National Testing Protocols
Version 2014.D

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Traceability Table

Protocol Name	Date Implemented	Change made by:	Protocol modification / evolution
CC_Testing_Protocols_2014D	Oct 31, 2014	M. Patton R. Rupf J. Martin A. Wooles	Complete rewrite of menu of tests
CCA National Lab Testing Protocols V4.5	Jan 2010	B. Sporer A. Wooles	Addition of submaximal and sprint tests
CCA Health and Athlete Monitoring Program		G. Thibault	Original set of standard tests for the CCA, including the MAP test

References

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Introduction

Purpose of testing

Testing is conducted to monitor changes in fitness and health throughout the season and over the course of an athlete's career, to provide information to athletes and coaches about the effect of training. Consistent, reliable, and accessible tests that are easily available in a number of locations across Canada will provide coaches with the information they need to create individualized training programs regardless of the location of the athlete, and will also help us improve our understanding of the strengths of each of our team members.

The purpose of this manual is to outline a set of standardized tests that provide useful information that can be performed in locations across the country, for a variety of levels of athletes, as well as to help us ensure a consistent data set for all of our current and aspiring National Team riders. This data will eventually be used anonymously to improve our understanding of the physiological development of cyclists as they progress up the athlete pathway.

The Testing "Menu"

We have developed a "menu" of tests for cyclists at each level of the development pathway, which coaches can select from as needed. The levels are defined as:

- **Initiation / Early Interaction:** Either athletes who are going through a Talent ID process, or who have recently started in the sport
- **Development:** Athletes who are committed to cycling, and are competing on a Provincial Team or National Development Team
- **Elite:** Athletes who are fully committed to cycling, who are training full-time with the National Team, and who are competing internationally for Canada

The tests progress from simple tests that can be performed on a variety of equipment, to more specific tests that require a lab and specialized equipment more frequently. Suggested frequencies for testing are included for each test type. Some tests are only needed for certain interventions, such as altitude training.

There are two "menus", one for endurance event riders and one for sprint event riders, shown below. With the options available, testing can be programmed to answer the specific questions and goals that the coach and rider have.

Table 1. Testing Menu for Endurance Cyclists

		Development		Elite		Approx. Frequency						
Level	Test	Core	Optional	Core	Optional	Daily	1 Wk	1 Mo	3 Mo	6 Mo	12 Mo	Once
Level 1	Max/1s" MMP											
	30" MMP											
	4’ MMP											
	10’ MMP											
	20-30’ MMP (e.g. 20' FTP test)											
	Height (Standing & Seated)											
	Weight											
	Quad Girth											
	SCAT 3 (concussion testing)											
	Ferritin & STfR											
	Complete Blood Count											
	Bi-acromial Distance											
Level 2	AnT (MLSS$_0$)											
	CdA											
	Thigh Volume											
	Sleep Q											
	Hydration Monitoring											
	Draft Ratio (team pursuit)											
	Fat Free Mass											
	Pulmonary Function											
Level 3	VO_{2max}											
	AeT											
	VO_2 Kinetics											
	Cycling Efficiency (W,t)											
	Power-PR relationship											
	Cardiac output											
	Torque Profile – Pedal Stroke Analysis											
	HEC (hypoxic response)											
	Hb mass											

Monitoring	Morning Heart Rate											
	HRV											
	DALDA/Hooper-Mac											

Table 2. Testing Menu for Sprint Cyclists

		Development		Elite		Approx. Frequency						
Level	Test	Core	Optional	Core	Optional	Daily	1 Wk	1 Mo	3 Mo	6 Mo	12 Mo	Once
Level 1	Max/1s" MMP											
	5" MMP											
	30" MMP											
	1' MMP											
	Repeated Sprint Ability											
	Seated & Standing Height											
	Weight											
	Quad Girth											
	SCAT 3 (concussion testing)											
	Ferritin & STfR											
	Complete Blood Count											
Level 2	RFD (e.g Force Plate)											
	Max Force											
	Power-PR relationship											
	10" low-cadence											
	15" high-cadence											
	CdA (seated and standing)											
	Draft Ratio (team sprint)											
	Fat Free Mass											
	ISAK Level 1 Profile											
	Thigh Volume											
	Sleep Q											
	Pulmonary Function											
Level 3	VO_{2max}											
	Torque Profile – Pedal Stroke Analysis											
	HEC (hypoxic response)											
	Hb mass											

Mo nito ring	Morning Heart Rate											
	HRV											
	DALDA/Hooper-Mac											

Pre-testing Instructions

For any physiological testing it is imperative that athletes follow the same preparation plan to ensure test results are valid and comparable. The following are general guidelines that must be followed for **ALL** testing sessions. Specific tests may have additional guidelines.

Preceding 24 hours:

- No intense or long duration exhausting exercise
- Consume a standard meal plan used for all testing sessions
- No alcohol

Day of testing:

- No caffeine 4 hours prior beyond habitual intake levels
    - A cup of coffee in the morning is fine as long as it represents a normal daily routine. Inform testers of the amount and timing of any caffeine intake within the 4 hours prior to testing.
- Last meal 3 hours prior
- Small snack up to 1 hour prior is ok

*** NOTE: athlete preparation should be recorded so that the same can be completed prior to each test.

Medical Clearance and Informed Consent

All athletes are required to complete a health questionnaire and consent form prior to commencing any activity. This includes a section for consenting to the sharing of test results or any medical information that is discussed during the testing session. It is important to point out to the rider that they can withdraw consent at any time***. If the athlete is ill, or has an injury that may be aggravated by the tests, or answers "yes" to any question on the PAR-Q, rebook the test for a later date*.** The athlete's long-term health is more important than a test result. If the athlete has any injury, ensure that they are referred to the appropriate professional (only if the athlete consents).

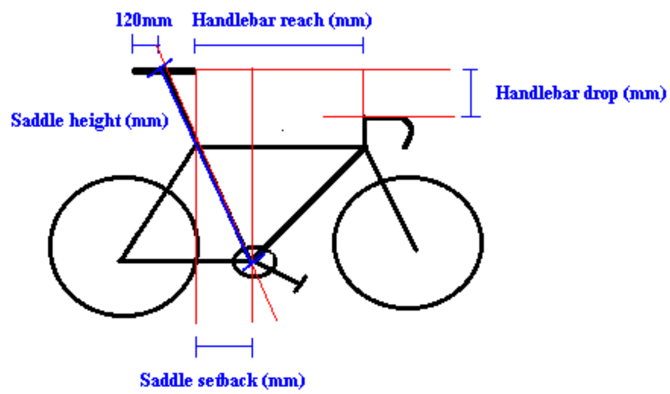
It is important to be aware of the legal requirements regarding Data Protection, which are particularly relevant given the sensitive personal information that is collected and stored. All test subjects need to be aware of the information that is being collected and need to be informed of their right to confidentiality.

Bike Measurement and Ergometer Setup

Athletes should bring their bike to the testing session, so that the measurements may be copied as closely as possible to the ergometer. They also need to bring the pedals they would like to use for the test.

The bike should be on a level surface for measuring process. Five measurements are required, as follows:

1) Setback: From the centre of the bottom bracket to the tip of the saddle *along level planes*.
2) Saddle height: Using a flexible measuring tape, measure from the centre of the bottom bracket to the centre of the saddle at a point 120mm from the rear of the saddle. If there is a "bite" out of the saddle, place a straight edge against the rear of the saddle and measure from that.
3) Reach: From the tip of the saddle to the centre of the handlebars *along level planes*.
4) Drop: From the bottom of the spirit level to the top of the handlebars, when the spirit level is resting on the saddle.
5) Crank length: As stated on the crank by the manufacturer, or as measured from the centre of the bottom bracket to the centre of the pedal axle.



These measurements can then be transferred to the ergometer being used. Ensure that all of the quick-release levers are adequately tightened to prevent slipping during the tests, but do not over-tighten.

Once the correct position has been set on the ergometer, attach the athlete's pedals.

Ensure that whatever power meter is being used is zeroed and that the calibration is correct. Check that the date is set correctly in the bike computer that is being used to collect the data, and that there is room in the memory to store the test file. Double-check that the battery is charged, and check that the tire circumference setting is correct.

