Concept2 Indoor Rower
Fact Sheet 3:

Force Curve, Power (Watts), Pace And Stroke Rate

The Performance Monitor (PM) of the Concept 2 Indoor Rower displays a range of useful features that allow the user to accurately monitor performance. It is important to understand how the **Force Curve, Power (Watts), Pace** and **Stroke Rate** interrelate and how they can be used to optimise rowing performance.

- **Force Curve**

  The **Force Curve** is an immediate graphical representation of the application of force during a stroke. It shows how the total force applied to the flywheel through the handle and chain, varies as you use your legs, back and arms in sequence during the **Drive**. A smoother-shaped curve indicates a smoother application of force.

- **Power (Watts)/Pace**

  The average power applied during each stroke is displayed in **Watts** (the unit of power). In general the more **Power** applied the faster the **Pace**. The relationship between **Power** and **Pace** is non linear.

  To get the best result for any rowing session, row at an even **Power/Pace** throughout the session – this will use less energy, concentrate technique and produce a smooth **Force Curve**.

- **Stroke Rate**

  The **Stroke Rate** to use for a rowing session depends on the objective of the session – the **Stroke Rate** range varies from 18 strokes for low aerobic, base exercise and technique work through to as high as 34 strokes when racing over 2000 m or the School Year Group race time or even 36-38 for very short sprint intervals. The effective racing range is generally 28-34 but will vary from rower to rower.

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What is the Force Curve and why is it important?

The **Force Curve** is an immediate graphical representation of the application of force during a stroke. It shows how the total force applied to the flywheel through the handle and chain, varies as you use your legs, back and arms in sequence during the **Drive**. A smoother-shaped curve indicates a smoother application of force.

Key Point 1: In general the greater the area under the curve the better the result for that stroke.

What should the Force Curve look like?

In general a broad arching **Force Curve**, without any sharp peaks or spikes should be the aim. This indicates that a smooth, continuous drive is being achieved (Figure 1).

How and why does the shape of the Force Curve change?

The shape of the **Force Curve** can be changed by varying the relative timing and emphasis of the legs, the back and the arms during the **Drive** phase of the stroke. "Exploding" at the **Beginning** of the **Drive** phase will shift the peak of the curve to the left (Figure 2). If the transition from legs to back swing through to the **Finish** position is not smooth multiple peaks may appear in the curve (Figure 3).

Key Point 2: If the application of force is applied smoothly throughout the entire **Drive** phase of the stroke the curve will be flatter and broader and a more efficient stroke will be achieved (Figure 1). It is not necessarily better to reach a higher maximum force. The aim should be to generate a smoother, more evenly distributed force profile.

Figure 1

Figure 2

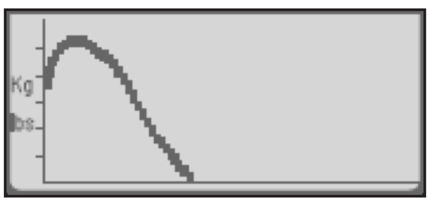
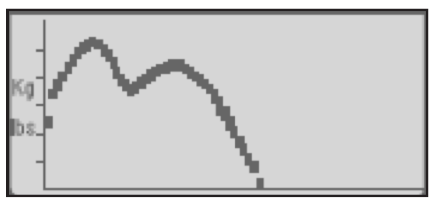


Figure 3



Key Point 3: An inefficient force profile will produce a slower pace than an efficient (less spiky) profile for the same average power.

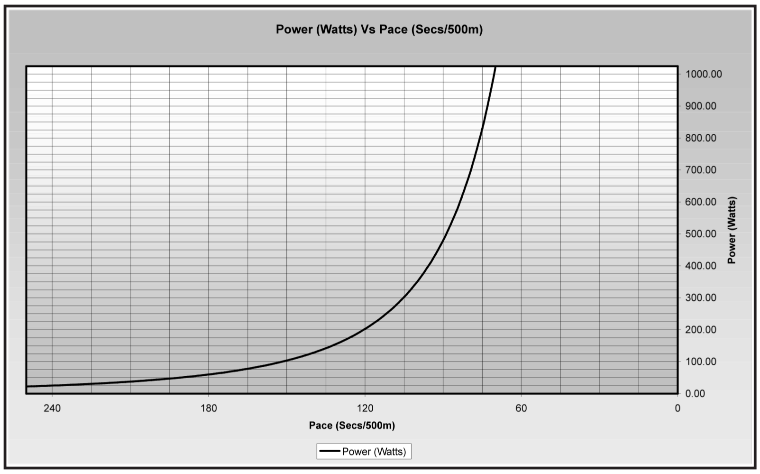
NB – The Force Curve does not start at zero, this is because the Performance Monitor takes a moment to detect the stroke by which time force has already been applied.

