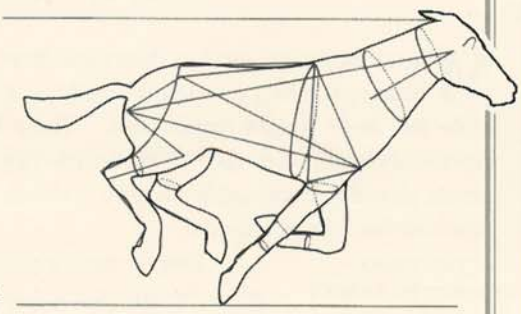
BIOMECHANICS IN PLAIN ENGLISH

The science of biomechanics examines how the biological system of an animal converts "fuel" (food) to interact with the mechanical system—bones, muscles, tendons—to produce a given level of energy to perform a specific function.



It is a tool which has ***revolutionized human athletic conditioning***, and has led to major advances in human health.

Biomechanics has also had a major impact on Thoroughbred racing over the past two decades, in large part due to the success of racehorses which were either selected, identified, or bred, with the assistance of biomechanical programs developed and marketed by EQUIX Biomechanics.

EQUIX's ***Racing Analysis*** helps owners, trainers, breeders and pinhookers to ***identify as yearlings or 2-year-olds horses*** which are efficiently built and more likely to succeed under various racing conditions;

EQUIX's ***Broodmare Analysis, Stallion Analysis*** and ***OptiMatch*** programs help breeders and stallion managers to objectively select structurally compatible matings within their own pedigree and economic guidelines, to produce well-balanced offspring which can race successfully at the highest levels, and/or sell successfully in the marketplace.

THE EQUIX MISSION

EQUIX helps the client to focus on breeding or acquiring those horses which have a statistically higher chance for success while eliminating those horses whose chances for success are historically low.

EQUIX has conducted extensive research since the early 1980s seeking solutions to the following complex problem:

◆ How can the breeder, owner, trainer or stallion manager improve the odds of getting winners–from out of the breeding shed or out of the sales ring?

EQUIX"s answer, which is capsulized from our Mission Statement above, is simple:

"We provide objective information in order to help you focus on the future."

EQUIX accomplishes this by:

◆ Personally inspecting the horse, making note of its physical strengths and conformation faults;

◆ Measuring more than 30 separate bones and muscle groups which make up the mechanical systems of its body;

◆ Ultra-sounding the heart and relating its size and pumping efficiency to body size and structure;

◆ When necessary, analyzing video tapes of actual races, or works, to determine stride efficiency and length.

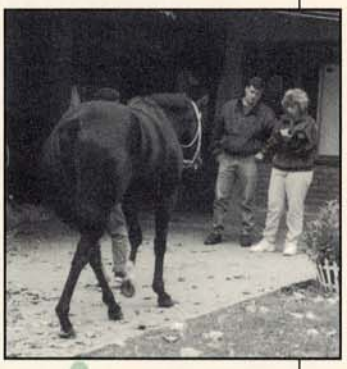
The data is entered into EQUIX's computers, where our mathematical and growth curve programs generate a biomechanical analysis report which gives a wealth of objective data about that particular horse:

◆ How it is built, i.e., its *Phenotype* (or model)–the dozen physical types which separate the classic runner from the sprinter.

◆ How the horse's structure will influence its running style–under which conditions, and at what distances, is it most likely to succeed?

In addition, when requested, we provide a breeding analysis report which reveals:

◆ Whether the horse in question, male or female, can be counted upon to reproduce desirable racing qualities in its offspring, irrespective of its own racing aptitudes.



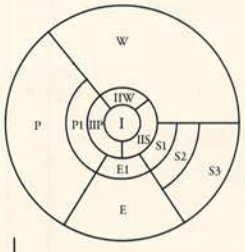
EQUIX provides easy-to-read reports which detail each horse's performance potential. Samples are enclosed for your inspection.

the mission

WHAT "MODEL" DO YOU HAVE?

Measurements are used to determine how a horse is "balanced" based on the relationships of its power, stride and body weight (trunk size). These factors are expressed visually on the EQUIX Phenotype Target *(below)* which classifies Thoroughbreds into a dozen groupings based on that relative balance.

THE EQUIX PHENOTYPE TARGET



This is an easy concept to grasp, because it is so logical.

- **Adequate Power** is needed to generate speed;
- **Efficient Stride** is needed to cover a distance of ground;
- **Appropriate Body Weight** (Trunk Size) for a horse's Power and Stride is needed to process energy.