Athlete/Facility Preparation

Coming to a lab or testing for a National program can be an unnerving experience so do all possible to make the situation comfortable for the athlete.

a. Explain location of washrooms and other key locations of the facility
b. Explain the protocols clearly to the athlete and ask if they have any questions
c. Explain that the test results are being used to identify strengths and weaknesses in further helping them reach their potential
d. Enter athletes name, age, sex, coaches name, and discipline on the appropriate data sheet – make sure to print this clearly

e. Record any previous participation in endurance sports including sport, age, and length of time (voluntary but not mandatory)
f. Ask all unnecessary personnel to leave the testing area prior to beginning the test process

Equipment Used

Test station:

Bike ergometer with power meter	Computer	Tool kit
Tape measure	Power Bar/Extension cord	Data sheets
Bleach Spray bottle	Bucket/ soapy water/ rag	HR monitor
Fan	Towel	

Blood Station

Blood Cart	Lancets (2)	Alcohol Swabs (box)
Lactate Analyzer	Lancet Tips (box)	Gauze (pkg)
Lactate Strips	Dilute Bleach/Beaker	Band-Aids (box)
Calibration Strips	Bleach Spray Bottle	Biohazard Bag
Gloves (box)	Sharps Container	Garbage Can

Anthropometry

Scale (accurate to +/-0.05kg)	Wall-mounted stadiometer
Anthropometric measuring tape	Skinfold Calipers (Harpenden)
Bone calipers	Landmarking pen
Data sheet	Calculator

Off-bike Protocols

Anthropometry

Anthropometric measures are taken to enable a more comprehensive interpretation of any changes in fitness observed in the cycling tests. It is vital that care be taken to ensure that these measures are as accurate and reproducible as possible. Skinfold and girth measurements are to be done according to **ISAK Standards**. *If the athlete is less than 18 years old, ensure that there is another adult present during the measurement procedures.*

Initiation / Early Interaction riders

- Standing Height (cm) (used for calculation of Frontal Surface Area, and Peak Height Velocity)
- Mass (kg) (used for determining relative power)
- Biacromial distance (cm) (used for calculation of Frontal Surface Area)
- Quadriceps girth (cm) (used as indicator of sprint or endurance profile)

Development riders

At this level, the following variables can be added, with the focus on power and performance and not on "fatness":

- Fat-free mass
- Thigh volume

Elite riders

No additional tests. Frequency of testing can be increased if desired, or if a rider is managing their weight with the support of a Dietitian. The focus remains on power and performance through the measurement and emphasis on muscle mass.

Lung Function

Lung function tests are done to provide baseline information that can be used to help identify any respiratory issues that the athlete may have. If any suspicious results are found, refer the athlete to the Team Doctor, their Sports Medicine doctor, or their GP with a copy of the test results.

Testing should be performed according to the Canadian Thoracic Society's (CTS) guidelines (http://www.respiratoryguidelines.ca/sites/all/files/CTS_Spirometry_Primary_Care_2013.pdf), preferably by someone who has obtained accreditation from the SpiroTrec course offered by the CTS.

Initiation / Early Interaction riders

Pulmonary function testing not typically performed. Can be done if there is a specific need.

Development riders

Basic flow-volume loops should be performed once in conjunction with a difficult exercise session, ensuring that the spirometer is calibrated immediately before use. Record the FVC, FEV_1, FVC/FEV_1, Peak Flow, FEF_{50}, and FEF_{25-75} and percentages of predicted values for each of these variables.

Repeat the testing procedure 5, 10, and 15 minutes after the end of the exercise bout to obtain post-exercise values.

Elite riders

Flow-volume loops should be performed annually, with any specific provocation tests that are appropriate (i.e. methacholine challenge, hypersaline challenge, EVH) or with exercise.

Spirometry should also be performed in the case of unexplained drops in performance.

Blood Tests

Blood tests for any level athlete should only be completed on advice of the Team Doctor or the athlete's doctor. Performing blood tests at regular intervals for "screening" purposes without the presence of any symptoms is not recommended. The doctor may, however, recommend a single set of tests in order to obtain a baseline measure for an athlete. Common tests for athletes include Complete Blood Count (CBC) and Ferritin.

If any athlete is displaying symptoms of excessive fatigue, difficulty recovering, or any abnormal symptoms, please refer them to a doctor for appropriate testing.

Concussion Testing

Baseline concussion testing using the SCAT3 questionnaire should be performed pre-season for all cyclists. In some cases where the athlete is French-speaking, the French version of the ACE questionnaire may be used instead, although the SCAT3 is the international standard. Ideally, the questionnaire should be administered by medical or paramedical staff, although coaching staff may also administer it. If the athlete subsequently has an accident, the baseline test can be used to determine the severity of the potential concussion, and to help track recovery back to that person's own "normal" state.

If the athlete is on the National Cycling Team, we can provide this test through our medical records database, CAMP.

Sleep Assessment

Sleep quality and duration are an important part of recovery and health. It is worthwhile to assess sleep as part of an annual or bi-annual medical appointment, using the ASSQ (Athlete Sleep Satisfaction Questionnaire, developed by Dr. Charles Samuels). This can be done for National Team athletes using the "Sleep Questionnaire – ASSQ v3.5" form in CAMP.

Sleep is important at all levels of development, and even if the ASSQ is not available, coaches may want to consider adding a question about sleep to their regular interactions with each athlete. If an issue is identified, the athlete's doctor can make a referral to a sleep specialist.

On-bike Tests

These tests have been designed so that they can be done in the field as much as possible, on whatever equipment is available. Some of the more specific tests at the Development and Elite levels do require special lab-based equipment.

AIS Power Profile Test

* from Cycling Australia's "National Cycling Protocols (NP_Cycling_v2.0_2011)"

Maximum powers for 1", 30", 4', 10', and 30' can be gathered from training and racing data using a power meter, or from the Australian Institute of Sport (AIS) Power Profile Test, as follows.

The power profile test aims to determine the highest power output (maximal mean power: MMP) a cyclist can hold for a particular duration of effort when in a controlled environment and prepared for testing. The resulting time-power continuum determines the maximal capabilities of the cyclist at that phase of the season. The test has recently been shown to provide an ecologically valid assessment of a cyclist's power producing capabilities, when compared to the efforts of the same duration obtained during actual competition (Quod et. al. 2010). Therefore, the test may be useful for quantifying aspects of race performance as well as for talent identification and training prescription.

Initiation / Early Interaction riders, Development riders

The AIS Power Profile test can be completed, without the lactate and gas analysis components.

Elite Riders

If the coach feels that the lactate and gas analysis data will add value to the testing and subsequent training planning, then these variables can be added. Torque profiling can also be done for these riders, to look for biomechanical issues that may affect performance.

Test Procedure

- The power profile test may be performed on a calibrated air-braked cycle ergometer or using a calibrated power meter mounted to the cyclist's bicycle which is then placed in a wind-trainer or rear wheel ergometer. When choosing the ergometer on which the test is to be performed, it is important to consider the kinetic energy associated with the 'system' so as to replicate the 'feel' associated with riding on the road as closely as possible. The ergometer's gearing should be adaptable to allow the cyclist to self-select a cadence that will allow them to produce a maximal effort over the duration of each effort.
- The power meter should be set to a sampling rate of 1 s (or less) with the correct slope entered.
- A 5 min warm-up at 75-100 W is conducted to familiarize the cyclist with the bike set-up and should include at least 2, 3-5 s sprints to ensure the correct gearing is selected for the test (this gearing should be recorded when possible). The gear selected should enable the cyclist to self-select a cadence which is appropriate to the duration of the effort and similar to when road riding.

- Following the warm-up, the power meter should be zeroed and the value recorded.
- Instruct the cyclist to produce as much power as possible for the duration of each effort. For the shorter efforts (6 s-30 s), the cyclist will typically engage in an all-out sprint. However, for the longer efforts (1 min-10 min), an element of pacing is required.
- The test protocol is outlined in the table below. Note that the first two sprints are conducted from a standing start, with the remaining efforts completed from a rolling start between 70-80 rpm.
- On completion of the test, the zero offset of the power meter should be checked for drift.

