ABSTRACT

Jumping over obstacles, like other branches of equestrianism, is a point of interest in development and modernization if horsemanship. Because equestrian sports have requirements specifically targeted towards the enlargement of formative influences for high level developement of physical qualities, it is necessary for the instruction in training programs to be modernized using new ways and solutions.

To obtain athletic performance, both in humans and animals, it is necessary to know in detail the kinetic movement correlated with biochemical and physiological phenomena which allow the development and evaluation of physical effort.

Accumulating these experimental data we can understand the mechanisms that can lead to sport horse's performance or counter performance, this phenomena being a constant challenge for training team of horse-rider pair (veterinarian, trainer, horse owner).

The purpose of this research is oriented towards the improvement of physical, technical and tactical training at jumping over obstacles discipline, by optimizing the means and methods used in training; optimization is an accurate way to approach the structure of training process, based on the unity of training priciples, on the particularities of the studied theme content, all forms and methods of training, as well as learning particularities of the experimental group.

By conducting a detailed research in literature was found that equine training programs for jumping over obstacles has not been studied previously. Previous research have shown that obstacles height (*Sloet* şi colab*.,* 1995) and speed (*Munk,* 2009) will influence horse blood lactate concentration. Given these facts, we must consider several parameters as required for objective evaluation of physical condition for jumping. Besides, the need of standardized tests which include jumping over obstacles become obvious for physical condition determination, which is specific for the effort made in obstacles trail. In riding in field conditions, were used heart rate and lactate concentation for measuring the intensity of exercises. (*Persson,* 1983*; Sloet şi colab., 1987; Sloet şi Barneveld, 1995)*.

Doctoral thesis ,''Research on sport horses physical qualities developement in pre-competition phase at jumping over obstacles discipline" shows the effects of different intervals of training which led to a significant improvement on the descriptive indices of the physical

condition defined by heart rate, lactate concentration, speed, number of obstacles thrown down, the energy and technique of the jump, on the metabolic state described by evaluating hematological and biochemical profile and on the jumping over obstacles biomechanics, characterized by descriptive parameters of propulsion, soaring and landing.

The paper is structured in two distinct parts: the first part presents in five chapters a research in literature on wide variety of published results reffering to training and physiological factors which may have influence on horses physical qualities, and the second part, which include my own research, detailed in five chapters in which the general objectives were founded on the evaluation of the effects caused by two different training patterns (constant practiced training and a training model in which are included gallop, sprint and jumping exercises) on the metabolic profile (defined by hematological and biochemical indices) which reflects on the equine physical condition, evaluated before, during and after making effort through lactate concentration, heart rate, speed, number of obstacles thrown down, jumping technique and energy. Besides, in thesis are included the summary, introduction, conclusions, recomadations and references.

Getting horses athletic performances in conditions of health security is directly correlated with understanding the influence and interaction between the typology of applied training methods and the factors that depend on the organism, after *Gogny and Souilem* being morpho-functional, psychological, environmental and food factors, in current research we intend to approach in detail the pre-competitional period in terms of improving the sport horse training and dressage methodology in relation with the specific individuality of each studied specimen.

Morphologically speaking, the horse qualities are genetically transmitted, such as overall conformation, muscle mass / body weight ratio, metabolic type of muscle fiber and conformation of the respiratory tract.

Most of the physiological factors are influenced by training, being correlated with the production of energy in different metabolic pathways, as well as the cardiovascular and respiratory necessary adaptations for the transport of the precursors from the site of synthesis and utilization of ATP.

Psychological factors, some of them hardly measurable, like motivation during the effort, human-horse relationship and social interrelations may have a decisive influence on athletic performance.

Social and environmental factors, most of them uncontrollable, such as: transport at the competition, meteorological factors (temperature, humidity, wind), condition of the competition field (track quality, slope,obstacles shape and color), environmental factors (sound level, public behavior, aggressiveness of the competition partners), the start type (individual departure, in line, in group), all these factors are involved in multiple stresses undergone by sport horse.

