THE EFECTS OF DRUGS ON RACE HORSE PERFORMANCE

THOMAS TOBIN, M.V.B., Ph.D. and THOMAS WOOD, B.S., A.S.*

SUMMARY

Since the turn of the century, stimulant drugs have been used illegally in attempts to improve the performance of racing horses. More recently, anti-inflammatory and a variety of other drugs have been used in attempts to restore normal performance. Careful characterization of the responses of horses to drug administration, followed by studies in larger numbers of racing horses is required to demonstrate an effect on performance. Classic "performance trials" using small numbers of horses have generally failed to detect drug effects on maximal performance. While much of the groundwork has been laid for the characterization of the effects of drugs in horses, the use of properly controlled double blind trials on large numbers of racing horses is just beginning.

INTRODUCTION

In the early 1900s, George Lambton, a leading English racehorse trainer, publicly announced that he was "doping" horses with newly available American "dopes". His purpose was to demonstrate to the English Jockey Club what stimulant medications could do for racing horses. What the performance effects of these treatments were has been lost, but the regulatory effects of his experiments are still with us. Based on Lambton's work, the Jockey Club banned the use of drugs in racing horses and made the penalty for a violation a sanction known as "ruling off." Since then, virtually all racing jurisdictions have banned the use of stimulant drugs in horses, and enforce the ban by chemical testing. We still do not know how effective these medications are in improving performance but a number of investigators have tried to answer this question. It is a difficult question to answer because it requires detailed knowledge of the specific ways in which such drugs are used, their pharmacokinetic and pharmacodynamic properties in the horse and, unfortunately, access to large numbers of horses. In addition, there is an abundance of agents and methods that one might employ to alter the performance of a horse.

MEDICATIONS AND THE PERFORMANCE HORSE

In Table 1 are listed some of the various ways that medication can be used to influence the performance of a horse. The least sophisticated method is known as acute stimulant medication, the classic "doping" or "hopping" of a horse. In this procedure, the horse is given an acute dose of a stimulant as close to post time as possible. The purpose of this is to ensure that the horse is maximally stimulated at the time of the race and therefore puts in a superb or "supra-maximal" performance and wins the race. In theory this sounds easy but in practice it is far more challenging than might appear at first glance.

* Authors' address: The Maxwell H. Gluck Equine Research Center and the Kentucky Equine Drug Research and Testing Programs, Department of Veterinary Science and the Graduate Center for Toxicology, University of Kentucky Lexington, Kentucky 40546-0099

1. Medication to Win
   a) Acute: short-acting stimulants, amphetamines, cocaine, narcotics.
   b) Chronic: repeated dosing for weeks or months, vitamins or anabolic ste
   c) "Washy" horses: dosing with a small dose of depressant or tranquilizer to "
      edge off" an excitable horse.
   d) Always illegal and usually an "inside job."

2. Medication to Lose
   a) Depressants: large doses of a tranquilizer, sedative or depressant.
   b) Always illegal and usually an "outside job."

3. Medication to Restore Normal Performance
   a) Non-steroidal anti-inflammatory drugs, phenylbutazone, etc.
      Often permitted under controlled rules.
   b) Corticosteroids: administered intra-articularly to control joint pain; co
      permissible.
   c) Local Anesthesia: nerve or joint blocks; always illegal.
   d) Fluids and electrolytes: often permissible.

4. Accidental or Inadvertent Doping
   The accidental occurrence of a positive
   a) Procaine from procaine penicillin
   b) Caffeine from coca husks in food pellets
   c) "Robaxin" from glyceryl guaiacolate
   d) Botanical positives or false positives

5. Medication to "Mask" Other Drugs
   Administration of dipyrone or polyethylene glycol, thought to interfere with the
   of other drugs.

6. Medication to "Dilute" other Drugs
   Diuretics: furosemide, ethacrynic acid, hydrochlorothiazide

7. Miscellaneous Mechanisms
   "Blood doping"
   "Bicarbonate doping"

Table I. Various categories of medication in performance horses.

To effectively stimulate a racehorse, one has to select the right dose and admi
the drug at the appropriate time prior to post time. For some drugs, selecting
right dose simply requires knowing the pharmacology of the drug in the horse.
other drugs, however, this is not as simple as there are large differences between h
in their responses to a particular drug or dosage. One of the best examples o
is the response of horses to cocaine. Figure 1 shows that when measuring re
behavior in operant conditioned horses, cocaine can induce both increases
decreases in horses' behavioral rates following variable doses of cocaine." The
message of this is that for certain drugs one needs to know reasonably well h
individual horse will respond to certain medications or doses to use them effect
and this information is often not readily available.