Power Profile Test Protocol

Time (min:sec)	Effort	Power Output	Heart Rate	Gas Analysis	Blood Sample	Notes
0:00 - 0:06	6 s, small gear	*	*			Standing start
0:06 - 1:00	Active recovery (54s)	*	*			50 – 100 W
1:00 – 1:06	6s, big gear	*	*			Standing start
1:06 - 4:00	Active recovery (174s)	*	*			50 – 100 W
4:00 – 4:15	15 s	*	*			Rolling start (70-80 rpm)
4:15 – 8:00	Active recovery (225s)	*	*			50 – 100 W
8:00 – 8:30	30 s	*	*			Rolling start (70-80 rpm)
8:30 – 14:00	Active recovery (330s)	*	*			50 – 100 W
14:00 – 15:00	1 min	*	*		^^	Rolling start (70-80 rpm)
15:00 – 23:00	Active recovery (480s)	*	*			50 – 100 W
23:00 – 27:00	4 min	*	*	*	^^	Rolling start (70-80 rpm)
Endurance Athletes Only						
27:00 – 37:00	Active recovery (600s)	*	*			50 – 100 W
37:00 – 47:00	10 min	*	*	*	^^	Rolling start (70-80 rpm)

* indicates sampling during effort
^^ indicates sampling pre and post effort

Data collection

- Record age, height and body mass prior to the test.
- Record power output and cadence data throughout the test using a sampling rate

of 1 s or less.

- Record heart rate throughout the test using a sampling rate of 5 s. In addition, the heart rate at the end of each effort should be recorded.
- Record VO_2, VCO_2, RER, VE, Ve/VO_2, Ve/VCO_2 during the 4 and 10 min efforts.
- Collect a capillary blood sample from the fingertip or ear lobe 1 min prior to and 1 min post the 1 min, 4 min and 10 min efforts. Analyze the sample for lactate concentration and (if required) pH, blood gases and bicarbonate concentrate

Data Analysis and practical application

- Average power (MMP) and cadence for each effort are determined using commercially available software (e.g. SRM training software, GoldenCheetah, or TrainingPeaks WKO+ (PeaksWare, USA). For the 2 x 6 s efforts, the highest average for 5 s (MMP5s) is reported. Peak power output for 1 s may also be of interest. MMP for each effort should be reported in W and $W.kg^{-1}$.
- Report VO_{2peak} produced during the 4 and 10 min effort in $L.min^{-1}$ and $ml.kg^{-1}.min^{1}$.
- Providing the cyclist produces a well-paced, maximal effort during the 4 min piece, the VO_{2peak} obtained during the effort provides a valid estimate of VO_{2max} (Gore et al. 1998).
- Peak heart rate obtained during the 4 or 10 min effort and / or the MMP_{4min} can be used to determine training zones based on a five-zone model.
- The time-power relationship can be plotted and used to monitor changes over time, or compare characteristics between athletes (see figure 3 below). Typically, sprinters will display higher values over the shorter efforts, with a steep decline in the curve as the duration of effort increases. Time trial specialists and hill climbers may exhibit flatter curves with minimal drop off in the tail of the curve.
- If the cyclist has access to a mobile power measuring device, it is possible to relate testing performance to in-field race performance. An appreciation for measurement error associated with different power measuring devices is important here (Gardner et. al. 2004; Paton and Hopkins 2001). In addition, it is unlikely that a maximal effort for each duration assessed during the power profile test will be produced during a single race, thus analysis over series of races may be more appropriate (Quod et. al. 2010)

Power-Duration Curve

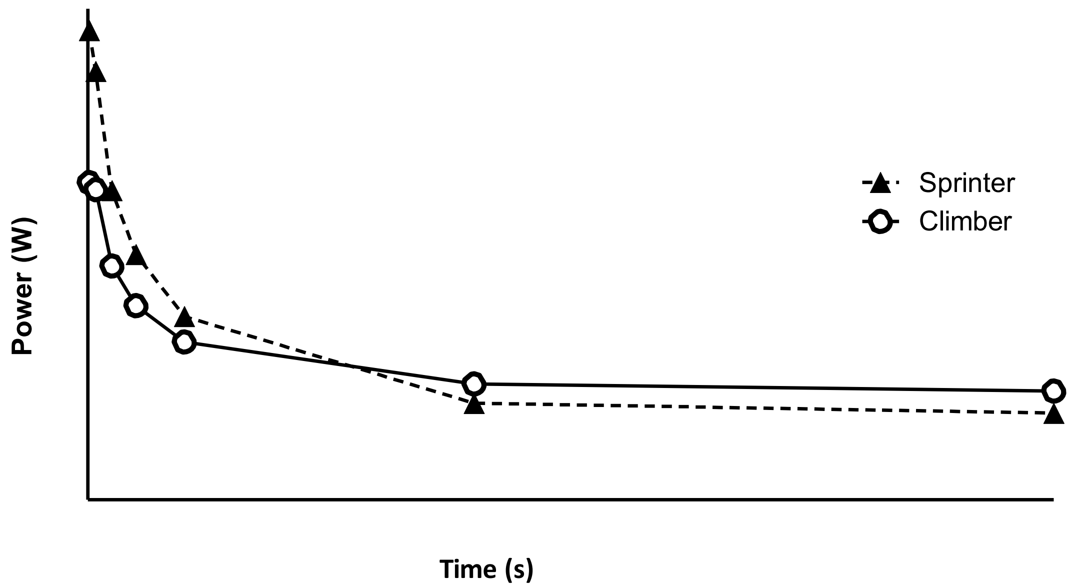


Figure 3: Examples of Time – Power relationship in two cyclists displaying different characteristics

Limitations

A familiarization trial on the test ergometer is recommended. Aspects of the test require an element of pacing and cyclists may perform better on a second attempt at the test. In addition, gear selection can have a limiting role on the power output produced. The average cadence of the effort may provide insight as to whether the gear selection was appropriate. Finally, some cyclists may find that they produce lower power outputs during the shorter efforts compared to the field due to an inability to 'move the bike' laterally in a laboratory setting (Quod et. al. 2010).

Normative data

Normative data collected on male and female cyclists of different disciplines are presented in the table below.

Power Profile data for female and male high performance cyclists (mean ± SD; range)

	Senior Female Road (n=8)	Junior Female (n=4)	U23 Male Track Endurance (n=6)	U23 Male Road (n=9)
Body Mass (kg)	63.6 ± 8.5 (50.2-76.3)	58.1 ± 1.9 (56.1-60.6)	76.4 ± 3.0 (72.4-80.2	72.6 ± 6.7 (64.1-81.9)
MMP 5s (W)	877 ± 191.7 (659-1222)	788 ± 63.4 (715-858)	1126 ± 128.8 (984-1330)	1062 ± 103.1 (864-1175)
MMP 15s (W)	680 ± 128.6 (516-875)	664 ± 59.4 (576-705)	910 ± 53.8 (846-994)	836 ± 94.1 (677-945)
MMP 30s (W)	526 ± 77.9 (438-658)	518 ± 59.7 (436-577)	739 ± 94.5 (644-905)	671 ± 73.0 (560-776)
MMP 60s (W)	415 ± 54.6 (356-523)	368 ± 31.0 (334-398)	571 ± 47.8 (528-647)	536 ± 72.2 (427-651)
MMP 4min (W)	302 ± 41.8 (243-361)	265 ± 5.3 (259-271)	423 ± 59.0 (376-523)	403 ± 64.5 (345-517)
MMP 10min (W)	264 ± 29.6 (228-318)	239 ± 9.4 (228-249)	365 ± 45.6 (330-441)	354 ± 38.8 (314-433)
MMP 5s ($W.kg^{-1}$)	13.7 ± 1.8 (10.6-16.0)	13.6 ± 0.9 (12.5-14.7)	14.7 ± 1.3 (13.6-17.2)	14.6 ± 0.8 (13.2-15.9)
MMP 15s ($W.kg^{-1}$)	10.7 ± 1.0 (8.7-11.9)	11.4 ± 1.0 (10.1-12.4)	11.9 ± 0.5 (11.3-12.8)	11.5 ± 0.6 (10.3-12.6)
MMP 30s ($W.kg^{-1}$)	8.3 ± 0.6 (7.6-9.3)	8.9 ± 0.9 (7.6-9.5)	9.6 ± 0.9 (8.8-11.3)	9.2 ± 0.6 (8.3-9.9)
MMP 60s ($W.kg^{-1}$)	6.6 ± 0.5 (5.7-7.1)	6.3 ± 0.6 (5.8-7.1)	7.5 ± 0.6 (6.6-8.2)	7.4 ± 0.7 (6.1-8.2)
MMP 4min ($W.kg^{-1}$)	4.8 ± 0.5 (3.6-5.4)	4.6 ± 0.2 (4.3-4.7)	5.6 ± 0.7 (5.1-6.6)	5.5 ± 0.4 (4.9-6.3)
MMP 10min ($W.kg^{-1}$)	4.2 ± 0.4 (3.4-4.8)	4.1 ± 0.3 (3.8-4.4)	4.8 ± 0.5 (4.3-5.6)	4.9 ± 0.2 (4.5-5.3)
VO_2peak ($L.min^{-1}$) 4min	3.98 ± 0.44 (3.57-4.60)	3.46 ± 0.14 (3.35-3.66)	n/a	5.05 ± 0.39 (4.46-5.74)
VO_2peak ($ml.kg.min^{-1}$) 4min	63.0 ± 5.2 (52.9-71.1)	59.7 ± 3.2 (56.3-64.0)	n/a	70.31 ± 4.11 (65.9-76.7)
VO_2peak ($L.min^{-1}$) 10min	3.82 ± 0.40 (4.60-3.28)	n/a	n/a	4.90 ± 0.38 (4.48-5.63)
VO_2peak ($ml.kg.min^{-1}$) 10min	60.4 ± 3.8 (53.4-65.3)	n/a	n/a	68.33 ± 4.79 (62.0-76.9)
Typical Error: Power Output: MMP5s = 22 W, 2.0%; MMP15s = 9 W, 1.6%; MMP30s = 18 W, 2.4%; MMP1min = 15 W, 2.4%; MMP4min = 6 W, 2.7%; MMP10min = 7 W, 2.8%; VO_2peak = 0.04 $L.min^{-1}$, 1.2%				
Source: Senior Female (Jan 2010), Junior female (July, 2008), U23 Road (Feb 2007) Track Endurance (April 2010)				

