Use of blood biochemistry for positive performance diagnosis of sport horses in practice

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SUMMARY

The measurement of many biochemical and other type of variables is done for performance diagnosis of sport horses. However, the term performance diagnosis in practice has different meanings. The parameter of differentiation between the meanings is the regularity of measurements. When variables are measured on a regular basis they provide formation for sports performance diagnosis (= positive performance diagnosis). When variables are measured sporadically they are used to give information for poor performance diagnosis of sport horses (=negative performance diagnosis). Most persons involved in performance diagnosis do the latter even though they believe they are doing the former. Variables shown to give some information about the likelihood of horses not competing successfully, thus providing information on negative sports performance (poor performance), do not seem to provide useful information for positive performance diagnosis. Also, variables allowing a distinction between untrained and trained horses are of no use for positive performance diagnosis. Positive performance diagnosis has to provide a means to discriminate between similarly trained horses at certain times during the training programme or the competitive season. The only single informative biochemical blood variable of benefit for positive performance diagnosis of sport horses in practice is lactate. However, two conditions to use it successfully for positive performance diagnosis have to be fulfilled: it has to be measured regularly in the same horse during standardized exercise, and a data base built with results of horses tested the same way is needed to compare the values and draw the conclusions on the competitive level and optimization of training programmes.

KEY-WORDS: performance - diagnosis - biochemistry - blood - lactate - horses.

Introduction

For a long time, the measurement of many biochemical and other types of variable has been suggested to allow for an objective assessment of the competitive capability of sport horses [39, 41, 45, 48]. Many different variables are indeed supposedly measured for this purpose. This has been demonstrated with the results of the evaluation of a questionnaire answered by veterinarians and trainers working with sport horses in Germany, Austria, Italy and Switzerland during a series of six two-day practical courses on equine performance diagnosis in 1997-8. One of the questions addressed was: Which variable/s do you use for performance diagnosis of your horse/s at rest or during and after exercise?

Out of a total of about 150 course participants 76 answered the questions. The evaluation of the questionnaire showed that many different variables were being measured (figure 1), physiological variables more frequently than hematological and blood biochemical ones. Although this result is most likely biased because the practical courses were on performance diagnosis and training control with blood lactate measurements, only the measurement of lactate concentration in blood or plasma was done as often as the physiological variables. The reason for favouring the physiological variables was that their measurement was practical and veterinarians and trainers believed that it supplied them valuable additional information on health and performance of their horses. Blood or plasma lactate concentration was measured so often because it provided additional information on actual performance of a horse, and sometimes on health status as well.

Another interesting result of the evaluation was that the large majority of the biochemical and hematological variables were measured in the horse under resting conditions (figure 1). In most cases, heart and respiratory rate were measured consecutively in horses at rest and after exercise, and blood for lactate analysis was preferentially taken after exercise, in most cases only once.

The key question on the use of any variable for performance diagnosis is whether it provides the expected benefit (validity). Another questionnaire given to the participants of the performance diagnosis courses addressed the question “What do you mean with performance diagnosis?”. The evaluation showed that the meaning of performance diagnosis was very ambiguous. This result fully reflects the situation in practice. Discussions on the definition demonstrated that most participants meant to objectively evaluate actual or potential sports performance capacity. However, most of them admitted that they were measuring the variables when they felt that they needed information on the lack of expected sports performance capacity of their horses. Although sometimes it may be difficult to differentiate between terms there is one clear parameter of differentiation: regularity of measurement. When variables are measured on a regular basis in horses they provide information for sports performance diagnosis (= positive performance diagnosis). When variables

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**Figure 1.** Variables measured for performance diagnosis (76 veterinarians and trainers).

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are measured sporadically, in some cases even only once in life, they are used to attempt to add information for poor performance diagnosis of sport horses (= negative performance diagnosis). Some of the blood or plasma biochemical variables which have been shown to inform about the likelihood of not competing successfully, thus providing information on negative sports performance, are: Bilirubin (when increased [48]), Gamma-glutamyltransferase (when increased [46]), Creatine-phosphokinase (when increased [1, 26, 43, 45]), Potassium (when above 4.0 mmol/l [50]), and Phosphate (when increased [16]). But nobody has demonstrated that measuring these variables also may allow for positive performance diagnosis.

