Training with RP3 for Dummies

An instructional document for rowers getting acquainted with RP3

Date: February 2025
Version: 1.2 - English

Introduction

More and more clubs, alongside the familiar Concept2 ergometers, also have RP3s available at their facilities. The latest edition of the NKIR (Dutch Indoor Rowing Championships, December 2024) was organized for the first time using RP3. Almost 800 people from more than 60 Dutch clubs participated across different categories. Having more RP3 available is causing more and more questions about its usage.

Quick links:

RP3 Portal: https://portal.rp3rowing.com/

RP3 Rowing White Papers, Data Sheets and Instructions: https://rp3rowing.com/rp3-academy-whitepapers

Knowledge Base: https://rp3rowing.com/customers/knowledge-base

This instructional document is intended for members of Dutch rowing clubs who wish to use RP3 as part of their rowing and fitness training but are not yet familiar with its functionalities and potential. But it can be used by anyone all over the world.

Similarities and Differences

Rowing on an ergometer is an excellent way to develop and maintain endurance and strength. Nearly all rowers worldwide, at all levels and ages, incorporate ergometer training into their rowing programs.

Particularly in the dark, wet, and cold months, many rowers add at least one ergometer session per week to their regular schedule, sometimes as an alternative to boat training. The rowing movement is often considered a full-body workout, engaging about 86% of the body's muscles. This makes rowing one of the most efficient training methods, effectively combining muscle activation with cardiovascular endurance.

Increasingly, rowing teams train on the RP3 at least once a week throughout the season because it enhances boat speed. The RP3 Coach Approach provides tools to monitor progress and support self-coaching. This document explains how that works.

A crucial factor is that rowing technique influences performance, which can be monitored via the ergometer's display. Incorrect technique on the ergometer may lead to injuries or lower performance scores.

The primary difference between Concept2 and RP3 is the distinction between static and dynamic rowing motion:

- **Concept2 (Static Ergometer)**
  The frame with the flywheel, chain, and footplate remains stationary, while the rower moves back and forth on a sliding seat.
- **RP3 (Dynamic Ergometer)**
  Both the frame (flywheel, chain, and footplate) and the seat move independently along the rail.

In on-water rowing, where the boat moves freely over the water and the rower moves on the seat to execute the rowing motion, the movement is also dynamic. This is why the world's best rowers and an increasing number of national and club-level rowers train with RP3—it closely mimics the rowing motion in a boat. However, blade work (oar technique); the interaction with the water, cannot be trained on an ergometer.

Research[1] has shown that dynamic rowing on an ergometer is nearly identical to rowing in a boat.

Physics and Biomechanics Differences

The difference between the rowing movement on the Concept2 and RP3 is actually quite logical when you think about it. When rowing on the Concept2 (static), the rower's body weight is moved back and forth with the seat over the rail. In each rowing stroke, the movement is slowed down twice, reversed, and then accelerated again, only to be slowed down once more.

To slow down, reverse, and reaccelerate, energy from the rower is used, with forces for this movement being counteracted by the frictional resistance of the rubber feet of the ergometer against the floor. The remainder of the energy (the majority) from the rower is transferred through the chain to accelerate the flywheel. At higher stroke rates, this percentage increases because the movements become more intense, requiring more braking and reversing. On a smooth floor, the ergometer can start to slide. Many clubs have installed blocks on the floor to prevent this sliding.

When rowing on the RP3, the rower remains (almost) stationary. The seat moves freely on the rail (usually just before the bend) but can still move. The rower's body weight and center of gravity remain nearly in the same position. The rail of the RP3 is set horizontally, with the adjustment knob on the back leg, whereas the rail of the C2 is tilted slightly downward to facilitate movement toward the start of the stroke.

With technically proficient rowing on the RP3, the rower moves only a few centimeters up and down along the rail. The rower moves the flywheel casing, chain, and footplate over the rail. The weight of the RP3 is approximately 20 kg, which is comparable to the weight of a rowing position in a boat on the water. A single scull (skiff) weighs around 14 - 16 kg (the minimum allowed weight [2]), and an eight-person boat weighs approximately 8 x ~16 kg = 120 kg (the minimum allowed weight is 96 kg).