6 second Sprint

Test Purpose

The purpose of this test is to get an indication of peak muscle power, for endurance and sprint riders. The data reported from this test should ideally be the peak power from one crank revolution, but if the ergometer running the test does not have the 'torque' option, a 0.10 second or 0.5 second power directly from the power meter file is acceptable.

Test Protocol

Two trials should be done, with at least 2 minutes of active recovery between them. They should be done after the warm-up, and before any other tests (after another 10 minutes of active recovery, minimum).

- Explain to the rider that they will be **accelerating as fast and as hard as they can from a seated position**. They should start in their strongest position on the bike. All riders should perform the test in a gear that allows them to reach their peak cadence in the first 2 or 3 seconds, so that they rev out well before the end of the test. The gear can be changed after the first trial, simply record the change on the data sheet.
- Record the effort with the power meter, and directly on a connected computer if there is one.
- Ask the rider to stop pedaling, and allow the flywheel to stop completely.
- Tell the rider when to start the effort (count down from 5), and when to stop (6 seconds later).
- Allow the rider 2 minutes of active recovery, and then repeat the test. Report the better of the two tests. If the two tests are more than 20W different, consider doing a third test.

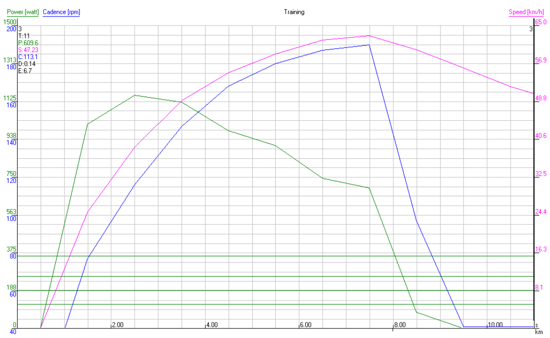
Data collection

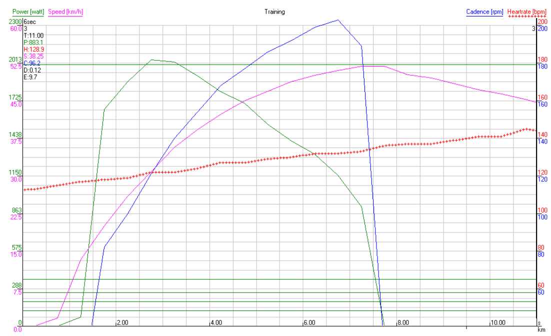
- Record age, height and body mass prior to the test.
- Record power output and cadence data throughout the test

Data Analysis and practical application

- Maximum power for the smallest sampling rate possible should be reported (i.e. 1 revolution, or 0.1/0.5/1 second if that is the fastest rate achievable with the equipment you are using)
- Report peak power, peak cadence, and peak power to weight ratio

In the example files below, the file on the left shows a typical endurance rider while the file on the right shows a sprinter. You can see that they both rev out after a couple of seconds, and that the sprinter's power curve and cadence curve are both steeper than an endurance rider. The art of this test is helping the athlete select a gear that will allow them to hit their peak power and cadence in the first 1-3 seconds, with enough resistance to show their true capabilities.





Limitations

A familiarization trial is recommended. Cyclists should be strongly encouraged to produce a maximal effort throughout the test, and not to hold back at the start. No feedback about time remaining during the test should be given, to prevent pacing as much as possible. Cyclists may perform better on a second attempt at the test. In addition, gear selection can have a limiting role on the power output produced. The average cadence of the effort may provide insight as to whether the gear selection was appropriate.

Normative data

Normative data collected on male and female cyclists of different disciplines will be presented when we have a large enough dataset.

4 Minute Mean Maximal Power Test

Test Purpose

This is listed here as a stand-alone test for use as part of Cycling Canada's Talent ID protocol. 4 minutes was chosen because it ensures continuity with the test protocols that are used once athletes move into a talent development program and beyond, where they will start to use the AIS Power Profile protocol. It is an important indicator of an athlete's maximal aerobic power.

This test can be conducted on any bike with a power meter, especially in the context of Talent ID initiatives. If lab equipment is available, an SRM ergometer would be the best choice, although any bike ergometer or trainer can work as long as there is a calibrated power meter measuring the effort.

Test Protocol

Time (min:sec)	Effort	Power Output	Cadence	Heart Rate	Notes
0:00 – 10:00	Warm-up				Self-selected. Should match typical race warm-up
10:00 - 15:00	Rest				

15:00 – 17:55	Unloaded pedaling	*	*	*	At rider's preferred cadence
17:55 – 18:00	Increase cadence to 100 rpm	*	*	*	Preparation for start of effort
18:00 – 22:00	Self-Paced 4-minute effort	*	*	*	Strong verbal encouragement given
22:00 – 27:00	Active recovery			*	50 – 100 W

Data collection

- Record age, height and body mass prior to the test.
- Record power output and cadence data throughout the test using a sampling rate of 1s or less.
- Record heart rate throughout the test using a minimum sampling rate of 5s. In addition, the heart rate during the active recovery portion of the test should be recorded.

Data Analysis and practical application

- Average power and cadence are determined using commercially available software (e.g. SRM training software, Golden Cheetah, or Training peaks WKO+ (PeaksWare, USA)).
- Report 4-minute mean power as well as peak 1-minute power (to indicate the evenness of the pacing strategy used by the athlete).
- Report Peak heart rate obtained during the 4-minute effort.

Limitations

A familiarization trial is recommended, although it is recognized that this may not be possible in a Talent ID context. Cyclists should be strongly encouraged to produce a maximal effort throughout the test. No feedback about time remaining during the test should be given, to prevent pacing as much as possible. In addition, gear selection can have a limiting role on the power output produced. The average cadence of the effort may provide insight as to whether the gear selection was appropriate.

Normative data

Please refer to table from the AIS Power Profile section.

Repeated Sprint Ability (6 x 3 seconds)

* modified from Cycling Australia's "National Cycling Protocols (NP_Cycling_v2.0_2011)"

Originally developed by the AIS for their BMX riders, this test may be relevant to other types of cyclists as well, as the ability to produce power over multiple sprint efforts is common to many cycling events.

Test Procedure

- The test is performed on a calibrated cycle ergometer. The gear ratio should be consistent for all athletes and tests. Depending on the ergometer used, and the event the rider participates in, the selected gearing should approximate the cadences achieved during racing conditions. When using an air-braked ergometer with a lightweight flywheel, a slightly heavier gear is recommended which would slightly underestimate the peak cadences, hence the work-to-rest ration must be greater than that observed in racing conditions. The 19-tooth sprocket is recommended (e.g. 48/14/40/19) for BMX riders.
- The test consists of 6 x 3 s maximal sprints on a 30 s cycle (i.e. 27 s of recovery between each 3 s maximal effort). The test begins from a standing start. The recovery periods are undertaken at a cadence of ~80 rpm and ~80-100W depending on the ergometer and gearing, with the cyclist remaining in the saddle for the full length of the test. The test is completed in exactly 153 s.

