Explore biomechanics - the science of movement

T. rex has often been portrayed as being as fast as a galloping racehorse. New research in biomechanics suggests that a very large animal, like T. rex could not have run that fast. You can learn why here. This program is based on the research of John R. Hutchinson of The Royal Veterinary College, UK.

Could a T. rex run fast?
- Move the CENTER OF MASS, POSTURE and LEG MASS sliders to find out.
- Click on any ANIMAL ICON to compare it to T. rex
**Explore biomechanics - the science of movement.**

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Could a *T. rex* run fast?

- Move the Center of Mass, Posture and Leg Mass sliders to find out.
- Click on any animal icon to compare it to *T. rex*. 
Posture has a huge impact on leg mechanics. A bent leg permits fast, spring-like running, but a straighter leg keeps muscles from having to work too hard to support body weight. Because T. rex, like other big animals, had a lot of weight to support, biomechanics suggests that it used a more upright posture.
The location of center of mass affects balance. A balanced animal—with its center of mass over its base of support—can move more easily than an animal whose weight is far forward or back. For T. rex to remain stable at any speed, a center of mass closer to the hips would require a straighter leg and need smaller leg muscles. A center of mass closer to the head would require a more bent leg and larger leg muscles.
The amount of muscle mass an animal needs is determined by how fast it moves, its posture, and where its center of mass is, among other factors. Because T. rex probably had no more relative leg muscle than a human or ostrich, we conclude that it probably could not move very fast.
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<td>Posture:</td>
<td>Posture has a huge impact on leg mechanics. A bent leg permits fast, springlike running, but a straighter leg keeps muscles from having to work too hard to support body weight. Because <em>T. rex</em>, like other big animals, had a lot of weight to support, biomechanics suggests that it used a more upright posture.</td>
<td>A simple animation of our <em>T. rex</em> going from crouching position to standing position.</td>
<td>This 3D model of a <em>T. rex</em> leg shows the hindlimb muscles that probably helped support body weight. A more crouched posture requires larger, harder-working muscles. A more upright posture has better “mechanical advantage” or leverage. Because <em>T. rex</em> was so large and heavy, we think that it used a more upright, straight-legged posture, one that would not be very effective for running.</td>
<td><em>T. rex</em> OptimalPosture animation created by J.H.</td>
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<tr>
<td>Center of Mass:</td>
<td>The location of center of mass affects balance. A balanced animal—with its center of mass over its base of support—can move more easily than an animal whose weight is far forward or back. For <em>T. rex</em> to remain balanced, the center of mass must move forward and back.</td>
<td>Animation of the <em>T. rex</em> with a red dot representing CoM that moves forward and back.</td>
<td>Computer models like this let researchers change <em>T. rex</em>’s size and center of mass and observe how those changes affected its ability to run. Because we don’t know a lot about <em>T. rex</em>’s shape and center of mass, we use</td>
<td>Use J.H. animation named Trex alive.</td>
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stable at any speed, a center of mass closer to the hips would require a straighter leg and need smaller leg muscles, whereas a center of mass closer to the head would require a more bent leg and larger leg muscles. models to examine how much these unknowns would affect running ability.

| Leg Muscle Mass: | The amount of muscle mass an animal needs is determined by how fast it moves, its posture, and where its center of mass is, among other factors. Because *T. rex* probably had no more relative leg muscle than a human or ostrich, we conclude that it probably could not run very fast. | Animation of *T. rex* with the leg getting bigger and smaller. | This model lets us calculate how much leg muscle mass an animal needs to run fast. It is a simple 2D stick figure of a fully grown *T. rex*, frozen in the middle of a running stride, with all its weight on one leg. The relative leg mass of a *T. rex* might have been somewhere between a fit human (10% body mass per leg) and a supermuscular ostrich (20% body mass per leg). The posture shown in this stick figure is quite bent-legged. If this Animation GA will create using a selection of the 2D figures. |
were the posture *T. rex* assumed, it could not run fast, because it would have needed improbably large leg muscles to do so.