Top Tip 1: Row with the Force Curve profile display screen to develop an efficient stroke.

Power (Watts) and Pace

The relationship between **Power** and **Pace** is complex. The average power applied during each stroke is displayed in **Watts** (the unit of power). In general the more **Power** applied the faster the **Pace**. **Pace** is shown in terms of minutes and seconds per 500 m (mins:secs). There is no direct relationship between **Power** and **Pace** because of the variations in efficiency between strokes with different force time profiles (**Key Point 3**). For practical purposes a **Power** to **Pace** conversion equation gives an approximation of the relationship (**Table 1**).

<u>Key Point 4:</u> The relationship between **Power** and **Pace** is non linear – for this reason it is important to work in **Watts** and then for practical purposes use **Table 1** to convert to **Pace** in minutes and seconds per 500 m.



An example of the non linear relationship should make this clear:

A 2000 m row at 175 **Watts** would be completed in 8:24, a **Pace** of 2:06 per 500 m. A 25 **Watt** improvement to 200 **Watts** would improve that time by 22 seconds to 8:02, a **Pace** of 2: 00.5 per 500 m.

Conversely a 2000 m rowed at 475 (475.3) **Watts** would be completed in 6:01.2, a **Pace** of 1:30.3 per 500 m. A 25 **Watt** improvement to 500 (499.8) **Watts** would improve that time by only **6 seconds** to 5:55.2, a **Pace** of 1:28.8 per 500 m.

<u>Key Point 5:</u> When calculating paced based exercise/training intensities start with **Watts** and then convert to **Pace** per 500 m (**Table 1**) rather than **Pace** per 500 m +/- X seconds. This will ensure that intensities are not disproportionate, particularly at the slower end of the scale (very relevant when dealing with children and young adults – see **Fact Sheet 4 Children and Exercise Intensities**).