Data Collection

- Record age, height, and body mass prior to the start of the test.
- Record power output and cadence continuously at a sampling rate of 5Hz (1 sample/0.2s).

Data Analysis and Practical Application

- Peak power for each 3 s sprint should be reported in W and $W.kg^{-1}$.
- The decrement in peak power over the 6 efforts is reported in absolute terms (W) and in percent (%).
- The test protocol can also be utilized as an actual training session as it provides instantaneous feedback regarding progress.

Normative Data

Normative data from male and female BMX cyclists are presented in the table below.

Peak power and 6 x 3 s Sprint test results for high performance female and male BMX cyclists (mean ± SD; range)

	Senior Female (n=4)	Junior Female (n=4)	Senior Male (n=9)	Junior Male (n=4)
Body Mass (kg)	70.2 ±2.9 (67.4-74.3)	68.9 ±7.2 (60.5-78.2)	84.4 ±6.7 (71.0-93.0)	85.1 ±2.8 (81.4-87.6)
Peak Power ^ (W)	1239 ±67.5 (1188-1338)	1161 ±143.3 (1005-1346)	1993 ±142.6 (1790-2158)	1721 ±45.4 (1679-1783)
Peak Power ^ ($W.kg^{-1}$)	17.5 ±1.2 (16.2-18.8)	16.8 ±0.4 (16.8-17.2)	23.7 ±1.9 (19.8-25.5)	20.2 ±1.1 (19.2-21.2)
Peak Power * (W)	1198 ±71.4 (1157-1305)	1090 ±102.8 (971-1215)	1876 ±120.9 (1700-2029)	1579 ±45.7 (1537-1638)
Peak Power * ($W.kg^{-1}$)	16.9 ±1.1 (15.7-18.3)	15.8 ±0.3 (15.5-16.2)	22.4 ±2.0 (918.8-24.6)	18.6 ±1.0 (17.6-19.5)
Sprint 1 Power (W)	1219 ±63.3 (1170-1311)	1141 ±127.1 (991-1277)	2000 ±99.0 (1837-2092)	1700 ±45.3 (1658-1750)
Sprint 2 Power (W)	1118 ±53.6 (1077-1197)	1063 ±144.5 (868-1217)	1880 ±132.0 (1727-2005)	1574 ±39.0 (1520-1613)
Sprint 3 Power (W)	1018 ±54.3 (946-1042)	1026 ±126.8 (853-1154)	1807 ±134.0 (1646-1907)	1513 ±35.7 (1483-1565)
Sprint 4 Power (W)	958 ±66.9 (908-1055)	1020 ±116.1 (867-1136)	1773 ±114.0 (1628-1887)	1484 ±56.0 (1426-1556)
Sprint 5 Power (W)	963 ±82.6 (904-1085)	1003 ±141.0 (821-1154)	1749 ±110.0 (1633-1863)	1472 ±55.8 (1413-1544)
Sprint 6 Power (W)	975 ±57.0 (919-1041)	1001 ±127.4 (826-1121)	1727 ±89.0 (1598-1822)	1448 ±56.3 (1410-1531)
Decrement (Sprint 1-6) %	19.9 ±7.0 (14.0-28.6)	12.4 ±3.3 (8.5-16.6)	13.7 ±1.4 (12.1-15.8)	14.7 ±4.9 (7.7-18.1)
Drop Off (max-min) (W)	276 ±98.1 (169-407)	146 ±26.2 (109-170)	284 ±27.0 (239-310)	254 ±89.5 (127-324)
^ - Chain Rings: 48; 14; 40; 19 * - Chain Rings 48; 14; 40; 21				
Typical Error: Peak Power = 18.2 W, 1.1% (^), 21.5 W, 1.3% (*); 0.23 $W.kg^{-1}$, 1.1% (^),0.26 $W.kg^{-1}$, 1.3% (*); % Decrement = 2.0%; Drop Off = 26.6 W, 23.4%				
Source: July 2009,2010				

Anaerobic Threshold: Maximum Lactate Steady State

Test Purpose

Performance in cycling events lasting between 30 and 60 minutes can be directly predicted by the absolute power output associated with anaerobic threshold (AnT) (Billat 1996). Endurance performance potential in other events is also related to AnT power (Faria et al. 2005). The definition of AnT is as follows:

> "An intensity of exercise, involving a large muscle mass, above which measurement of oxygen uptake cannot account for all of the required energy. Stated in other terms, this is the exercise intensity above which there is a net contribution of energy associated with lactate accumulation" (Svedahl & MacIntosh, 2003).

AnT can therefore be described as a power output where the rates of production and disappearance of blood lactate are equal. This power output is also referred to as the Maximal Lactate Steady State workload (MLSSw). In contrast to the power output at MLSS, the blood lactate concentration at MLSS is not related to performance (Billat 2003). Within a group of athletes, the *average* concentration at MLSS is about 4mmol/L, but it can range between 2 and 7mmol/L depending on the individual (Billat 2003). As a consequence, it is of little interest in the present context.

AnT can be defined in a number of ways, with a number of test protocols. The MLSS protocol outlined here is designed to identify AnT with maximal precision. Unpublished experimental evidence suggests that AnT can be measured to within less than 10W. The test is designed to complement the MMP curve data by providing a physiological context for the mean maximal power data. For example, it is typical to have individual differences in the relationship between CP (or FTP) and MLSSw. An individual with a large difference between MLSSw and CP may not have as much capacity to lift their pace in the final key moments of a race. For such a rider, long sustained efforts require a gradual accumulation of lactate and other metabolites, meaning that they are becoming less efficient and will have less anaerobic reserve to draw upon if the pace increases. Furthermore, the MLSS protocol is essentially independent of motivation levels, which is an important factor to consider when interpreting MMP data.

Test procedure

This assessment consists of two 25-minute tests. Test 1 is ideally high enough above MLSS that you see a rise of more than 1mmol/L from 10-25 minutes. That way, the wattage for test 2 can be tailored based on the results of the first one. Using FTP as the first workload (or 95% of 20min mean max power), or 95% of Critical Power calculated from the mean maximal power curve is often a good starting point if you have confidence in the mean maximal power data for an athlete.

The two tests should be separated by at least 3 hours (ideally 24), and the two test workloads by at least 10W. If the workload is a bit too high, but the athlete can complete at least 20 minutes, the data from the test can still be used.

Along with the AIS Power Profile protocol, this test is an excellent candidate for biomechanical analysis of the pedal stroke if the requisite equipment is available. High-frequency torque measurement is of primary interest here, to assess where in the pedal stroke torque is being applied. New power meters which report pedal metrics such as "Torque Effectiveness" and "Pedal Smoothness" (e.g. Garmin Vector, Factor, etc.) can make this type of analysis more accessible. Analysis of raw torque data should provide these same metrics (Google Search "torque effectiveness calculation" to find resources on how to calculate these metrics if you are processing raw torque data).

Test protocol

- Record age, height, and body mass as normal
- The athlete should warm-up on the testing ergometer if possible to ensure that the bike geometry matches their race bike as closely as possible (road bike, not time trial). Warm up should match the athlete's typical 'light' race warm-up.
    - Typically, this includes a 10-minute progressive build to anaerobic threshold, and one or two 30 second efforts around MAP, followed by 5 minutes of easy pedaling and possibly a bathroom break before starting the test.
    - Please provide a fan for the athlete during the warm up and the test.
- Perform a zero-offset calibration on the power meter and any other necessary calibrations, if not already completed.
- Perform the first 25-minute MLSS test at the pre-selected constant power output.
    - Ramping up to the desired workload should be done without abruptly increasing the workload so as to avoid undue muscular fatigue at the start of the test.
    - Cadence is self-selected, and no feedback is provided to the athletes unless they're pedaling at extremely low revs (e.g. 60) or extremely high revs (eg. 110).
    - Lactates should be collected every 5 minutes, and power and HR measured continuously.
    - Assuming the selected power is right, the rider should get through the full 25 minutes.
    - If the lactate is at 2 mmol after 5 minutes, have the athlete pedal easy for 5 minutes to clear the lactate, and try again 10-20 watts higher depending on how much you and the athlete agree that the power was under by.
    - If the power is way too high, there are two options: 1) abort the test as early as possible, or 2) try to motivate the athlete to complete at least 15 minutes and collect a lactate sample as the athlete stops pedaling if it doesn't fall on a 5-minute interval. If the test is aborted early, providing a 15-minute break including a short time off the bike is advisable.