A different kind of medication protocol involves chronic administration of a
for weeks or months prior to a race. The classic example of this type of med
is treatment with anabolic steroids. In this case, the trainer presumably can

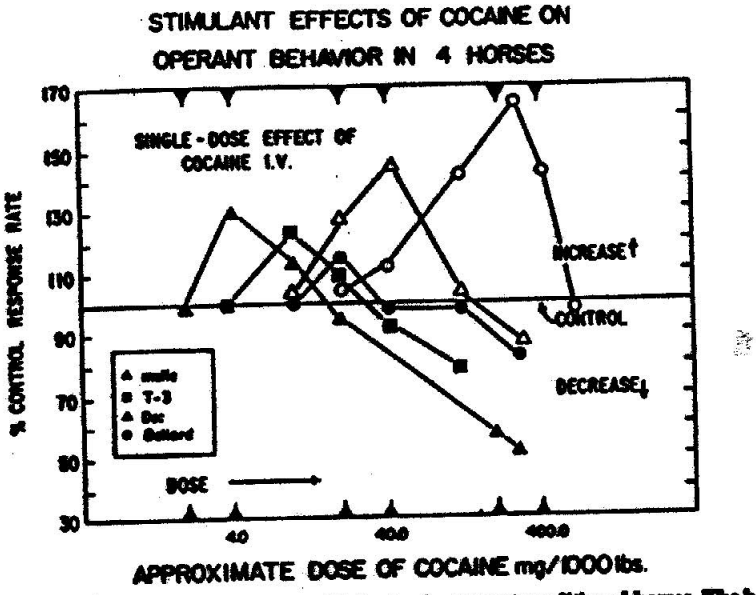


Fig. 1. Acute effects of cocaine on rates of behavior in operant conditioned horses. The horses were trained to break a light beam with a head-bobbing movement with a variable interval reinforcement schedule. Their control responding rates were considered 100% and increases or decreases were calculated on that basis. Reproduced with permission from Tobin, Drugs and the Performance Horse, 1981.

mine from observing the animal how the horse is responding and can titrate the dose for optimal effect. This pattern of medication was widely used in England before the introduction of chemical tests for anabolic steroids. When these tests were first introduced, they uncovered a pattern of abuse in about 10% of the horses tested. This pattern of abuse dropped substantially in the following weeks with the advent of effective chemical testing.[17]

A rather subtle form of doping is the judicious use of tranquilizers on "washy" horses. A nervous or washy horse can expend considerable energy in the paddock and have little left for the race. In addition, an overly excited horse can be difficult to control in a race and such horses may respond with an improved effort after a small dose of a tranquilizer. Tranquilizers, such as acepromazine, when used in this manner are classified as stimulant medications, even though they are pharmacologically sedatives. Recently, a large pattern of acepromazine abuse was detected in Illinois racing with the use of the newly developed immunoassay technology.[4]

A much less subtle way in which depressant medications are used to influence the outcome of a race is to sedate one or more of the horses. This may involve someone outside the horse's stable who wishes to alter the outcome of an event by "stopping" the competition. For example, detomidine is a new and extremely potent sedative that is currently very difficult to detect.[21] A small dose of detomidine administered to one or more horses could have a definite effect on an equine event and there is concern that this drug is being abused in some circles. While it is difficult to be sure that stimulant doping is actually affecting performance, it is easy to see the effects of depressant doping in an equine athlete.

Restoration of "normal" performance is another objective of medication. Gen... this takes the form of anti-inflammatory drug administration to combat joint or ... pain or the use of a diuretic to lessen the effects of exercise-induced pulmonary h... rhage (epistaxis or "bleeding").[2] The use and effect of these "soft" drugs on e... athletes remains to this day a controversial subject. For example, one of the supp... of the early work on equine performance was an apparent performance stimula... effect of phenylbutazone in supposedly sound horses.[17] These horses improved ... treatment with phenylbutazone which leads many to suggest that the horses were ... tually subclinically unsound and were merely "normalized" by phenylbutazone. ... retrospect, it seems reasonable that in order to truly analyze a drug's effects on ... formance, an accurate and discriminating indicator of the animal's musculoskele... status as well as a sophisticated performance trial would have to be employed.

