SYNERGYair

SynergyAIR CVT and Air Displacement Dynamics

An important aspect of training on the SynergyAIR Power range of conditioning ergometers (Power Tower, Power Climber, Power Cycle, Bionic Power Cycle and Power Swimming & Board Paddling Erg) is developing a clear understanding of the unprecedented training potential facilitated by our revolutionary patented system of coupling air displacement dynamics with a Continuously Variable Transmission (CVT).

Using an air displacement turbine or flywheel as a form of resistance in exercise equipment was first patented by Repco in Australia on their Bionic Bike and Cycle ergometer way back in 1979 and was later used by Schwinn, under license from Repco, on the original Schwinn AirDyne and it was also adopted by Concept2 on the model A rowing ergometer in 1981. However, we have seen a resurgence in recent years in the appreciation and popularity of working against air on exercise machines, as not only does it offer a more authentic and smooth feeling form of resistance, but it also provides considerably higher degrees of potential load to work against, compared to traditional electronic, magnetic or motor driven fitness equipment, that ultimately are constrained by their inherent mechanical limits. This is not the case with an appropriately geared air displacement system, most especially when coupled with a CVT gearing system, where the only limiting factor is human capacity.

Air, like water, is a fluid and what makes fluid dynamics unique is the cubed relationship between incremental changes in power output and speed, which is very different to what you experience when working against frictional resistance experienced when running on a treadmill, or training on an exercise bike, or elliptical cross trainer utilising various forms of electronic, magnetic or BLDC motor/generator resistance. When you run on a treadmill, or ride most exercise bikes, there is a linear relationship between power output and speed, so if you double your effort, or power output, then you also double your resultant speed. However, the unique nature of fluid dynamics means that when you work against either water (e.g. swimming, rowing, kayaking), or air (air displacement ergometers), if you want to double your speed, then you actually need to increase your power output by a multiple of eight, because you need to cube (i.e. express to the power of 3) the incremental change in speed (2 x 2 x 2). Likewise, it takes 33.1% more power just to go 10% faster (1.1 x 1.1 x 1.1 = 1.331).

As a side note, it's interesting to understand that unlike running on a treadmill, when you're running on the road, or track, that whilst linear frictional resistance is the predominant resistance at low speeds, the faster you run, the more fluid dynamics, caused by frontal air resistance, rapidly becomes a significant factor, especially at elite sprinting speed. Running at say only 12km/h (5 min/km pace) on the track still only creates minimal frontal air resistance, so you would only have to run at approximately 12.5 km/h on a treadmill to replicate the same effort. 20 km/h on the road equates to about 21.5 km/h on a treadmill, or alternatively 20 km/h + roughly 1.5% incline. However, when Usain Bolt hits top speed on the track at around 45km/h, with a peak force output of 2619.5 watts, at a bodyweight of 94kg, over 92% of that power is required to overcome drag caused by frontal air resistance, so that same power applied when running effectively in a virtual vacuum on a treadmill should theoretically give him a top speed of over 100 km/h (2620w/94kg = 27.9 metres/sec = 100+km/h), however absolute peak leg speed unfortunately becomes a limiting factor well before peak power output becomes the limiting factor, so his peak speed on the treadmill won't in reality be very much faster.

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The cool thing about coupling a CVT with an air displacement turbine is that we are able to produce totally insane resistance levels without the speed of movement ever remotely becoming the limiting factor. The CVT used on the SynergyAIR Power range of ergometers allows a gearing ratio change by a multiple of almost four (3.9 to be exact), so we are therefore able to produce both extremely low and extremely high levels of resistance at both very slow and very high speeds of movement, because when we multiply the cumulative effect of changes in movement speeds by the gearing changes and then cube the sum of those figures, we can potentially create some unbelievably staggering numbers. Whilst on our bikes we keep the gearing down to a relatively sedate level (see table below), to appropriately cater for the full range of small, large, beginner and advanced users, we let our freaky capabilities free to fly a little more on our Power Tower and Power Climber.