Data Collection

Time (hr:min:sec)	Effort	Power Output	Lactate	Heart Rate	Notes
0:0:00 – 0:15:00	Warm-up				Self-selected. Choose gear for test.
0:15:00 – 0:20:00	Rest				
0:20:00 – 0:45:00	Constant load MLSS test	*	* every 5 minutes	*	At pre-agreed workload

0:45:00 – 3:45:00	Rest (3-24 hrs)				Analyze data, determine workload for 2nd effort
3:45:00 – 4:00:00	Repeat warm-up				
4:00:00 – 4:05:00	Rest				
4:05:00 – 4:30:00	2nd constant load MLSS test	*	* every 5 minutes	*	At pre-agreed workload

Data Analysis and practical application

If you wish to use this test protocol, then a spreadsheet is available upon request from Cycling Canada to enable easy calculations. The data analysis procedure involves the calculation of the lactate kinetics (i.e. the rate of change in lactate over time) for each constant load ride. Briefly, the calculation uses the linear slopes of the rising lactate concentrations over time and their associated power outputs from the two rides, to extrapolate to the power output that should elicit a maximal lactate concentration that doesn't change over time.

Once the MLSS power output is identified, it can be correlated with the data from the mean maximal power profile of a rider. More importantly, this test is designed to be used at appropriate times during the year along with the power profile assessments. That way, coaches can evaluate the effects of their training programs more precisely.

Limitations

This test protocol often requires a second visit to the lab in order to test athletes at a similar time of day. This can sometimes be logistically difficult, but portable lactate analyzers and bike ergometers (e.g. the athlete's own bike with a power meter) mean that geographical constraints can be overcome much more easily than tests requiring more specialized and expensive lab equipment.

Normative Data

To be included when the sample size is large enough

Aerobic Threshold

Test Purpose

This test is designed for athletes and coaches who wish to further refine training zones beyond that which is possible from power profiling and MLSS testing. Having a clear understanding of the power output that elicits the first increase in lactate above resting values is important for guiding the training done at low intensities. Endurance athletes train at low intensities so extensively, that ensuring it is done at the correct intensity means that time spent in that zone is maximally effective.

Test Procedure

This test is entirely submaximal, and looks like the first part of a standard incremental test. Riders are asked to begin riding at a very low intensity, from which the power is increased every three minutes until a lactate of no higher than 6mmol/L is achieved. The starting workloads and incremental loads should be proportional to rider level and size. For example, a young female rider may need to start at 100W and increase by 25W every three minutes, whereas an established male endurance rider would start at 180-200W and increase by 30W every three minutes.

Test Protocol

- Refer to the test protocol for the MLSS test for initial setup instructions.
- Following initial setup of the equipment and the athlete's warm-up the athlete will ride at the defined initial workload for 3 minutes
- The lactate sample is taken at the end of the 3 minutes with the rider pedaling continuously. No pauses in the protocol are required in order to take the lactate sample.

Data Collection

- Record age, height and body mass prior to the test.
- Record power output and cadence data throughout the test using a minimum sampling rate of 1Hz (1 sample/s).
- Record heart rate throughout the test using a minimum sampling rate of 0.2Hz (1 sample/5s).

Data Analysis and Practical Application

- The Aerobic Threshold is defined as the last workload before an increase in lactate is observed above resting levels.

Limitations

The limitation of this test is similar to that of the MLSS protocol above. That is, additional testing may be logistically challenging to accommodate in an athlete's schedule. As with any test, a cost/benefit analysis will have to be established for each athlete before adding it to the list of protocols an athlete will undergo.

Normative Data

To be included when the sample size is large enough

Power – Pedaling rate relationship

The "inertial load" test is to be added in the next draft. If you are interested in running this, please see the relevant Cycling Canada Physiologist for your team.

Coefficient of Aerodynamic Drag x Frontal Surface Area (CdA)

This test is available through the Track Endurance Physiologist. For more details, please contact them.

Test Purpose

Aerodynamic drag is the dominant drag force for most cycling disciplines. As such, CdA is one of the most important variables that can explain the relationship between power output and the speed achieved on the bike. Simply measuring an athlete's CdA without seeking to optimize it can still be extremely valuable because it can explain the power output requirements an athlete has to meet in order to perform. In other words, an athlete might improve their performance by increasing their power output, or they might simply need to become more aerodynamic. If an athlete is already aerodynamically optimized, then their pathway to the podium can be assessed based mostly on increases in power output.

It is important for race performance that we identify an aerodynamic bike position for each rider that gives them the best balance between aerodynamics and their ability to produce power. This can be done one the Velodrome with tools from Cycling Canada and Alphamantis.

In addition to identifying an excellent bike position, this session can also produce the measures needed for us to help optimize pacing through software models that we have developed.

Draft Ratio (Team Pursuit, Team Sprint, Team Time Trial)

This test is available through the Track Physiologist. For more details, please contact them.

VO2$_{max}$, VO2 kinetics and Cycling Efficiency

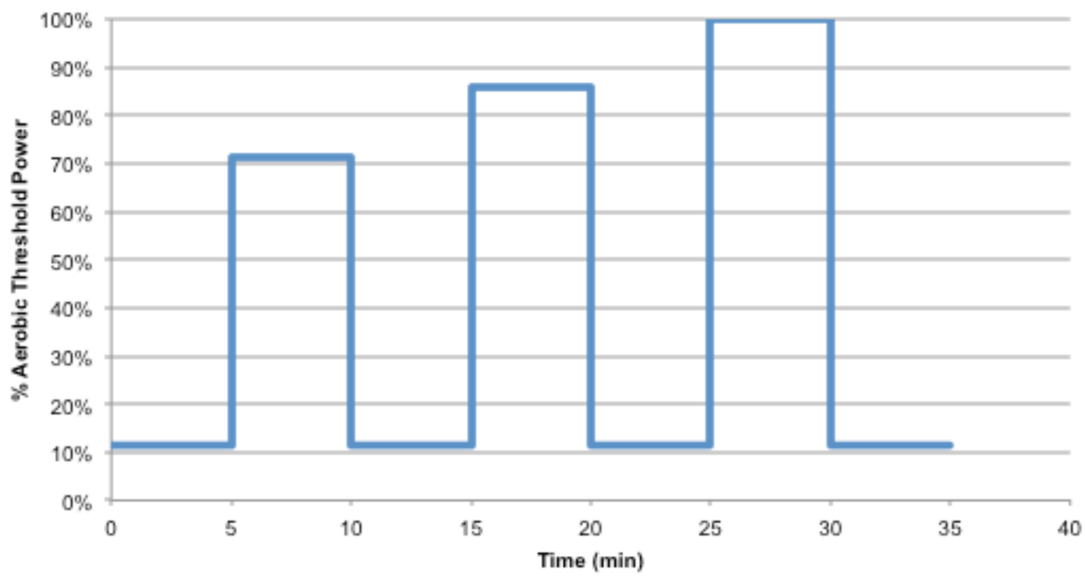
In addition to MLSS, variables such as VO_{2max} and cycling efficiency can help explain the power profile of an athlete. Furthermore, an excellent review by Burnley & Jones (2007) showed that the kinetics of oxygen uptake is fundamentally related to these other well-established performance determinants.

Test Purpose

Very few cycling events (if any) are truly steady-state in nature, and thus having an understanding of how quickly an individual's aerobic system can respond to changing demands is fundamental to understanding their performance. This test is submaximal in nature, and should not add significantly to the training load an athlete is experiencing at any given point.

Test Procedure

Assuming VO2max was measured during the 4- and 10-minute portions of the AIS power profile, athletes simply need to complete a series of three 5-minute on/off transitions to various power outputs up to and including the Aerobic Threshold. During the "off" phases, athletes should pedal at a light 20-30 watts. An example protocol is shown below, based on percentage of power at Aerobic threshold:



The average VO2 in the last 2 minutes of each "on" stage, should give enough information to identify the cycling efficiency (O_2 cost/watt) as well as provide the data for various types of VO2 kinetics modeling.