To achieve the objective, the investigations were conducted on a total of 10 stallions, representatives of Romanian sport horse, each of it having a specific background, both in terms of competitions and pre-competitive training.

Prior to commencement of initial evaluations, knowing the results from jumping competitions and coaches indications, the horses were divided in two experimental groups (GroupC and Exp Group), constituted depending on age, performance and random selection. The horses are from Dumbrava stallions warehouse, located in Dumbrava village, Timișești, Neamț county.

Considering that the experimental protocol of the current research includes monitoring and developement of physical qualities defined by speed, strenght and resistance, it was fallowed features improvement by improving the specific parameters, which are:

- blood parameters: hematological - erythrocyte indices (the number of erythrocytes- RBC, hemoglobin – HGB, medium erythrocyte volume – MCV, the hematocrit – HCT), leucocytar indices (the number of leucocytes – WBC) and biochemical (total proteine, glucose, lipids, triglycerides, fatty acids, calcium, potassium, sodium, chloride, and phosphate)
- physiological parameters : maximum, medium and at rest heart rate and the concentration of lactic acid after each round, at V2 and V4 and two minutes after finishing the exercise.
- techincal parameters: speed (V2 at 2 mmol/l lactate concentration and V4 at 4 mmol/l lactate concentration), the number of the obstacles thrown down at jumping over obstacles discipline, as well as the jumping technique and the energetic level evaluated by an observer and a horseman.
- descriptive parameters for jumping biomechanics: propulsion : Vxtotal – speed on a horizontal plane of the center of gravity in final part, V_{XT0}- speed on a horizontal plane of center of gravity, V_{YT0}- speed on a horizontal plane of ceneter of gravity, angle of center of gravity, H_{T0}- vertical distance between the center of gravity and soil, D_{T0} – the horizontal distance between the center of gravity and the first element of the oxer, $LdHCG_{TO}$- the horizontal distance between hindlegs and center of graviry, tarsal right angle at the propulsion, tarsal left angle at the propulsion, carpal right angle at the propulsion, carpal left angle at the propulsion; for soaring : $H_{planare}$ – soaring height and for landing : V_{XAT}- the speed in a horizontal plane of center of gravity at landing, V_{YAT}- the speed in a verical plane of center of gravity at landing, H_{AT} - vertical distance between center of gravity and soil at landing, D_{AT} – horizontal distance between the oxer's second element and the center of gravity at landing.

The analysis methods usend in my own research are included in a legislative framework,

provided in the Romanian Standards, harmonized with European Community law and International Standards, or in accordance with the methods used in literature.

Evaluation of equids physiological status revealed the following:

The dynamics of hematological indices reflect higher values after completing cross test, in compared with the values from the samples taken before cross test for both horses groups.

At the initial evaluation (before making effort) the hematological indices results showed very similar values for both groups, but after cross tests is found that Lc horses stood out by higher values compared with horses from Lexp, which have been subject to a more intensive training during training sessions.

Comparing these results with those obtained by other authors (*Stewart, (1977); Mason and Kwok (1977); Revington (1983); Snow (1983); Allen and colab. (1984)andi Carlson, (2008*)) in literature is found that the horses are in a good physiological condition.

Pronounced blood changes are transient and return to rest values in a few minutes after ceasing the effort.

Average values which defined hematological indices (RBC, HGB, HCT and MCV) showed dominant superiority for samples taken from both groups sport horses after performing jumping over obstacles tests. This superiority didn't indicate significant statistically differences when we compare both groups samples taken before and after jumping over obstacles than for RBC at Lc ($p<0,001$).

If in the initial moment (before making the effort) for hematological indices there were no significant diferences between the two groups depending on the type of training practiced previos research, after practicing eight special training sessions by Lexp, evaluating the physiological condition through blood constants showed significant diferences for RBC ($p<0,01$) and distinctly significant for HCT ($p<0,001$) between the two groups. Lexp stands up through lower values for most of indices after making the effort, as a response to intensive training, showing a significant improvement in the metabolic state and physical condition.

