CityU Briefing Session for Standard Chartered Hong Kong Marathon 2016-2017

Coach: Wong Tak Shing

About me…

Year	Coaching
1984-1987	Coach (middle & long distance) of Colgate Women Athletics Training Course
1987-now	Teacher-in-charge of Athletics and Cross Country Team at school
1996-1998	Coach (middle & long distance) of HKAAA Athletics Junior Squad
1996-2001	Coach (middle & long distance) of TCAA Summer Athletics Training Course
1997-Feb	Team Manager of Hong Kong Junior Cross Country Team for the 4th Asian Cross Country Championships

About me…

Year	Coaching
1997-2002, 2006-2014	Lecturer of Level 1, 2, and 3 (Sports Psychology) Sports Coaching Courses of the Hong Kong Coaching Committee
2006-2010	Tutor/Coach of Joint Sports Centre* Running Classes
2007-2008	Tutor/Coach of CityU Quali-run for Wellness 2007
2007-now	Tutor/Coach of CityU Standard Chartered Hong Kong Marathon Running Classes
2009-2012	Tutor/Coach of BU Standard Chartered Hong Kong Marathon Running Classes

* Joint Sports Centre – BU, CityU, and PolyU

Reasons for Running

Ng & Lonsdale (2010)

- **Five main reasons** for running:
  1. Physical health
  2. Mental health
  3. Social factors
  4. Achievements
  5. Fun

Reasons for Running

Curtis & McTeer (1981)

- For **most** **marathon** runners,
  - **At the beginning**
    - Physical and mental health
  - **Eventually**
    - Achievements and challenges

Goals for Running

- Just for **health** & **fitness**
- Just to **finish** the race
- To achieve **personal best**
- To obtain **medals**

Singer (1986, p. 31)

- "If you don't know where you're going, it is difficult to select a suitable **means** of getting there."

What is Training?

Klafs & Arnheim (1981)

- Training is a **systematic** process of **repetitive** and **progressive** exercise of work.
- Through systematic training and constant repetition, movements become more **automatic** and require less concentration by the higher nerve centers.
  - As a result, the amount of **energy** expended is **reduced**.

How to Train?

- **What** to train?
  - **Running**, cycling, swimming, weight training
- **How much?**
  - More is better?
  - Practice makes perfect?
- **How hard?**
  - No pain, no gain?

More is Better?

Grand, et al. (1984)

- Mileage↑ ⇒ Performance↑ (**but**, $r^2 = 0.1444$)
- 74% of runners who trained an average of **60 km/week** claimed that they had different degrees of overuse injuries.

Fredericson, et al. (2007)

- Risks of running injuries **significantly increase** when the weekly mileage **exceeds 40 miles (64 km)**.

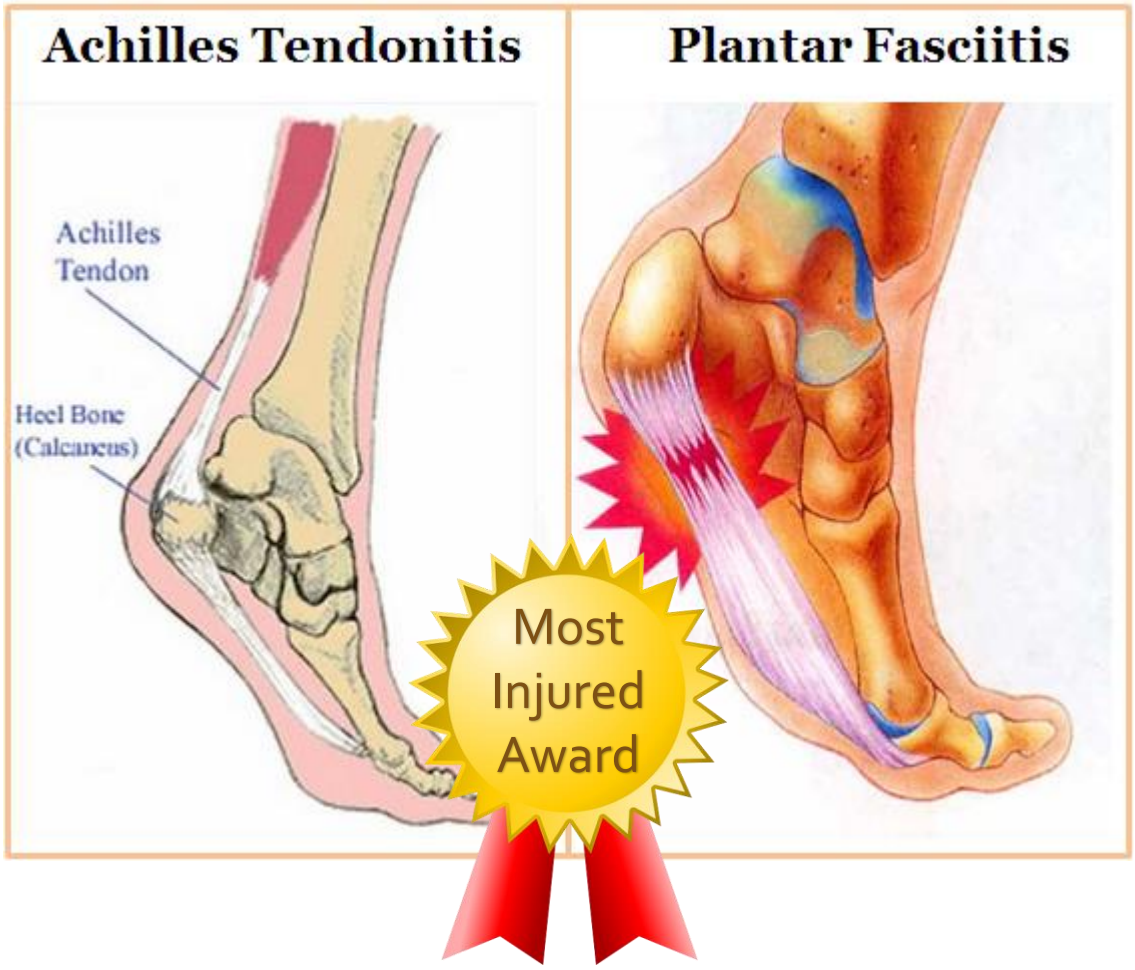
Practice Makes Perfect?

Vernacchia, McGuire & Cook (1992, p. 105)

- "Practice **does not** make perfect; **perfect**, **planned**, **purposeful** practice makes perfect."

