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Utilization of cardiac work indices for estimating free jumps of young half-bred stallions

Wykorzystanie wskaźników pracy serca w ocenie skoków luzem młodych ogierów półkrwi

Summary. The study material was composed of 550 half-bred stallions (Polish thoroughbred half-bred, Wielkopolski, Malopolski, and others including mainly foreign breeds stallions) trained within frames of 100-day test. Examinations during the free jumps consisted in measuring the length of five following jumps over oxer of 100 cm width with variable height ranging from 100 to 120 cm. Then, jumping indices were calculated on the basis of withers height to achieve jumping efficiency parameters of required high values from a point of view of a jump description. During the observations, pulse was also recorded by means of telemetric devices. The following heart rates were determined: mean resting heart rate, heart rate during a jump, mean exercise heart rate, and mean restitute heart rate. It was used for calculating the Exercise Reaction Index (WRW) – during a jump and mean exercise value. Such achieved low-value cardiac work parameters that define a proper level of training progress were divided into those directly and indirectly associated with an exercise. Dependencies between traits were estimated on the basis of Pearson coefficients. It was found that analyzing the mean resting heart rate of young stallions may be useful when estimating their show-jumping predispositions as well as training progress. Values of cardiac work indicators during a jump gives a better view for a horse's stress level rather than real efforts to jump an obstacle. Therefore, the mean values of restitution heart rates should be taken into account to assess the exercise. Practical use of other cardiac work indices (e.g. WRW) may appear to be little precise. Breed characteristics of Wielkopolski breed and other foreign breeds should also be taken into account during the heart rate control to estimate the jumper's predispositions. In the case of the former, the control should be very thorough, while analyzing only randomly selected cardiac work parameter seems to be sufficient for the latter.

Key words: half-bred stallions, jumps, heart rate, correlation

INTRODUCTION

A detailed estimation of saddle horse performance value is a basis for achieving a success at producing individuals predisposed to a sport [Art. et al. 1990, Szarska 2006]. For outstanding breedings of popular jumpers, it usually consists of several to dozens of elements. For instance, the assessment used in The Netherlands includes gallop, reflex, technique, abilities, and general jumping ability. When writing into the records, general scores for jumps are additionally completed with linear scores for take-off direction, take-off rapidity, techniques of particular limbs, croup working, abilities, flexibility, and concentration, whereas during the performance test, it includes - besides widely understood „jumping abilities", also the take-off analysis, jump technique, and jump strength [Koenen *et al*. 2004, Lewczuk 2008].

In Polish system of performance testing, score for a jump is only general and not precisely defined, while control of traits that directly affect the usefulness of particular individuals (i.e. training progress and physiological potential of their organisms) is considered as secondary or even neglected [Program hodowli koni rasy małopolskiej 2005, Program hodowli koni rasy polski koń szlachetny półkrwi 2005, Program hodowli koni rasy wielkopolskiej 2005]. The cardiac work analysis is a simple and non-invasive method, because it indicates not only the general health status and emotional excitation level, but also allows for estimating the influence of applied training and individual predispositions for exercise [Kędzierski and Janczarek 2009]. Publications including above issues refer mainly to sport and racehorses, and the authors underline that lower heart rates during a rest, exercise, and just after the exercise is indispensable feature of a horse regardless their performance [Kaproń 1999]. However, that information on horses during domestic performance test has to be completed, because studies upon these problems have been only of a cognitive character up-to-date and included the associations between heart rate vs. pace or jump type, biometric dimensions, and confirmation bonitation [Kaproń *et al.* 2000, Kaproń *et al*. 2004, Pietrzak *et al*. 2006].

Completing the studies by correlation of heart rate indicators with measured jump parameters proving the predispositions of young stallions to jump obstacles, should give the opportunities to complete the preliminary estimation of their performance value, to choose appropriate training methods, and to control the training progress [Pietrzak *et al*. 2004, Powers 2005].

