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# Measurement of the pressures exerted by saddles on the horse's back using a computerized pressure measuring device

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**Summary**

Saddles contribute in a major way to the poor-performance syndrome. A great deal of money is spent trying to define poor performance, and the effects of the saddle are generally overlooked. Saddles create pressures greater than the capillary closure pressures in the skin and muscle, causing inflammation and pain which can cause performance problems. These pressures can be recorded with the horse in motion using computerized pressure sensing equipment.
This study was conducted to document the effects of saddles on horses' backs in 30 clinical cases where performance problems were related to back pain and inadequate saddle fit. Performance problems, such as decreasing speed on the racetrack, resistance to work, or the horse being unable to round its back, affect many of the competition horses today and are a primary reason for horses to decline in value or be retired from competition.

**keywords:** saddle, backs, pressure sensing, performance horses, resistance array

**Druckpunktmessung von Sätteln auf dem Pferderücken mittels eines computergesteuerten Druckmeßgerätes**

Beim Leistungsabfall eines Sportpferdes spielt häufig ein inadäquat angepaßter Sattel eine Rolle. Um die Ursachen von Leistungseinbußen zu diagnostizieren, werden meist größere Summen ausgegeben, ohne dabei das Problem des schlecht sitzenden und drückenden Sattels zu berüchsichtigen. Der von einem belasteten Sattel ausgehende Druck übersteigt den Kapillardruck der Haut- und Muskelgefäße weit, so daß Entzündungen und Schmerzen verursacht werden, die zu Leistungseinbrüchen des Pferdes führen können. Ziel dieser Arbeit ist die Analyse des von einem Sattel ausgehenden Drucks auf den Pferderücken mittels einer computergesteuerten Druckmeßvorrichtung.
Die Autorin testete das elektronische Druckmeßsystem an 30 Pferden, die Anzeichen von Leistungseinbußen zeigten, welche auf Rückenprobleme und inadäquat angepaßte Sättel zurückzuführen waren. Der Leistungsabfall der Pferde manifestierte sich z.B. in schlechter Rennleistung, Widersetzlichkeit beim Training sowie in der Unfähigkeit, den Rücken zu gymnastizieren. Dies sind typische Symptome, wie sie heutzutage bei einer ganzen Reihe von Sportpferden vorkommen. Im Endeffekt büsstenen viele Pferde wegen Rückenproblemen an Leistung ein und werden aus dem Leistungssport genommen. Da inzwischen technisch hochentwickelte Methoden wie Laufbandanalysen und Sensitivitätstests existieren, sind die Probleme des Hochleistungspferdes recht gut bekannt.
In dieser Studie wurden 30 Pferde mit dem Saddletech-Druckmeßsystem unter dem Reiter getestet, um die individuelle Sattelpaßform zu überprüfen. Die Fälle stammten aus dem Patientengut der Klinik, wobei Dressur-, Spring-, Vielseitigkeits-, Renn- und Westernsportpferde vertreten waren. Nach Ausschluß anderer möglicher Ursachen der Leistungseinbußen wurde die Verarbeitung, Polsterung, Kammerweite und Symmetrie der Sättel überprüft und die Sattelpaßform manuell kontrolliert.
Das Computer-Druckmeßsystem besteht aus 256 Sensoren, die in einer 61x68 cm großen Auflage auf dem Pferderücken angebracht werden. Zum Schutz vor Schweiß und Schmutz liegt noch eine dünne Unterlage auf. Die Sensoren registrieren Druckunterschiede, welche mit einem Analog-zu-Digital-Konverter und einer speziellen Computergrafik-Software auf einen Farbmonitor übertragen werden, wobei die einwirkenden Druckkräfte in Psi (Pfund pro Quadratinch), kPa (Kilopascal) oder mmHg wiedergegeben werden können.
Sättel mit einem Hauptdruck bis zu Werten von 49,9 mmHg gelten als dem Pferderücken exzellent angepaßt, solche mit 50–99,9 mmHg ohne persistierende Druckpunkte als gut angepaßt und solche mit 100–149 mmHg und leichten Druckpunkten als ausreichend für den jeweiligen Pferderücken. Sättel, deren Druckmessung Werte zwischen 150–224 mmHg ergab, wiesen gravierende Mängel auf und fielen beim Test durch.
Die Satteldruckmessung der 30 Pferde unter dem Reiter im Schritt und Trab ergab Werte zwischen 24,9 und 224 mmHg. Nur 5 Sättel (=16,7%) paßten gut. Die Autorin ermittelte bei vielen Sätteln grundlegende Probleme in der Paßform. Hierzu gehörten vor allem Sättel, die dem Pferderücken steif auflagen und bei denen starke Druckpunkte im vorderen und hinteren Bereich der Sattellage registriert wurden, während die Mitte der Sitzfläche kaum belastet wurde. Weitere Mängel, von denen häufig mehrere zugleich vorlagen, beinhalteten zu enge Kammern mit Druck auf die Wirbelsäule, zu weit nach vorne verlagerte Schwerpunkte mit Druck auf den Widerrist sowie Druckpunkte unter den Pauschen. Bei einem Sattel drückten die Lederteile an ihrer Innennaht am Sattelbaum.
73,3% der Sättel wiesen Verarbeitungsfehler bzw. Abnutzungsmängel auf, 56,7% von ihnen besaßen mehrere schwerwiegende Probleme. Die Autorin ermittelte bei 36% der beanstandeten Sättel leichte und bei 64% schwere persistierende Druckpunkte auf dem Pferderücken. Bei 12 Sätteln ergaben sich Druckstellen durch zu enge Kammern, bei 6 Sätteln direkte Druckschäden auf die Wirbelsäule. Insgesamt paßten 11 Sättel überhaupt nicht zum jeweiligen Pferderücken. 4 Sättel erwiesen sich anhand der Computer-Druckanalyse als „durchgesessen".
Die Analyse der Daten dieser Studie demonstriert, daß inadäquat angepaßte Sättel schwerwiegende Druckschäden am Pferderücken hervorrufen, die eine der wesentlichen Ursachen für Rückenprobleme und Leistungseinbußen bei Sportpferden darstellen. Die Computer-Sensor-Druckanalyse bietet sowohl der Sportmedizin als auch der Sattlerindustrie neue Möglichkeiten, dem Hochleistungspferd gerechte Wettkampfbedingungen zu ermöglichen. Leider existieren nur selten Maßanfertigungen, sodaß die meisten Pferde mit einer weniger gut passenden oder völlig inadäquaten Sattelausrüstung gearbeitet werden.