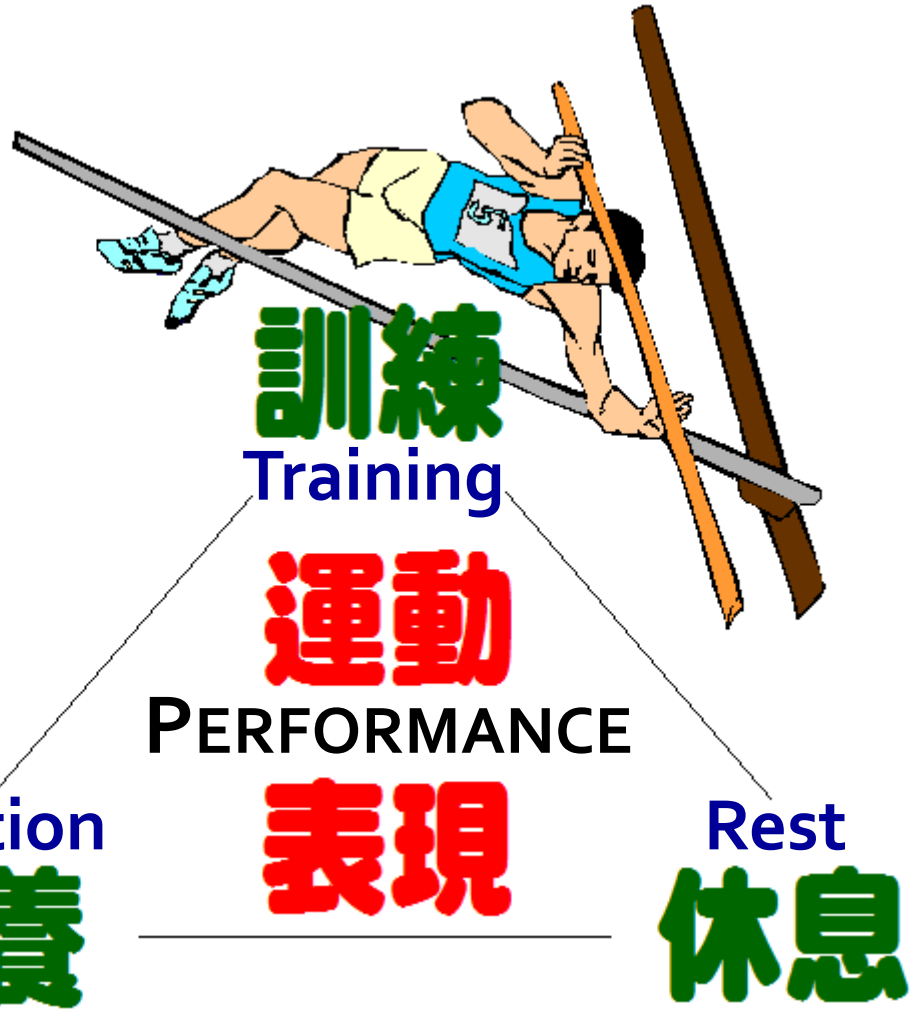
No Pain, No Gain?

No Pain, No Gain?



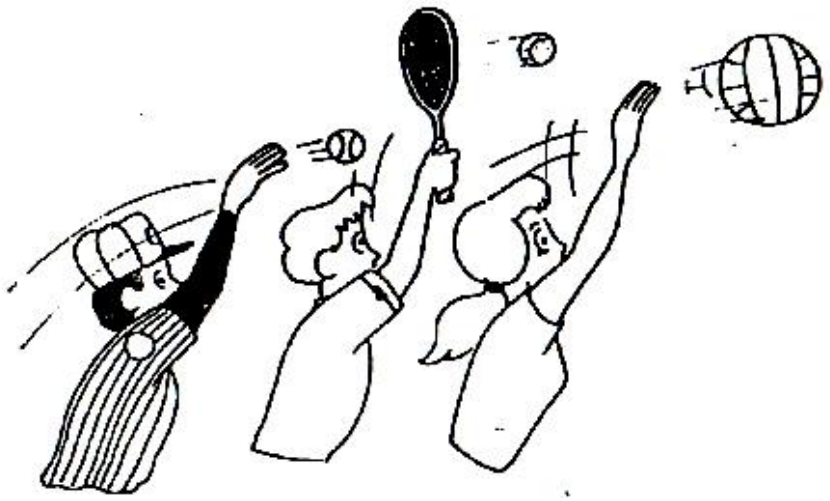
The Scientific Basis of Training

- **Rest** and **nutrition** are too often **neglected**.
- The **longer** the race, the more important is **nutrition**.



The Scientific Basis of Training

- **Sports Psychology**
  - **Psychological skills:** goal setting, arousal management, concentration & relaxation, imagery, building up confidence, …
  - **Cognitive strategies:** association and dissociation
- **Motor Learning**
  - Acquisition of skills
  - Transfer of learning



The Scientific Basis of Training

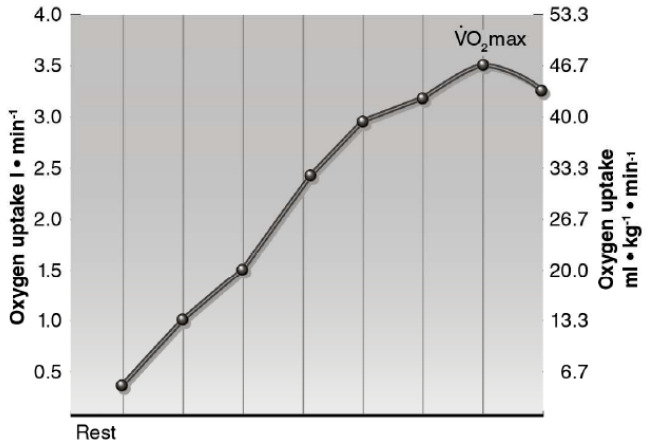
- **Biomechanics**
  - Analysis of **running skills**
  - Running economy
  - Wind resistance & equipment

The Scientific Basis of Training

- **Nutrition**
  - Energy systems of the human body
  - Balanced diet & weight control
  - **Water replacement** and **fuel supply** during training and competition
  - **Pregame meal** & carbohydrate loading

The Scientific Basis of Training

- **Exercise Physiology**
  - **Principles of Training**
  - **Training Methods**



