

Project: Speed 2

How to increase your speed: All about rolling resistance

Translated from mountainbike-magazine.de

Narrow tyres or wide ones?

High tyre pressures or low?

A coarse or a fine tread pattern?

Read here what really makes you go fast:

The truth about rolling resistance

Nearly 350 test rides totaling a distance of 150 kilometers (c. 93 miles). Including 8500 m elevation (28000 ft), covered in strenuous 16.2 hours accumulated uphill riding time. A very demanding exercise. And why all this? Quite simple: In the interests of science. Peter Nilges, for his graduate dissertation at the German College of Physical Education, Cologne, researched the subject of rolling resistance.

Ever since the early days of mountain bike sports there has been a heated and, most of all, controversial discussion on the significance of tyre models, tyre width and tyre pressure, since potential energy savings are significant. As the Nilges study shows, off-road rolling resistance can consume up to 50% of the overall power available for propulsion. So what tyre characteristics contribute to less resistance and a faster ride?

- Course or fine tread pattern?
- Narrow or wide footprint?
- High or low pressure?

Opinions have differed significantly. On one hand most cross country and marathon riders still swear by 1.7" cutting wheels at high pressures of around 4 bar (c. 57 p.s.i.) that are liable to loosen the odd filling in a rough descent. On the other hand there are many that have discovered wide tyres and soft low-pressure-riding as ideal for themselves. But who is right? Answers were pure speculation until this study was published. Until now there has been no scientifically established data on the subject of rolling resistance for mountain bike tires.

Finally have a hard and fast foundation on which to decide which tyre and which set-up are best for a specific purpose, so that rolling resistance can be kept to a minimum.

Peter Nilges measured rolling resistance under varying conditions. Three different tyres (Schwalbe's Fast Fred, Racing Ralph and Albert Brothers) in three different widths and at four different pressure levels (1.5, 2.0, 3.0 and 4.0 bar – c. 21, 28, 43 and 57 p.s.i.) had to prove their worth. The test course is an uphill grade, 460 m (503 yards) in length, offering directly side by side road, gravel and a meadow. Power was measured



precisely by an SRM-system (see graph on page 8). Speed was a mere 9.5 kph (5.9 mph) to eliminate air resistance influence. Compensation was made for differences in the weights of individual tyres. To provide reference data Bohle (the Manufacturers of **Schwalbe** Tyres) measured rolling resistance on a test stand. Results were largely identical with those of the field tests.

The results (charts on pages 5 to 8) tell a clear tale. As expected, rolling resistance is largest on the uneven grassy ground (meadow), followed in order by gravel and hard surface road. The Albert Brothers, with their coarse tread pattern, were the hardest to roll on all surfaces. Surprisingly enough studded Racing Ralph's fine pattern rolls easier on-road than Fast Fred, a semi-slick, while positions are reversed off-road. The explanation is likely to be found in the structure of the tread pattern and the carcasses' flexibility ([Evolution Design](#)). Racing Ralph's studs protrude significantly further but in the tread area are spaced more closely so that they nearly form an uninterrupted center ridge. This lets the tyre roll more smoothly on firm ground, as opposed to continually descending into the gaps between individual studs, only to have to rise again. Off-road on the other hand flexibility has a more significant influence than the tread pattern. The thinner rubber layer on the carcass of a semi-slick can more easily adapt to an uneven surface.

What effect does the width of a tyre have? The test covered widths from 2" to 2.4", or 50 to 62 mm. The resulting data makes narrow-gauge-riders prick up their ears. While on-road there is no marked difference between a narrow and a wide tyre, off-road the wide tyre is proven to roll more easily! The rougher the ground, the greater the advantage, as the data obtained on grass proves. A look at the respective contact areas of two tyres of different width (diagram on page 4) shows that the areas are nearly equal in size but different in shape. The wider tyre's contact area is wider, but shorter. This then means that the 'retarding' lever that the tyre has to overcome ('F' in the diagram) also shortens. Moreover wider tyres have larger diameters, and again that improves rolling.