Other forms of medication which restore normal performance include the ... articular administration of corticosteroids. In this case the drug is injected dir... into the inflamed joint and its performance effect is due to its anti-inflamma... action. If the joint is inflamed to the point where performance is adversely affec... these maneuvers are very effective and can restore normal performance. How... corticosteroids carry their own particular problems in that they interfere with ... regeneration of articular cartilage and lead to degenerative changes in the joint ... face and surrounding tissue. There can be little doubt though, that in the short ... corticosteroids can have a positive effect on equine performance.

A similar effect can be obtained with the use of local anesthetics. These ag... are so rapid and effective in the alleviation of pain that they are widely used in ... diagnosis of lameness. If a treatment is so clearly effective that it can be use... diagnosis lameness, it is likely to have a positive effect on an ailing athlete. L... anesthetics are, in fact, important therapeutic agents used in both equine and hu... sports medicine in the restoration of normal performance. While local anesthe... are often legal and permissible in human sports medicine, they are illegal in v... equine sporting events. This is because of the potential for a horse to misstep d... a blocked leg and cause a serious mishap. Such a mishap could lead to an accid... that could put the lives of both horses and jockeys at risk. At this time virtually ... racing jurisdictions expressly forbid the use of local anesthetics.

The final category of medication methods to be discussed here is blood dop... or the administration of an animal's own blood cells prior to an event. In perform... this procedure, one is attempting to mimic the animal's own splenic reservoir fu... tion. No clear evidence exists to suggest that this method actually is effective in ... proving the performance of a horse. It is quite clear however, that this manev... is an attempt to follow what mother nature has given the athlete and that is the ab...

1. "Pharmacologist's experiment": study the effects of drugs on simple behavioral model...
2. "Sub-maximal output experiment": trot or canter horses with or without drug for sho... distances.
3. "Maximal output experiment": run horses with or without drug at top speed for one ...
4. "Statistician's experiment": retrospective study of times with/without drug in large numb... of horses.

Table II. Experimental approaches to the effects of drugs on equine performance.

y to increase the supply of red blood cells when maximum performance is required.

The pharmacological properties of many of today's drugs are quite well known. If or how they may affect the performance of a racehorse however, is largely unknown. Over the years, different types of performance trial protocols have been employed by investigators attempting to answer these questions. In Table II are outlined four of these experimental approaches.

EVALUATION OF THE EFFECTS OF DRUGS ON PERFORMANCE

1. The Pharmacologist's Experiment

The most effective way of obtaining information about the effects of drugs in horses is to test the horses' actions in simple behavioral models. For example, narcotic analgesics in the horse produce a well-defined locomotor response which can be accurately measured by simply counting steps that the animal takes with its left front leg (Fig. 2).[27] Using this model, one can generate classic dose and time response data for these drugs in the horse (Fig. 3) and demonstrate the likelihood of performance effects.[5,10,28] These models produce data qualitatively similar to that obtained with the sub-maximal output performance experiment, but which are far more detailed and informative. For example, these experiments can identify dosage rates and times