Data Collection

- Record age, height and body mass prior to the test.
- Record power output and cadence data throughout the test using a minimum sampling rate of 1Hz (1 sample/s).
- Record heart rate throughout the test using a minimum sampling rate of 0.2Hz (1 sample/5s).
- Record oxygen uptake breath-by-breath, with a metabolic cart specifically designed to do so. It is inappropriate to use a metabolic cart with a mixing chamber for this type of analysis.

Data Analysis and Practical Application

- The specific analysis used on this data is still under development. Traditional methods of fitting mono-exponential curves to the smoothed data are appropriate, but newer methods such as those proposed by Stirling (2005) may provide additional insight into individual athlete physiology.
- Consult the physiologist working with your team for additional information on the collection and interpretation of this type of data.

Cardiac Output

Test Purpose

The cardiovascular system is one of the main limiting factors associated with an athlete's VO_{2max}, and increases in VO_{2max} can usually be tied to increases in cardiac output. This test provides strong evidence for the physiological changes occurring due to training. Coaches can use this information to help individualize training, as some athletes may not be able to increase their cardiac output beyond a certain point. In this case, it would be pointless to attempt to continue with training designed to increase cardiac output, whereas training geared toward other physiological limiting factors may be more effective. This test is only run for specific projects by the National Team, and currently can be run at the CSI-Calgary physiology laboratory, according to their protocol.

Hypoxic Ventilatory Response

Test Purpose

When people go up to altitude, their bodies adapt to the lower level of oxygen available in the air by breathing faster - this is called the hypoxic ventilatory response. Because it changes as you adapt to altitude, it is a marker of how someone responds over time to altitude, and therefore to altitude training. In specific cases, National Team Coaches may request this type of test be done in order to monitor individual responses to altitude training camps.

The testing can be done at CSI-Calgary Physiology lab, according to their standard protocol.

Hemoglobin Mass

Test Purpose

Hemoglobin mass testing can be done to determine the effect of altitude training on the body's ability to transport oxygen. This is a test that requires specific equipment, and is likely to be used only for specific projects by riders on the National Team.

This test can be done at the CSI labs in Victoria, Vancouver, Calgary, or CSI-Ontario (when available), according to their standardized protocol.

Rate of Force Development (RFD)

Test Purpose

To assess the athletes ability to explosively overcome inertia and produce force as quickly as possible. Rate of force development is critical for acceleration on the bike, both from a start (zero velocity) and in-race (increasing existing velocity). The test can assess force production in over defined fractions of time between the on-set of force to maximal force, specific to targeted race components.

Test Procedure

The athlete should perform a general warm-up of 5-10 minutes stationary cycling, followed by dynamic movement and stretching. Submaximal trials of the 3 test protocols are recommended to be a part of the warm-up

Testing will include the completion of:

- 5 maximal effort Squat Jumps (no countermovement) at a starting depth of 110 degrees (could be deeper if more specific to a start angle),
- 5 maximal effort Countermovement Jumps at a starting depth of 110 degrees (could be deeper if more specific to a start angle), and
- 5 maximal effort Single Leg Squat Jumps at a starting depth of 90 degrees on each leg.

The jumps are to be completed on force plates capable of bilateral data collection at 1000Hz. The data is saved and exported to a proprietary MatLab script for analysis.

Test Protocol

1. Tare both force plates and ensure force values are showing less than 1N.
2. Athlete steps onto plates with one foot on each of the plates.
3. Athlete establishes comfortable foot position and has hands on hips.
4. Athlete is asked to remain as still as possible for 5s to allow for a steady sample of body weight only force.

5a. SJ: Athlete is instructed to go “down” and hold for 2 seconds (audible countdown by tester: “ONE, TWO, JUMP”). The 2-second count does not start until the athlete is in the testing position and static. Brief the athlete just prior to jumping of the expected movement.

5b. CMJ: Athlete is instructed to “JUMP”. Brief the athlete just prior to jumping of the expected movement.

5c. SL SJ: Athlete is instructed to go “down” and hold for 2 seconds (audible countdown by tester: “ONE, TWO, JUMP”). The 2-second count does not start until the athlete is in the testing position and static. Brief the athlete just prior to jumping of the expected movement.

6. Athlete Jumps maximally as **quickly and high** as possible all while maintaining the hands on the hips.
7. Upon landing, athlete re-establishes a comfortable foot position and remains still for 3 seconds before subsequent jump trial.
8. Complete 5 total Jumps

Data Collection

Open data collection and recording of bilateral force plates set to sample at 1000Hz. Save and export file in .csv format for MatLab analysis.

Data Analysis and Practical Application

The mean data of the 5 trials for each protocol will be analyzed for the following variables (L; Left, R; Right, T; Total).

Squat Jump

- Peak Force (L/R/T)
- Rate of Force Development (any other fractional rates can be discussed)

- Peak Power
- Impulse

Limitations

The protocol is a direct measurement of ground reaction forces produced during very standardized and familiar jumping movement patterns. Only vertical GRF is being analyzed and therefore, poor jumpers who 'leak' excessive forces transversely will exhibit compromised scores. Those who are not skilled jumpers should also be identified through visual assessment for further follow up.

Ensure adequate time between jumps to allow the MatLab script to identify discreet jumps and properly analyze.

Normative Data

Normative data will be established as our testing database grows. There are large pools of data existing on other cohorts of Olympic athletes in Canada for comparison.

Force-Velocity Profile

Test Purpose

The purpose of this test is to characterize the athlete's ability to develop power across a spectrum of external loads. The slope of the relationship between force and velocity will provide insight to the specific areas of performance (high velocity or high force starts) that require improvement through training.

Test Procedure

The force/velocity data will be collected from a concentric only Squat Jump movement from a starting angle of 110 degrees at the knee. The loaded bar should be resting on the safety catches inside of squat rack, or if possible, on the IM Lifter set to a Squat Jump protocol at WinSport or TPASC. Data collection will be done on bilateral force plates (Pasco) and should be tared prior to stepping on. The athletes should create tension in their muscular system just prior (~1s) to jumping to avoid any unnecessary spinal compression upon take off, but not so much as to lift the bar and create momentum. Athletes should be repeatedly reminded to land under full control of the load to avoid injury. The athlete is instructed that this is maximal effort jumping and should come off of the blocks as explosively as possible. The athlete will complete 3 trials of each load. Measured vertical force, calculated vertical velocity, and calculated vertical power should be recorded and the mean of each variable for each load should be used for analysis.

Test Protocol

1. Determine the height the safety rack should be set so that when the athlete is under the squat bar, they are as close to 90 degrees at the knee as possible.
2. Athletes should complete a thorough warm up, which includes some practice reps with moderate load on the bar and a low to medium intensity jumping.
3. Begin recording the force plate data.

4. The athlete should step under the testing bar and onto the force plates, establish a comfortable foot position, and then place a small amount of upward force to engage the neuromuscular system without lifting the bar from the rack.
5. Approximately 1 second after cueing the athlete to put tension in their neuromuscular system, they should maximally and explosively jump upwards.
6. Return to the testing position and repeat 2 more jump trials. 3 total trials should not take more than 60 seconds.
7. Have the athlete rest passively for a minimum of 3 minutes and maximum of 5 minutes before beginning the next test load.
8. Females will test at loads of 20-40-60-80 Kg. Males will test at loads of 40-60-80-100 Kg.

Data Collection

All data will be collected at 1000Hz and exported as a .csv file for analysis.

Data Analysis and Practical Application

Data will be run through a custom MatLab script to extract Peak Force, Peak Velocity, and Peak Power data for each jump. The 3 trials for each load will be averaged, and the value for each of the 3 variables will be plotted. First Force vs. Velocity will be graphed and fitted with a trend line, and secondly the power values will be graphed and fit with a trend line. Regression analysis can be used to determine the athlete's 1RM.

Further inspection of the linear force/velocity relationship may provide insight into the athletes training requirements with respect to needs for enhanced speed or strength work. The power curve will highlight the load at which Peak Power is achieved and can provide more specific training prescription parameters for speed, speed strength, power, starting strength, or maximal strength.