The data on tyre pressure yields near-revolutionary results. On the road the principle of 'the more, the merrier' applies, as has been common road-racing-knowledge for years. A firmly inflated tyre makes for good propulsion. To this present day many mountain bikers have adhered unflinchingly to this rule, too, transferring it without reflection, so to speak, into the dirt.

Way off! As soon as you leave the road, reducing tyre pressures does not just leave rolling resistance more or less unaffected, as can be heard here and there, but actually reduces rolling resistance! This is true even on level paths of fine gravel (Chart 3 on page 7), but the rougher the ground, the greater the effect, as the grassy ground shows. Reducing tyre pressure from 4 to 1.5 bar (57 to 21 p.s.i.) can save an averaged 20 W! The main reason for this is the unevenness of the ground.

Any such unevenness means that part of the forward propulsion force is required to lift machine and rider upwards. This is equivalent to riding a



short uphill grade that requires a certain amount of lifting energy. A tyre with less inflation can adapt to unevenness more easily. The total system needs to be lifted to a lesser degree and less frequently. Resistance is reduced, less power is required.

Chart 4 on page 8 demonstrates that up to 50 W (!!!) can be saved on average by applying the newly gained knowledge, that is, given the same course and speed, by substituting the widest tyre tested (2.4") at 1.5 bar (21 p.s.i.) for a narrow 2.1-incher at 4.0 bar pressure (57 p.s.i.).

In case of a cross-country-race or a marathon course using the right tyre, adequately set up, means gaining minutes and positions!

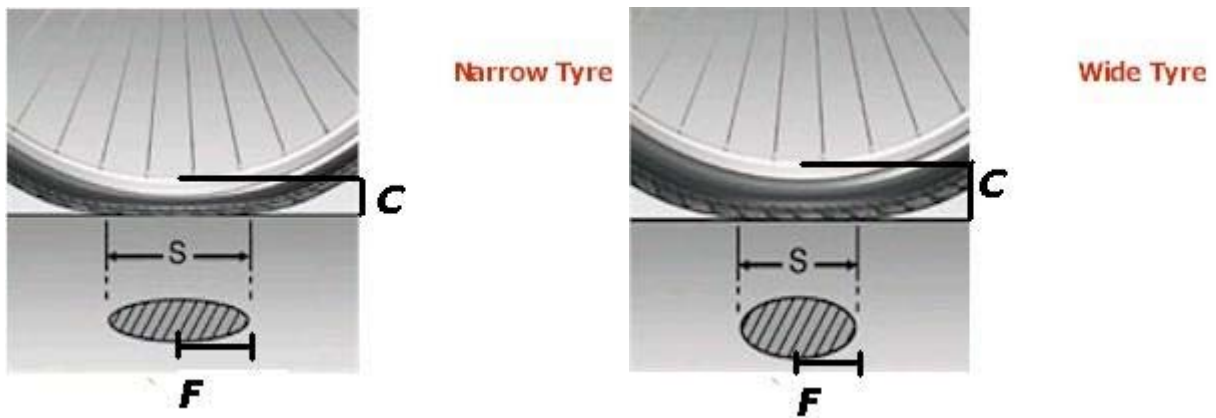
What does this mean in practical terms? Only cyclists who primarily ride on the road should inflate their tyres firmly. Even here, however, as of a certain pressure level rolling resistance does not lessen any further.

Comfort, on the other hand, reduces dramatically. The best kind of tyre for the road is a slick or a tread pattern with closely spaced studs. Even though the width has no influence, due to superior shock absorbing properties bikers should, if in doubt, go for the wider model.

Anyone who wants to ride really fast off-road needs to decrease tyre pressure. The rougher the ground, the more pronounced the effect. In addition traction and comfort increase, too. Due to their thin and flexible structure, semi-slicks offer the best start-up values for minimizing rolling resistance off-road. With a reduction in pressure, however, the risk of a flat increases. And traction with the semi-slick is limited. So the answer to the question of which width is best off-road clearly reads 'fat tyre' both for superior traction and snake bite prevention.