The above issues made formulating the goals of present study, which is the estimation of that type of associations within cardiac work indices as well as jump length and index for young half-blood stallions representing various breeds.

MATERIAL AND METHODS

Studies carried out since 2001 till 2005 at Polish Training Centers (ZT) involved 550 half-bred stallions representing Polish thoroughbred half-bred (thoroughbred half-bred), Wielkopolski, Malopolski, and other breeds (mainly foreign saddle breeds). Number of animals in particular groups was 240, 95, 117, and 98 horses respectively.

Observations during free jumps were made after 50 days of testing. In each case, stallions made five subsequent jumps over the oxer installed as a last one in a series of obstacles: rail just after the turn, then trestle after 2.5 m, next trestle after 5.8–6.5 m, and

second oxer after 6.5 m. The height of analyzed obstacle was elevated after each successful jump according the pattern: 1st jump – 100 cm; 2nd jump – 105 cm; 3rd jump – 110 cm; 4th jump – 115 cm; 5th jump – 120 cm. The arrangement of obstacles was identical as that proposed in performance test scheme for half-bred stallions [www.pzhk.pl]. Prior to a trial, horses were subjected to 20-minute warm-up including walk, trot, and gallop on a longe, as well as 3-4 trial jumps over a post-and-rails.

Jump length and index became desirable high-value parameters (jumping efficiency) from a point of view of jump description [Skulicz 1992]. The length of jump measurement was made using a measuring tape starting from a fore of the hind hoof trace situated closest to an obstacle during the take-off and ending at a fore of the front hoof trace situated nearest an obstacle during the landing. Based on a height of withers and achieved results of jump lengths for examined stallions, the jump index (Is) was calculated according to the formula:

$$\text{Is} = \frac{x_1}{x_2} \times 100;$$

where: Is – index of jump,
x_1 – length of jump,
x_2 – height of withers.

In order to determine the cardiac work indices that would appropriately low as required from a proper training progress level, the resting, exercise, and restitute heart rates were recorded [Barry 1993, Kaproń 1999]. The measurements were made applying telemetric devices by POLAR, type S 810. The Polar Precision Performance software allowed for determining the following types of heart rates:

– mean resting – measured at stables for 5 minutes,

– during jumping – measured during an obstacle jumping,

– mean exercise – measured from the moment of relax beginning till the start of relaxing walk (measurement duration – 30 minutes),

– mean restitute – measured during the relaxing walk (measurement duration – 10 minutes).

Achieved results were used to calculate the Exercise Reaction Index (WRW) with a help of the following formula [Kaproń 1999]:

$$\text{WRW} = \frac{x_1}{x_2} \times x_1;$$

where: WRW – Exercise Reaction Index,
x_1 – exercise heart rate,
x_2 – relax heart rate.

The above index was calculated for three variations: WRW during the jump, mean exercise WRW, and mean restitute WRW.

Dependencies between general jump parameters and cardiac work indicators were determined applying Pearson coefficient (Statistica 6.0 package). Cardiac work indicators were divided into groups indirectly and directly associated with the exercise. The former included mean relax heart rate, mean restitute heart rate, and mean restitute WRW, while the latter – heart rate during a jump, WRW during the jump, mean exercise heart rate, and mean exercise WRW.

RESULTS

Table 1 presents the associations between analyzed parameters of free jumps and heart rate parameters indirectly affected by an exercise. Correlations with mean relax heart rate appeared to be significantly negative in all breed groups. The most prominent dependencies characterized both jump parameters of thoroughbred half-bred stallions as well as single jump parameters in Malopolski stallions and other breeds group. Mean restitute heart rate was significantly positively correlated with jump length and index in each of distinguished breed group. Value of jump length correlation was higher than that achieved within the jump index in majority of cases. Mean restitute WRW appeared to be much less dependent on jump parameters. The associations included mainly Malapolski stallions classified to other breeds group as well as Wielkopolski breed. They referred only to the jump length in the latter breed group.