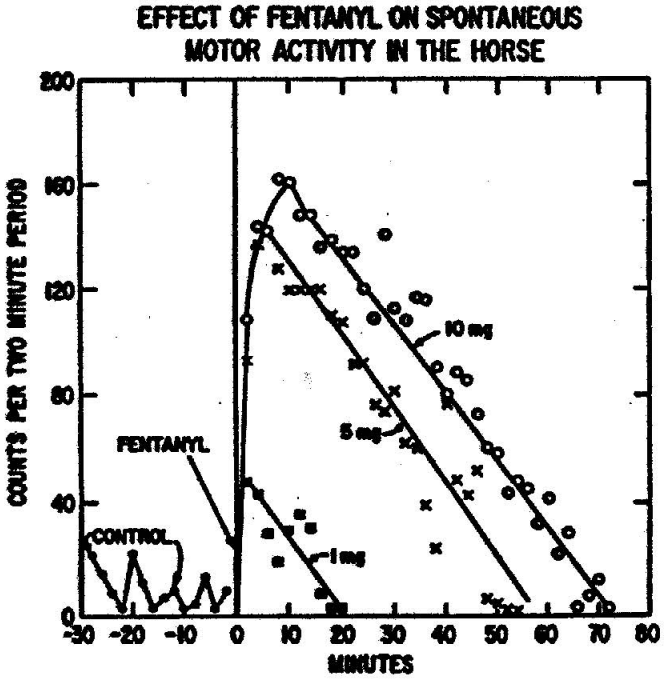


Fig. 2. Effect of fentanyl on spontaneous locomotor activity in four horses. The lower panel shows the normal activity of a horse at rest in his stall, about four steps per two minutes. The top panel shows the locomotor response produced in horses by injection of 1, 5 and 10 mg of fentanyl per horse by rapid I.v. injection. Reproduced with permission from Tobin, Drugs and the Performance Horse, 1981.

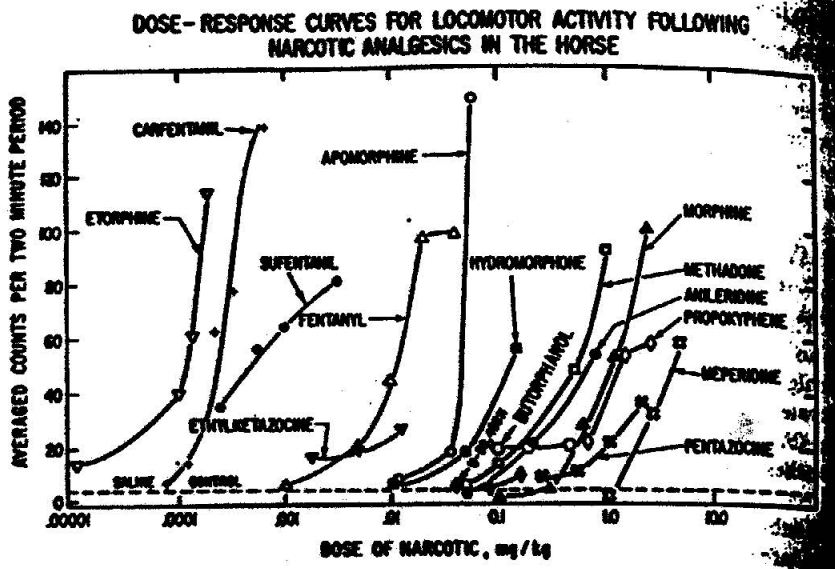


Fig. 3. Dose-response curves for locomotor activity following narcotic analgesic administration in the horse. Horses were dosed with increasing amounts of the indicated drug and the average number of steps taken during the peak two-min. period were plotted. The average counts per two-min. period for the saline control are shown by the dashed line near the bottom of the graph. Reproduced with permission from Kaneeing et al. Equine Vet. J. 1968.

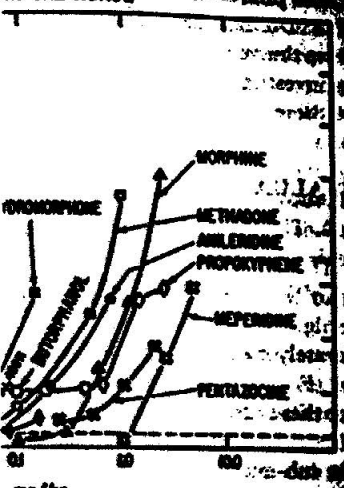
post-dosing at which one obtains peak drug effects. They can also show that some drugs do not produce consistent behavioral effects in the horse, and that the effective doses of some drugs can vary up to 100-fold between individual horses. For these reasons, simple behavioral experiments to characterize the pharmacological effects of drugs in horses are necessary before performance experiments of any kind are attempted in horses.

The necessity of careful characterization of the pharmacological actions of drugs in horses was brought home to us by our experiments with fentanyl. Fentanyl is a highly lipid-soluble narcotic analgesic, about 80 times more potent than morphine. It was reportedly widely used in racing horses in America during the 1970s. When we started our performance work on this drug, we used the dose and route of administration (0.25 mg/ horse, 30 min before race time) reportedly used illegally on the racetrack. In this work, we saw no behavioral or performance effects due to fentanyl whatsoever.