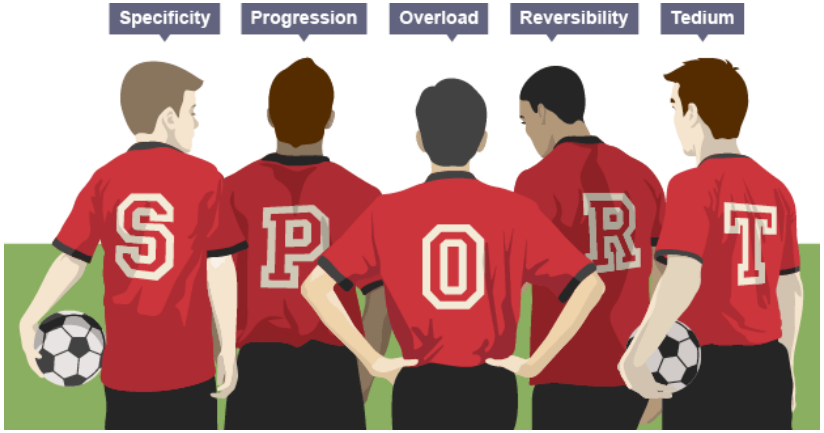
Exercise on the treadmill

Speed km/h	4.8	8.0	11.2	11.2	11.2	11.2	11.2
Treadmill grade, %	0	5.5	7.5	9.5	11.5	13.5	15.5
Time, min	0-2	2-4	4-6	6-8	8-10	10-12	12-14

Wong-Sir's Comments on Running Skills

- **Vertically** aligned head and body.
- Look **forward** and **further away**.
- Arms bent at **90° or smaller** at the elbow.
- **Do not over stride**.
- Use **forefoot** strike or **mid-foot** strike, **avoid heel** strike.
- Land **within 30 cm** in front of the projection of the C.G. on the ground.
- Run in a **steady** and **relax** manner.
- **Do not overemphasis** arms movement.

Principles of Training

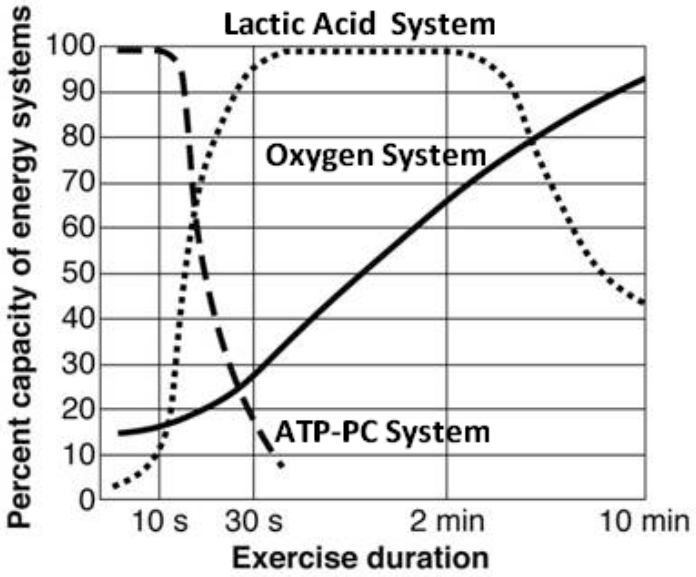


- Principle of Specificity
  1. Energy system
  2. Exercise mode
- Principle of Progressive Overload
- Principle of Hard and Easy Days
- Principle of Periodization

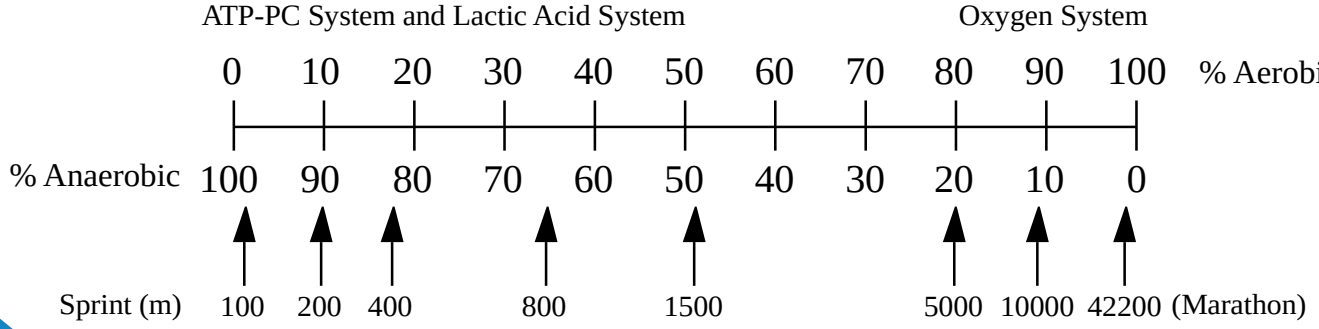
Principle of Specificity

1. Specificity of Energy System

- **ATP-PC system:** Less than 10 s
- **Lactic acid system:** 30 s to 2 min
- **Oxygen system:** Over 3 min