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[1] https://biorow.com/index.php?route=information/news/news&news_id=94

[2] https://d2cx26qpfwuhvu.cloudfront.net/worldrowing/wp-content/uploads/2023/02/14151038/Appendix-R3-2023-Weight-of-Boats-Proposal-to-Council.pdf

Looking at Rowing: An Optical Illusion

It is sometimes thought that rowing in a boat consists of the rowers moving up and down. However, the mass of the rower or the crew is five to nine times greater than the mass of the boat. Because of this, the rower or crew maintains a constant speed, while the boat, being a much lighter object, moves up and down beneath the rowers. Since the boat is relatively long and moves at a certain velocity, it often appears as if the rowers are moving up and down. Any spectator of a rowing race, where boats sometimes compete side by side for victory, will recognize that the tips of the boats continuously shift slightly ahead and behind one another, and races can be won or lost based on the final stroke.

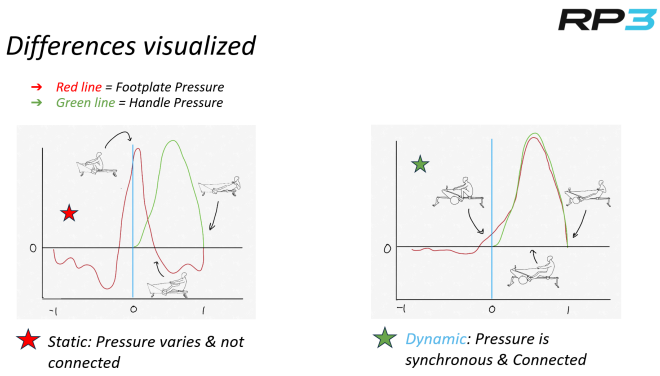
Because the RP3 has nearly the same weight as the boat (a rower's seat position), the rowing stroke (pushing off from the flywheel casing) on the RP3 feels nearly identical to rowing on water. In dynamic rowing, ideally, no energy is lost at the turnaround points due to body weight reversal, which would otherwise slow down the boat.

Also watch the YouTube video with multiple World and Olympic Champion single scull Karolien Florijn, where the rowing movement is merged identically towards rowing the RP3: https://youtu.be/CrkDm1MEHsA

As a result, the rower does not need to pull (at the end of the stroke) or push (before the start of the stroke) against the footplate to facilitate this movement. Just like in a boat, the rower can allow the boat— in this case, the RP3— to move towards them naturally, keeping the turnaround moment as short and smooth as possible without energy loss.

On a static ergometer, however, to prevent falling off the seat at the end of the stroke, when body weight is propelled backward with maximum speed, the feet must be securely fastened to the footplate. The rower must engage in a sit-up-like movement, pulling themselves forward using their feet. Logically, this means that the connection with the footplate is lost at this point.

In contrast, on an RP3, the connection with the footplate can be maintained until the very last moment. It is entirely possible to row without securing the feet on the RP3. Short turnaround moments and maintaining connection with the footplate for as long as possible benefit boat propulsion, as it ensures effective power transfer with the blade in the water.



A smooth power buildup after the catch (beginning of the stroke) and maintaining connection with the blade in the water until the highest force peak— just before the oar reaches 90 degrees to the boat (orthogonal position)— allow the power to be applied fluidly. The force

should then gradually taper off so that, at the end of the stroke, the oar can be removed cleanly from the water without pressure, ensuring the most effective rowing technique.

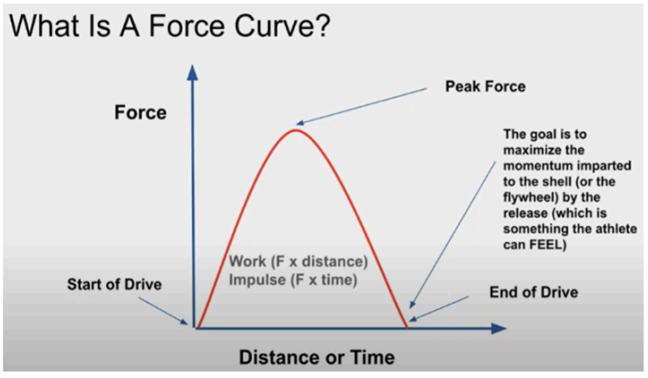
Lift through Hydrodynamic Effect

Due to the hydrodynamic effect of the blade in the water and the lateral movement (sideways) of the blade relative to the boat, combined with the concentric movement of the oar, the ideal peak force position is between 43 - 45% of the stroke (on a 0 - 100% scale). In faster boat types, this position is slightly further forward (lower percentage), whereas in slower boat types, it is further back (higher percentage). However, the target value is always relative, and the theoretical optimal range is between 30 - 70%.