In literature an innumerable amount of references are found in which authors describe or at least allude to the benefit of certain biochemical and other variables for discriminating between untrained and trained horses (table I). We have to be aware that this is not what matters in positive performance diagnosis of sport horses. Positive performance diagnosis has to provide trainers, riders and veterinarians with a means to discriminate between similarly trained horses at certain times during the training programme or the competitive season. Through continuous application of positive performance diagnosis it is possible to help find an answer to the question why a horse is better than others: Is it the genetic make-up? Or is the environment (training and health management)?

Fine, but with which variable/s can positive performance diagnosis be provided? A search through literature for studies on the validity of biochemical variables for positive performance diagnosis demonstrates that there are not many. This also holds for other types of variable. The vast majority of variables reacts to exercise, but this does not ensure that they are also suitable for positive performance diagnosis of sport horses.

We have examined the potential of several biochemical variables for positive performance diagnosis in sport horses. For this purpose, on one occasion, 15 standardbred race horses (six were two-year-olds and the others between 3 and 6 years old) were submitted to a standardized exercise test (SET) on a racetrack. Conditions were kept as similar as possible for all horses during the testing day [31, 32]. The SET consisted of four or more runs depending on when the blood lactate concentration of a horse exceeded 4 mmol/l. Speed in the first run was 6 m/s, and it was increased by 1 m/s for each run. Blood samples were taken within 30 seconds after each run from jugular vein and analyzed for Creatine-kinase (CK), Aspartate-aminotransferase (AST), Lactate dehydrogenase (LDH), Cortisol, Alanine, Free Fatty Acids and Thiobarbituric Acid-like reactive Substances (TBArS).

To determine whether a variable allowed a distinction between horses of different performance capability we first plotted running speed for each horse in each run against the measured value of a variable. Performance capability was defined in the horses older than 2 years by their actual racing record. Horses of two years of age had not yet raced but were in full training. Only blood lactate concentration allowed clearly to discriminate between faster and slower horses, and it was also possible to distinguish between most of the two-year-old horses and the older ones (figure 2). All the other variables measured did not allow for distinguishing discriminating between horses of differing racing records, and if at all only partially between horses two-years old and older. The graph for TBArS is presented as an example of this type of variable (figure 3).

Further analysis of data among groups demonstrated that the values of Lactate, Cortisol and TBArS, and to some extent also CK, after the fourth run allowed to distinguish between two-year-old horses and older ones. For this purpose the median (for CK, AST and LDH) or mean value of each group for each variable after the fourth run was compared

<table>
<thead>
<tr>
<th>Variable</th>
<th>Higher value in trained horses</th>
<th>Lower value in trained horses</th>
<th>No differences between trained and untrained horses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td></td>
<td>[7, 29]*</td>
<td>[35, 44]</td>
</tr>
<tr>
<td>Bilirubin</td>
<td>[6, 7, 21]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cholesterol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total plasma proteins</td>
<td>[25]</td>
<td>[25]</td>
<td>[7, 42, 44]</td>
</tr>
<tr>
<td>Alkaline phosphatase</td>
<td>[25]</td>
<td>[7, 25, 36, 47]</td>
<td>[8]</td>
</tr>
<tr>
<td>Aspartate aminotransferase</td>
<td>[8, 9, 12, 34, 40, 47]</td>
<td></td>
<td>[22]</td>
</tr>
<tr>
<td>Lactate dehydrogenase</td>
<td>[22, 40]</td>
<td>[23]</td>
<td>[7, 33, 47]</td>
</tr>
<tr>
<td>Creatine kinase</td>
<td>[6, 8, 10, 27, 34, 40]</td>
<td>[1, 2, 3, 10, 27]*</td>
<td>[33, 43]</td>
</tr>
</tbody>
</table>

* = after exercise; in all other references cited blood was taken from horses under resting conditions

Table I — Studies in which the use of biochemical variables other than blood or plasma lactate was investigated for differentiation between trained and untrained horses (only variables which were cited in at least two independent studies were considered)
FIGURE 2. — Concentration of lactate in blood of two year old and older Standardbred racehorses during a standardized exercise test (15 horses).