For cross-country-races and marathons involving only a small percentage of tarmac a wide tyre with low pressure is recommended. The most overestimated aspect here is the frequently criticized extra weight of the wider tyre. To accelerate a pair of tyres with an extra weight of 500 g (16 oz) from 0 to 25 kph (15.5 mph) in 4 seconds requires an additional 4.2 W power. On the other hand the wider tyre on a grassy surface saves you 15.5 W against a narrower specimen, and this at the low speed of 9.5 kph (5.9 mph). Moreover the rolling resistance reduction has a continuous effect while lighter weight is only of relevance during acceleration.
Peter Nilges

Fat or thin? If you want to go fast, go for wide tyres in order to save energy.

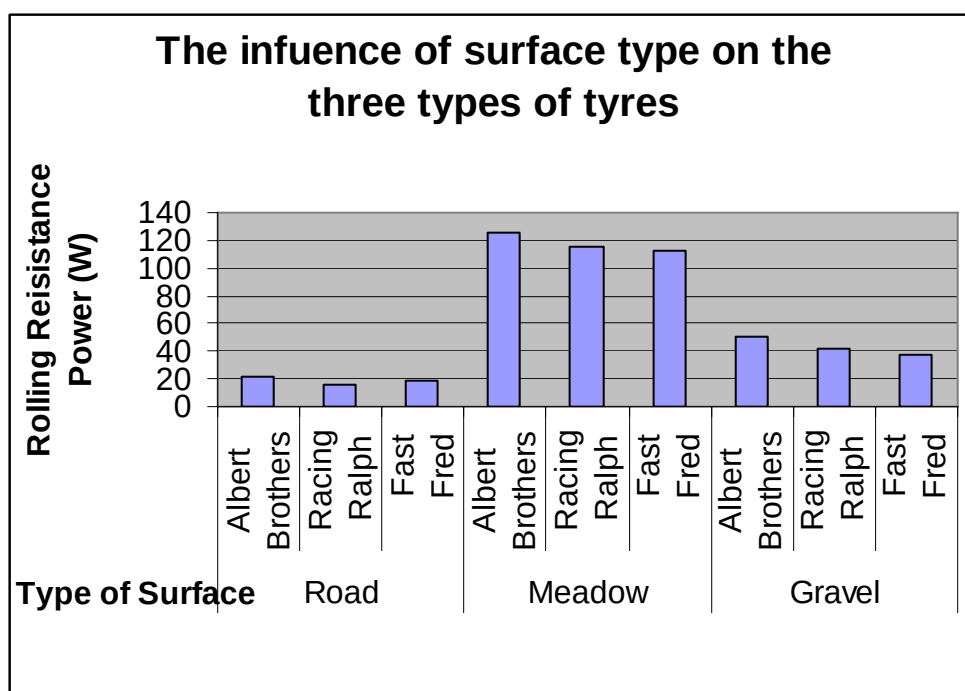


The combined weight of bike and rider flattens the tyre at the point of contact with the ground (in technical terms: patch). Narrow tyres compress **C** more and thus deform more. Given identical tyre pressures, the size of the resulting patch does not vary with tyre width. The shape however differs. The wider tyre has also a wider, but shorter patch. This reduces lever **F**. Picture the process of rolling as a tilting motion with **S** as its anchor point. Due to the shorter lever the wider tyre then rolls more easily.