In practice, the relative peak force position shifts slightly forward (lower percentage) at higher power outputs and higher boat speeds. Additionally, stroke length decreases as peak force increases. The total energy delivered per stroke remains almost constant when comparing low- and high-intensity efforts (+/- 5-10%).

Producing a smooth force curve minimizes blade pressure loss in the water. A full, rounded force curve indicates the most optimal biomechanical movement, where the area under the curve represents the energy applied by the rower during the stroke.

The “energy per stroke” (Joules) value, displayed via the RP3 App, is the most logical indicator of propulsion efficiency with the blade in the water. The round, parabolic shape of the force curve further indicates stroke quality. These two metrics together can be used as an efficiency value, which will be discussed later in this document.



Source: coach Neil Bergenroth

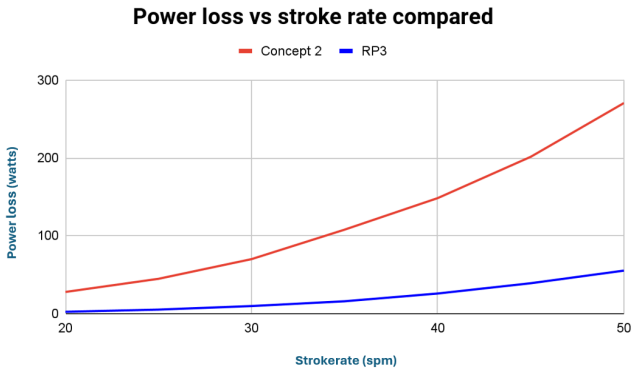
“The Force Curve is a window into the effort of the force application during the drive phase”

In addition to strength and endurance, coordination and proper rowing technique

are also critical factors in training. Training the perfect rowing movement (coordination) into muscle memory is one of the most difficult yet essential skills. When fatigue sets in, the body automatically reverts to stored muscle memory.

Furthermore, when experiencing significant fatigue, rowers will instinctively adjust their movement to minimize energy loss. If the desired movement differs from what has been trained, particularly at higher intensities, the muscle memory will store this alternative movement, which will then be executed automatically during key performance moments. This can have negative effects if the stored movement deviates even slightly from the ideal movement for maximum boat speed.

RP3 Rowing Whitepaper:
Findings and conclusions Static versus Dynamic power calculations



Significant energy losses during static rowing causing (major) adjustments in rowing technique (body movement) for a better score:

→ Extend legs during stroke and recovery to limit loss
→ Recovering energy from the drive: falling through ("yenking") and pulling high to the chin
→ Leads to *lower stroke rate* and other physiological training effects than desired for best performance in the boat
→ Reward for a longer recovery, longer strokes, higher resistance factor (for not falling off) and different boat feeling: lightness and stroke rates

"it pays to row very hard at slower/lower rate on a static erg!"

More information:
https://rp3rowing.com/wp-content/uploads/2024/06/Findings_and_conclusions_Static_vs_Dynamic_power_calculations_1_0.pdf

Using Quantitative and Qualitative Data

Most rowers recognize and compare each other based on their ergometer scores. The **split** is a worldwide standard, representing the time required to complete 500 meters. This value is calculated by converting energy per stroke (Joule) to power (Watt), where Watt equals Joules per second. A formula that accounts for air resistance (deceleration) from the flywheel and the moment of inertia of the mass determines the split value.

Drag Factor & K-Factor

For both RP3 and Concept2, air intake can be adjusted using the vent slider on the side to modify air resistance. The *Drag Factor* on Concept2 and the *K-Factor* on RP3 play a role in these calculations. On Concept2, the Drag Factor has a larger impact on rowing than the K-Factor on RP3. The resistance from the flywheel through the chain significantly affects Concept2's biomechanics. The sit-up motion at the end of the stroke allows the rower to pull themselves up using the chain, often resulting in the rower pulling the handle toward the

chin. However, this movement is not desirable in a boat, where the correct technique involves moving the handle downwards to lift the blade out of the water.

The **K-Factor on RP3** is designed to simulate the boat feel. Slower boats typically use a more open air intake, while faster boats opt for reduced air intake. Because the K-Factor is generally around ‘1’, any changes in split calculation are minimal. RP3 users are encouraged to experiment with the vent slider setting to find the most comfortable configuration for their training.