As these proportions vary, the horses adapt to distance and speed.

- When Power is greater than Stride and Body Weight, the horse is generally adapted to speed over shorter distances;
- When Stride is greater than Power and Body Weight the horse is generally adapted to longer distances.
- When all three factors are about the same, the horse *can* adapt to a wide variety of distances.

However, this is just a rough guide to distancing a horse. Other factors come into play such as heart capacity and efficiency, which could alter the equation:

- "Power" horses with great heart efficiency may be able to race up to the lower middle distances;
- "Stride" horses with less efficient cardio systems may not be able to get more than a mile.

PHENOTYPICAL DEGREES OF SEPARATION

By categorizing horses into Phenotypes, a basic guide to *racing form* can be ascertained. In addition, **when type is consistently bred to type**, the foals tend to be of another similar type–a *genotype*.

Except for Type I, there are varying degrees of factors which separates the Phenotypes into "Sub-Types."

The most important subdivision on the EQUIX scale is "Sub-Type II," which consists of IIS, IIP and IIW phenotypes. These horses are closest in structure to the Type I horse. They generally make better breeders than horses which are more "tilted toward" Stride, Power or Weight in structure.

This is only logical, as one can see from the Phenotype Target above: Sub-Type II horses are closer to the Target's center and therefore closer to overall balance.

Equix has determined 12 Phenotypes, or "models" of the Thoroughbred within five general "Types":

Type I	Basically even balance of Power, Stride and Body Weight
Type S	More Stride than Power (Sub-Types: IIS, S1, S2, S3)
Type P	More Power than Stride (Sub-Types: IIP, P1)
Type E	Body Weight Inadequate For Power and Stride (Sub-Type: E1)
Type W	Body Weight Excessive For Power and Stride (Sub-Type: E1)

TYPE I

If all three factors are in balance, there is the potential for the best of all possible worlds: A versatile racehorse. They have the potential to adapt to virtually any distance, although other "Types" may hold an edge at the distances *for which they are ideally constructed.*

TYPE I

According to our data, their versatility goes beyond the racetrack when sent to stud: **Colts with these biomechanical properties are more likely to become breed shapers; fillies with such properties can become foundation mares.**

This is because they are excellent "mixers"–their overall balance blends well with the widest variety of physical types in the population. Thus, their offspring tend to "rise to the top".

Type I's occupy center stage, a spot within the bulls' eye position of the Phenotype Target, illustrated above.

EQUIX has a long-standing policy of not publicly disclosing the Phenotype of an individual horse during its lifetime. But it should surprise no one that based on the criteria listed above, deceased sires such as **Northern Dancer, Nijinsky II, Roberto, Blushing Groom [Fr], Lyphard, Raise a Native, Fappiano** and **Grey Dawn II**, were classified Type I based on their biomechanical properties.

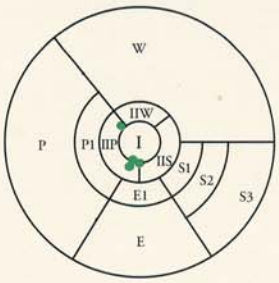
These eight are situated on the Type I Target in their respective positions, some with a little bit more Power (off to the left), some with a little more Stride (leaning toward the right). All, however, were wonderfully balanced, and none could be accused of being anything other than great as either a racehorse or a sire.

PHENOTYPES

On The Left Wing

Where Power is greater than Stride, the horse is generally adapted to speed over sprints and lower middle distances. That makes it a *P-Type*, expressed on the Target as P, P1 and IIP. Horses classified as IIP have just slightly *more power than stride and body weight.* P1 and P horses can be overpowered.

P-Types



Type IIP horses have been more successful as two-turn racehorses and/or as Leading Sires than P or P1 horses. *They are positioned closer to the center of the Target, and therefore biomechanically compatible with more types of mares, than those further off to the left.*

Examples of Type IIP horses include **Damascus** and **Tri Jet**, as well as both **Ack Ack** and **Tom Rolfe**. That the first two mentioned are IIP Types may not be surprising, but Ack Ack and Tom Rolfe? Yes, their grandams were full sisters–but they were from completely different sire lines and were generally accepted to reflect almost diametrically opposite racing aptitudes.

It may be logical that Damascus' son **Cutlass** would be a similar Type–and he is positioned above as a P1. But, interestingly, the other two P1's on the Target are **Ace of Aces** and **Mississippian**, sons of **Vaguely Noble**.