**Animal Text**
Comparing crocodiles and T. rex helps demonstrate how size limits speed.
Crocodile

Comparing crocodiles and *T. rex* helps demonstrate how size limits speed. **Smaller species of crocodiles use gaits more typical of mammals, like bounding and galloping, as shown here.** The larger crocodiles don’t, probably because of their size. The same was likely true of larger animals such as *T. rex.*
Even though elephants move on four legs, and T. rex moved on two, elephants can help us understand why T. rex could not have been a fast runner. That's because the animals are roughly comparable in weight.
Elephant

Even though elephants move on four legs, and *T. rex* moved on two, elephants can help us understand why *T. rex* and other large animals cannot be very fast runners. That’s because the animals are roughly comparable in weight.

Weight-bearing dictates the leg design of elephants--and presumably of *T. rex*. Elephants tend to have fairly straight legs, especially when compared to smaller animals. It takes less muscle activity to carry weight on a straight leg than on a bent leg, so it makes sense that elephants usually get around on straighter legs—and *T. rex* probably did, too.
In speed, was T. rex more like a horse or an elephant? Biomechanics suggests that T. rex was closer to the elephant than the horse. Horses are much faster than elephants and T. rex for at least two reasons: they are much smaller, and they maintain a bent-legged posture.
Horse

In speed, was *T. rex* more like a horse or an elephant? Biomechanics supports the conclusion that *T. rex* was closer to the elephant than the horse.

Horses are much faster than elephants and *T. rex* for at least two reasons: they are much smaller, and they maintain a bent-legged posture. In addition, quadrupeds such as horses have many more gaits than bipeds because they have more limbs. Trotting, cantering and galloping are what we call typical running gaits in quadrupeds. A striding biped like *T. rex* only walked or ran.
When bipeds run they must bounce slightly, as this familiar running biped does. Note that the runners are fairly straight-legged.
Human

When bipeds run they must bounce slightly, as this familiar running biped does. Note that the runners are fairly straight-legged. The speed of humans, *T. rex*, and other animals is determined by the same rules. Though humans benefit from their smaller size, their straighter legs limit running speed.
Highly-trained human athletes can achieve remarkable speed over short distances, attaining 40kph (25mph) or more. An average runner, in contrast, clocks in at between 16 and 24kph (10-15mph) or so. When T. rex moved at its top speed, where would it fit in? Probably somewhere in between.
Olympic sprinter

Highly-trained human athletes can achieve remarkable speed over short distances, attaining 40kph (25mph) or more. An average runner, in contrast, clocks in at between 16 and 24kph (10-15mph) or so. When *T. rex* moved at its top speed, where would it fit in? Probably somewhere in between.

Part of what makes a human sprinter so fast is big, strong leg muscles that can apply a large force against the ground. Typical humans have about 10% of their body mass in each leg as supportive muscle, but an Olympic sprinter has a bit more. *T. rex* would have needed unrealistically large leg muscles to be a fast runner like the sprinter.
Why is an ostrich fast? It bounces when it runs, it is airborne during part of its stride and its upper leg joints are very bent. An ostrich also has among the largest leg muscles (for its size) of any animal.
Ostrich

Many things contribute to the speed of an ostrich: it bounces when it runs, it is airborne during part of its stride, and its upper leg joints are very bent. An ostrich also has among the largest leg muscles (for its size) of any animal.

What about *T. rex*? Could the animal have used a form of locomotion as extreme as this, with a long airborne phase? Or did it keep at least one foot on the ground, not bouncing as much as ostriches do? Regardless, *T. rex* probably did not have big enough leg muscles to run like an ostrich. If, in relative terms, *T. rex* ran as fast as a sprinting ostrich, its leg muscles would have needed to be over 50% of its body, much more than in any animal, ever.