Test results

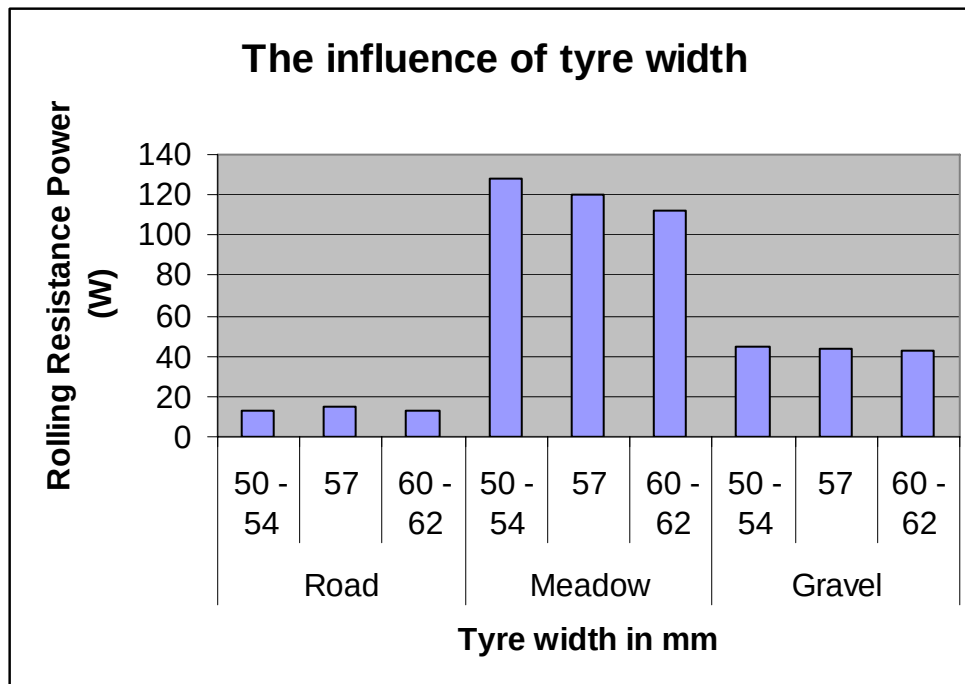
Data that revolutionizes the world of the mountain bike. The readings show clearly that a reduction of tyre pressure and wider tyres reduce rolling resistance.

1. The influence of the surface type on three tyre models



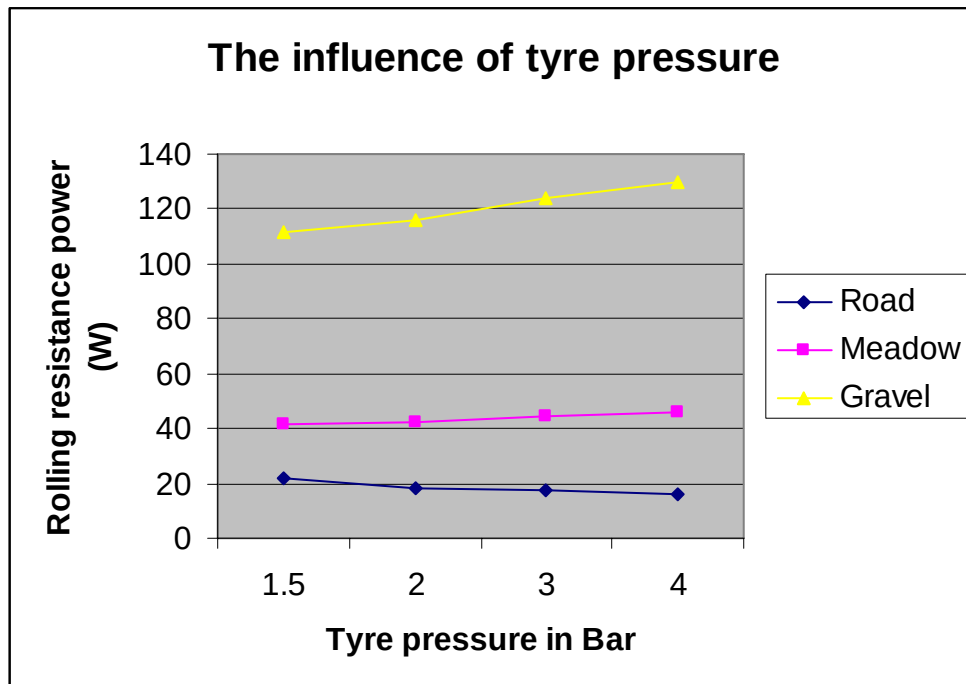
Rolling resistance on a grassy surface is about six times as high as on the road. Schwalbe's Albert Brothers tyres with their coarse tread pattern on all three surfaces had the greatest resistance.