**Schlüsselwörter:** Sattel, Rücken, Druckmessung, Sportpferd, Widerstandsfähigkeit

## Introduction

With the advent of treadmills and sophisticated tests performed on exercising horses much has been learned about the physiology of the equine athlete. However, crossing the bridge between the research laboratory and the real world of performance has been less conclusive (*Rose*, 1994; 1995).

**Tab. 1:** Problems observed in horses with poor saddle fit.

Probleme bei Pferden, die aufgrund eines schlecht sitzenden Sattels beobachtet wurden.

| Performance Problems | |
|---|---|
| 1) | showing any objection to being saddled |
| 2) | being „cold-backed" during mounting |
| 3) | slow to warm up or relax |
| 4) | decreasing speed on the racetrack |
| 5) | slow out of the starting gate |
| 6) | hock, stifle, or obscure hind limb lameness |
| 7) | front leg lameness, stumbling or tripping |
| 8) | excessive shying at all sorts of things |
| 9) | lack of concentration on rider and aids |
| 10) | rushing to/from fences; refusing jumps |
| 11) | rushing downhill or pulling uphill with front legs – unable to use hind end |
| 12) | inability to travel straight |
| 13) | inability to round back and/or neck |
| 14) | swishing tail, pinning ears, grinding teeth, tossing head |
| 15) | hypersensitivity to being brushed or touched |
| 16) | exhibiting a „bad attitude" |
| 17) | difficult to collect or maintain impulsion |
| 18) | twisting over fences |
| 19) | bucks or rears regularly |
| 20) | resistance to work |
| 21) | resistance to or requires training aids |
| 22) | ducking out of turns |
| 23) | starts ride doing well, gets more resistant later |
| 24) | not moving, or bucking, rolling excessively in field |
| 25) | difficult to shoe |

Saddles are the necessary evil of most competition and race horses. A saddle is a rigid structure that connects the dynamic structures of the horse with the rider. The fit and position of the saddle affect the movement of the horse and the ability of the rider to communicate his/her wishes to the horse. Soft tissue pain created by saddles contributes significantly to the poor-performance syndrome, as well as many of the behavior and lameness problems seen in horses in every sport (Table 1, *Harman* 1992). There are many causes of back pain and poor performance; one of the most frequent seen by this author is saddle-induced pain, either from a poor fit or improper positioning.