Table 1. Correlations between general jump parameters of studied stallions vs. their cardiac work indicators indirectly associated with an exertion
Tabela 1. Korelacje między podstawowymi parametrami skoku badanych ogierów a ich wskaźnikami pracy serca pośrednio związanymi z wysiłkiem

Indices of training progress Wskaźniki zaawansowania treningowego	General jump parameters – Podstawowe parametry skoku		
	mean relax heart rate średnie tętno spoczynkowe	mean restitute heart rate średnie tętno restytucyjne	mean restitute WRW średni WRW restytucyjny
Polish thoroughbred half-blood stallions (n = 240 × 5) Ogiery rasy polski koń szlachetny półkrwi			
Length of jump Długość skoku	-0.162**	0.080*	0.039
Index of jump Indeks skoku	-0.181**	0.071*	0.041
Wielkopolski breed stallions (n = 95 × 5) – Ogiery rasy wielkopolskiej			
Length of jump Długość skoku	-0.129*	0.066*	0.088*
Index of jump Indeks skoku	-0.111*	0.073*	0.066
Małopolski breed stallions (n = 117 × 5) – Ogiery rasy małopolskiej			
Length of jump Długość skoku	-0.129*	0.221**	0.091*
Index of jump Indeks skoku	-0.108**	0.301**	0.089*
Foreign breeds stallions (n = 98 × 5) – Ogiery ras zagranicznych			
Length of jump Długość skoku	-0.196**	0.289**	0.111*
Index of jump Indeks skoku	-0.114*	0.266**	0.099*

* correlation coefficient significant at $P \leq 0.05$;
** correlation coefficient significant at $P \leq 0.001$.
* współczynnik korelacji istotny przy $P \leq 0,05$;
** współczynnik korelacji istotny przy $P \leq 0,001$.

Table 2. Correlations between general jump parameters of studied stallions vs. their cardiac work indicators directly associated with an exertion
Tabela 2. Korelacje między podstawowymi parametrami skoku badanych ogierów a ich wskaźnikami pracy serca bezpośrednio związanymi z wysiłkiem

Indices of training progress Wskaźniki zaawansowania treningowego	General jump parameters – Podstawowe parametry skoku			
	heart rate during jumping tętno podczas skoku	WRW during jumping WRW podczas skoku	mean exercise heart rate średnie tętno wysiłkowe	mean exercise WRW średni WRW wysiłkowy
Polish thoroughbred half-blood stallions (n = 240 × 5) – Ogiery rasy polski koń szlachetny półkrwi				
Length of jump Długość skoku	-0.153**	-0.145**	-0.068*	-0.121**
Index of jump Indeks skoku	-0.131**	-0.164**	-0.079*	-0.124**
Wielkopolski breed stallions (n = 95 × 5) – Ogiery rasy wielkopolskiej				
Length of jump Długość skoku	0.056	-0.054	-0.058	-0.111*
Index of jump Indeks skoku	0.074	-0.047	-0.049	-0.108*
Malopolski breed stallions (n = 117 × 5) – Ogiery rasy małopolskiej				
Length of jump Długość skoku	-0.226**	-0.026	-0.114*	-0.042
Index of jump Indeks skoku	-0.233**	-0.176**	-0.044	-0.024
Foreign breeds stallions (n = 98 × 5) – Ogiery ras zagranicznych				
Length of jump Długość skoku	0.154**	0.145**	-0.088*	0.087
Index of jump Indeks skoku	0.195**	0.166**	-0.085	0.062

* correlation coefficient significant at $P \leq 0.05$;
** correlation coefficient significant at $P \leq 0.001$.
* współczynnik korelacji istotny przy $P \leq 0,05$;
** współczynnik korelacji istotny przy $P \leq 0,001$.

