



Half the Effort – Twice the Climb

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WHEN IS MORE WEIGHT ON A WHEELCHAIR A GOOD THING?

We agree that added weight is not normally desirable on manual wheelchairs (WC). Added weight is also not normally desirable on other human powered transport devices such as bicycles, row boats, kayaks, canoes, etc.

Bikes with 24 gears weigh considerably more than those without gears – and indeed some special racing bikes have only one gear to save this added weight (some single speed velodrome racing bikes are to be pushed by a helper to get the cyclist started). However, the added hill climbing and extra speeds provided by the gears is generally acknowledged as more than enough to compensate for the added weight, cost and complexity. The vast majority of bicycles made today have a wide range of multi-speed gears. Our goal is to bring the similar benefits of geared wheels to manual wheelchair users.

A number of papers have been presented in recent years indicating the probable health benefits to wheelchair users by propelling lighter weight wheelchairs in everyday activities. Many industry leaders are currently lobbying CMS and other 3rd parties to fund more expensive lightweight wheelchair technology (K0008) on a routine basis so that more MWCU can take advantage of these possible improved health benefits.

Reducing arm stress & strain by making the wheelchair lighter has very finite limits because the wheelchair weight is a small percentage (15-20%) of the total weight of the WC, user, cushions and backpack (estimated 150-200 lbs average). Even if the wheelchair weighed ZERO lbs (not remotely possible at any price), the maximum beneficial effect would only be about 15-20% reduction in propulsion arm stress and strain and maybe 10% added mobility & control. An expensive titanium chair & Spinergy wheels with 10 lbs weight reduction only provides about 5-7% decrease in arm stress & strain during up hill propulsion with some corresponding added mobility. Clearly, the benefits of weight reduction on arm stress and strain are severely limited and if much greater benefits are needed, gears need to be added to the wheels, even if the addition of the gears results in a moderate overall weight increase.

Others have recognized the potential huge benefit of geared wheelchair wheels and have attempted unsuccessfully many times to develop shiftable geared manual wheelchair drives. A NIDRR sponsored symposium published a list of 10 criteria for geared wheelchair wheels (see <http://www.magicwheels.com/cache/1990.html>) and specified an increase in weight was reasonable. The **MAGICWHEELS**[™] 2-gear wheelchair drive meets 8 ½ of these criteria and has several features not mentioned.

At Magic Wheels, Inc. we have been very cognizant of this added weight issue and have done everything possible to reduce the added weight and friction from our 2-gear product and to minimize these effects on the manual wheelchair user during the 95+% of the time the low gear is not in use. Our 2-gear drive, however, can never be as light as standard spoked wheels that are empty in the center (air in center) and have no moving parts or other mechanisms. If you want the large benefit of gears and other added functionality in a wheel, you must add some weight. Our choice was to add some weight to get significant important new functionality & capability, or do nothing. We think we have provided an exciting new option in manual wheelchair wheels that by adding a little weight gives the user a huge reduction in arm stress & strain on hills (many times

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more load reduction than the industry efforts to reduce weight have provided). The 2-gear drive has been shown to dramatically reduce arm pain and give incredible added mobility.

ABOUT INERTIA IN A MANUAL WHEELCHAIR: Inertia is the effect weight (mass) has on a wheelchair by making the chair harder to get started moving and also making it harder to stop quickly (acceleration / deceleration). If a user starts and stops slower the inertial effect is less. There are 2 kinds of inertia in a wheelchair – linear (traveling across the ground) and wheel rotation (flywheel effect). The added 10 lb of the **MAGICWHEELS**[™] 2-gear drive is on the wheels and can affect both types of inertia. The added linear inertia cannot be changed as weight is weight, however, the rotational (flywheel) inertia can be minimized (or even eliminated) by locating the added weight close to the axle and removing weight near the tire. The inertial (flywheel) effect of a pound of weight increases as the square of the distance from the axle. This huge inertial effect of moving weight in and out from the axis of rotation can be seen when a spinning ice skater increases their spinning to several times faster by moving their arms from fully outstretched to close to the body. Changing the 21” diameter handrim by 1 lb has the same rotational inertia effect as changing the 9” hub weight by 5 pounds on its circumference