With the advent of a computerized saddle-pressure measuring device (Saddletech, Woodside, CA), it is now possible to measure the effects of saddle pressure on a horse's back. Since tissue damage causes pain and pain leads to performance problems, it follows that saddles contribute to performance problems. The goal of this study was to observe the effects of saddles on horses' backs in a clinical setting. All of the horses in the study had one or more performance problems currently, or had experienced performance problems in the past that had been corrected with improving the fit of the saddle. The riders wanted to check the current saddle to be sure it was fitting.

## Materials and Methods

Recordings were collected from 30 routine clinical cases presented to the author's clinic. Data was gathered with the usual rider mounted. Saddles from most sports were represented by this group of riders: dressage, jumping, eventing, endurance, flat racing, western roping and western pleasure.

Saddles were examined for symmetry, and manufacturing and structural defects. Saddles were examined from the top and bottom, particularly for symmetry of the panels and width of the gullet (Figures 1, 2). Other structural defects checked were twisted or broken trees, uneven flaps, uneven billets and stirrup bars.

Saddle fit was evaluated by hand using the following parameters:

1) the contact of the panels against the horse's back, absence of bridging;
2) whether the panels were wide enough to distribute the rider's weight correctly;
3) whether the gullet was wide enough to clear the spine completely (2–1/2 to 3 inches);
4) the fit of the tree to the horse's back, especially across the withers;
5) whether the saddle sat squarely in the center of the back and
6) the levelness of the seat when the saddle was in the correct position.

The relationship between these parameters and performance are included in the discussion.

The computer sensor pad consists of 256 sensors, in a 61 by 68 cm sheet of woven material, shaped so it will lie flat on each side of the horse's back (*Harman* 1994). A clear, thin rubberized cover is used to protect the sensors from sweat and dirt. The sensors are a resistance array of pressure-sensitive-ink sensors printed on a polyester film. The ink changes resistance as pressure is applied to the surface. The changes in pressure are monitored and processed by an analog-to-digital converter and a computer with dedicated software for graphic display on a color monitor, similar in appearance to a thermogram. Each color of the display represents 24.9 millimeters of mercury (mmHg) of pressure. The pressures can be measured in pounds per square inch (psi), kiloPascals (kPa) or mmHg by changing the settings.

A 22.86 meter ribbon computer cable connected the pressure pad on the horse to the computer. Since most horses have been trained with lunge lines, using this wiring system did not present any problems. A quick-release connection was used for the cable where it attached to the pad at the saddle.

Saddles with the majority of pressures up to 49.9 mmHg were graded an excellent fit; saddles (50 – 99.9 mmHg) without persistent pressure points, and with the majority of the scans showing less than 100 mmHg were graded a good fit; saddles (100 – 149 mmHg) with moderate pressure points were graded fair and saddles that exceeded 150 - 224 mmHg or had