Regarding the medium values of leukocyte is distinguished a downward trend between initial moment of blood samples collection and those taken after makeing the effort (races completed after 8 weeks of differentially training depending on the group.) Thereby, for this indicator were highlighted significant diferences statistically speaking ($p<0,001$) at Lexp between the results of the samples taken before and after jumping over obstacles.

Regardin mineral profile, the medium obtained values for both groups presented a ascending trend from the initial moment to the final moment after cross tests. Dominant superiority is found for measured values after cross test for all mineral indices, results which reflect the existing of very significant diferences ($p>0,001$) between two measuring range both for Lc horses and Lexp horses for Na, K, PO_4 and Ca only for Lc. Statistical analysis in terms of the type of training applied between the evaluations reflect insignificant differences between the two groups for before effort evaluation, the differences standing out after performing cross test, ($p<0,001$) for Na and PO4, and very significant ($p>0,001$) for Ca.

Analysing mineral indices before and after jumping over obstacles for both groups, it was shown that the values fit in the limits of reference presented in literature by *Carlson and Mansman, 1974; Keenan, 1979; Snow and colab., 1982; Judson and colab., 1983; Craig and colab., 1985*, as they were presented previosly.

We notice the difference in value between the two groups for the Na content obtained after effort, standig out the horses which were subject to an intensive training by smaller electrolyte concentration increase after making the effort *(table 8.4)*. These variations, in terms of the moment of sampling (between effort vs. after effort) are highlighted through statistical analysis, being shown very significant diferences ($p>0,001$) both for Lc and Lexp for Na, C, PO_4 concentrations, and for K just at Lc.

Regarding the statistical comparisons between the two groups of horses, we distinguish the significant differences ($p<0,01$) before making the effort just at Na concentration, and after making the effort are very significant differences ($p>0,001$) for Na, distinctly significant differences ($p<0,001$) for Ca and significant ($p<0,01$) for K.

At equine cross tests from the studied two groups, the value of energetical indices presented a increase after effort, by reporting to those obtained in the initial moment of the research (before effort and special trainings).

This variation of values after the effort is highlighted through statistical analysis, showning significant differences between the two groups (Lc vs. Lexp) after effort and very significant differences both for Lc and Lexp by comparison of the obtained values before effort vs, after effort. Testing the semnification of the differences between before and after values in the case of tryglicerides, it's shown that between Lc and Lexp are significant differences ($p<0,01$). Testing between obtained values before and after effort vs obtained values after effort it's been showed very significant differences ($p>0,001$) both for Lc and Lexp. The values of fatty acids in cross test have a oscillatory amplitude of values.

We distinguish a slight increase of protein content after the effort in both of the groups. Total protein presented significant differences ($p<0,01$) statistically speaking, for compared values between both groups after effort and for Lc through comparison of the values obtained before effort with the values obtained after effort.

Statistical tests that were effectuated for fatty acids showed very significant differences ($p>0,001$) for the values between the two groups (Lc vs. Lexp) after effort as well as between the obtained values before effort vs. after effort, both for Lc and Lexp.

Evaluation of the influence of training on sport horses

Equine speed at a lactate concetration of 4 mmol/l increases with the level of the training and the heart rate depends on the intensity, duration and frequency of its training.

Given the fact that till now there have been no research in terms of corelation between effort, medium heart rate and maximum heart rate, it jas been found that it is necessary

contucting the research of which has been highlighted that the maximum heart rate is an useful parameter in determination of sport horse physical condition.

By applying the three standardized tests, it has been showed that Lexp obtained significant better result than Lc, which have shown no improvement.

Approaching the biochemical physiological processes was dictated by the need of identification of practical methods of objective evaluate the sport horse energetical capacity, which can help to specifically measure the duration and intensity of trainings, as well as to apreciate the effects of these processes on the level of physical condition.