Parameters directly associated with exercise underwent slightly different dependence pattern (Tab. 2). Referring to heart rate and WRW during a jump, considerable negative correlations characterized thoroughbred half-bred and Wielkopolski animals. The adverse situation was observed for other breeds stallions. Less interdependencies were related to mean exercise heart rate. They were present namely in Polish thoroughbred half-bred breed with always negative sign. Mean exercise WRW appeared to be negatively dependent only to general jump parameters at Polish thoroughbred half-bred breed group as well as to jump length of Wielkopolski stallions. It is worth underlining that it was the only significant relation of that type for the latter breed.

DISCUSSION

Control upon the cardiac work parameters has been applied for a horse's organism efficiency, training progress, emotional excitement level, and stress estimation for a long time [Kaproń 1999, Szarska 2006, Kędzierski and Janczarek 2009]. However, studies on comparison of a jumper's heart rate with its performance predispositions were analyzed mainly in a context of its jump jumping style. Pietrzak *et al*. [2006] reported that the lowest exercise heart rate was accompanied to animals characterized by the best style of free jumps. Authors indicated the possibility to utilize the heart rate indices for preliminary estimation of jump predispositions. They suggested that the control of the exercise heart rate would be the most suitable. Here achieved results underline the advisability of these methods application. At the same time, it indicates that recorded dependence between low relax heart rate and high values of jump parameters for stallions, confirmed the significance of heart rate monitoring also during the resting, which makes such examination much easier [Szarska 2006, Kędzierski and Janczarek 2009]. The efficiency as well as – to a large extent – the performance predispositions estimation on a base of relax heart rate was earlier proven during the study upon racehorses, as well as three day event and long-distance race. The dependence was also suggested to be used for a control of other performance forms [Kaproń 1999].

Mean restitute heart rate also can be utilized in practice to indicate the cardiac work, because it was characterized by a positive correlation with jump parameters in each of distinguished breed groups. It may indicate that the level of a real exertion can be controlled on a base of heart rate indicators measured directly after the jump training complete. Although horse's predisposition to discussed performance makes it jumping the obstacles, making long and high jumps is always accompanied by large physical exertion. Therefore, loading the apt horse's organism becomes automatically larger than worse apt ones [Potgieter 1991]. It is difficult to compare results achieved on a base of the jump style and its measureable parameters, because dependencies between obstacle jumping ways vs. general jump parameters are not always positive [Chrzanowski *et al*. 1997, Kaproń *et al*. 2001]. It thus seems that the control of cardiac work analyzed in a context of measurable jump traits should be applied both due to its objectiveness and possibility of using it for training the older jumpers that are not judged in a view of their jump style [Lewczuk 2008]. Providing the fact that the influence of an obstacle height on heart rate is prominent in a case of young stallions that jump quite low obstacles, applying a monitoring of cardiac work during the performance test seems to be also advisable [Kaproń *et al*. 2004]. Mean restitute WRW here analyzed did not reveal such prominent pattern of associations with jump efficiency parameters, which can indicate the advisability of practical applying the heart rate control at maintaining at least an auxiliary function of indices based on them [Kaproń *et al.* 2000].

The heart indices associated directly with an exertion were characterized by distinct pattern of inter-relations. Earlier studies conducted upon sport horse breeds revealed positive correlations of a jump length with heart rate levels [Kaproń *et al*. 2004]. Here achieved results showed that negative correlation took place for domestic breeds in that system. It may indicate that animals having problems with obstacle jumping – the symptoms of which are short jumps – are characterized by higher exercise heart rate probably due to a stress and not a real physical exertion [Paalman 1979]. These considerations can