Conventionally, international brand exercise equipment manufacturers rate the maximum watts capacity of a bike or an elliptical at 150 rpm, or 150 movement/stride cycles. So typically the three major international brands (Life Fitness, Technogym and Matrix) all have max power outputs on their cycles and elliptical at around 650 watts. In the table below, you'll see that whilst we can still provide very low watts resistance on the minimal gearing setting on our SynergyAIR bikes, we achieve massively higher numbers at the top end of the gearing range. Whilst even the best cyclists in the world obviously aren't capable of achieving anywhere near these sort of maximum power outputs, what it does mean is that you have the option to use a big gear and get out of the seat and realistically simulate the most challenging hill climbing scenarios, or even simply do some super effective strength endurance training, grinding away at a very big gear, at a very low cadence.

	Min W	Max W			Min W	Max W	
RPM	Power Cycle		Cycle Ergometer	RPM	Bionic Power Cycle		Bionic Cycle
30	15	175	30	30	20	450	30
40	25	355	55	40	40	950	55
60	50	1060	150	60	85	3250	50
80	90	2,470	330	80	170	7,800	30
100	165	4,825	650	100	290	15,300	650
150	590	16,500	2,370	150	950	52,000	2370
200	1390	39,000	5,600	200	2,200	125,000	5600

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We advertise the max watts @ 150 step/stroke cycles on the Power Tower as well over one million (1M) watts and on the Power Climber as over 1.5M watts. Now obviously no-one is powerful enough to achieve these astronomical and seemingly unbelievable power outputs, because at maximal possible gearing levels the resistance is simply too heavy for anyone to be able to achieve anywhere near 150 step cycles per minute at a full range of motion, but believe it or not, these are actually extremely conservative measurements, based on a perfectly even paced speed of movement, with no degree of acceleration at the max stroke rate. When acceleration occurs during the stroke rate, replicating stroke power indexes (SPI) achievable by the best athletes, then these numbers get much, much bigger.

Before we attempt to show you mathematically how these numbers are possible, let us try to help you understand what is possible by considering how power output (measured in watts), on say a Concept 2 rowing ergometer, is totally dependent on your stroke power index (SPI). SPI is calculated by dividing the average power in watts by the average stroke rating. So if you are rowing at a stroke rating of 20 and are producing 20 watts of power, then that's an SPI of just one (1), but if at the same rating of 20, you accelerate sufficiently fast enough to produce 500 watts, then your SPI is 25 (500/20=25), even though you've using the same effective gearing (by maintaining the same drag factor, or vent damper setting). Within the normal real life range of people using the rower in the gym we see SPI's as low as 0.1 (in very light little old ladies rowing very slowly) all the way up SPI's of 30+ in world record sprint rowers hitting peak speeds on very low drag stings.

When we calculated 1M+ watts @ 150 movement cycles on the Power Tower, movement was driven by a motorised machine generating the movement at a constant no-accelerating speed through the range of movement. However, when we build into our calculations acceleration capabilities achievable by the best athletes, then the strictly theoretically possible numbers become astronomically high. We've worked through a theoretical example below. Please note that this theoretical calculation has been simplified, to make it more easily understandable, by removing the complex variable of frictional resistance, which comprises a small component of the total resistance, but becomes miniscule as a proportion of the total resistance at the speeds calculated below.

Imagine, that by maximizing explosive acceleration through the stroke cycle an absolute world class power athlete can achieve say 500 watts of power on the Power Tower at a cadence of only 10 (SPI of 50) at the lowest gearing setting. If they now maintain that same level of explosive acceleration at a cadence of 150 (15 times higher cadence), at the top gearing (3.9 times greater gearing), then the theoretically resultant power output necessary to achieve movement speed would be (15 x 3.9) cubed, multiplied by 500 watts, which is 200,201.625 times 500 watts, which equals a staggering 100,100,812 (100+M) watts.

Once again, whilst that's not remotely humanly impossible, nevertheless, hopefully that clearly demonstrates the fantastically incredible power producing capabilities facilitated by our patented technology of simply coupling a CVT with an air displacement turbine and maximizing the naturally inherent physical properties of fluid dynamics, facilitating extremely effective strength training, as well as optimal total body speed, power and aerobic/endurance development in a wide range of very functional compound movements targeting every muscle group in the body.