Heart rate (describet through FC2 and FC4) during the gallop race was significant improved at both groups after applying those two patterns of training, noting that the Lexp equines larger differences , experienced a higher heart rate value decrease after training period.

We highlight the fact that before applying two types of training, the values of both groups were included in uniform areas of variation, conversely, after eight sessions of special training, Lexp is distinguished by the high values both in V_{LA2} and V_{LA4}, concluding that this type of training has a positive impact on sport horses physical condition.

By applying TS2, the medium values of maximum heart rate and medium heart rate were higher in the initial moment (T0) than the measured values after 8 weeks of training (Tf), being noticed the positively impact of the trainings on both groups. It can be seen that the medium values of heart rates increase proportionally with those of plasma lactate during the three measurement intervals. It can be concluded that Lexp showed clear improvement of physical condition as response to the 8 special training sessions practiced.

We also highlight that in the initial moment (T0) the two groups had very close values, statistical differences being insignificant ($p<0,05$) in all intervals in which the measurements were taken, and in final moment (Tf) the values uniformity is not kept, blood lactate concentration with higher values being presented for Lc equines in all measurement intervals, statistical differences between the two groups after training period being very significant ($p>0,001$) both for the 3 intervals and after 2 minutes from effort.

Looking from the differences occuring for equine physical condition perspective (expressed in blood lactate concentration during and after effort) between the two periods of taken measurements (before and after training) it's been showed that Lc equines have insignificant improved its physical condition, the medium values ranging in related fields.

Instead, for Lexp equines it's showed that the training had a significant effect on physical condition in terms of performinng jumping over obstacles in the standard teste no. 2, the medium values of lactate concentration from the 3 followed intervals and 2 minutes after effort being lower after training than before training period. The level of lactate shows the Lexp equine aerobic capacity improvement, during training periods.

In TS2, blood lactate concentration two minutes after effort shows a distinctly significant improvement for Lexp equines, that being very important for planning training sessions.

The average number of thrown down obstacles increased with every jumping interval, this result being unsurprisingly, because the hight of the obstacles was increased at the same time in wich the horses bicame tired. The number of thrown down obstacles in every jumping interval and the total number of thrown down obstacles decreases after 8 weeks period of training. Lexp equine stand out through a significant decrease of thrown down obstacles number after training period, in comparison with Lc equine which have a decrease of obstacles number, but not that pronounced.

In terms of jumping technique, there were not revealed significant effects of training for both groups, instead, the energy level during the jump was significantly improved ($p<0,01$) for Lexp after training.

There are no differences between the two equine groups for thrown down obstacles in the three jumping intervals in T_0 moment (before training), instead, after applying the differentiated training sessions on the two groups is remarkable the fact that are significant differences ($p<0,01$) in 2 and 3 intervals between Lexp and Lc, and distinctly significant differences for the total number of the thrown down obstacles. It can be concluded that the Lexp physical condition was improved after 8 weeks of training.

After evaluating the technique and jumping energy by equestrian, it showes that in T0 moment the differences between the two groups are unsignificant, instead, after the training sessions, Lexp equines were appreciated by higher score, highlighting significant differences between the two groups. The training method proposed by current research showed a distinctly significant improving effect ($p<0,001$) on heart rate evaluated in three jumping intervals, very significant ($p>0,001$) for lactate concentration and significant for thrown down obstacles number, jumping technique and energy.

The thrown down obstacles total number on the three intervals at the application of TS2 in Tf moment showed values that are involving the existance of distinctly significant differences ($p<0,01$) between the two groups as a response to the type of training.

In TS3 decreasing blood lactate concentration for Lexp equines was distinctly significant ($p<0,001$) after 8 weeks of our proposed exercises, also being noticed distinctly significant differences ($p<0,001$) between the two groups in final moment(Tf). Through statistical calculations it is shown that in the previos moment of training sessions there were no differences between the two groups (Lc vs Lexp). Lactate concentration for TS3 was found to be higher by age and by a higher jump over obstacles.