Later, when we increased the dose of fentanyl for kinetic studies, we discovered the characteristic behavior effects presented in Figure 2. It then became apparent to us that the behavioral effects of fentanyl require a minimum dose of about 2-3 mg/ horse and the drug has to be given i.v. This lesson highlighted the necessity of defining carefully the pharmacology of a drug in racing horses before starting expensive performance experiments.

The demonstration of clear-cut pharmacological responses of the horse to the opioids allows one to ask and answer important questions about the closely related opioid

MOTOR ACTIVITY FOLLOWING
IN THE HORSE



following narcotic analgesic administration,
ncreasing amounts of the indicated drugs
; the peak two-min. period were plotted.
e saline control are shown by the dashed
d with permission from Kaneeling *et al*,

ects. They can also show that some
cts in the horse, and that the effec-
old between individual horses.[8] For
characterize the pharmacological ef-
rformance experiments of any kind

e pharmacological actions of drugs
iments with fentanyl. Fentanyl is a
times more potent than morphine.[9]
n America during the 1970s. When
we used the dose and route of ad-
ce time) reportedly used illegally on
l or performance effects due to fen-

A for kinetic studies, we discovered
igure 2. It then became apparent to
a minimum dose of about 2-3 mg/
m highlighted the necessity of defin-
ing horses before starting expensive

l responses of the horse to the opiates
ons about the closely related endor-

phins. The term endorphin is a generic term for a family of endogenous opiates which vary in their amino acid residue makeup.[3] The enkephalins, which contain five amino acid residues, are the smallest members of this group. They are all neurohormones and, as such, the brain contains enzymatic pathways for their synthesis. As neurohormones the brain must also contain mechanisms for their inactivation to ensure that the signal transmitted by the endorphins can be inhibited. Because of this, most of the natural enkephalins have a relatively short half-life in the body, and tend to be rapidly broken down.[7]

As well as being rapidly broken down, the endorphins tend to be poorly distributed in the body. For this reason the natural enkephalins are generally not active after oral or i.v. administration.[7] The enkephalins have, therefore, been synthesized as enkephalin analogs that do not break down as rapidly in the body as the natural enkephalins in an attempt to accentuate their action in the body.[4]

The question of concern to racing administrators is whether or not these endogenous opiates are similar to the opiate drugs in their pharmacological effects. One expectation might be that one could administer these agents and reproduce the pharmacological effects of the opiates. On the other hand, because of the difficulties with the absorption of these agents into the CNS an equally likely possibility might be that their pharmacological effects would be minimal or quite different from those of the opiate drugs.

In an attempt to answer these questions, we administered enkephalins to horses and evaluated the pharmacological effects of these agents.[9] The enkephalins studied were leucine-enkephalin and ala-met-enkephalinamide which we administered to horses both intravenously and intracisternally. Leucine-enkephalin had little effect on locomotor activity by either route, consistent with the concept that the natural enkephalins are less likely to be effective because of their poor distribution and short half-life. Similarly, ala-met-enkephalinamide, an enzyme resistant enkephalin, had very little effect when given i.v. However, when given intra-cisternally this drug elicited an increase in body temperature, a locomotor response, a marked increase in blood pressure, hyperventilation and the appearance of a rapid eye blinking reflex. These responses were also associated with a lack of coordination and quivering, and very clearly distinguishable from the response after administration of fentanyl either i.v. or intracisternally. Overall, the data tend to support suggestions that the pharmacological effects of endogenous opiates in horses are not necessarily similar to those of the opiate drug and, may in fact, be markedly different.

2. Sub-maximal Performance Experiments

The simplest type of performance experiment is the sub-maximal performance experiment. It is in essence a modification of the behavioral model experiment in which the horses are run at less than maximal output with and without the drug. Because the horses are not being tested at maximal output, there is a better chance of obtaining statistically significant changes in times than in the maximal performance experiment. Using this approach, statistically significant effects of drugs in horses can be shown, but whether or not these effects are important in a racing situation is unknown. Therefore, a major problem with this type of experiment is that one cannot know how the results from these experiments relate to a "supra-maximal" performance effect.