RP3 Setting

Unlike Concept2, RP3 settings can be customized via the app to display more realistic splits. Rowers can adjust boat type and body weight from the default setting of 4x (quad) and 90kg. This feature benefits rowers aiming for split scores comparable to their boat performance and coaches comparing athletes with different body weights. It also allows multiple rowers training side by side to adjust their split settings for more accurate comparisons. Keeping a consistent setting is recommended for tracking progress effectively. The **RP3 Coach Approach** provides tools for this, which are covered later in this document.

The RP3 Setting only affects the displayed split; the power output remains unchanged. Scores eligible for the RP3 Leaderboard [3] are only recognized when the RP3 Split Setting is used.

Using all available Data for better and faster rowing

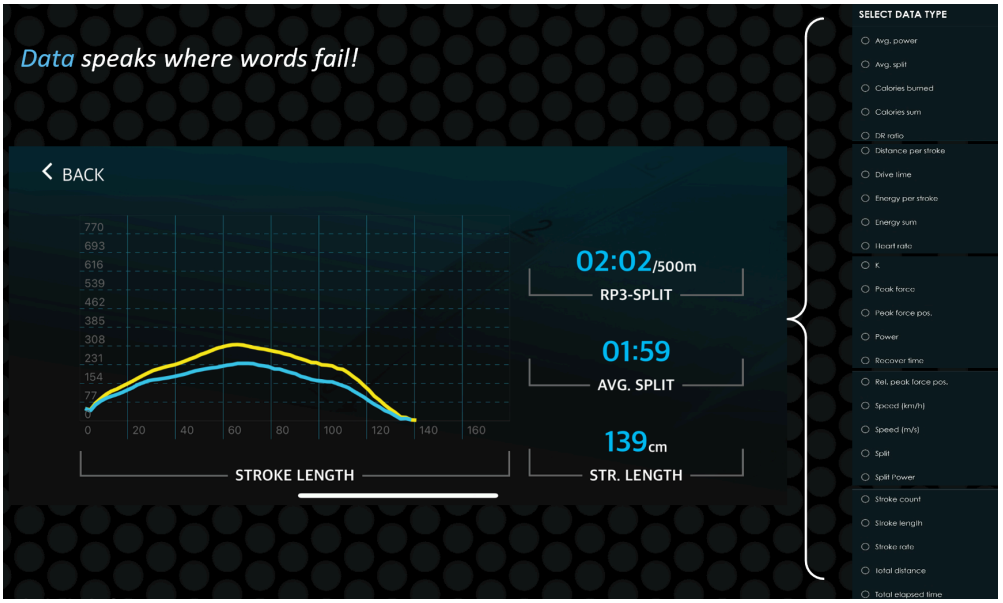
In addition to commonly used metrics such as time, distance, stroke rate, split, and power, RP3 provides qualitative data for a more detailed analysis of rowing performance. The force curve shape during each stroke offers insights into stroke consistency and efficiency. Stroke length, drive time, peak force, and relative peak force position indicate power application and rowing technique. Energy per stroke (EpS) and the stroke/recovery ratio help analyze endurance and pacing.

The R-square analysis, visible in the **RP3 Portal Advanced Edition**, measures how closely (%) the stroke follows the ideal parabolic stroke model, providing a valuable tool for technique refinement.

Training & Coaching with RP3

Due to the biomechanical similarities between rowing in a boat and on the RP3, it is evident that training with RP3 improves rowing efficiency and boatspeed. Using the RP3 App on a smartphone or tablet as a monitor during training, rowers receive instant feedback on their rowing motion. Besides the prominent Force Curve display, users can select three fields on a smartphone or eight on an Andriod tablet from a total of 25 available metrics.

[3] https://portal.rp3rowing.com/leaderboard



By holding down the relevant field on the screen for a little longer, the selection menu will appear, to select another value.

The Force Curve is defined by four key parameters:

1. stroke length as the foundation of the curve,
2. peak force as the highest point,
3. relative peak force position indicating where on the x-axis the peak occurs,
4. the overall shape of the curve, including pre-peak and post-peak phases.

