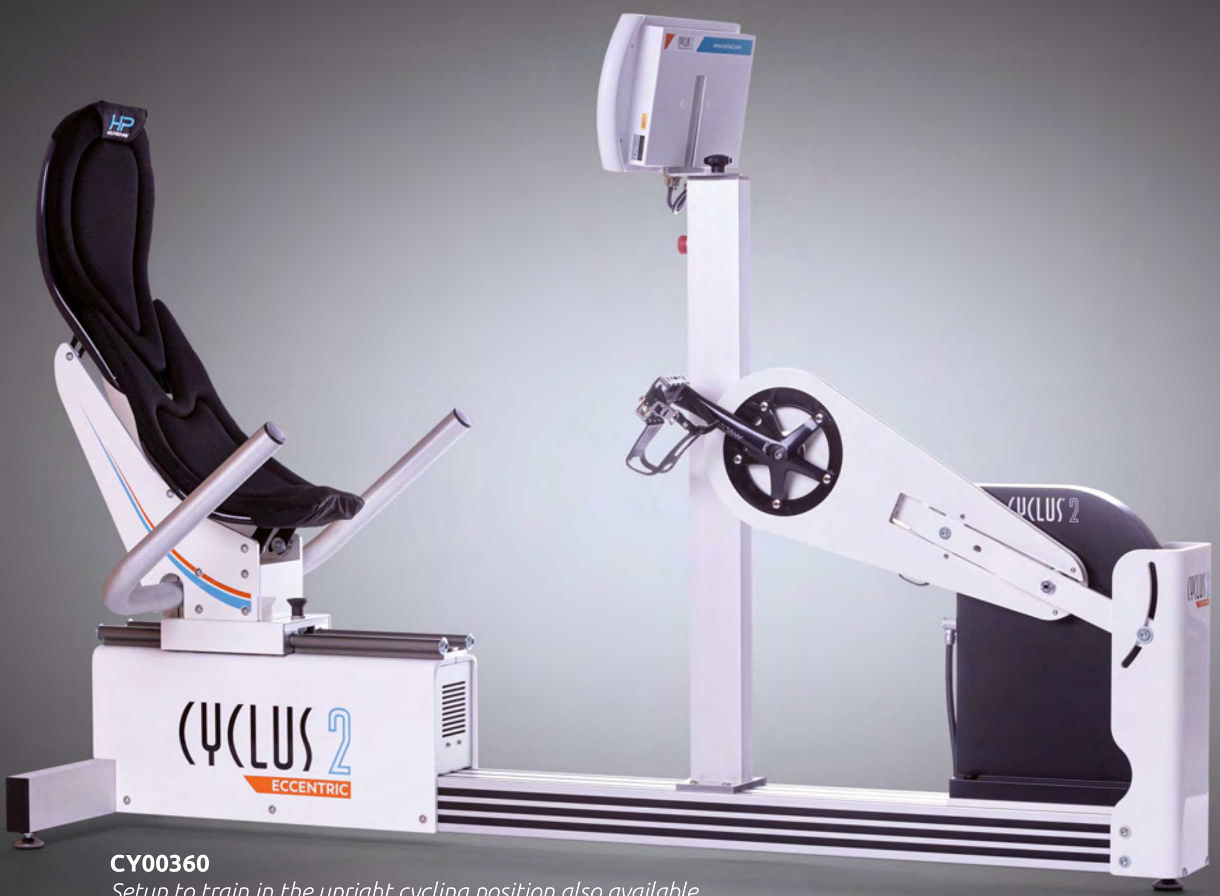
ECCENTRIC CYCLE ERGOMETRY

Next Generation
NOW SUPPORTING ECCENTRIC AND CONCENTRIC EXERCISES!



CY00360
Setup to train in the upright cycling position also available

CYCLUS 2
ECCENTRIC

Experience the unique benefits of eccentric cycling!

High intensity work with lower metabolic cost
to increase concentric and eccentric muscle strength
for more power production.

Highlighted features

- Bidirectional 10 to 100 RPM
- Maximum power output up to 1000 watts from 40 to 100 RPM
- Low cadences with high workloads
- Smooth accelerations
- Eccentric exercises in isokinetic and constant power mode
- Concentric exercises in isokinetic mode
- Mixed load profiles backward/forward, eccentric/concentric and isokinetic/power
- Feedback display
- Export feature for research

Typical applications

- Strength training
- Coordination training and fall protection
- COPD and cardiac rehabilitation
- Cruciate ligament rupture and replacement rehabilitation
- Post Covid rehabilitation

Eccentric cycle ergometry:
an old concept turned into a novel training modality

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In concentric (CON) muscle work, the muscle shortens during activation and performs motor actions, whereas in eccentric (ECC) muscle work, the muscle undergoes a forced lengthening while bearing an external load and performs braking actions. The last 25 years have seen a renewed interest for ECC cycle ergometry [1, 2].