Through applying TS3 in T0 and Tf moments it's been shown a decrease of heart rates parameters (FC_{max}, FC_{med}, $FC_{2minaftereffort}$) as a response to training, and an improvement of physical condition of the equines from both groups. The medium heart rate values, and the ones

measured at 2 minutes after effort were lower for Lexp equine than for Lc, both before and after training, this fact showing the superior physical condition of Lexp equine.

There are no big differences between the two groups of quines in the moment T0 in terms of thrown down obstacles numer (3 at Lc and 2.8 at Lexo), instead, in the Tf moment, after 8 weeks of training, there is a significant improvement ($p<0,01$) for Lexp, when the equines obtained a medium value of 0.6.

The scorse given by both rider and observer in T0 and Tf moment for jumping technique shows that there are no differences between the two groups ($p<0,05$) .

In terms of energy level (tiredness) evaluated by rider, the values are very close between the two groups (2.87 for Lotc vs 2.98 for Lexp). Also, the results for energy during the jump evaluation by observer shows insignificant differences ($p<0,05$) between the two groups in T0 moment.

Training influence over descriptive parameters of biomechanics of jump evaluation

The height of the obstacle requires a technique of making the jump according to the difficulty degree, some of the trends being highlighted through kinematic data, like horizontal speed. At high obstacle height, horizontal speed VX_{TO} present a decrease trend, while the vertical speed VY_{TO} records a proportional increase with obstacle height at champions horses.

Thereby, for the horizontal speed of CG it shows a slight decrease comparing to the total speed in horizontal plane before approaching the oxer, as a result of a slight deceleration, the limits of framing for both groups.

At the third interval, the horses that didn't managed to make the jump without taking down the obstacle presented lower horizontal and vertical speeds at departure, this situation can be the result of a lack of impulse neccesary for jumping over oxer. Through an increase of horizontal speed during approaching the obstacle, the horses are improving the speed at the departure simultaneously with increase of traction from the same phase of the jump. In case of penalties, at departure, the equines presented a weak position of the body, CG having an inferior height and eventually positioned in proximity of the oxer.

It's been concluded that vertical speed at departure and the vector angle of horizontal speed of CG (angle of projection) were strongly correlated, influencing the success / failure of jumping over obstacle.

In the moment of departure (propulsion), this model is less active, involving a blocking action over the support member, the result being the transformation of horizontal speed in vertical speed; this action is similar to camber.

Correct performance of the jump involve creating an optimal distance at departure between CG and the obstacle's first element, involving a minimum vertical height (H_{TO}). Creating a distance in horizontal plan between CG and an obstacle that is too high or proximal,

require a large height. It involves also moving horse CG both on horizontal and vertical, issuing a certain reaction force from the ground, generated by the front of hindlimbs, the location of this vector being in the tarsal area. Because the activity made by hindlimbs produces a great propulsion force during the departure (deposited in distal tendons), it can be told that the hindlimbs perform a big part of the work needed durin the jump.

It must be highlighted the decisive influence over the jumping of angular acceleration, horse's body positioning during take-off, direction of CG and the movement of the hindlimbs and forelegs, especially in high obstacles and speed.

For soaring, the medium height in veritcal plan between CG and soil for every group (table X) express a small variation, slightly higher in LotC (with 0.01 m). The height difference between oxer (with H= 1 m) and the actual jump, varied between 0.65 – 0.92 m at LotC horses and 0.69-0.87 m for Lotexp.

In the final stage of the jump, at landing, the horses take a downward oblique position of the body, with a slight modification of the horizontal plan speed of CG.

Upper and lower delimitation of the variation interval for each group has shown a media in an interval of 0.92 units ($M*S^{-1}$) for LotC, and 0.59 units ($M*S^{-1}$) for Lotexp.

The paper ends with conclusions and recommendations resulting from the research conducted.