Together, these define the area under the curve, representing the ‘energy per stroke’ (EpS - joule), a crucial indicator of the energy delivered by the rower to accelerate the boat. A smooth and full Force Curve characterizes an effective rowing stroke:

- ➔ An optimal stroke minimizes catch slip, ensuring the shortest possible time between blade entry and force connection.
- ➔ It also minimizes release wash, keeping horizontal pressure on the blade for as long as possible while allowing a clean blade exit.
- ➔ Maintaining connection throughout the stroke length, producing a smooth force application,
- ➔ Sustaining a full, rounded curve without loss of connection or force fluctuations are essential factors for maximizing performance (in the context of hydrodynamics).

By configuring relevant data fields such as split time, stroke rate, stroke length, and energy per stroke, rowers can refine their stroke technique and achieve the most efficient Force Curve.

What does ***quality*** of the stroke mean?

Rower 1

Rower 2

- *Comparing erg scores?*
- *Do you know the quality of your strokes?*
- *Want to get better?*

Look at this:

- About the same split
- Lower stroke rate: 22,3 vs. 28,1

- More length: 5 cm
- Some more power: 3,36%
- Some more force: 0,66%
- **Much** more "Energy per Stroke" → 24,31%

- Train your efficiency!
- Perfect Coordination has *the* effect on the boat speed

Combining the two values:

- ➔ Energy Per Stroke
- ➔ R2 (square) Total - stroke quality indicator

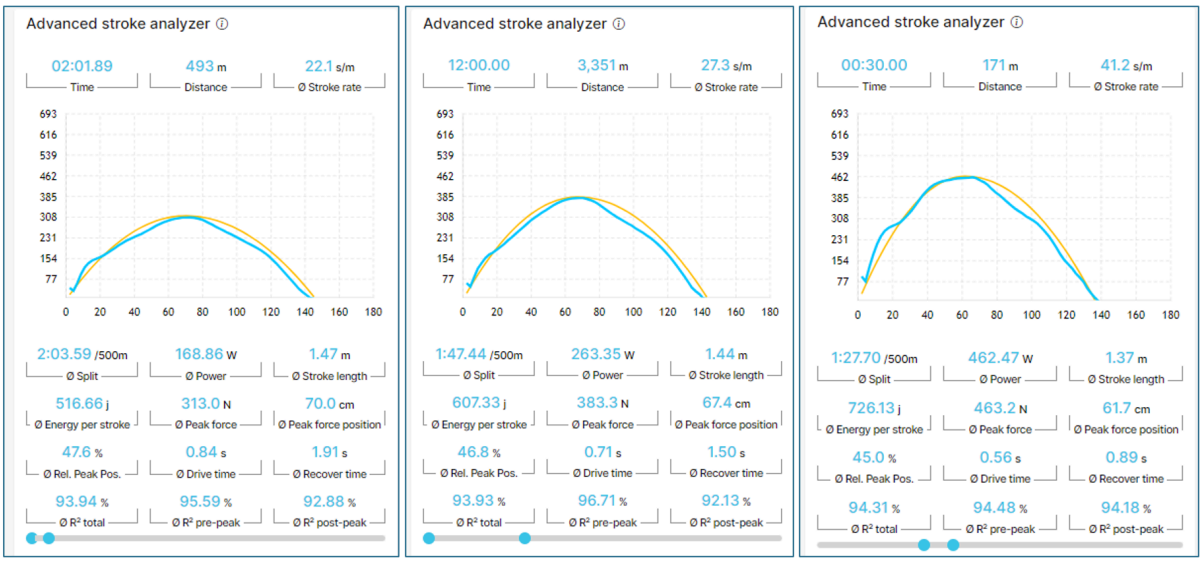
Will provide the "Effective Work per Stroke" (EWpS) indicator [4], which is a perfect value to use for progression reporting and qualitative crew rankings. These numbers / values are also used in the RP3 Coach Approach.

Consistency

Good rowing is consistent rowing. Each stroke should contribute equally to acceleration and boat speed across all conditions. Synchronizing rhythm and motion within the boat, avoiding unnecessary pulling or pushing against the footplate, ensures smooth movement. The goal is to manage the greater mass of the rower or crew relative to the lighter boat in a cadence that maximizes energy transfer without disruption. Only horizontal forces should be applied, while vertical forces should be minimized to maintain boat balance. External factors such as wind, waves, steering adjustments, or changes in stroke execution by teammates can all impact an individual's rowing stroke.

[4] https://biorow.com/index.php?route=information/news/news&news_id=116

Maintaining consistent technique at higher speeds, increased tempo, or greater power output is crucial. A rower should serve as a stable factor within the crew, allowing others to rely on them while adapting seamlessly to changes in race strategy, such as shifting from a starting pace to race tempo or executing mid-race sprints.