The Energy Continuum for Selected Track Events



Principle of Specificity

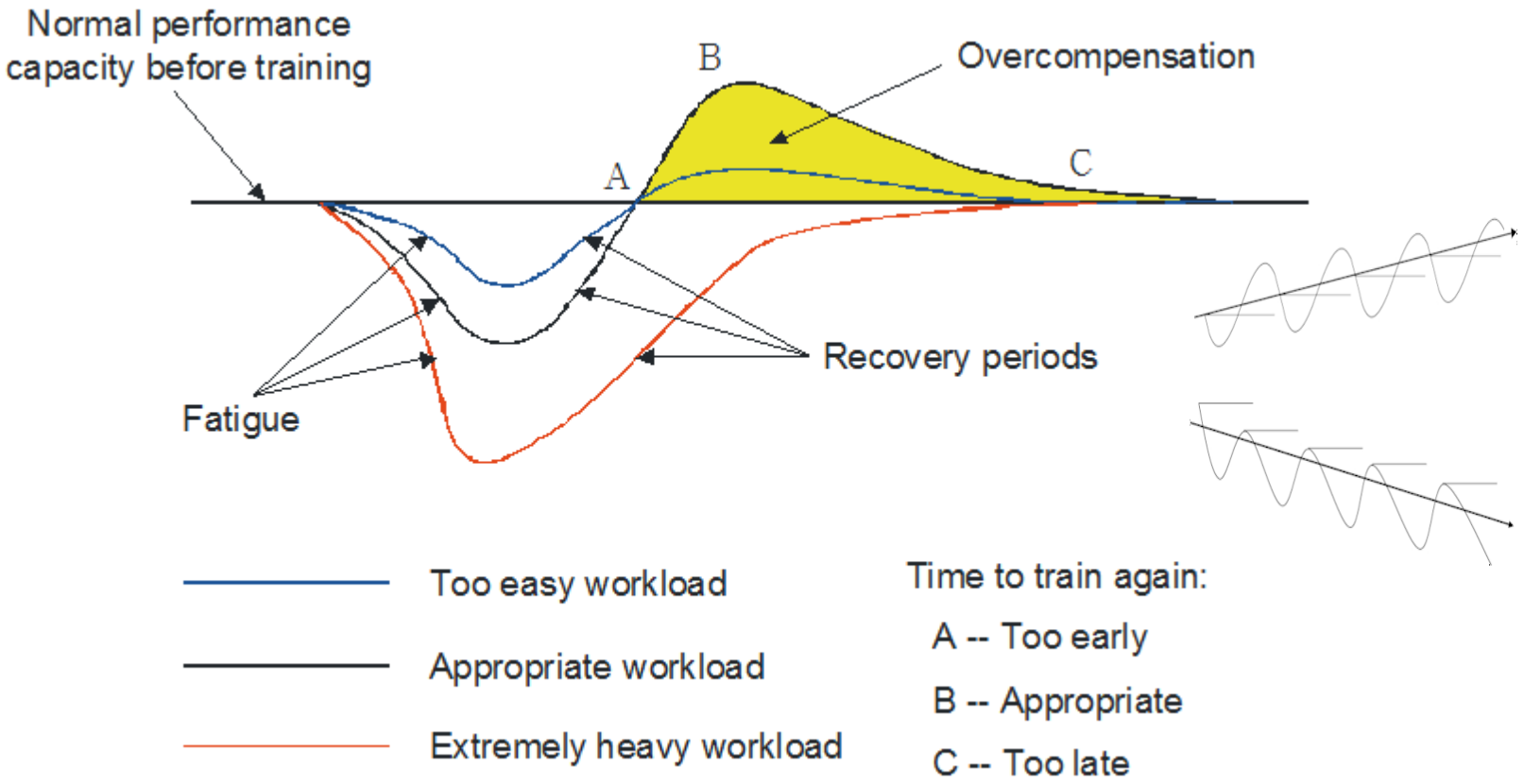
2. Specificity of Exercise Mode

- Cyclists should pedal
- Swimmers should swim
- **Runners should RUN**

Principle of Progressive Overload

- Once the athlete has **adapted** to a workload of the training program, the workload should be **increased**.
- The workload should be increased **progressively throughout** the training program whenever the condition of the athlete has been improved so that the workload is always **near to** the **maximal** fitness capacity of the athlete.

Principle of Progressive Overload



Principle of Hard and Easy Days

Grobler, et al. (2004)

- **Prolonged**, **exhaustive** **endurance** exercise can induce skeletal muscle damage and temporary impairment of muscle function.

Knitter, et al. (2000)

- If the exercise involves a large **eccentric** component, such as downhill running, damage is generally more severe.

Principle of Hard and Easy Days

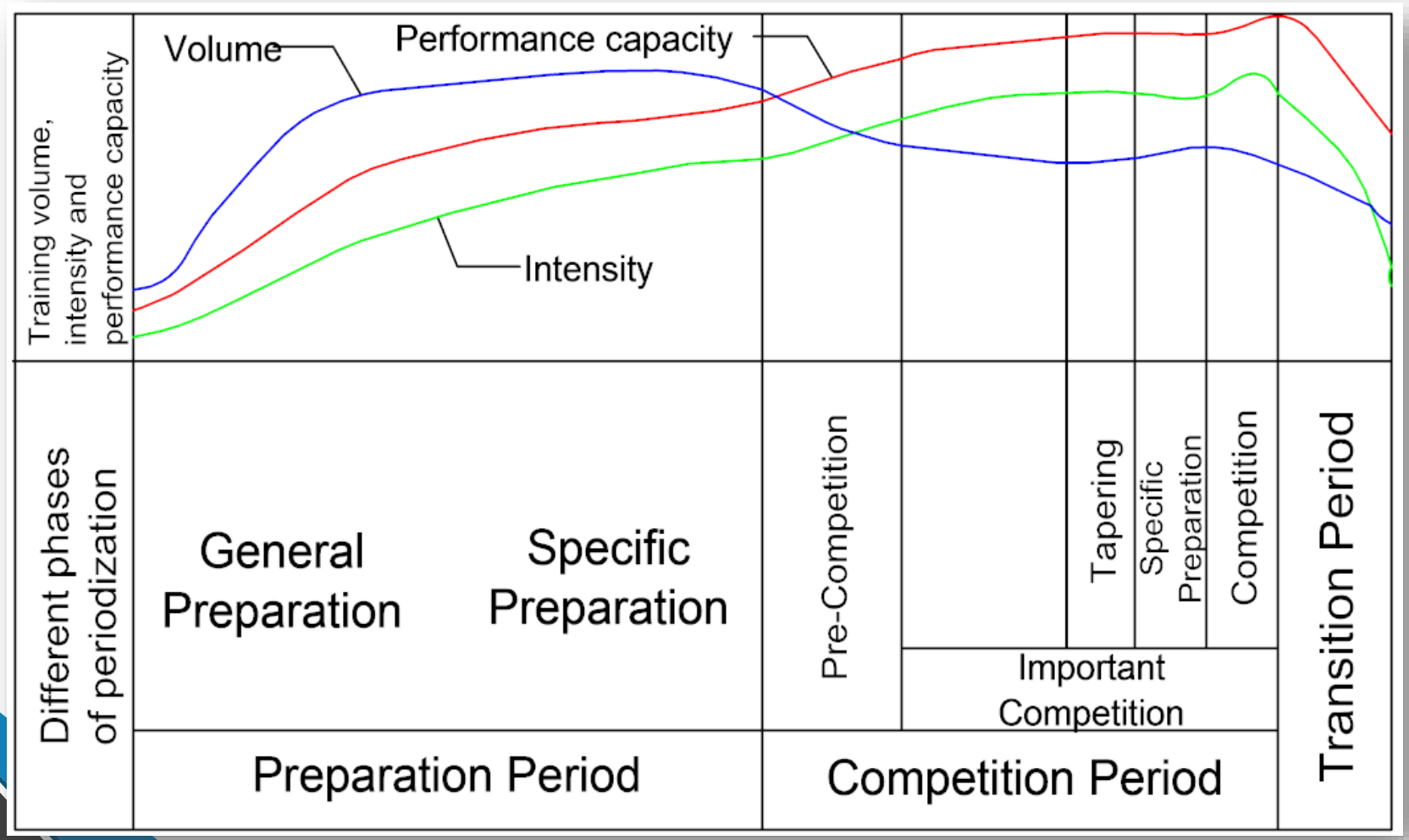
Gómez, et al. (2002)

- It took about **48 hours** to recover from a 10-Km race.