The very first ECC cycle ergometer for the lower limbs was described by Abbott et al. [3] (Fig. 1) and was subsequently adapted as new technologies became available for both lower [4] and upper limbs [5]. Nowadays, an eccentric cycle ergometer has been made commercially available offering the possibility to use a normal bike to generate both CON and ECC muscle work on the same apparatus (Cyclus2 Eccentric Trainer©).

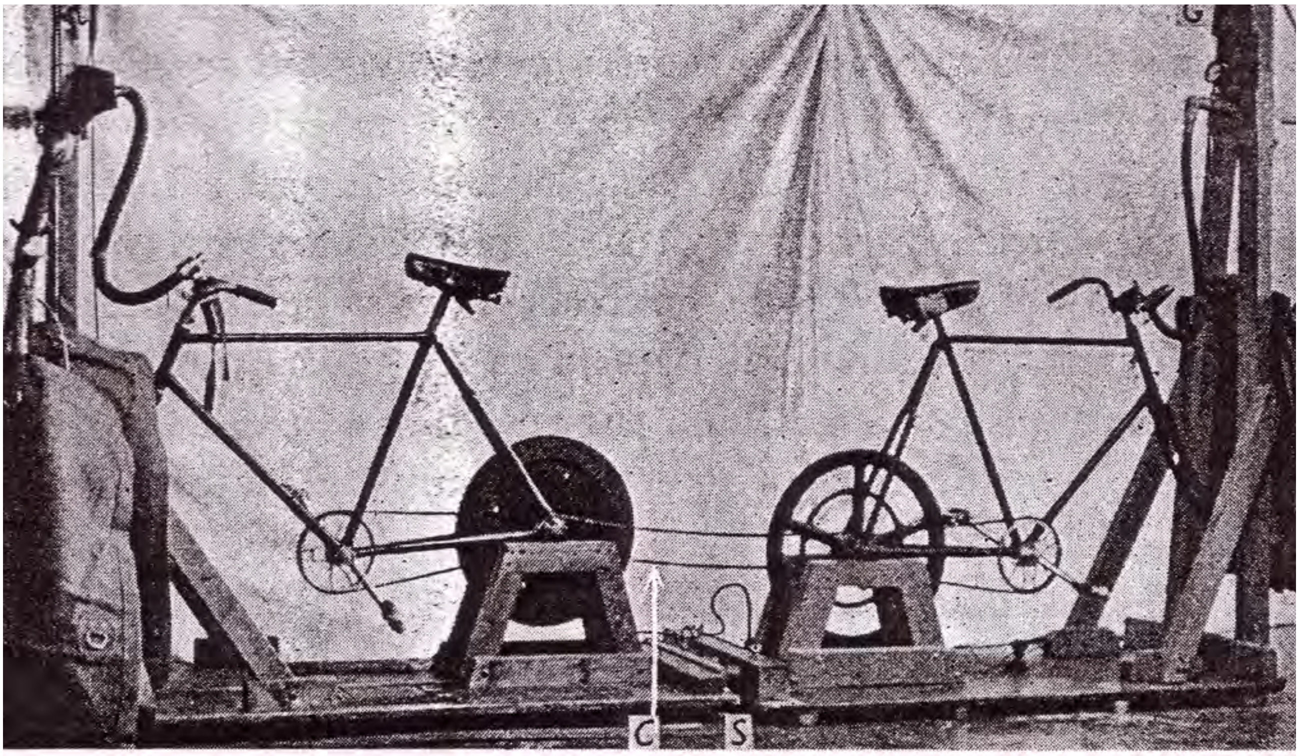

Figure 1: The first eccentric cycle ergometer. Two bicycle ergometers were placed back to back and coupled by a chain; when one cyclist pedaled concentrically in the conventional forward direction, the legs of the other cyclist were driven backwards allowing eccentric muscle work to be performed (reproduced from Abbott et al. [3])

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1. Major physiological properties of eccentric muscle work

Eccentric muscle actions can produce greater force than CON or isometric muscle actions[6-8] and maximal power can be much higher in eccentric than in conventional concentric cycling[9, 10]. The greater force produced during ECC muscle actions arise from a combination of specific, although not yet fully identified, molecular events involved in the cross-bridge cycle[11] and of specific neural control strategies[12]. At similar mechanical power output, ECC cycling elicits a lower oxygen consumption (VO_2) [13, 14], and reduced ventilatory[15] and cardiocirculatory responses (Figure 2).[16, 17]

The lower oxygen cost of ECC cycling might be due to a combination of non-adenosine triphosphate (ATP)-dependent "mechanical" rupture of the actin-myosin crossbridges [18, 19], a greater distance covered by each individual actin-myosin crossbridge[20, 21] and a lower recruitment of motor units [22].

