002).

The COP anteroposterior deviations are characterized by more pronounced tendencies to reduce the extent of deviations with the participants' growing experience. The COP movement in the direction of horse's locomotion is less demanding in terms of balance maintenance for the CNS. Locomotor impulses of a walking horse arise from the take-off of the rear limbs and the impact of the front limbs. These findings confirm practical experience from hippotherapy where the bound energy, softness of tread, and frequency of step are values that mainly affect the patient's muscle tone.

Since the aim of the present research was to discover and verify the theoretical regularities without clinical conclusions, the authors only invited healthy individuals to participate in the experiment. In this group, we expected a "normal or natural" reaction to the horse's movement. We increased the demand on balance by the non-existence of handles, which in regular therapy are used for manual grasp. The narrow back of a thoroughbred horse induced maximal stimulation of balance function in a healthy body. We assume that due to an increase of these demands, the obtained data are also valuable for other population groups. With respect to data collection and analysis, we may conclude that inviting only healthy

individuals to participate was an adequate choice for the purpose of this study. Despite the small sample of participants, we can deduce prerequisites for further research in this field.

In particular, we believe that the present research theme and measurement method will be beneficial for hippotherapy. In particular, for the future, we recommend to use this method not only in theoretical investigations of the locomotor coordination between a horse and a patient during therapy, but also to directly evaluate and enhance the quality of hippotherapy in specific individuals.

Acknowledgment

The work reported in this article was supported by grant MSMT CR VZ 6198959221.

References

- Benetinova, J. (2000). Hipotherapy and its importance in the treatment of the patients with consequences after craniocerebral and spinal cord injuries [in Czech]. *Rehabilitacia*, 2, 99-105.
- Bertoti, D. B. (1988). Effect of therapeutic horseback riding on posture in children with cerebral palsy. *Physical Therapy*, 68, 1505-1512.
- de Cocq, P., van Weeren, P. R., & Back, W. (2006). Saddle pressure measuring: Validity, reliability and power to discriminate between different saddle-fits. *Veterinary Journal*, 172, 265-273.
- Engel, B. T. (Ed., 2003). *Therapeutic riding II. Strategies for rehabilitation* (3rd edition). Durango, CO: Barbara Engel Therapy Services.
- Fruehwirth, B., Peham, C., Scheidl, M., & Schobesberger, H. (2004). Evaluation of pressure distribution under an English saddle at walk, trot and canter. *Equine Veterinary Journal*, 36, 754-757.
- Harman, J. C. (1994). Practical use of a computerized saddle pressure measuring device to determine the effects of saddle pads on the horse's back. *Journal of Equine Veterinary Science*, 14, 606-611.
- Hermannova, H. (2002). From enthusiasm to the professionalism or from carting to the methodology [in Czech]. In *Sbornik praci z hiporehabilitacih seminaru, 24. 5. 2002* (pp. 1-9). Plzen: Ustav socialni pece pro telesne postizenou mladez ve Zbuchu.
- Holly, K., & Hornacek, K. (2005). *Hippotherapy. The treatment by means of equine* [in Czech]. Ostrava: Montanex.
- Ionatamishvili, N., Tsverava, D., & Avaliani, L. (2001). Riding therapy rehabilitation methods of child cerebral palsy. *Scientific & Educational Journal of Therapeutic Riding*, 7, 7-14.

- Jeffcott, L. B., Holmes, M. A., & Townsend, H. G. (1999). Validity of saddle pressure measurement using force-sensing array technology – preliminary studies. *Veterinary Journal*, *158*, 113-119.
- Kubota, M., Nagasaki, M., Tokudome, M., Shinomiya, Y., Ozawa, T., & Sato, Y. (2006). Mechanical horseback riding improves insulin sensitivity in elder diabetic patients. *Diabetes Research and Clinical Practice*, *71*, 124-130.
- Künzle, U. (2000). *Hippotherapie auf den Grundlagen der funktionellen Bewegungslehre Klein-Vogelbach*. Berlin: Springer.
- Lechner, H. E, Kakebeeke, T. H., Hegemann, D., & Baumberger, M. (2007). The effect of hippotherapy on spasticity and on mental well-being of persons with spinal cord injury. *Archives of Physical Medicine and Rehabilitation*, *88*, 1241-1248.
- Meschan, E. M., Peham, C., Schobesberger, H., & Licka, T. F. (2007). The influence of the width of the saddle tree on the forces and the pressure distribution under the saddle. *Veterinary Journal*, *173*, 578-584.
- Peham, C., Licka, T., Girtler, D., & Scheidl, M. (2001). The influence of lameness on equine stride length consistency. *Veterinary Journal*, *162*, 153-157.
- Rothaupt, D., Laser, T. & Ziegler, H. (1998). Hippotherapy and its position in rehabilitation [in Czech]. *Rehabilitacia*, *1*, 34-37.
- Sterba, J. A., Rogers, B. T., France, A. P., & Vokes, D. A. (2002). Horseback riding in children with cerebral palsy: Effect on gross motor function. *Developmental Medicine & Child Neurology*, *44*, 301-308.
- Strauss, I. (1995). Das Therapiepferd. *Therapeutisches Reiten*, *4*, 14-18.
- Strauss, I. (2000). *Hippotherapie, neurophysiologische Behandlung mit und auf dem Pferd* (3rd ed.). Stuttgart: Hippokrates.