Grobler, et al. (2004)

- Evidence suggested that the repairing process after a 42.2 Km Marathon race might take **1 to 10 weeks** to be completed.

Principle of Periodization



Training Methods

- **Continuous Running Training**
- **Interval Training**
- Fartlek
- Hill running
- Time trial
- …

Continuous Running Training

Fox, Bowers, & Foss (1993)

1. Continuous Slow-Running Training

- Generally, athletes should cover from **2 to 5 times** of their race distance at a pace that can bring their **heart rate** to **80 to 85%** of the **HR_{max}** (i.e., maximal heart rate).
- Use as **foundation training** before moving up to **continuous fast-running training**, or as easy running sessions on **recovery days**.

$$HR_{max} = 220 - age$$

Continuous Running Training

Fox, Bowers, & Foss (1993)

2. Continuous Fast-Running Training

- The intensity of the run should bring the athlete's **heart rate** to **85 to 95%** of the **HR_{max}**.
- **Simulates** the **race situation better** than **continuous slow-running training**.

Interval Running Training

- Refers to a series of **repeated** bouts of **runs alternated** with periods of **recovery**.
  - e.g. 1, 20 x 200 m, 60 s each, jog 1 min between each.
  - e.g. 2, 8 x 1000 m, 5 min each, jog 3-4 min between each.
- The **intensity** or speed of the runs is usually **greater** or **faster** than that can be done **continuously** for the whole training session.
- The recovery periods are usually occupied by light or mild exercise (e.g., walking or jogging) rather than complete rest.
- **Advantage: quantity** of the runs can be increased while **quality** can be maintained.

Interval Running Training

Åstrand et al. (1960)

	Workload	Work	Rest	Total Time	Blood Lactate Concentration	Feeling of Subject
Continuously	350W	-	-	9 min	16.5 mM	Exhausted
Intermittently		3 min	3 min	30 min	13.2 mM	Exhausted
		30 s	30 s	30 min	2.2 mM	Not too tired

Interval Running Training

Christensen et al. (1960)

- Running on a **treadmill** at a speed of **20 km/h** (i.e., **2:06** marathon time)
  - The subject could only run **continuously** for **4 min** (covering a distance of about **1300 m**)
  - The blood lactic acid level at the end of the test was **16.5 mM**.
- When the activity was conducted as alternating periods of 10-s run and 5-s rest
  - the subject completed **20 minutes** of running at **20 Km/hr** in a **30-min** period (covering a distance of **6670 m**) **without** undue fatigue.
  - The blood lactic acid level at the end of the test was only **4.8 mM**.

Interval Running Training

Sharkey (1986)

- Approximately **equal work** and **rest** intervals between **2 to 5 min** seemed to produce the greatest **aerobic** improvements.
- Shorter work intervals (e.g., 15 s) with a **work-rest ratio** of **1:1** are also effective in developing the **aerobic** system.
- For **anaerobic** training, the **maximum** duration for any work interval **should not** exceed **90 s**, or the body might switch to the aerobic system to support the ongoing activity.

Training for Health and Fitness

USDHHS (2008) and WHO (2012)

- **For Health Benefits**
  - **Adults** should do **at least 150 minutes** (2 hours and 30 minutes) a week of **moderate-**intensity, or **75 minutes** (1 hour and 15 minutes) a week of **vigorous-**intensity **aerobic** physical activity, or an **equivalent combination** of **moderate-** and **vigorous-** intensity **aerobic** activity.
  - Aerobic activity should be performed in episodes of **at least 10 minutes**, and preferably, it should be spread throughout the week.

Training for Health and Fitness

USDHHS (2008) and WHO (2012)

- **For Additional and More Extensive Health Benefits**
  - **Adults** should increase their **aerobic** physical activity to **300 minutes** (5 hours) a week of **moderate-**intensity, or **150 minutes** a week of **vigorous-**intensity **aerobic** physical activity, or an **equivalent combination** of **moderate-** and **vigorous-**intensity activity.
  - **Additional** health benefits are gained by engaging in physical activity **beyond** this amount.

Training for Health and Fitness

USDHHS (2008) and WHO (2012)

- **Moderate-intensity**
  - At **3 to 5.9 METs** (i.e., 3 to 5.9 times the intensity of rest).
  - About **5 or 6** on a scale of **0 to 10** relative to an individual's personal capacity, where 0 is the level of effort of sitting, and 10 is maximal effort.
  - **2.5 mph** or **4 km/h** (3 METs) or faster (Ainsworth et al., 2011).

Training for Health and Fitness

USDHHS (2008) and WHO (2012)

- **Vigorous-intensity**
  - **6 METs or above** (i.e., 6 or more times the intensity of rest).
  - About **7 or 8** on a scale of **0 to 10** relative to an individual's personal capacity.
  - **4 mph** or **6.4 km/h** (6 METs) or faster (Ainsworth et al., 2011).
  - 1 minute of vigorous-intensity activity counts the same as 2 minutes of moderate-intensity activity.

Ainsworth, Haskell, & Leon et al. (2011)

The compendium of physical activities（體力活動綱要）

Speed				Intensity
mph	min/mile	min/km	min/400 m	MET
4	15	9:19	3:43	6.0
5	12	7:27	2:59	8.3
5.2	11.5	7:09	2:51	9.0
6	10	6:13	2:29	9.8
6.7	9	5:36	2:14	10.5

Ainsworth, Haskell, & Leon et al. (2011)

The compendium of physical activities（體力活動綱要）

Speed				Intensity
mph	min/mile	min/km	min/400 m	MET
7	8.5	5:17	2:07	11.0
7.5	8	4:58	1:59	11.5
8	7.5	4:40	1:52	11.8
8.6	7	4:21	1:44	12.3
9	6.5	4:02	1:37	12.8

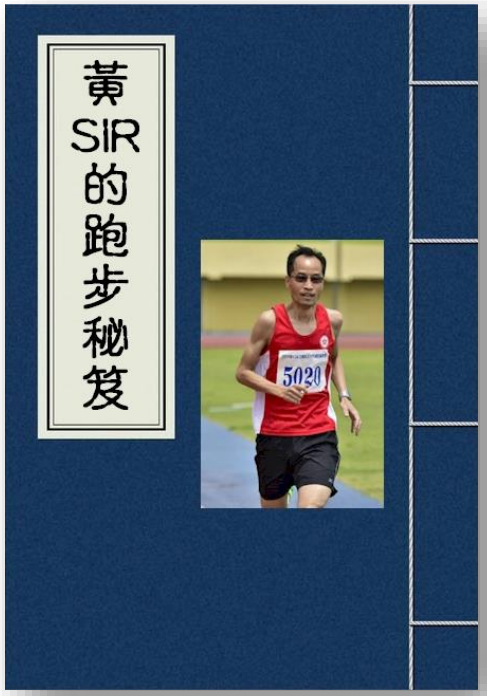
Ainsworth, Haskell, & Leon et al. (2011)