Therefore, the general feeling of subjects cycling eccentrically is that exercise is much easier compared to the CON cycling, as attested by lower levels of perceived exertion. Also of particular interest are several reports which suggest that despite being "energy efficient", ECC muscle work might increase post-exercise resting energy expenditure for up to 72 h [22, 23].

ECC cycling can also be performed at a similar VO_2 as CON cycling provided that the mechanical power output in the ECC mode is high enough (i.e., ~5-fold higher in ECC than CON cycling). In this specific condition, Q and HR are higher during ECC cycling [25].

This observation has important repercussions for the management of exercise intensity and training load as exercising at a similar VO_2 actually requires a higher HR in ECC than in CON cycling.[13]

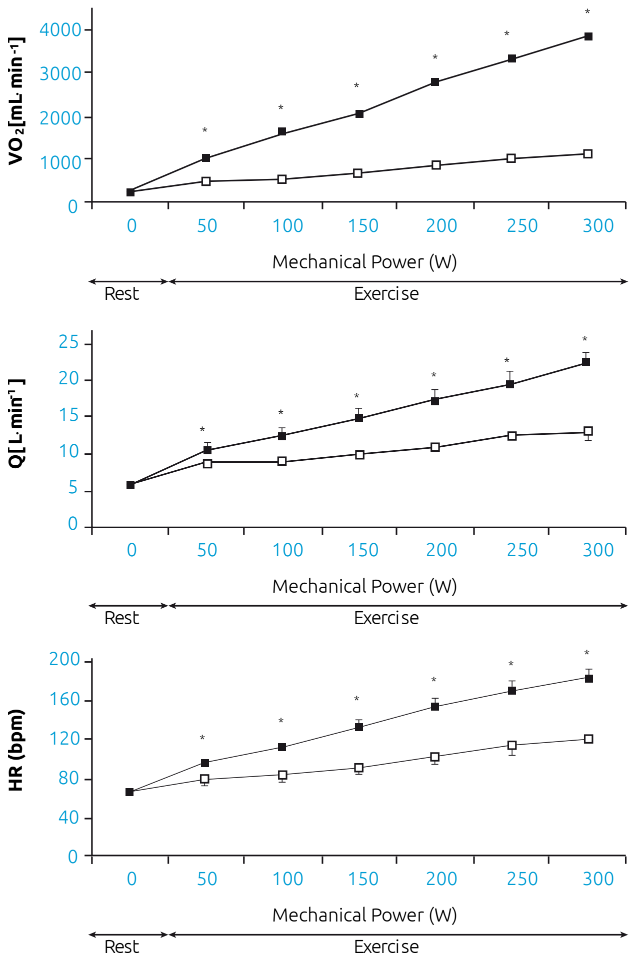

Figure 2: VO_2, cardiac output (*Q*) and heart rate (HR) as a function of the mechanical power during CON and ECC cycling. (adapted from Dufour et al. [13]). bpm beats per min, ECC: white symbols; CON: black symbols, $*p < 0.05$: significant difference CON vs ECC.

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2. Eccentric cycle exercise does not necessarily generate muscle damage

ECC muscle work can lead to marked exercise-induced muscle damage (EIMD), especially when high muscle forces are generated [26, 27] and/or if the ECC muscle actions are performed at high velocity [28] or short/long muscle length [29]. However, the magnitude of EIMD is progressively reduced after repetition of the same ECC exercise (i.e repeated bout effect) [30] and subjects engaged in regular ECC training become less susceptible to EIMD [30]. Therefore, if ECC cycling intensity is increased gradually, young [31, 32] and older [33, 34] healthy subjects as well as patients with various chronic diseases (i.e cancer, cardiac, respiratory disorders,…) can adapt to high-force ECC cycling sessions without muscle damage but improved locomotor abilities and health outcomes [35].

3. Training Response After ECC Exercise Training Programmes

A major advantage of ECC cycling is the possibility to achieve very high mechanical load (up to 900W over 30min continuous training session [36]) with limited energy expenditure. ECC cycling as a training strategy was shown to improve isometric strength (+33 %) and induce greater hypertrophy of the quadriceps muscle (+52%) than CON cycling training in healthy subjects [37, 38]. In high-school basketball players and top level junior alpine skiers, ECC cycle training improved jump height by 6-8% compared with weight-training [39]. Increased jumping power and leg spring stiffness were also documented after ECC compared to CON cycle training [40], suggesting that ECC cycle training might improve muscle ability to store and restore elastic strain energy. The interest of ECC cycling is also appearing for rehabilitation purposes in athletes as elevated quadriceps strength and volume were observed after ECC compared to CON cycle training after ligamentoplasty of the anterior cruciate ligament of the knee [41, 42].