When it comes to pure Power horses (Type P), it's no surprise that one positioned is **Whitesburg**. But the other Type P's on the Target are active grandsons of Northern Dancer through three different sons; each horse has a pedigree (and dosage) which indicates classicity, or in our terminology, more Stride than Power, yet they are actually Power horses.

Biomechanics can complicate the rigidities of certain pedigree theories.

On The Right Flank

Where Stride is greater than Power, a horse runs more on stride rhythm and is generally adapted to longer distance. As such, EQUIX classifies these as S-Types, expressed on the Target left as IIS, S1, S2 and S3.

S-Types

Horses classified as IIS have more power than stride and body weight compared to Type S3, which are basically all stride.

Like IIP horses relative to P and P1 Types, it should not surprise that more Classic winners, and successful sires, are found among Type IIS horses than S1, S2 and S3 Types. Examples of Type IIS horses are **Sir Ivor**, **Graustark** and his full brother **His Majesty**, as well as **Caveat** and his sire, **Cannonade**. On the other hand, **Copelan**, a sprinter, was a IIS, while his sire, Tri Jet, was a IIP.

One of the clues to the way both **Secretariat** and **Alydar** performed as sires-of-sires and as broodmare sires is revealed on the Target. They were both outstanding examples of the S1 Type, and they are shown along with V**aguely Noble, Time for a Change** (by Damascus, a IIP), and **Sovereign Dancer**.

Type S2 horses on the Target include such logical ones as ***Le Fabuleux** as well as **Pretense**; however, one would probably be surprised that the other dot represents **Bold Hour**, considered by many to be a speed, or Power, horse.

Type S3 horses on the Target–increasingly rare in North America–are **Big Spruce** and **Riva Ridge**.

Special Considerations Needed

A horse evenly balanced as to Power and Stride, but with inadequate Body Weight to process the energy its body needs, is classified as an E-Type.

E-Types

They are generally less successful as racehorses because they do not possess the energy reserves needed for greater distances–unless a superior cardio system is present. E-Type horses are usually erratic as producers because they tend to perpetuate problems associated with inadequate body weight. Type E1 horses, which are closer to the center of the Target, are not as affected by this problem, either as racehorses or as sires. Good examples of the E1 Type would be ***Forli, Cox's Ridge**, and **Olden Times**, while **Gate Dancer, Youth, Silent Screen, Romeo** and **What Luck** were among the pure E-Types who had varied success.

Simply Overwhelming

Occupying the largest area of the Target, but in reality the smallest sector in the population, is the Type W horse, which has the opposite problem of Type E: too much Body Weight for its Power and Stride. These horses rarely become successful racehorses because their weight is hard to control, hence breakdown chances are so high.

W-Types

While mares of this Phenotype can be successful producers (because they have ample room for a foal to develop in utero) colts are usually one-dimensional as sires, either getting pure sprinters or 2-year-olds who run early, win, and then disappear.

Though no Type W horse has won a Classic in the past 40 years, one, Irish Castle–probably the best sire of this Type in the past 30 years–did sire a Classic winner in **Bold Forbes**, who was a Type I. Other exceptions such as **Rollicking** and **Blade** also did well enough as sires among this Type. On the whole, however, this is a small, if not hardy, group.

Biomechanical Efficiency Scores

A Thoroughbred's Biomechanical Efficiency Score (BME Score) is a relative value expressing how a horse's individual "body parts" work together in order for it to compete effectively on the racetrack.

The effective scoring range is from about 90 to 100. These scores are generated from growth curves programmed into our computer models and are based on measurements taken by our equine analysts.

The BME Score is then projected in the EQUIX report on a chart *(right)* at six month intervals until a horse reaches its final growth stage of 72 months.

Predicted Biomechanical Efficiency Scores

Age in Months	Predicted Score
24	96.2
30	96.7
36	97.2
42	97.5
48	97.6
60	97.6
72	97.5

Age Does Not Matter

It is important to understand that the EQUIX programs can project *forward or back* in time using growth curves, which are a known genetic factor.

Thus, if a horse is measured at age 14 months, EQUIX projects its biomechanical efficiency into the future.

Horses measured at older ages—at four, six, ten, or 15 years old, for example—will have their scores computed back to the age of 24 months, and then forward to full growth, at 72 months.

Here are guidelines which EQUIX offers for interpreting the BME Scores generated by our computer programs:

98 + Exceptional biomechanical efficiency with high probability to race in allowance or stakes company. Most horses in this category who fail to be successful either lack desire, are injured, or suffer other medical problems.