2. The tyre width factor



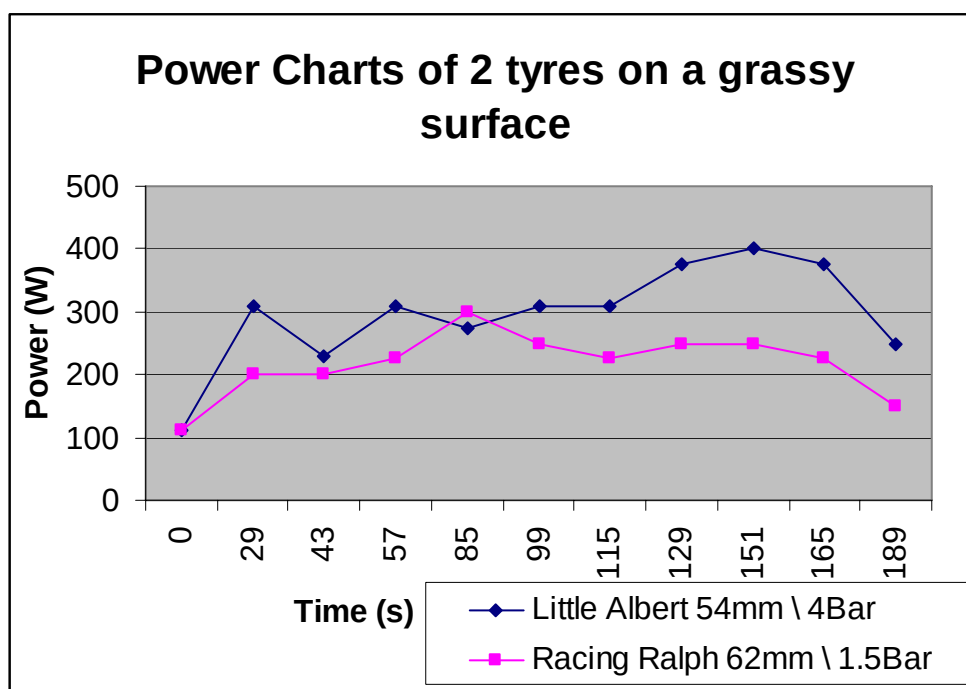
Off-road rolling resistance decreases significantly with increased tyre width. For instance on grass the wide mountain bike tyres required 15.41 W less rolling resistance power than their narrower equivalents.

3. The tyre pressure factor



Off-road a reduction of tyre pressure reduces rolling resistance. In a meadow for instance going back from 4.0 to 1.5 bar (57 to 21 p.s.i.) can save remarkable 18 Watts of power.

4. Power charts of two tyres on grassy surface



On an identical course and at exactly the same speed, the widest of the tyres tested here at 1.5 bar (21 p.s.i.) requires a solid 50 W less power than a narrow tyre at 4.0 bar (57 p.s.i.).

FIRMLY inflated narrow tyres are history. 'Fat' and less air speed things up!

The test course

A 460 m long, continuous grade – offers three different surfaces side by side. On average the inclination amounts to 5.7 %.

Hardware

Three Schwalbe tyre models in various widths, plus an SRM-system to measure power.

ALBERT

Light, wide of a lot of grip.

**Albert Brothers**

Full fledged, studded tyre for tough off-road use. Available in widths from 2.1 to 2.35".

RACING RALPH

The ultimate competition tire!

NEW!**Racing Ralph**

Studded tyre with light tread pattern for cross country and marathon. Width: 2.1 to 2.4".

FAST FRED

Lightweight and light running.