Compound	Dose (mg/kg)	Route	Number tested
Methylamphetamine	0.1	i.m.	4
	0.2	i.m.	4
Methylphenidate	0.25	s.c.	4
	0.5	s.c.	4
Pemoline	4.0	oral	3
	8.0	oral	3
Caffeine	2.0	oral	3
	4.0	oral	3
Phenylbutazone	8.0	oral	4
	6.6	i.m.*	4

* Injection made 23 h before test. In these gallop tests, horses were run singly over a 200-meter course from a flying start. After an interval of about 5 min. during which period the horse returned to the start at a trot or slow canter, this gallop was repeated. No data on the dosing times, the actual performance times, or the variability in the performance times on which these conclusions were drawn were presented.
Source: Sanford, Symposium on Large Animal Therapeutics, University of Surrey, Guildford, Surrey, 1978. Courtesy of Blackwell Scientific Publications.
Cited in Tobin, T., "Drugs and the Performance Horse," 1981.

Table III. Gallop test 2 x 200 m. Compounds suspected of increasing speed in Thoroughbred horses.

This experimental approach has been taken by Sanford in England[11,12,13] and by Fujii in Japan.[13] Some of Sanford's data, which are typical of the data generated by this approach, are presented in Table III. With this type of experiment, Sanford reported statistically significant effects of drugs in gallop tests, but how these data may relate to effects of drugs on maximal or near maximal performance is not clear.

3. The Maximal Output Performance Experiment

The conceptually simplest approach to the study of equine performance is in the maximal output performance or Horseman's Experiment, so-called because horsemen are the people who usually suggest it. In this experiment, one runs about six horses, with or without the drug, for about a mile at top speed. The distinguishing characteristic of this experiment is that the control horses are run at maximal output, and the drug is being asked to produce a supra-maximal performance effect. Drugs studied in this type of experiment include amphetamines, furosemide and the anabolic steroids.[5,10,11,12,14] Perhaps, not unexpectedly, such a drug-induced supra-maximal performance effect has yet to be demonstrated.

The problem with this experiment is that the drug effect is likely to be small, while the noise or background variability found in the controls may be large. We are aware of several such studies in racing horses, and all have yielded inconclusive results.[5,10,11,12,14,15]

More recently, we analyzed the data from these experiments to determine the potential for these tests to produce statistically significant results. Unfortunately, no other workers have presented individual data points or a mean and a statistical estimate of the variance encountered in their performance trials. However on the basis of the variance reported in time trial work from our laboratory, one would need a performance improvement about 3.75% on top of an already maximal performance in control animals for statistical significance. This is a large increment in performance to expect of any medication, and is unlikely to be observed in the small number of animals tested in maximal output performance experiments to date.

4. The Statistician's Experiment

The last type of experiment to be discussed is the so-called statistician's experiment. In this type of experiment, the data are obtained by a study of the effects of approved medication on actual track times of racing horses. This is potentially the most powerful of all the experimental methods available for answering questions about the actions of drugs in racing horses.

This type of experiment was first proposed by Mr. Carl Larsen of the Kentucky Harness Racing Commission, who pointed out that in 1977 the only drug permitted in harness racing in Kentucky was furosemide. He suggested that we study the differences in track times for harness horses racing at Louisville Downs with and without furosemide. Furosemide (pre-race) is recommended in racing horses for the treatment of exercise-induced pulmonary hemorrhage (epistaxis or "bleeding"). Whether or not it is effective in the treatment of this condition and whether or not it improves the performance of racing horses is unknown. We identified 232 times for these horses while they were on furosemide, compared with 160 times for the horses without furosemide.[20] The results of this study (Table IV) suggest that the horses treated with furosemide were about one-tenth of a second slower after treatment than before. The numbers are large, and the experiment undoubtedly relates to the performance situa-

	Number of horses	Number of trials	Mean times	S.E.M.
Pre-furosemide F=0.31	58	160	128.5925	0.2031
With furosemide (F for significance should be >3.0)	58	232	128.7366	0.1594

At this meet, furosemide was the only permitted medication, and its use was monitored by urinalysis. Horses could elect to go on furosemide at any time throughout the meet, but once on furosemide had to stay on it. Performance times for horses pre-and post-furosemide treatment were obtained from the meet programs and compared. Only times on good or fast tracks were taken. For the 58 horses selected, 160 pre-furosemide times were available and 232 post-furosemide times. A randomized block design was used where each horse represented a block. After adjusting for blocks (*i.e.* differences between horses), there was no significant difference between treatments (*i.e.* times on and off furosemide). Reproduced with permission from Tobin *et al*, J. Equine Med. Surg.