The compendium of physical activities（體力活動綱要）

Speed				Intensity
mph	min/mile	min/km	min/400 m	MET
10	6	3:44	1:29	14.5
11	5.5	3:25	1:22	16.0
12	5	3:06	1:15	19.0
13	4.6	2:52	1:09	19.8
14	4.3	2:40	1:04	23.0

Wong-Sir's Comments on Training for Race Performance

- **No** definite answer from **authorities**
- Take part in a race for the first time
  - **Goal: Finish** the race
- Take part in the race again
  - **Goal: PB** or **medal**
- **Pace judgement** is extremely important



Wong-Sir's Comments on Training for Race Performance

Pace Running

- Run at a **steady pace** as much as possible.
  - Newton's 1st and 2nd laws of motion
- Most of the runs should be conducted at **race pace** or **slightly faster** than **race pace**.
  - To facilitate **Transfer of Learning**

Constant Speed Tables for Selected Distances

100 m	200 m	300 m	400 m	600 m	800 m	1000 m	1200 m	1500 m	1 Mile	2000 m	3000 m	4000 m	5000 m	10000 m	H-Mar	Marathon
0:00:15	0:00:30	0:00:45	0:01:00	0:01:30	0:02:00	0:02:30	0:03:00	0:03:45	0:04:01	0:05:00	0:07:30	0:10:00	0:12:30	0:25:00	0:52:45	1:45:29
0:00:16	0:00:32	0:00:48	0:01:04	0:01:36	0:02:08	0:02:40	0:03:12	0:04:00	0:04:17	0:05:20	0:08:00	0:10:40	0:13:20	0:26:40	0:56:16	1:52:31
0:00:17	0:00:34	0:00:51	0:01:08	0:01:42	0:02:16	0:02:50	0:03:24	0:04:15	0:04:34	0:05:40	0:08:30	0:11:20	0:14:10	0:28:20	0:59:47	1:59:33
0:00:18	0:00:36	0:00:54	0:01:12	0:01:48	0:02:24	0:03:00	0:03:36	0:04:30	0:04:50	0:06:00	0:09:00	0:12:00	0:15:00	0:30:00	1:03:18	2:06:35
0:00:19	0:00:38	0:00:57	0:01:16	0:01:54	0:02:32	0:03:10	0:03:48	0:04:45	0:05:06	0:06:20	0:09:30	0:12:40	0:15:50	0:31:40	1:06:49	2:13:37
0:00:20	0:00:40	0:01:00	0:01:20	0:02:00	0:02:40	0:03:20	0:04:00	0:05:00	0:05:22	0:06:40	0:10:00	0:13:20	0:16:40	0:33:20	1:10:19	2:20:39
0:00:21	0:00:42	0:01:03	0:01:24	0:02:06	0:02:48	0:03:30	0:04:12	0:05:15	0:05:38	0:07:00	0:10:30	0:14:00	0:17:30	0:35:00	1:13:50	2:27:41
0:00:22	0:00:44	0:01:06	0:01:28	0:02:12	0:02:56	0:03:40	0:04:24	0:05:30	0:05:54	0:07:20	0:11:00	0:14:40	0:18:20	0:36:40	1:17:21	2:34:43
0:00:23	0:00:46	0:01:09	0:01:32	0:02:18	0:03:04	0:03:50	0:04:36	0:05:45	0:06:10	0:07:40	0:11:30	0:15:20	0:19:10	0:38:20	1:20:52	2:41:45
0:00:24	0:00:48	0:01:12	0:01:36	0:02:24	0:03:12	0:04:00	0:04:48	0:06:00	0:06:26	0:08:00	0:12:00	0:16:00	0:20:00	0:40:00	1:24:23	2:48:47
0:00:25	0:00:50	0:01:15	0:01:40	0:02:30	0:03:20	0:04:10	0:05:00	0:06:15	0:06:42	0:08:20	0:12:30	0:16:40	0:20:50	0:41:40	1:27:54	2:55:49
0:00:26	0:00:52	0:01:18	0:01:44	0:02:36	0:03:28	0:04:20	0:05:12	0:06:30	0:06:58	0:08:40	0:13:00	0:17:20	0:21:40	0:43:20	1:31:25	3:02:51
0:00:27	0:00:54	0:01:21	0:01:48	0:02:42	0:03:36	0:04:30	0:05:24	0:06:45	0:07:14	0:09:00	0:13:30	0:18:00	0:22:30	0:45:00	1:34:56	3:09:53
0:00:28	0:00:56	0:01:24	0:01:52	0:02:48	0:03:44	0:04:40	0:05:36	0:07:00	0:07:31	0:09:20	0:14:00	0:18:40	0:23:20	0:46:40	1:38:27	3:16:55
0:00:29	0:00:58	0:01:27	0:01:56	0:02:54	0:03:52	0:04:50	0:05:48	0:07:15	0:07:47	0:09:40	0:14:30	0:19:20	0:24:10	0:48:20	1:41:58	3:23:57
0:00:30	0:01:00	0:01:30	0:02:00	0:03:00	0:04:00	0:05:00	0:06:00	0:07:30	0:08:03	0:10:00	0:15:00	0:20:00	0:25:00	0:50:00	1:45:29	3:30:59
0:00:31	0:01:02	0:01:33	0:02:04	0:03:06	0:04:08	0:05:10	0:06:12	0:07:45	0:08:19	0:10:20	0:15:30	0:20:40	0:25:50	0:51:40	1:49:00	3:38:00
0:00:32	0:01:04	0:01:36	0:02:08	0:03:12	0:04:16	0:05:20	0:06:24	0:08:00	0:08:35	0:10:40	0:16:00	0:21:20	0:26:40	0:53:20	1:52:31	3:45:02
0:00:33	0:01:06	0:01:39	0:02:12	0:03:18	0:04:24	0:05:30	0:06:36	0:08:15	0:08:51	0:11:00	0:16:30	0:22:00	0:27:30	0:55:00	1:56:02	3:52:04
0:00:34	0:01:08	0:01:42	0:02:16	0:03:24	0:04:32	0:05:40	0:06:48	0:08:30	0:09:07	0:11:20	0:17:00	0:22:40	0:28:20	0:56:40	1:59:33	3:59:06