FIGURE 3. — Concentration of TBArS in blood of two year old and older Standardbred racehorses during a standardized exercise test (15 horses).
statistically. The fourth run was selected because it was the most intensive one run by all horses tested, and it was expected that at the highest comparable work stress distinguish between horse groups would be easiest (table II). The results demonstrated very clearly that only blood lactate, as well as plasma TBArS and plasma cortisol concentration, allowed to significantly distinguish between the two age groups’ build.

The really important step of positive performance diagnosis is to inform accurately about the actual competitive level of a horse. To examine the validity of the variables for this purpose the relation of values of the variables measured after a defined workload and the racing record of the horses tested was examined with linear and exponential regression analysis. The racing record is defined internationally as time needed to run a kilometre (or a mile), and is used to objectively compare performance of Standardbred horses. Again the value chosen for the variables measured was the one after the fourth run of SET. The results of the regression analysis demonstrated that only the blood lactate concentration after the fourth run gave a reasonable explanation for the racing record (linear regression; $r^2 = 0.89; p = 0.001; n = 7$).

Another approach to examine the dependence of biochemical or other variables from competitive performance parameters like racing record is to derive parameters which describe the development of the values of a variable with increasing workload. Out of the measured biochemical variables only the blood lactate concentration of each horse had a positive exponential relation with the speed of exercise. The other variables were not always related exponentially or linearly in all horses with speed of exercise. Thus a parameter to describe the relation between these variables and speed was not calculated. Only the blood lactate concentration measured after each run was plotted against running speed to derive mathematically $v_4$ from the blood lactate-running speed relation ($v_4 = \text{velocity run under defined conditions inducing 4 mmol/l blood lactate concentration}$). This parameter is used widely to examine effects of conditioning and to diagnose positive performance of sport horses [13, 20, 24, 37].

The result was that $v_4$ was linearly correlated with the race record of the Standardbred horses tested (figure 4). This negative correlation is corroborated regularly in our tested horses. Our conclusion is that $v_4$ and therefore lactate measu-

<table>
<thead>
<tr>
<th>Result</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differentiation possible</td>
<td>Lactate ($p&lt;0.01$; higher in 2-yr olds)</td>
</tr>
<tr>
<td></td>
<td>TBArS ($p&lt;0.01$; higher in 2-yr olds)</td>
</tr>
<tr>
<td></td>
<td>Cortisol ($p&lt;0.05$; lower in 2-yr olds)</td>
</tr>
<tr>
<td>Differentiation not possible</td>
<td>CK ($p&lt;0.09$; higher in 2-yr olds)</td>
</tr>
<tr>
<td></td>
<td>Free fatty acids ($p = 0.13$)</td>
</tr>
<tr>
<td></td>
<td>LDH ($p = 0.38$)</td>
</tr>
<tr>
<td></td>
<td>Alanine ($p = 0.42$)</td>
</tr>
<tr>
<td></td>
<td>AST ($p=0.75$)</td>
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</tbody>
</table>

Table II. — Validity of certain biochemical variables for differentiation of age groups in Standardbred horses (6 two-year old horses and 9 older ones) comparing values after fourth run of a standardized exercise test.

Figure 4. — Relation between best actual racing time and $v_4$ of Standardbred Trotters ($n = 7 ; r = 0.77 ; p < 0.01$).
rement in blood or plasma (not interchangeable [30, 51]) is actually the best parameter or variable to offer veterinarians and trainers the service of positive performance diagnosis of sport horses. This conclusion is supported by studies done by several other authors where correlations between competitive success and $v_4$ or blood/plasma lactate concentration has been described (for endurance riding DEMONCEAU [15], ERICKSON et al [17]; for three day eventing GALLOUX [20]; for Standardbred racehorses CASINI and GREPPI [11], COUROUCÉ [13], KRZYWANEK [28], PONCHARD [38]; for Thoroughbred racing BAYLY et al [5], DAVIE [14], EVANS et al [19], HARKINS et al [24], PONCHARD [38]; for Quarterhorse racing ERICKSON et al [18]). No other variable has shown so frequent and so good a relation with competitive performance.