Table IV. Effect of medication with furosemide on the performance of horses racing at Louisville Downs, Summer 1977.

tion, and statistically the answer is unequivocal. Furosemide treatment had no effect whatsoever on the performance of Standardbred horses at this Louisville Downs meet.

In contrast with the small probability of obtaining statistically significant data from maximal output performance experiments, these racetrack experiments are much more promising. From the data of Table IV one can calculate that a true mean difference of 0.72 s. (a 0.56% improvement) would be required to produce significant differences from controls at the 0.05 level, assuming that it is desired to obtain a significant result 80% of the time. These are far more attainable figures than those developed from maximal output performance trials, and they suggest that this experimental approach should be pursued.

This approach has been taken a step further by Soma of the University of Pennsylvania in his studies on Thoroughbred horses.[13,14] Dr. Soma and his colleagues observed the effects of furosemide at Keystone Racetrack on horses whose times had declined for three successive races and whose owners had then had them endoscopically examined. Those found positive for epistaxis (pulmonary bleeding) were then put on furosemide. The results showed that furosemide restored the performance of the epistaxis-positive horses to the level observed prior to their decline in performance. This experiment, therefore, suggests that the action of furosemide is to restore "normal" performance in racing horses. While there were difficulties with the controls available for this experiment, this work clearly points to the racetrack as the most satisfactory experimental tool for answering questions about drugs and racing performance.

In summary, therefore, the classic performance trial or maximal output performance experiment is expensive, time consuming, and difficult to perform. Furthermore the information yield from these experiments has been minimal. If one reduces the output demanded of the animals, as in the sub-maximal output performance experiment, one can produce statistically significant results, but these results do not necessarily demonstrate effects of drugs on maximum performance.

Simple behavioral experiments can be used to determine the suitability of drugs for performance experiments, the optimal dose of drug to use, and the time period dosing to test performance. They can also be used to determine the responsiveness of individual horses to drugs. Because of the expense of performance experiments, it is advisable to use these simple experiments to characterize the action of drugs in horses before performance experiments are begun.

The most satisfactory performance experiments are those carried out at a racetrack during an actual race. Such experiments are limited to those drugs which are legal for racing horses or which are approved by racing authorities. This experimental approach has yielded good results with the diuretic furosemide and could be extended to other drugs.

In the final analysis, however, the impact of any performance experiment on the way in which society views the use of stimulant drugs in racing horses is likely to be small. If the drug is found to have a stimulant effect, regulators will conclude that the ban on that particular drug is proper. On the other hand, negative results are not likely to lead to changes in the way society or racing regulators view stimulants. For these reasons, research efforts on the performance effects of drugs might be

ter directed towards drugs for which experimental results will resolve doubts or influence decisions by regulators or society in general.

ACKNOWLEDGEMENT

Published as Kentucky Agricultural Experiment Station Article #88-4-270 with the approval of the Dean and Director, College of Agriculture and Kentucky Agricultural Experimental Station.

Publication #159 from the Kentucky Equine Drug Testing and Research Programs, Department of Veterinary Science and the Graduate Center for Toxicology, University of Kentucky.

Supported by a grant entitled "Immunoassay Tests for High Potency Narcotic Analgesics in Racing Horses" from the Kentucky Equine Drug Research Council and the Kentucky State Racing and Harness Racing Commissions. Additionally, this research was supported by grants for research on detomidine from the American Horse Shows Association, research funds from the Illinois Racing Board to support their pre-race testing programs, research funds from the Oklahoma Horse Racing Commission and the Oklahoma Horsemen Association for work on Lasix and research support to the University of Kentucky from International Diagnostic Systems Corporation.