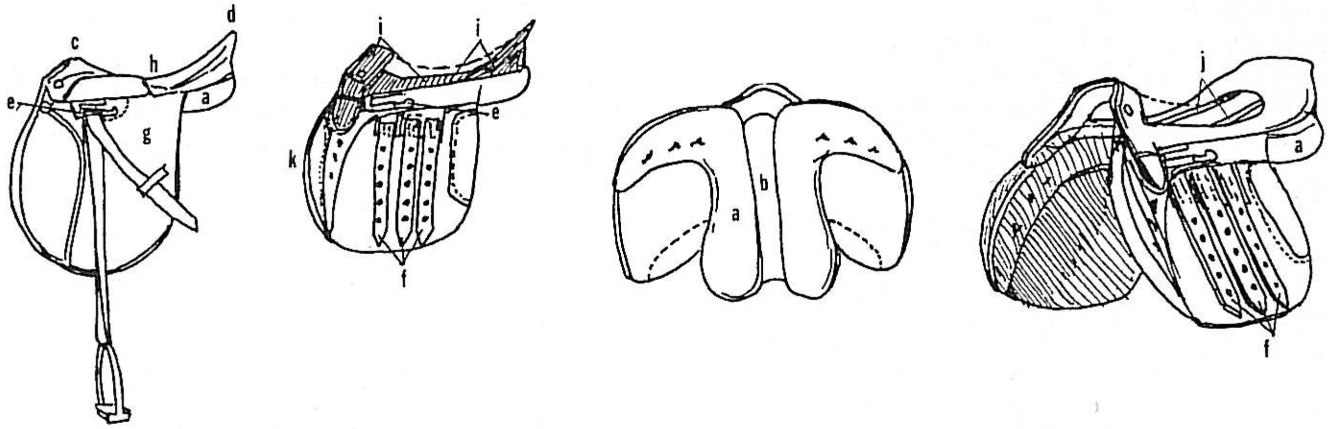


**Fig. 1:** Top, bottom and side view of English saddle showing parts.
a. Panel b. Gullet c. Pommel d. Cantle e. Stirrup bar f. Billets
g. Flaps h. Seat i. Tree j. Spring of tree k. Knee roll

Ober- und Unterseite sowie Seitenansicht von einem Englischen-Sattel mit seinen Teilen
a. Sattelpolster b. Kammer c. Vorderzwiesel d. Hinterzwiesel e. Bügelschloß f. Gurtstrupfen
g. Sattelblatt h. Sitzfläche i. Sattelbaum j. Trachten Pauschen

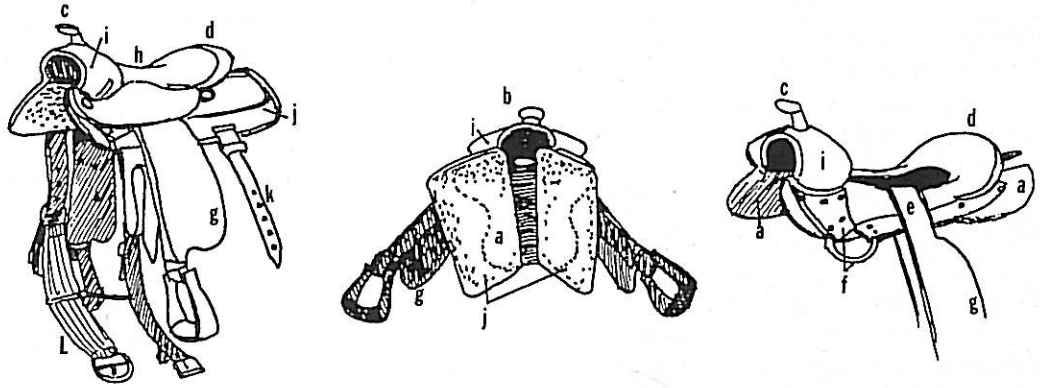


**Fig. 2:** Top, bottom and side view of Western saddle showing parts.
a. Bars (covered with sheepskin in the finished saddle)
b. Gullet c. Horn d. Cantle e. Stirrup leather around bars f. Rigging
g. Fender h. Seat i. Fork j. Skirt k. Flank billet l. Girth

Ober- und Unterseite sowie Seitenansicht von einem Western-Sattel mit seinen Teilen.
a. Sattelbaum b. Kammer c. Horn d. Hinterzwiesel
e. Bügelaufhängung f. Gurtbefestigung g. Fender (Bügelriemen)
h. Sitzflächei. Fork j. Unterfläche Sattel k. Hintergurtstrupfe l. Bauchgurt