Nowadays the practical application of positive performance diagnosis, once it has been recognized that this is the service wanted, is not a matter of which variable should be used but how we use the measurement of blood/plasma lactate concentration for this purpose. The participants of the courses on performance diagnosis and training guidance expressed their interest in this service. Of the above mentioned authors, COUROUCÉ [13], DAVIE [14] and ourselves offer the service of positive performance diagnosis in practice. The measurement of lactate in blood or plasma is a routine inexpensive procedure, and the testing procedures are no mystery either. Although each group uses different exercise test prescriptions, we seem to be providing useful service to our clients.

The bottleneck in providing positive performance diagnosis is that it is necessary to have a data base. No reference value can be formulated because $v_4$ or lactate values depend on the test prescription, and the test prescriptions are influenced by many factors. The most important ones are track length and surface as well as horse type. For anybody wanting to offer the service it is necessary to realize that a data base is necessary to compare results of horses. The more specific and larger the data base for each client’s horses is the better the service that can be provided. As a matter in fact: it is the only way to provide satisfactorily the service. Most persons wanting to provide the service to a client do not explain to them sufficiently that to build a data base takes time, the longer

- the less horses the client has or wants to be tested regularly,
- the less different the competitive level of horses of a client is.

The sports disciplines for which it is easiest to build up a data base are Standardbred and Thoroughbred/Quarterhorse racing. In many cases in these sports disciplines, one owner owns several horses, or several trainers and owners of horses in a race-track cooperate. But even for these sports disciplines it takes time before the service provides useful information (table III).

Of the services offered the ranking of horses according to their actual competitive level is most quickly achievable. In practice this is a very useful service of positive performance diagnosis, especially in trot, pace and gallop racing where horse fluctuation within barns is high, and time to race horses short. The service supplies the trainer or veterinarian with additional and objective information on the actual performance capability of a “new” horse, of a horse recovering from injury, or of the development of a horse through training.

The dream of all sport horse owners is to be able to tell at an early stage whether a horse will be fast or not. Potential positive performance diagnosis may give further information for this matter. For this purpose horses need to be regularly tested at an early age. Very many factors play a role in the outcome of elite athletes. The work published by BARREY et al [4] is very promising. They found a positive genetical relation between $v_4$ and racing success in Standardbred horses.

In conclusion, blood biochemistry for positive performance diagnosis of sport horses in practice relies on lactate measurements. Other biochemical variables may supply additional information but the only single informative bio-

<table>
<thead>
<tr>
<th>Service</th>
<th>Benefit</th>
<th>Time before it becomes useful</th>
<th>Conditions needed to become useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual performance (AP)</td>
<td>Performance status of horse</td>
<td>After several tests</td>
<td>Tests of several horses of different competitive quality</td>
</tr>
<tr>
<td>Potential performance (PL)</td>
<td>Selection</td>
<td>1 to 2 years</td>
<td>Many tests of horses, best if up to highest competitiveness</td>
</tr>
<tr>
<td>Control of training (CT)</td>
<td>Optimization of training</td>
<td>After one year of testing</td>
<td>• Testing in the preparation period of the season every 3–4 weeks</td>
</tr>
<tr>
<td>Guidance of training (GT)</td>
<td>Optimization of training</td>
<td>After two years of testing</td>
<td>• Protocolling training</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Testing in the preparation period of the season every 3–4 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Prescribing exercise workload based on lactate concentration in tests</td>
</tr>
</tbody>
</table>

Table III. — The services of positive performance diagnosis of sport horses.
chemical blood variable for this service is lactate. Positive performance diagnosis can only be provided if measuring of blood or plasma lactate is done regularly in the same horse. If measurement of lactate (or other variables) is not done regularly in a horse then the service of negative performance diagnosis is supplied. This service does not allow efficiently for assessing the competitive level of horses and optimization of training programmes.

References