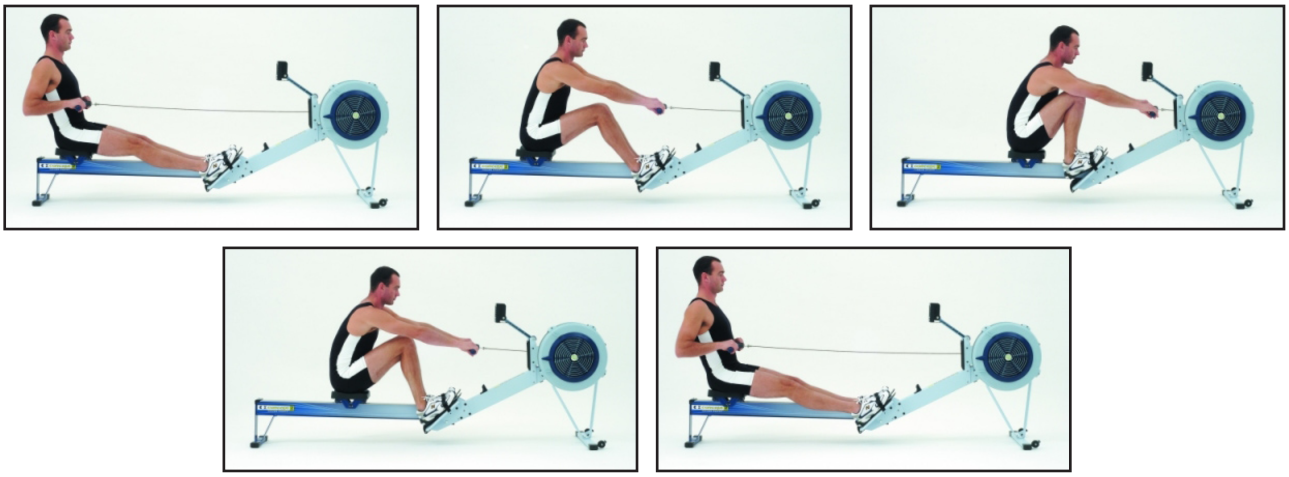
Table 1

Watts	**25**	**50**	**75**	**100**	**125**	**150**	**175**	**200**	**225**	**250**
Pace	4:01.0	3:11.0	2:47.1	2:31.8	2:20.9	2:12.5	2:06.0	2:00.5	1:55.9	1:51.9
Watts	**275**	**300**	**325**	**350**	**375**	**400**	**425**	**450**	**475**	**500**
Pace	1:48.3	1:45.2	1:42.5	1:40.0	1:37.7	1:35.6	1:33.7	1:32.0	1:30.3	1:28.8
Watts	**525**	**550**	**575**	**600**	**625**	**650**	**675**	**700**	**725**	**750**
Pace	1:27.3	1:26.0	1:24.8	1:23.6	1:22.4	1:21.4	1:20.3	1:19.4	1:18.4	1:17.6
Watts	**775**	**800**	**725**	**850**	**875**	**900**	**925**	**975**	**1000**	
Pace	1:16.7	1:15.9	1:15.2	1:14.4	1:13.7	1:13.0	1:12.3	1:11.1	1:10.5	

<u>Top Tip 2:</u> To get the best result for any rowing session, row at an even **Power/Pace** throughout the session – this will use less energy, concentrate technique and produce a smooth **Force Curve**.

Definition of a Stroke

If you pull on the handle the Performance Monitor will register a stroke. However in the context of effective rowing the definition of a stroke is a full cycle of the stroke technique sequence from the Finish position through the Recovery phase to the Beginning position and then through the Drive phase back to the Finish position (see Fact Sheet 2).



Optimum Stroke Rate Range

The **Stroke Rate** to use for a rowing session depends on the objective of the session – the **Stroke Rate** range varies from 18 strokes for low aerobic, base exercise and technique work through to as high as 34 strokes when racing over 2000 m or the School Year Group race time or even 36-38 for very short sprint intervals. The effective racing range is generally 28-34 but will vary from rower to rower.

For the best biomechanical and exercise response there is an optimum **Stroke Rate/Power/Pace** combination for any rowing session or race which will vary from rower to rower but which is usually in the ranges described above.

Varying the Stroke Rate and Power/Pace

As a general rule longer sessions are carried out at a lower **Stroke Rate** and slower **Power/Pace** – shorter sessions may have a higher **Stroke Rate** and greater **Power/Pace**.

Key Point 6: However, for the same **Stroke Rate** the **Power/Pace** can also be controlled by the application of more or less force during the **Drive** phase of the stroke. As a result of altering the force applied the time taken during the **Drive** phase will change and to compensate the timing of the **Recovery** phase will have to be adjusted in order to maintain a constant **Stroke Rate**.

Key Point 7: Similarly, for the same **Power/Pace** the **Stroke Rate** can be varied by changing the time taken during the Recovery to return the handle back towards the fan cage and the **Beginning** position. At lower **Stroke Rates** the fan will slow down more in between strokes resulting in a higher initial resistance at the start of each stroke.

Top Tip 3: To vary the **Power/Pace** while maintaining a constant **Stroke Rate** adjust the amount of power applied during the **Drive** phase accelerating the handle through to the body and the **Finish** position. To vary the **Stroke Rate** while maintaining a constant **Power/Pace** adjust the time taken returning the handle back to **Beginning** position.

Stroke Rate and Energy Use

The relationship between **Stroke Rate** and energy use is another complex non linear relationship – the higher the **Stroke Rate** the more disproportionate the energy required just to move the body mass up and down the slide. If the **Stroke Rate** becomes too high the energy required is so great that there is little left to contribute to the development of the **Power/Pace**. For this reason it is important to work within the **Stroke Rate** ranges for maximum benefit.