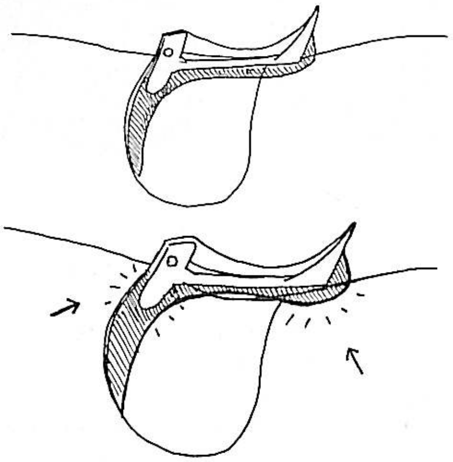
Recordings were taken with the horse standing still, walking around a twenty-meter circle, then trotting around the same circle. Race horses followed the same procedure because the cable restricted fast work on a straight track and these horses were not balanced enough to canter in a circle. A basic, non-therapeutic saddle pad was used with all saddles, either a fleece pad, cotton quilted pad or a standard western synthetic pad.

persistent pressure points throughout the session were graded poor. Pressure points were considered persistent if they were present in the majority of the scans from one horse.

## Results

Pressures underneath the saddles ranged from 24.9 to 224 mmHg with the rider mounted and walking or trotting.

Saddle fitting problems showed up in the majority of scans. Only five saddles fitted well, with pressures below 50 mm-Hg. Several basic fitting problems showed up regularly, with some saddles having several areas causing problems. The most common fitting problem seen was „bridging" where there were pressure points at the front and rear of the panels, with minimal pressure in the middle (Figure 3). Other findings included excessive pressure at the front of the saddle, narrow gullets putting pressure on the spine, uneven pressures, pressure points under the stirrup bars, and in one saddle pressure points where the leather flap was attached to the tree.



B

**Fig. 3:** A. Saddle fitting correctly with the panels almost flat against the back.
B. Bridging in an English saddle showing the areas of high pressure (arrows). Western saddles bridge in the same manner.

A. Ein richtig aufliegender Sattel mit den Sattelpolstern fast gerade auf dem Rücken.
B. Druckpunkte (Pfeile) auf dem Rücken eines Pferdes von einem zu hoch aufliegenden Englischen Sattel. Western Sättel können genauso hoch aufliegen.

Twenty-two saddles (73.3%) had uneven panels when examined for structural defects. The uneven panels showed up as significant pressure points on the scans. Seventeen saddles (56.7%) had multiple significant problems. Of the seventeen, 6 saddles (36.0%) had persistent moderate pressure points and 11 saddles (64.7%) had severe pressure points that remained in a majority of the scans. Twelve of the seventeen saddles (70.1%) had very narrow gullets exerting pressure on the spine and 6 saddles (35.3%) placed moderate to severe pressure directly on the spine. Thirteen saddles (76.5%) had a significant degree of bridging, 6 (36.0%) of which had a tree that was too narrow. The remaining eleven saddles did not conform to the shape of the horse's back. Of the 6 saddles that were not bridging, 4 (66.7%) had severe or persistent pressure points in the center of the panel. Four saddles (23.5%) showed pressures under the stirrup bars.

Eight saddles had one primary fitting problem, 3 (37.5%) had mild pressure points present on a frequent basis during the scan. One-half (50.0%) of the 8 had a very narrow gullet, although the pressures along the spine were lower than those in the first group. Three saddles (37.5%) bridged but the trees either fitted fairly well or were a little too wide. One saddle with a very thin panel had a pressure point where the back of the leather flap was attached to the tree.

Five saddles (16.7%) were classified as good to excellent, with only occasional pressures recorded up to 74.9 mmHg, or rarely to 99.9 mmHg. Several types of saddles were represented in this category, western, English and endurance. The gullets were wide enough to leave the spine free of pressure and with less than 24.9 mmHg next to the spine. One saddle (Sport Saddle, Paduca, KY) has no gullet since it is a flat piece of leather without panels similar to a modified bareback pad. The horse in this test had round back muscles with an inverted spine, so a gullet was not needed. With this flat type of saddle, horses with thin back muscles require a pad with a gullet or pressure will occur on the dorsal spinous processes.

## Discussion

Recorded pressures under saddles in many cases greatly exceeded the capillary closure pressures of 35 mmHg *(Harman, 1994)*, a situation that is well-known to begin muscle damage and ischemic necrosis in humans *(Le 1984, Holloway 1975)*. In humans and dogs it is well documented that it takes two hours at 70 mmHg psi for ischemic necrosis to begin *(Le 1984; Todd 1994)*. The primary reason open sores are seen infrequently in spite of the great number of poorly fitting saddles is because few people ride their horses more than an hour or two a day. Open sores are primarily seen in endurance and western ranch horses who are ridden all day, but clinically in this author's experience, pain and soreness exist without seeing the open wounds. In the early stages of tissue damage, inflammation is present. Along with inflammation comes pain and consequently pain-related performance problems *(Harman 1992)*.