Tauffkirchen, E. (2000). Kinder-Hippotherapie. In I. Strauss (Ed.), *Hippotherapie, neurophysiologische Behandlung mit und auf dem Pferd* (pp. 107-166). Stuttgart:

Hippokrates.

Winkelmayr, B., Peham, C., Fruewirth, B., Licka, T., & Scheidl, M. (2006). Evaluation of the force acting on the back of the horse with an English saddle and a side saddle at walk, trot and canter. *Equine Veterinary Journal, Suppl. 36*, 406-410.

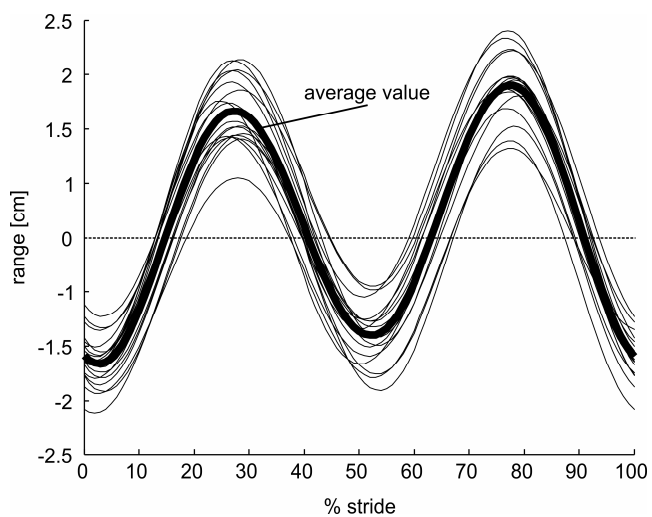


Fig.1

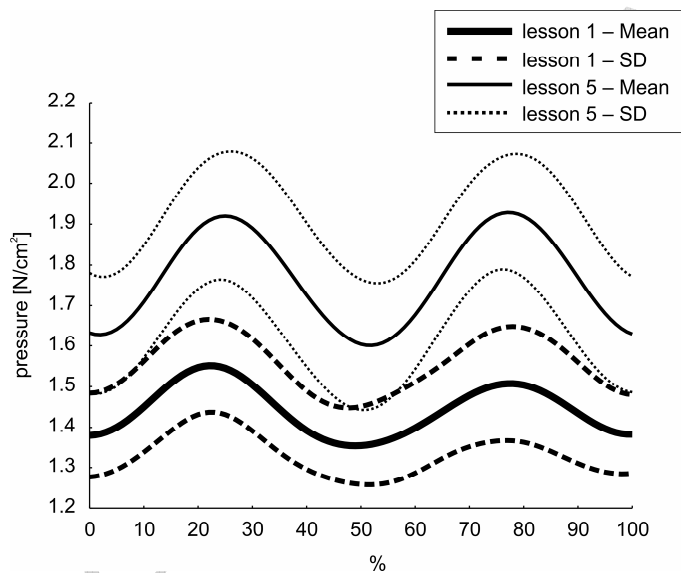


Fig.2

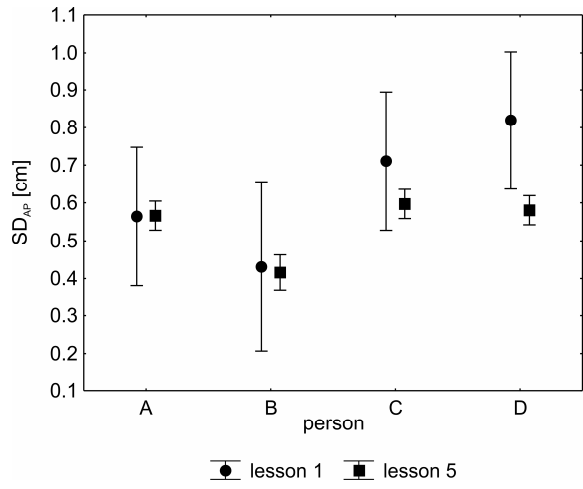


Fig.3