0:00:35	0:01:10	0:01:45	0:02:20	0:03:30	0:04:40	0:05:50	0:07:00	0:08:45	0:09:23	0:11:40	0:17:30	0:23:20	0:29:10	0:58:20	2:03:04	4:06:08
0:00:36	0:01:12	0:01:48	0:02:24	0:03:36	0:04:48	0:06:00	0:07:12	0:09:00	0:09:39	0:12:00	0:18:00	0:24:00	0:30:00	1:00:00	2:06:35	4:13:10
0:00:37	0:01:14	0:01:51	0:02:28	0:03:42	0:04:56	0:06:10	0:07:24	0:09:15	0:09:55	0:12:20	0:18:30	0:24:40	0:30:50	1:01:40	2:10:06	4:20:12
0:00:38	0:01:16	0:01:54	0:02:32	0:03:48	0:05:04	0:06:20	0:07:36	0:09:30	0:10:11	0:12:40	0:19:00	0:25:20	0:31:40	1:03:20	2:13:37	4:27:14
0:00:39	0:01:18	0:01:57	0:02:36	0:03:54	0:05:12	0:06:30	0:07:48	0:09:45	0:10:28	0:13:00	0:19:30	0:26:00	0:32:30	1:05:00	2:17:08	4:34:16
0:00:40	0:01:20	0:02:00	0:02:40	0:04:00	0:05:20	0:06:40	0:08:00	0:10:00	0:10:44	0:13:20	0:20:00	0:26:40	0:33:20	1:06:40	2:20:39	4:41:18
0:00:41	0:01:22	0:02:03	0:02:44	0:04:06	0:05:28	0:06:50	0:08:12	0:10:15	0:11:00	0:13:40	0:20:30	0:27:20	0:34:10	1:08:20	2:24:10	4:48:20
0:00:42	0:01:24	0:02:06	0:02:48	0:04:12	0:05:36	0:07:00	0:08:24	0:10:30	0:11:16	0:14:00	0:21:00	0:28:00	0:35:00	1:10:00	2:27:41	4:55:22
0:00:43	0:01:26	0:02:09	0:02:52	0:04:18	0:05:44	0:07:10	0:08:36	0:10:45	0:11:32	0:14:20	0:21:30	0:28:40	0:35:50	1:11:40	2:31:12	5:02:24
0:00:44	0:01:28	0:02:12	0:02:56	0:04:24	0:05:52	0:07:20	0:08:48	0:11:00	0:11:48	0:14:40	0:22:00	0:29:20	0:36:40	1:13:20	2:34:43	5:09:26
0:00:45	0:01:30	0:02:15	0:03:00	0:04:30	0:06:00	0:07:30	0:09:00	0:11:15	0:12:04	0:15:00	0:22:30	0:30:00	0:37:30	1:15:00	2:38:14	5:16:28
0:00:46	0:01:32	0:02:18	0:03:04	0:04:36	0:06:08	0:07:40	0:09:12	0:11:30	0:12:20	0:15:20	0:23:00	0:30:40	0:38:20	1:16:40	2:41:45	5:23:30
0:00:47	0:01:34	0:02:21	0:03:08	0:04:42	0:06:16	0:07:50	0:09:24	0:11:45	0:12:36	0:15:40	0:23:30	0:31:20	0:39:10	1:18:20	2:45:16	5:30:32
0:00:48	0:01:36	0:02:24	0:03:12	0:04:48	0:06:24	0:08:00	0:09:36	0:12:00	0:12:52	0:16:00	0:24:00	0:32:00	0:40:00	1:20:00	2:48:47	5:37:34
0:00:49	0:01:38	0:02:27	0:03:16	0:04:54	0:06:32	0:08:10	0:09:48	0:12:15	0:13:08	0:16:20	0:24:30	0:32:40	0:40:50	1:21:40	2:52:18	5:44:36
0:00:50	0:01:40	0:02:30	0:03:20	0:05:00	0:06:40	0:08:20	0:10:00	0:12:30	0:13:25	0:16:40	0:25:00	0:33:20	0:41:40	1:23:20	2:55:49	5:51:38
0:00:51	0:01:42	0:02:33	0:03:24	0:05:06	0:06:48	0:08:30	0:10:12	0:12:45	0:13:41	0:17:00	0:25:30	0:34:00	0:42:30	1:25:00	2:59:20	5:58:39
0:00:52	0:01:44	0:02:36	0:03:28	0:05:12	0:06:56	0:08:40	0:10:24	0:13:00	0:13:57	0:17:20	0:26:00	0:34:40	0:43:20	1:26:40	3:02:51	6:05:41
0:00:53	0:01:46	0:02:39	0:03:32	0:05:18	0:07:04	0:08:50	0:10:36	0:13:15	0:14:13	0:17:40	0:26:30	0:35:20	0:44:10	1:28:20	3:06:22	6:12:43
0:00:54	0:01:48	0:02:42	0:03:36	0:05:24	0:07:12	0:09:00	0:10:48	0:13:30	0:14:29	0:18:00	0:27:00	0:36:00	0:45:00	1:30:00	3:09:53	6:19:45
0:00:55	0:01:50	0:02:45	0:03:40	0:05:30	0:07:20	0:09:10	0:11:00	0:13:45	0:14:45	0:18:20	0:27:30	0:36:40	0:45:50	1:31:40	3:13:24	6:26:47
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0:00:58	0:01:56	0:02:54	0:03:52	0:05:48	0:07:44	0:09:40	0:11:36	0:14:30	0:15:33	0:19:20	0:29:00	0:38:40	0:48:20	1:36:40	3:23:57	6:47:53
0:00:59	0:01:58	0:02:57	0:03:56	0:05:54	0:07:52	0:09:50	0:11:48	0:14:45	0:15:49	0:19:40	0:29:30	0:39:20	0:49:10	1:38:20	3:27:28	6:54:55
0:01:00	0:02:00	0:03:00	0:04:00	0:06:00	0:08:00	0:10:00	0:12:00	0:15:00	0:16:05	0:20:00	0:30:00	0:40:00	0:50:00	1:40:00	3:30:59	7:01:57

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Determinants of Aerobic Performances

Joyner & Coyle (2008)

- **Maximal oxygen consumption** (**$\dot{V}O_2max$**), **anaerobic threshold** (**AT**) and **running economy** (**RE**) are the **three main factors** appear to play key roles in **endurance** performance.