The challenge for every rower, regardless of level, is to make each stroke identical in quality while contributing maximum propulsion with minimal disruption. Training should focus on ensuring the Force Curve on the RP3 remains consistent, allowing rowers to detect and correct inefficiencies.

Using Reference Mode [5] (RP3 App), rowers can establish a target Force Curve and attempt to replicate it. The settings for Reference Mode can be derived from a Stroke Quality Analysis Report or a previous workout's data using the RP3 Coach Approach. Alternatively, a crew's average stroke pattern can be analyzed and used for training through the RP3 Portal Advanced Edition.

RP3 Coach Approach

RP3 Rowing has developed a structured approach to (self-) coaching using data from the RP3 ergometer. This method is continually optimized and expanded based on feedback and user requests from different pilot groups since mid 2024.

Rowers or rowing teams complete at least one to two low-intensity workouts per week, each lasting at least 45 minutes. The final 10-15 minutes of these sessions are particularly useful for analysis. Additionally, a high-intensity workout is scheduled every two to three weeks, which could be a high-intensity interval training (HITT) or a low-stroke-rate endurance session, such as a 30-minute R20 workout (stroke rate max 20). These workouts generate reports and performance insights.

[5] https://youtu.be/0HJzHe5zji4

The RP3 Coach Approach consists of several components:

- **Stroke Quality Analysis Report:** Identifies technical rowing deterioration due to fatigue during a workout. This analysis determines values for the **Reference Mode** setting in the RP3 App.
- **Rowing Consistency Analysis Report:** Compares segments of workouts over time to establish reference points and identify trends for improvement.
- **Progression Reporting:** Tracks qualitative values over time for both low- and high-intensity training sessions. A Progression Dashboard (format) is available for detailed monitoring.
- **Quantitative and Qualitative Baseline, Summary, and Progress Reports:** Provides an overview of individual and team performance after key test moments or preparation periods.
- **Individual and Crew Progress Reports with Crew Curve Analysis:** Evaluates qualitative improvements in rowers and teams over time.

- **Training & Feedback Cycle Reporting:** Combines on-water telemetry data from the RP3 App's "On Water" feature with workout data for comprehensive feedback (future development).
- **RP3 Oarlock & Footplate Telemetry:** Connects rowing boat data with ergometer performance using motion sensors, integrating on-water training with RP3 data (future development).

All reports and analyses are conducted through the **RP3 Portal Advanced Edition** [6], using a set of structured templates (spreadsheets). This reporting functionality is continuously being expanded within RP3 Portal Advanced.

For more information about the RP3 Coach Approach, contact RP3 Rowing at **info@rp3rowing.com** or visit the **RP3 Academy** [7] on the website.

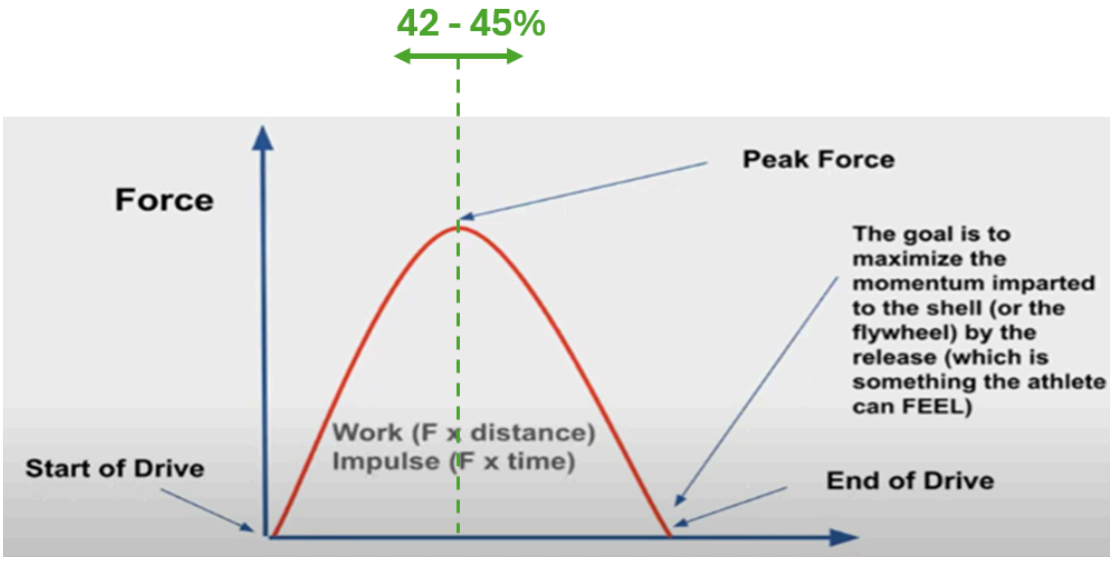
[6] https://portal.rp3rowing.com/login
[7] https://rp3rowing.com/customers/rp3-academy