97-98 Very good biomechanical efficiency. High probability of being a winning racehorse; very good probability to be able to race in allowance or stakes company.

96-97 Good biomechanical efficiency and probability of being a winner, fair probability to be an allowance or stakes horse, especially if strengths are emphasized and few weaknesses are avoided.

95-96 Fair to good biomechanical efficiency. Some horses in this category can race in allowances. However, the probability of these horses being successful is moderately low.

94-95 Fair biomechanical efficiency. Special training and racing techniques are needed to avoid their weaknesses in mechanics. The probability of these horses being successful under normal racing conditions is low.

93-94 Poor to fair biomechanical efficiency. Unlikely to be successful in higher claiming company.

UNDER 93 Poor biomechanical efficiency. Unlikely to be competitive in anything but lower claimers.

EQUIX considers only basic mechanical relationships to determine these scores and we urge that evaluating BME Scores be made in conjunction with other data, including veterinary, pedigree, conformation, and performance analysis. These scores add another dimension to the picture.

When properly used, BME Scores are one means to an end and can increase the probability for success in the selection of racing and breeding stock and in the choice of matings.

Cardio Analysis and EF Scores

Photo by Anne M. Eberhardt

The heart lies within the oxygen delivery chain and thus its size and, in particular, stroke volume, should play some role in how long, strenuous muscular exercise can be maintained prior to fatigue.

Using state-of-the-art cardio scanning equipment, EQUIX captures **ultra-sound images of a horse's heart to determine the capacity of the cardio system to deliver oxygen to its muscle structure given that horse's overall size and body structure.**

This is different from measuring the size of the heart. Rather, EQUIX calculates the efficiency of the cardio system, and expresses that efficiency as an *Ejection Fraction Score (EF Score).*

The EF Score is a relative value on a scale of 1 to 10 of an individual's resting stroke volume (amount of oxygenated blood ejected from the heart per beat). The EF Score is adjusted for age, body size, sex, and fitness.

Horses with a high EF Score have a greater potential for oxygen delivery to, and waste removal from, skeletal muscle, which results in less fatigue during strenuous exercise. Researchers generally agree that in the absence of clinical airway, lung, or blood disorders, stroke volume is the limiting factor in oxygen delivery potential.

EF Scores are distributed normally in the Thoroughbred population with a median of 6.5 (6.6 for colts and 6.4 for fillies). Two-thirds of the population have scores ranging from 5.8 to 7.2, while just 2.5% have an EF Score greater than 8.0.

EF Score Q & A

What's the difference between EF Score and Heart Size?

The EF Score is a direct indicator of a horse's stroke volume (adjusted for body size, age, and fitness), *i.e.*, it reflects oxygen delivery/metabolic waste removal potential.

The Heart Size, on the other hand, is an EKG-based indication of heart size only; it was developed long before diagnostic ultrasound was available.

Why is adequate oxygen important to muscle function?

Skeletal muscle contracts and energy is released when glucose is burned. When glucose is burned in the presence of oxygen, the by-products are carbon dioxide and water, which are relatively harmless. However, when burned in the absence of oxygen, less than 10% of the energy is liberated along with the by-product lactic acid, which causes muscle fatigue.

Can an individual's EF Score be increased with training?

Training does, indeed, increase heart size and stroke volume, and some horses are more affected than others. Since the EF Score is adjusted for the training effect as well as for age and body size, it measures the individual's inherent capacity to deliver his oxygen requirements. Any advantage due to relative stroke volume is reflected by the EF Score. It allows comparison of fit and unfit horses of different age and size.

Do most well-bred horses have above-average EF Scores?

Yes. For example, 60% of the progeny of an elite sire or dam may have EF Scores above the average EF Score for the breed. But that also means 40% of the progeny will have below-average EF Scores. For a lesser sire or dam, those figures might be reversed.

Do horses with high EF Scores always perform well?

Not always. Oxygen delivery potential, although important, is only one of a variety of factors that affect performance. If a horse has a high EF Score and is also above average in the other performance-dependent areas, then it is likely he will be an outstanding individual. Most of the elite performance horses we have scanned have high EF Scores.

What factors affect performance potential?

Exercise physiologist and sports medicine researchers worldwide now generally agree that race performance potential is based upon certain heritable features involving the following four areas: oxygen delivery, biomechanics, skeletal muscle function, and psychological competitiveness

How much emphasis should be placed on the EF Score?