Limitations

This type of profiling has some very applicable qualities to training and performance, but would likely be challenged at cellular level by some muscle physiologist/biomechanists as the force and velocity relationship loses reliability as we move from in vitro to dynamic compound in vivo movements. Safety should be a primary concern, particularly with landing with load. The IM Lifter can alleviate virtually all landing risk, however, compression of the spine when maximally exploding upwards is a reality. Preloading the system should help attenuate the translation of compressive forces to the disks.

The spectrum of loads used can remain highly adaptable for each athlete, as the objective is to establish a high R-value linear relationship for 1RM prediction and a clear peak in the power curve. Overloading an athlete who is developing will yield data that is unusable.

Normative Data

Normative data will be established as our testing database grows. There are large pools of data existing on other cohorts of Olympic athletes in Canada for comparison.

10 Second Low Cadence Test

Test Purpose

This is a strength endurance test that can help measure whether strength gains made to one or two repetition maximums in the gym have transferred onto the bike. It is best done before and after a heavy gym phase, and again after speed work is started on the bike. It is the "bridge" between the 1-second maximum power and the high cadence power that is required for success in sprint events.

Test Procedure

This test consists of two, seated, 10-second efforts. They should be done after the warm-up, a couple of 6-second sprints, and then the 15-second high cadence test.

The only equipment capable of running this test is the SRM ergometer, set up in isokinetic mode at 50rpm, with a very high gear.

The test is started with the isokinetic mode already running and data collection started. The rider is instructed to pedal lightly just at the speed where they can feel the brake starting to provide resistance. They then count themselves down from 5, until they start with their preferred leg in front. They then give a maximum effort for the full 10 seconds with the brake providing resistance at 50rpm.

Data should be collected with the "torque package" from SRM whenever possible, and calculated per pedal revolution. If this is not possible, the shortest possible time period (0.1 or 0.5 seconds) should be used, and the data collection type noted on the results.

Test Protocol

a. Set the ergometer to the highest gear (hardest).
b. Perform a zero-offset check on the power meter.
c. Select the isometric test file (pre-programmed to hold the rider at 50rpm in the gear used for the test) from the Stress Test Determination menu in the SRM Ergometer software, and press start.
d. Allow the athlete to get accustomed to the isokinetic mode at 50rpm by instructing them to pedal gently.
e. After approximately 10 seconds, ask the athlete to count down from 5 as their preferred starting foot passes their preferred starting position. The test begins when they reach 'go'. The athlete should exert as much force as possible against the resistance once the test starts. Count out the last 5 seconds of the effort, and instruct the athlete to stop (after 10 seconds).
f. Repeat the zero offset check.
g. Repeat after 15 minutes of active recovery.
h. Report average power, peak power, and fatigue rate (linear regression). Include the graph in the report.

Data Collection

Time (hr:min:sec)	Effort	Power Output	Torque	Cadence	Notes
0:0:00 – 0:15:00	Warm-up				Self-selected. Choose gear for test.

0:15:00 – 0:16:00	Let flywheel completely stop, provide final				
0:16:00 – 0:17:00	10-second low cadence test from a rolling start	*	* every pedal revolution	* every pedal revolution	Using SRM torque measurement package
0:17:00 – 0:35:00	Active recovery				
0:35:00 – 0:36:00	Repeat 10-second low cadence test	*	* every pedal revolution	* every pedal revolution	Using SRM torque measurement package
0:36:00 – 0:40:00+	Cool down or other tests				

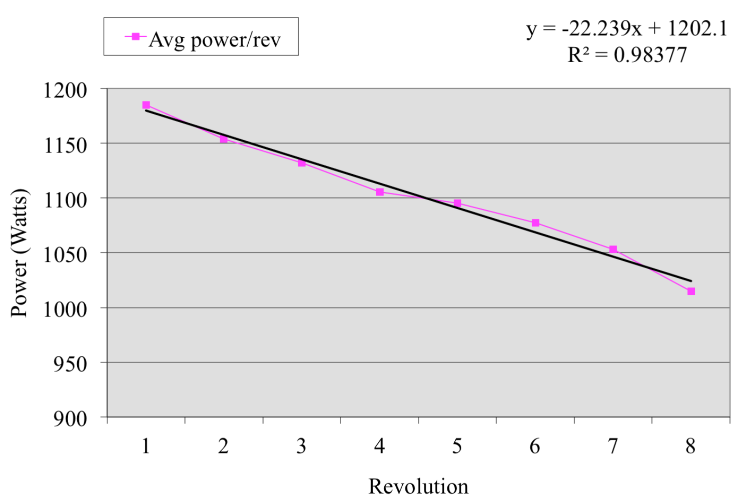
Data Analysis and Practical Application

This assessment looks at how well strength training has transferred to the bike – essentially, it's a strength endurance test. It has a rolling start, and feels a bit like riding through toffee. With the ergometer brake holding the rider at 50rpm for 10 seconds lets us look at how well they can produce strength (and hold it) by pedaling, rather than by doing something like a squat in the gym.

We look at the same kinds of things in this assessment that we do in the 15-second High Cadence assessment:

- The peak power that is hit in an acceleration
- The average power for the whole effort
- How many Watts are lost each revolution (or .5 second), called the "fatigue slope"
- How smooth the effort is (measured by how well the effort fits a line, called an R^2)

In the sample file below, the rider's highest average power for a full revolution was 1185W, and they fatigued down to 1015W by the last revolution. The average power for the test was 1102W, with about 22W lost per revolution (fatigue slope = 22.23). The fit of the data to the line was very good (R2=0.98, meaning 98% of the data is explained by the line), indicating good neuromuscular control. It is likely that this rider was doing a lot of track bike work when they did this test.



Riders tend to do well on this assessment in their first phase back on the bike after doing heavy strength training in the gym. It is likely to drop (lower peak power, lower average power) during the pre-competition and competition phases, when the neurological adaptations kick in and transfer that strength to speed (and when we see an improvement in the 15-second high cadence test).

Limitations

The test feels bizarre, and it can take a few attempts before a rider can produce a consistent effort. The fatigue slope should not be reported or interpreted if there is not a clear slope to the line (i.e. if it looks like an iceberg).

Riders with any injuries should not do this test until recovered, especially injuries aggravated by strength training.

Normative Data

Normative data collected on male and female cyclists of different disciplines will be presented when we have a large enough dataset.

15 second High Cadence Power Endurance Test

Test Purpose

This test is designed to assess the ability of a rider to hold their power at a high cadence, as they do in track sprinting and BMX. It is not meant to mimic any effort that is done in training, and so is not measuring how well a rider has "trained for the test". It gives an indication of how race-ready a rider is.

Why 15 seconds? Why 160rpm? 15 seconds is long enough to get a clear picture, but not so long as to make the rider sick. 160rpm is a bit above what most sprint cyclists race at, so we're not measuring whether or not they've done a specific training session or lots of racing, we're looking at an indicator of their neurological development.

Test Procedure

This is a "seated acceleration from rest", which means it starts just like the 6-second sprint. Once the rider has reached 160rpm, the brake will hold them to that cadence. They then push as hard as they can against that resistance for the rest of the 15 seconds.

Test Protocol

a. Set the ergometer to the lowest (easiest) gear (or second lowest, if chain jumps on the lowest gear)
b. Instruct the rider to stop pedaling, and wait for the flywheel to stop completely.
c. Select the appropriate file for the isokinetic effort at 160rpm from the Stress Test Determination menu in the SRM software.

d. Make sure the torque data collection software is ready to collect data.
e. Start the isokinetic test file, so that the brake will apply resistance as soon as the rider hits 160rpm.
f. Instruct the athlete to start after you count down from 5, and to pedal unpaced for 15 seconds until you instruct them to stop. Count out the last 10 seconds of the effort.
g. Report the average power (15 seconds), peak power (average within revolution), and fatigue slope (via linear regression analysis).

Data Collection

Time (hr:min:sec)	Effort	Power Output	Torque	Cadence	Notes
0:0:00 – 0:15:00	Warm-up				Self-selected. Choose gear for test.
0:15:00 – 0:16:00	Let flywheel completely stop, provide final				
0:16:00 – 0:17:00	15-second seated maximal acceleration from rest and maximal effort at 160rpm	*	* every pedal revolution	* every pedal revolution	Using SRM torque measurement package
0:17:00 – 0:35:00	Active recovery				
0:35:00 – 0:36:00	End of session, or continue with other tests				

Data Analysis and Practical Application

This test gives us lots of valuable information, mostly about how the rider's neurological system is adapted to their training.