REFERENCES

1. Fujii, S., Yoshida, S., Kusangagi, C., Mima, K. and Natusumo, Y.: Pharmacological Studies on Doping Drugs for Racehorses. Trans-anocamphor. Jap. J. vet. Sci., 32, (1970):307-317.
2. Fujii, S., Inada, S., Yoshida, S., Kusangagi, C., Mima, K. and Natusumo, Y.: Pharmacological Studies on Doping Drugs for Racehorses. III. Ephedrine. Jap. J. vet. Sci., 36, (1976):9-18.
3. Hughes, J., Smith, T., Kosterlitz, H.W., Morgan, B.A. and Morris, H.R.: Identification of Two Related Pentapeptides from the Rat Brain with Potent Agonist Activity. Nature, 258, (1975):577-579.
4. Janssen, P.A.: The Development of New Synthetic Narcotics. In Opioids in Anesthesia, Edited by Estafanous, F.G. Butterworth Publishers, Boston, 1985.
5. Kamerling, S., Wood, T., DeQuick, D., Weckman, T., Blake, JW. and Tobin, T.: Narcotic Analgesics, Their Detection and Pain Measurement in the Horse: A Review. Eq. vet. J., in press.
6. Kwiatkowski, S., Sturma, L., Dai, M., Tai, H-H., Watt, D., Tai, CL., Woods, WE., Weckman, T., Yang, J-M., Wood, T., Chang, SL., Blake, JW. and Tobin, T.: Immunoassay Detection of Drugs in Racing horses. VII. Detection of Acepromazine in Equine Urine and Blood by ELISA and PCFIA. Res. Comm. Chem. Path. Pharm., 61,(3) (1988):391-412.
7. Martin, W.R.: Pharmacology of Opioids. Pharmacol. Rev., 19, (1984):283-323.
8. Milne, DW., Gabel, A., Muir, W., Skarda, R., Hamlin, R. and Piper, R.: Effects of Furosemide on Cardiovascular Function and Performance when Given

Prior to Simulated Races: a Double-blind Study. Am. J. vet. Res. 41, (1978):1183-1889.
9. Nugent, T., Combie, J., Weld, J., Burns, P. and Tobin, T.: Effect of Enkephalins versus Opiates on Locomoter Activity in the horse. Res. Comm. Chem. Path. Pharmacol., 35, 405-419.
10. Raphel, C.F. and Soma, L.R.: Exercise-induced Pulmonary Hemorrhage in Thoroughbreds after Racing and Breezing. Am. J. vet. Res. 43, (1982):1123-1127.
11. Sanford, J.: Medication Affecting the Performance of Racehorses and its Control. Proc. 19th World Vet. Cong., (1971):382.
12. Sanford, J.: Drugs and Their Effects on Performance in the Horse. HBLB Conf. Res. Workers., (1973):40-41.
13. Sanford, J.: Drugs Affecting Equine Performance. in Pharmacological Basis of Large Animal Medicine. Edited by Bogan, J., Lees, P. and Yoxall, A. Blackwell Scientific Publications, Oxford., 1973.
14. Soma, L.R., Lester, L., Oppenlander, F. and Barr-Alderfer, V.: Effects of Furosemide on the Racing Times of Horses with Exercise-induced Pulmonary Hemorrhage. Am. J. vet. Res., 46, (1985):763-768.
15. Stewart, G.: Drugs, Performance and Responses to Exercise in the Race Horse. Aust. vet. J., 48, (1972): 544-547.
16. Snow, D., Munro, C. and Nimmo, M.: Anabolic Steroids in Equine Practice. Eq. vet. J., 14, (1982):224-228.
17. Tobin, T.: Drugs and the Performance Horse, Charles C. Thomas, Springfield, Illinois., 1981.
18. Tobin, T. and Combie, J.: Performance Testing in the Horse: A Review of the Role of Simple Behavioral Models in the Design of Performance Experiments. J. vet. Pharm. Therap. 5, (1982):105-118.
19. Tobin, T., Kamerling, S. and Nugent, T.: Drugs and Equine Performance: A review. Equine Exercise Physiology, Proc. First Intn'l. Conf. Edited by Snow, D., Persson, S. and Rose, RJ.) Oxford, U.K., (1982):510-520.
20. Tobin, T., Roberts, B.L., Swercsek, T.W. and Crisman, M.: The Pharmacology of Furosemide in the Horse. J. eq. Med. Surg., 2, (1978):216-226.
21. Wood, T., Tai, C.L., Taylor, D.G., Woods, W.E., Wang, C-J., Houtz, P., Tai, H-H., Weckman, T., Yang, J-M., Sturma, L., Chang, S-L., Goodman, S.D., Blake, J.W., Watt, D.S., Tobin, T., McDonald, J., Wie, S., Chung, R.A., Brecht, J., Conner, J., Dahl, P., Lewis, E. and Prange, CA.: Immunoassay Detection of Drugs in Racing Horses. IX. Detection of Detomidine in Equine Blood and Urine by Radioimmunoassay. Res. Comm. Substance. Abuse. in press.