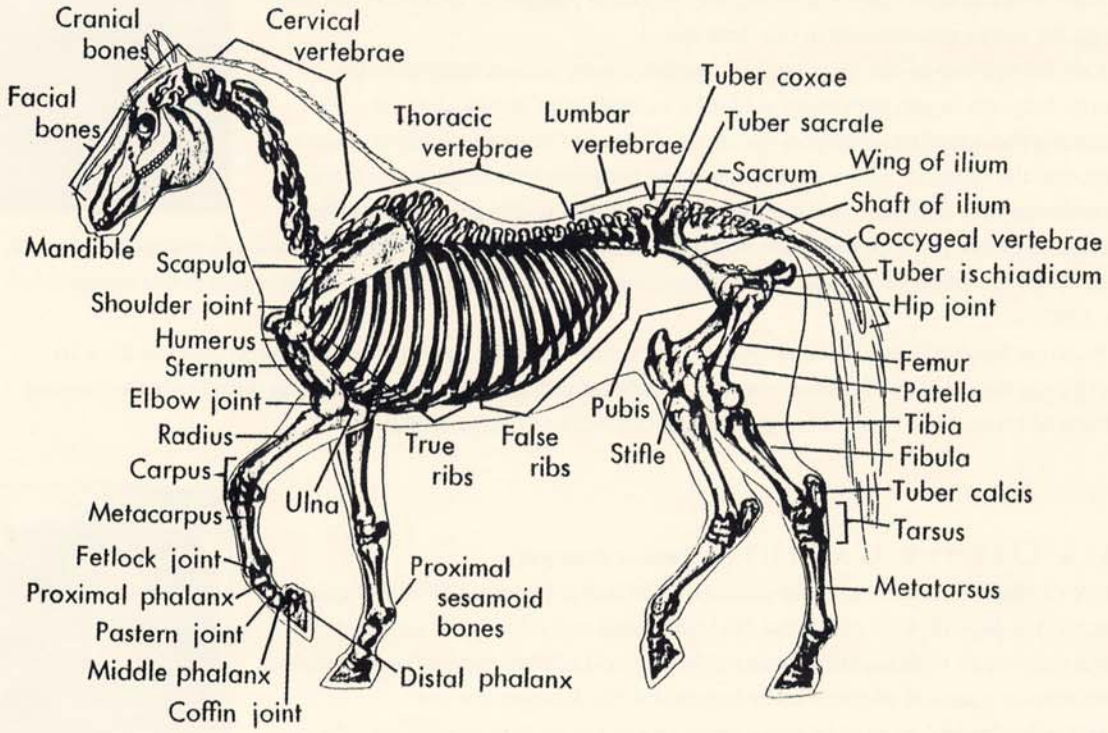
Although an important indicator of performance potential, it should not be the sole criterion upon which to purchase. **The most appropriate use of the EF Score is to use it to sort through a group of horses that have already satisfied other criteria**—pedigree, conformation, BME Score, etc. Thus, the buyer or breeder has a meaningful, scientifically based tool which can help eliminate some horses from consideration, while placing more emphasis on those with greater cardio efficiency.

Can horses with low stroke volume ever be competitive in Graded stakes?

To date, we have seen very few horses with an EF Score below 6.0 (especially colts) win or place in Graded or Group events at distances beyond 1 1/16 miles.

Q&A

CONFORMATION



EQUIX's analysts have been trained to "look at a horse" in a somewhat different way. This is particularly important at auction when clients request that EQUIX cull those horses which are not likely to meet minimum criteria established by our biomechanical programs. Part of the skill which our analysts bring to the task is an ability to gain an overall impression of whether a horse is "balanced"—or be able to produce balanced horses.

Another skill is the ability to judge conformation faults which may or may not compromise even the most superbly engineered biomechanical structure. Since the degree of heritability varies for different faults and because certain faults are considered more severe than others, EQUIX prefers to be very specific. Sometimes a fault must be fairly distinct before we reject a particular horse; sometimes, even a slight deviation from the norm will not pass. *On a scale of 0 to 5, EQUIX generally does not forgive fault scores over 2.0, excepting those in the next collumn.*

SCALE OF GENERALLY ACCEPTABLE FAULTS

Score	Fault
0 to 2.5	◆ Straight (hind) legs
0 to 2.0	◆ Cow hocked ◆ Tied-in at the knees ◆ Turned out at the knees
0 to 1.75	◆ Upright pasterns ◆ Sickle hocked ◆ Turned in at feet or ankles ◆ Offset knees
0 to 1.5	◆ Back at the knees ◆ Cocked ankles ◆ Club foot

structure