By concentrating the added weight of the 2-gear drive near the hub and providing extra lightweight handrims and carbon dish wheels (only ¼” thick), we have been able to keep the rotational inertia of the 2-gear wheels in 1:1 gear approximately equal to that of a standard wheel. In user tests with the 2-gear drive on one side of a manual wheelchair and a standard wheel on the opposite side (both wheels must use same type tires and handrim size / style), the wheelchair test subjects could not tell functionally which side had the 2-gear drive in 1:1. The testing was repeated after reversing the standard and the 2-gear drive with same results.

CAN ADDED WEIGHT / INERTIA SOMETIMES BE GOOD? In human powered water paddling sports (rowing, kayaking, canoeing) that have pulse type propulsion with the speed of the boat rising and falling with each stroke, (just like pushing a manual wheelchair), some people believe that added weight (inertia) under some conditions with skilled athletes can result in increased average speed. Basically, the added weight, while increasing the water drag a small amount has a larger effect of keeping the boat from slowing down as much between strokes, thus (some believe) resulting in a higher average speed through the water. It is possible that a manual wheelchair user when traveling a longer distance at constant speed on a smooth flat surface (mall, airport, bike trail, etc.) could actually get there faster with some added weight.

ABOUT FRICTION: Added friction, especially in 1:1 gear is also very important since no one wants added drag when pushing a wheelchair around all day. Friction in a gear drive is called “windage” and is always present when gears are used. We have minimized friction in the 2:1 hypocycloidal gear drive by using 19 rolling element (anti-friction) bearings in each 2-gear wheel. Additionally, we have **ELIMINATED** friction / windage in the 1:1 gear by bypassing the gear drive completely. In 1:1 gear none of the gears, bearings or seals rotate or move – the only friction is in the ball bearings that mount the wheels to the chair – and we have reduce that to a minimum by only using two seals on the bearings (standard wheels have 4 bearing seals).

This low friction in 1:1 gear can be demonstrated by again by putting a 2-gear wheel on one side of a wheelchair and a standard wheel on the opposite side (both wheels must have the same tires and air pressure), it should not be possible to tell by pushing with hands which side has the 2-gear drive. In our tests, we pushed the chair to a moderate speed on a flat smooth floor and then let the chair coast straight ahead (no hands on the wheels), the wheelchair tracked straight and did not swerve towards the side with the 2-gear drive – indicating no significant added friction from the **MAGICWHEELS**[™] technology.

As with bicycles, the negative effect on the wheelchair user of the added 10 lb weight of the 2-gear drive is offset by the incredible positive benefits of the new 2-gear technology. For a small 5-7% weight penalty (based on typical total of WC, cushion, backpack and user) the WC users gets a huge 50+% reduction in arm forces required (this reduction includes elimination of the need to

surge) to ascend hills and greatly added control when descending. This reduction in stress and strain on the user's arms has been shown to substantially reduce arm pain even though hills are usually navigated less than 5% of the time. Additionally, many weaker users also benefit from a greatly increased ability to navigate over uneven terrain and to manually propel and control the wheelchair where it was not possible for them even to go before with standard wheels.

To substantiate this arm pain reduction claim, Magic Wheels provided test wheels to the U of Maryland for a 2 year clinical test of arm pain reduction. This testing now shows beyond a doubt that the 2-gear drive when used 100% of the time by manual wheelchair users, significantly reduces arm pain by about 60% over a few weeks and provides substantial relief in the first few days. This amazing result was obtained even with test subjects propelling the added 10 lb weight of the 2-gear drive around all day / everyday. You can see from this testing that all added weight is not bad.

In conclusion, in general less weight is generally recognized as better in a manual wheelchair. However, as with bicycles, the added weight, cost and complexity of a **MAGICWHEELS**[™] 2-gear drive can be easily justified by the substantial reduction (or prevention) of arm pain and greatly enhanced mobility.

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