be confirmed by conclusions drew by Pietrzak et al. [2004] on minimization of a stress during the obstacle jumping that accompanies the stallions predisposed to that type of performance form. This suggests that the control of exertion and the training level should be made on a base of restitute heart rate, while indices directly associated with the exertion, such as heart rate during a jump or mean exercise heart rate for the whole training, may greatly determine the stress level. The breed features related mainly to Wielkopolski breed, for which no significant correlations were found, should be also taken into account. Available publications on the heart rate analysis indicate on the distinction of Wielkopolski horses. However, discussed results are divergent. They point out a great physiological exertion of that breed horses during tests of free jumps, on the other hand – its considerable weak points recorded in cross-country trial during three day event [Kaproń and Janczarek 1999, Lewczuk *et al*. 2001, Pietrzak *et al*. 2006]. In the case of other breeds stallions, found positive associations of heart rate with general jump parameters may suggest that horses representing mainly foreign saddle breeds, due to directed breeding procedures, have not only physical, but also mental predispositions for jumping. Such situation no doubt eliminates the stress during everyday training making that value of cardiac work indices may by a reflection of a real exertion put into the obstacle jumping.

CONCLUSIONS

1. Determination of the rest heart rate at young stallions may be useful in estimating their jump predispositions and their training progress. Values of cardiac work indices during the obstacle jumping gives a better view of a stress level than a real exertion put into the jumping. Therefore, mean values of restitute heart rate should be applied for the exertion estimation. Practical utilization of other cardiac work indices, including WRW, may appear to be not precise enough.

2. The breed differences should be taken into account during the cardiac work control at estimating the jump predispositions, which refers mainly to Wielkopolski breed and foreign breeds representatives. For the former, the control should be as precise as possible, while for the latter ones, direct heart rate analysis or randomly selected cardiac work indicator seems to be sufficient.

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Streszczenie. Materiał badawczy stanowiło 550 ogierów półkrwi (polskie konie szlachetne półkrwi, wielkopolskie, małopolskie oraz tzw. pozostałe, w tym głównie zachodnie rasy wierzchowe) trenowanych w ramach testu 100-dniowego. Badania podczas skoków luzem polegały na pomiarze długości pięciu kolejnych skoków przez przeszkodę typu bokser o szerokości 100 cm, której wysokość sukcesywnie zwiększano od 100 do 120 cm. Następnie w oparciu o wysokość w kłębie wyliczono indeksy skoku. Uzyskano w ten sposób parametry wydajności skokowej o pożądanych z punktu widzenia opisu skoku wysokich wartościach. Równocześnie w trakcie obserwacji rejestrowano tętno, wykorzystując do tego celu urządzenia telemetryczne. Określono poziom tętna:

średniego spoczynkowego, podczas skoku, średniego wysiłkowego, średniego restytucyjnego. Następnie na jego podstawie wyliczono wskaźnik reakcji wysiłkowej – WRW (podczas skoku, średni wysiłkowy). Uzyskane w ten sposób wskaźniki pracy serca o pożądanych niskich wartościach, które stanowią o prawidłowym stopniu zaawansowania treningowego, podzielono na grupę pośrednio oraz bezpośrednio związanych z wysiłkiem. Zależności między cechami określono w oparciu o współczynnik korelacji Pearsona. W oparciu o uzyskane wyniki stwierdzono, iż analiza poziomu tętna spoczynkowego młodych ogierów może być pomocna w ocenie ich predyspozycji skokowych i stopnia zaawansowania treningowego. Wartość wskaźników pracy serca w trakcie pokonywania przeszkód daje większy obraz poziomu stresu niż faktycznego wysiłku, który jest wkładany w pokonywanie przeszkody. Dlatego też do oceny wysiłku powinno się stosować średnie wartości tętna restytucyjnego. Praktyczne wykorzystanie innych wskaźników pracy serca, w tym np. WRW, może okazać się mało precyzyjne. Podczas stosowania kontroli pracy serca w ocenie predyspozycji skokowych należy zwrócić uwagę na odrębność rasową, jaka towarzyszy w tym układzie koniom wielkopolskim oraz reprezentantom ras zagranicznych. W przypadku pierwszych z nich wspomniana kontrola powinna być bardzo szczegółowa, zaś w obrębie drugich wystarczająca wydaje się być analiza dowolnie wybranego parametru pracy serca.

Słowa kluczowe: ogiery półkrwi, skoki, tętno, korelacje