**Fast Fred**

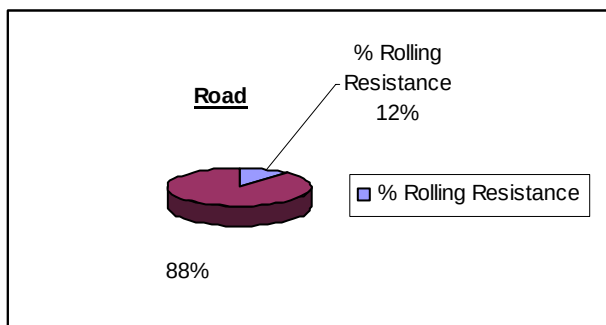
Very light and flexible semi-slick for dry conditions. Widths from 2.0 to 2.35".

SRM-crank: This special crank that is also used by professional riders is equipped with a torque sensor. With this the power that the rider puts into the cranks can be measured with high precision. The crank version used here is for scientific purposes and offers a difference of +/- 0.5% that brings to light even slight setup differences.

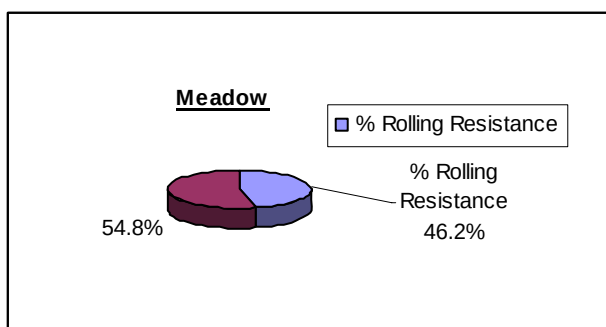
Comment: Bikers need to thoroughly revise their views on tyres, tyre width and tyre pressure. MB-member of staff Peter Hilges

Those who still put their money down on narrow cutting-wheels at more than 3 bar (43 p.s.i.) have got it wrong from the bottom up. Scientific research proves beyond doubt: Those who are after speed need to go for wide tyres at low pressures. Extreme 1.7" tyres and an old-fashioned pressure of 4 bar (57 p.s.i.) may speed things up on tarmac. Downhill however this is guaranteed to result in loss of control. Bottom line therefore: Off-road tyres should be as wide as possible (observing the limitations of frame and fork!) and only have as much pressure as is necessary (snake bite protection!). Tyres then roll with less resistance, and increased comfort, traction and safety come along with it.

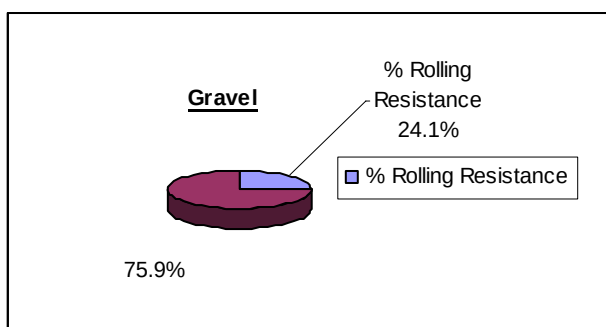
Percentage of overall power taken up by rolling resistance



Road



Meadow



Gravel

The three charts make vividly clear how significantly rolling resistance energy varies with different surface conditions. Road, grass, gravel, mud – depending on the particular ground rolling resistance can eat up more than 50% of the rider's power.

Practical recommendations

Surface	Tyre Pressure	Tyre Width	Model
Road	high (4.0 bar / 57 p.s.i.)	irrelevant	tread pattern with a high positive proportion (center ridge or closely spaced studs)
Meadow	very low (1.5 bar / 21 p.s.i.)	wide (60 / 62 mm – 2.3 / 2.4")	flexible carcass (semi-slick)
Gravel	low (2.0 bar – 28 p.s.i.)	wide (60 / 62 mm)	flexible carcass (semi-slick)

It is difficult to establish the minimum pressure level required off-road as this depends on several factors. The rider's weight, surface conditions, width of rim and tyre as well as the individual riding style are of major significance. All this needs to be considered on setting tyres up.