Appendix - target values for rowing / training with RP3

Stroke Length (meters) for low intensity workouts

body length	female < 1.65m	female 1.65 - 1.75m	female > 1.75m	male < 1.75m	male 1.75 - 1.85m	male < 1.85m
Beginner	1.15 - 1.20	1.20 - 1.25	1.25 - 1.30	1.25 - 1.35	1.30 - 1.40	1.35 - 1.40
Intermediate	1.20 - 1.25	1.25 - 1.30	1.30 - 1.35	1.30 - 1.40	1.35 - 1.45	1.40 - 1.50
Expert	1.30 - 1.40	1.35 - 1.45	1.40 - 1.50	1.35 - 1.45	1.40 - 1.50	1.45 - 1.55

Relative Peak Force Position (indication)



Boat Type:	***Single***	***Pair***	***Four***	***Double***	***Coxless Four***	***Quad***	***Eight***
Low Intensity	48%	47%	47%	46%	46%	45%	45%
High Intensity	46%	46%	46%	45%	45%	44%	43%

As mentioned above in the document, the relative peak force position should theoretically be slightly forward of the orthogonal position in order to achieve the most optimal hydrodynamic effect of the blade in the water at the greatest force the rower can exert. For faster boat types, the theoretically ideal point is slightly more forward (lower percentage). Furthermore, more power at a higher stroke rate results in a shorter stroke length and a (small) shift forward in the stroke (lower percentage). That is why training a higher relative peak force position at a lower intensity is recommended (as a target value).

In practice, it is also the case that a too low relative peak force position (below 40%) results in a lower quality of the post-peak curve and therefore a lower delivered “Energy per Stroke”.

Peak Force and Energy Per Stroke - guideline and target values

The Peak Force is one of the four values that together determine the area under the Force Curve. Whereby this Peak Force (Newton) represents the height of the peak of the curve. The stroke length is the basis of the curve.

The relative peak force position (see above) determines the place on the x-axis of this peak value. The shape of the curve also influences the “energy per stroke” - EpS - value (joule), which represents the area under the curve. That is the amount of energy that you as a rower can put into the flywheel and is very comparable to the energy that you can provide with the blade in the water in the acceleration and thus the speed of the boat. The calculation is from EpS (joule) to Watt (joule per second), which can be translated into a “split” (the time over 500m).

As described in this document, the shape of the curve is an indication of the effectiveness of the stroke and the ability of the rower to transfer energy into the boat speed. The shape can best be ‘full and smooth’, where ‘full’ stands for as much surface area under the curve as possible (with the width and the height) and smooth stands for the most efficient connection of the blade in the water.

A high peak force, with a full and smooth shape, and a wide base, ensures a high ‘energy per stroke’ (EpS). For every rower there is a physical limit to the height of the EpS. Usually the stroke length becomes shorter as the peak becomes higher and vice versa. For every rower the challenge is to find the highest efficiency and to improve the EpS score and to know which value of the EpS could and should be aimed for in every workout.

The height of the Peak Force is therefore dependent on the EpS value. The rower can choose to focus on Peak Force and give less attention to the other values, to the stroke length, to the quality of the shape of the curve or to focus on the EpS.

In a training approach, these individual values can be given full attention for a period to improve, after which the other value is next. In this way, the final ‘sum’ is improved step by step, which will result in a better and more effective rowing stroke.

Level [8]	**Female Club Rower**	**Female Intermediate**	**Female Elite**	**Male Club Rower**	**Male Intermediate**	**Male Elite**
Peak Force (N)	200 - 250	250 - 350	350 +	250 - 330	330 - 460	460 +
Energy Per Stroke (j)	300 - 400	400 - 480	480 +	350 - 500	500 - 650	650 +

[8] This classification is not restrictive. Experience, expertise and also age play a role.