The results of this study indicate that the fitting of any saddle to a horse is an individual process. There is no one brand of saddle that fits every horse, even though many manufacturers make claims that they can fit every horse.

This author, in an unpublished study, found serious manufacturing defects in all price ranges of saddles, with some brands having eighty to ninety percent of their saddles affected. Consequently, even the most dedicated client has a difficult time finding a saddle that fits and is free from manufacturing defects. The defects range from minor to major problems for either the horse or rider or both. The uneven panels noted in this study caused saddles to sit unevenly on the horses' backs, which in turn, caused the riders to sit unevenly. The uneven distribution of pressure on the horses' backs affected the way the horses moved and behaved, since, after the saddles were restuffed and the panels adjusted so they were even, the horses' performance improved.

The bridging seen in 76.5% of the saddles creates four pressure points, one on each side of the withers and one on each side of the back at the rear of the saddle. A very small bridge in the panel from front to rear allows the horse to lift its back into the saddle while it is working, however a large bridge allows excessive pressure points and prevents the raising of the back according to one of Britain's leading saddle makers *(Foster 1995)* and this author's observations. The fit of saddles needs to be compared to that of fitting a running shoe to an athlete. Even the weekend athletes need to have correctly-fitted shoes or they will be very uncomfortable. The serious athlete spends a great deal of time, money and energy finding the best shoes for the sport. Unfortunately saddles cost much more than running shoes, so the option to purchase a new saddle is often unavailable. This study points out that a large number of saddles do not fit horses correctly (56.7% of saddles had serious multiple fitting problems) and the riders were unaware that the saddle contributed to their horse's poor performance. The majority of the clients who presented their horses for examination in this study thought their saddles fit acceptably, though three people were aware they had a saddle fit problem but did not know how to correct it.

Seventy percent of the clients seen in this author's practice are clinically healthy horses presented for poor performance. Therefore, the cases are biased towards musculoskeletal pain and discomfort. Clinically this author sees horses' stride length, muscle structure and shape improve, and many of the „training problems" listed in Table 1 improve when the saddle fit is corrected. Other treatments such as acupuncture and gentle chiropractic are used, however, the clients who are not willing or able to correct saddle fit do not see the same increase in performance or the horses require considerably more frequent treatment than the horses with well-fitted saddles. If the saddle fit is corrected the response to any treatment, conventional or alternative, is much better, and there have been some horses in this author's practice that required no treatment after correcting the saddle fit.

The confounding variables of rider balance and rider pain, combined with the fact that horses change shape with work and age, and the difficulty in finding a correctly-made saddle makes fitting saddles more difficult than it looks on the surface. When interpreting the computer scans, all the variables need to be taken into effect, including the horse's conformation, symmetry of its back and shoulders, as well as the saddle and rider's influence. Observing and interpreting the rider's effect is extremely difficult, since most veterinarians are not trained riding instructors and most horse owners do not want input about their riding skills from the veterinarian. However, it is possible to determine whether the rider is influencing the scan by examining the symmetry of the saddle and the horse first. If both the saddle and horse are symmetrical, yet the scan is asymmetrical, the rider is probably the cause.

## Conclusion

The data from this study indicates that saddles can cause excessive pressures, leading to pain and discomfort. There are a number of changes that need to be made in the saddle industry to supply saddles without some of the defects in design (narrow gullet widths) and production (uneven panels) to serve increasingly astute riders. A great deal more research needs to be done to define the role of saddle fitting in sports medicine including back pain and blood flow studies of the equine skin and muscle.

Saddle-fitting is actually a complex and challenging part of sports medicine and the poor performance syndrome. Human athletes have spent a great deal of time and money determining exactly the correct shoes, skis or ice skates needed for the level of the sport they are participating in. The frustrating part of becoming involved with saddle-fitting is that there are few easy answers, since most manufacturers are not making saddles designed for horses.

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