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with George Costa

Dynamics of BMX: Weight

This will be the first of many articles relating to the dynamics of BMX racing. To start off the series we will take a look at two fundamental concepts that affect performance, Static weight and Rotating weight. The first is fairly straightforward and relates to your overall mass that you are trying to propel. The second is a subset of the overall mass but is strictly related to the distribution of mass on your wheel set. Both affect performance and we will see the differences.

Static weight:

This is the overall combined mass of you + your bike. Why is this important? Well, if we recall from physics, Newton's 2nd law $F = m \times a$, where;

F= Force applied to a mass; m=mass; a=acceleration of the mass

If we rearrange the above equation we can see the benefit more clearly: as mass goes down. acceleration will go up given the same applied force. Higher acceleration means getting to the first turn faster.

$$a = \frac{F}{m}$$

Here the benefit is clear, reduce the mass of your system (you+bike), while maintaining the same strength and you will go faster. Please don't go crazy drilling holes in every part of your bike, keep in mind this is applied to the system. The largest benefits will come just from loosing weight
due to it being the bigger percentage of the system. Weight weenies will still like to take advantage of being able to purchase an advantage, which I can say I am definitely guilty of. Maybe this wouldn't be the case if donuts weren't so tasty.

Rotating Weight:

Rotating weight is something that many people talk about, but few truly understand. It has to do with the mass of your wheels, more importantly the distribution of that mass on the wheel. If that confuses you then hopefully this next explanation will clear things up. Let's say you have two different wheelsets, which both are exactly the same mass. The first has a very heavy hub and has light rims/tires. The second wheel has a really light hubset but has heavy rims/tires. Even though these two wheels are equal in mass they will perform very differently. The second wheelset with the heavy rims/tires will not accelerate very well and will require more power from you in order to reach the same speed as the first wheelset.

To explain this phenomenon we will revisit Newton's 2nd law, but this time in a rotational sense.

$$T = I \times a$$

T=Torque applied; I= Rotational Inertia; α = angular acceleration

The key to this problem is in the rotational inertia, which is equivalent to mass and will be severely affected by the location of the mass. Rotational Inertia is based on the following equation.

$$I = m \times r^2$$

m=mass; r=radius of this mass

Here we can see that as mass is added to the radius there is a severe penalty due to the square of the radius. To the weight-conscious BMX'er this means that you should scrutinize the components of your wheels in this following order of importance.

Tires, Rims, Tubes, Rim tape, Nipples, Spokes, Hubs, Cog

The idea here is to assemble a wheelset that has a low rotational inertia (rotational weight). This will allow you to accelerate much faster out of the gate and turns. In order to do this you need to pay attention to the mass of the components from the outside radius in.

Lets prove this theory with some math. Lets say we want two wheels with the same rotational inertia. Wheelset 1 will add 10 grams of additional mass at the spoke nipples (radius of 19cm). wheelset 2 will have heavier spokes (radius of 9.5cm) to compensate for the lighter nipples that it wheelset 1 has.

$$Is = In$$

$$Ms \times Rs^2 = Mn \times Rn^2$$

Rearranging the variables

$$Ms = Mn \times \frac{Rn^2}{Rs^2} = 10 \times \frac{19^2}{9.5^2}$$

$$Ms = 40g$$

The mass of the spokes would need to be 40g heavier for wheelset 2 in order to compensate, but this second wheelset would be 30g heavier than wheelset 1. Just for fun if we looked at adding weight to the hub instead (radius of ~1cm) **the added weight would be 3610g that's 8 additional pounds!**

From this example you can see the importance of reducing the mass of the component list I put together. I hope you enjoyed this latest article, next month we will continue to break down the dynamics of racing.