In elderly people [33] or in patients suffering from cardiorespiratory diseases [43-46], metabolic disorders and obesity [47, 48], neurological pathologies [49, 50] and some types of cancers (i.e breast, prostate, lung, colon and lymphoma) [51, 52], ECC cycle training demonstrated its feasibility even at very advanced ages (i.e >80 yr old) with virtually no EIMD nor other side effects. Common to these differents conditions, ECC cycle training has demonstrated encouraging results in increasing muscle mass and force ultimately improving patients' exercise capacity and quality of life. Recent findings also indicate that ECC cycling might prevent bone fragility [53] and favor neuroplasticity [54]. Altogether, these findings suggest that ECC training might be particularly suitable for improving body composition and muscle strength even in the more frail subjects, possibly via the specific expression of transcripts encoding factors involved in muscle growth, repair and remodeling [55].

Although its specific mechanical, metabolic and cardiovascular responses deserve particular attention for optimal monitoring of training load, ECC cycle ergometry currently emerges as a promising training strategy not only for athletes but also in the elderly and many diseased states.

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Specification Cyclus2 **ECCENTRIC TRAINER**

	STANDARD 2022 unidirectional (backward only)	**EXTENDED 2022** bidirectional (backward / forward)
Set-up:	Upright cycling position	
Eccentric load types:	Isokinetic mode Constant power mode	
Concentric load types:	n/a	Isokinetic mode
Cadence:	10 to 100 RPM	
Maximum power:	1000 watts from 40 to 100 RPM (short term)	
Controls:	Manual controlled Program controlled	
Power accuracy:	Maximal error 4 % of reading (for power values less than 100 Watt maximal 4 Watt)	
Cadence accuracy:	Maximal error ±1 RPM	
Connectivity:	Bluetooth smart (Heart rate monitors, Moxy monitor, VO2 Master Pro) 2 x USB (flash drive, printer, external keyboard) 1 x RS232 (data streaming) 1 x LAN (data streaming, printer, VNC, FTP) Optional 1 x Wifi (data streaming, printer, VNC, FTP)	
Printer support:	PCL3, PCL5 (e.g. HP Color Laserjet), PDF, TIFF	
Data export:	User-defined CSV format	
Languages:	German, English, French, Italian, Russian, Spanish, Portuguese	
Optional accessories:	Bike frame (CY01550) ANT+/BTLE Heart rate transmitter (CY1701) Floor mat (CY01400)	
Power input:	1000 Watt (maximum), 100 – 240 VAC / 50 – 60 Hz	
External power supply:	Desk power supply 48 VDC including emergency stop button 29 x 30 x 11 cm (L x W x H), 4.5 kg	
Dimensions (approx.):	140 x 50 x 105 cm (L x W x H) 35 kg	
Crank length:	Depending on the type of bike used	
Order number:	CY00300	CY00310

Specification Cyclus2 **RECUMBENT ECCENTRIC TRAINER**

	STANDARD 2022 unidirectional (backward only)	**EXTENDED 2022** bidirectional (backward / forward)
Set-up:	Semi-recumbent cycling position	
Eccentric load types:	Isokinetic mode Constant power mode	
Concentric load types:	n/a	Isokinetic mode
Cadence:	10 to 100 RPM	
Maximum power:	1000 watts from 40 to 100 RPM (short term)	
Controls:	Manual controlled Program controlled	
Power accuracy:	Maximal error 4 % of reading (for power values less than 100 Watt maximal 4 Watt)	
Cadence accuracy:	Maximal error ±1 RPM	
Connectivity:	Bluetooth smart (Heart rate monitors, Moxy monitor, VO2 Master Pro) 2 x USB (flash drive, printer, external keyboard) 1 x RS232 (data streaming) 1 x LAN (data streaming, printer, VNC, FTP) Optional 1 x Wifi (data streaming, printer, VNC, FTP)	
Printer support:	PCL3, PCL5 (e.g. HP Color Laserjet), PDF, TIFF	
Data export:	User-defined CSV format	
Languages:	German, English, French, Italian, Russian, Spanish, Portuguese	
Optional accessories:	ANT+/BTLE Heart rate transmitter (CY1701) Floor mat XL (CY01405)	
Power input:	1000 Watt (maximum), 100 – 240 VAC / 50 – 60 Hz	
Dimensions (approx.):	195 x 61 x 125 cm (L x W x H) 70 kg	
Crank length:	172 mm	
Order number:	CY00350	CY00360

Safety instruction:

Please note that the Cyclus2 eccentric ergometer is only permitted to use in the presence of specifically trained staff. In case of any irregularities, this staff has to be able to promptly switch off the ergometer using the emergency stop button.

Technical details and colours may vary from those shown in the picture.

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