Midgley, et al. (2007)

- These three determinants explain **> 70%** of the between-subject variance in **long distance running** performance.

Determinants of Aerobic Performances

Helgerud et al. (2007)

- Among these three, **$\dot{V}O_2max$** is probably the single most important factor determining success in **aerobic** endurance sport.

$\dot{V}O_2max$

$\dot{V}O_2max$

- Known as **maximum oxygen consumption**, **maximal oxygen uptake**, or **maximal aerobic power**.
- The **dot** over the letter **V** (i.e., $\dot{V}$) simply means **per minute**.

Bassett & Howley (2000)

- Defined as the **highest rate** at which **oxygen** can be taken up and **utilized** by the body during **severe** exercise.

$\dot{V}O_2max$

Subjects	SV_{rest} (ml/beat)	SV_{max} (ml/beat)
Untrained	50-70	80-110
Trained	70-90	110-150
Highly trained	90-110	150-220+

The Fick Equation

- $\dot{V}O_2 = \dot{Q} \times (a - \bar{v})O_2$ difference

  $= HR \times SV \times (a - \bar{v})O_2$ difference

Bassett & Howley (2000)

- In the exercising human, **$\dot{V}O_2max$** is limited primarily by the **rate of oxygen delivery** (**70-85%** linked to maximal **cardiac output**), **not** the ability of the muscle to take up oxygen from the blood

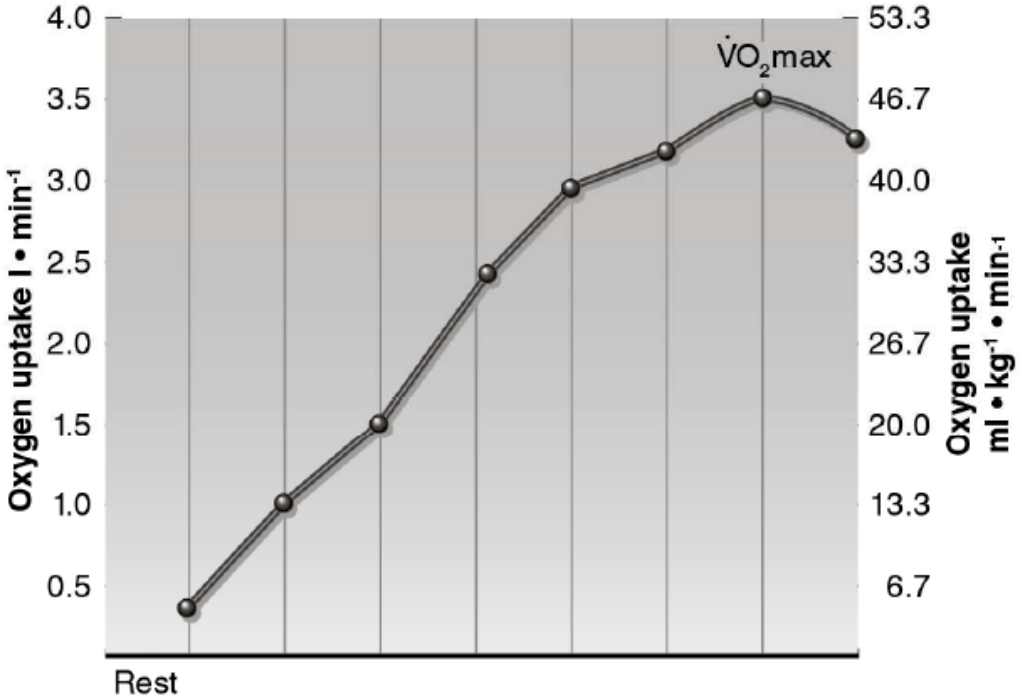
$\dot{V}O_2max$

Joyner & Coyle (2008)

- **Champion** endurance athletes have **$\dot{V}O_2max$ values** of between **70 and 85 ml/kg/min**, which may be **50-100% greater** than those seen in normally active healthy young subjects.
- Values in **women** are typically averaging about **10% lower** due to lower hemoglobin concentrations and higher levels of body fat.

$\dot{V}O_2max$

- **$\dot{V}O_2$** increases as the **intensity** of exercise increases, until a **plateau** (i.e., **$\dot{V}O_2max$**) is reached.



Exercise on the treadmill

Speed km/h	4.8	8.0	11.2	11.2	11.2	11.2	11.2
Treadmill grade, %	0	5.5	7.5	9.5	11.5	13.5	15.5
Time, min	0-2	2-4	4-6	6-8	8-10	10-12	12-14

$\dot{V}O_2max$

Leger and Mercier (1984)

- For speeds **between 8 and 25 Km/h**, the following linear equation could accurately describe the **gross energy cost** of track running.

$$\dot{V}O_2 \text{ (ml/kg/min)} = 3.5 \times \text{Speed (Km/h)}$$

$\dot{V}O_2max$

- Energy cost to run **5000 m** in different speeds according to

$$\dot{V}O_2 \text{ (ml/kg/min)} = 3.5 \times \text{Speed (Km/h)}$$

Time	Speed (Km/h)	$\dot{V}O_2$ (ml/kg/min)
20 min	15	$3.5 \times 15 = 52.5$
16 min	18.75	$3.5 \times 18.75 = 65.63$
13 min	23.08	$3.5 \times 23.08 = 80.78$

$\dot{V}O_2max$

- Often used to assess the **aerobic capacity** of **endurance** athletes.
  - **Direct Measurement during Maximal Work**
    - Provide the most accurate value.
    - Technically demanding and require access to expensive laboratory equipment and skilled personnel.
  - **Field Test** (e.g., **Cooper's 12-minute run/walk Test**)
    - Requires great motivation and a knowledge of pacing.

$\dot{V}O_2max$

Uth et al. (2004)

- Formula to **estimate** **$\dot{V}O_2max$** simply by using **heart rates** ($r = 0.87$).

$$\dot{V}O_2max\ (ml/kg/min) = 15.0 \times \frac{HR_{max}}{HR_{rest}}$$

$\dot{V}O_2max$

Exercise Prescription using $\dot{V}O_2max$

- **ACSM (2014)**
  - Very light: **< 37%** $\dot{V}O_2max$
  - Light: **37 to < 46%** $\dot{V}O_2max$
  - Moderate: **46 to < 64%** $\dot{V}O_2max$
  - Vigorous: **64 to < 91%** $\dot{V}O_2max$
  - Near maximal to maximal: **≥ 91%** $\dot{V}O_2max$

$\dot{V}O_2max$

Exercise Prescription using $\dot{V}O_2max$

- **Problems**
  - Equipment
  - Portability

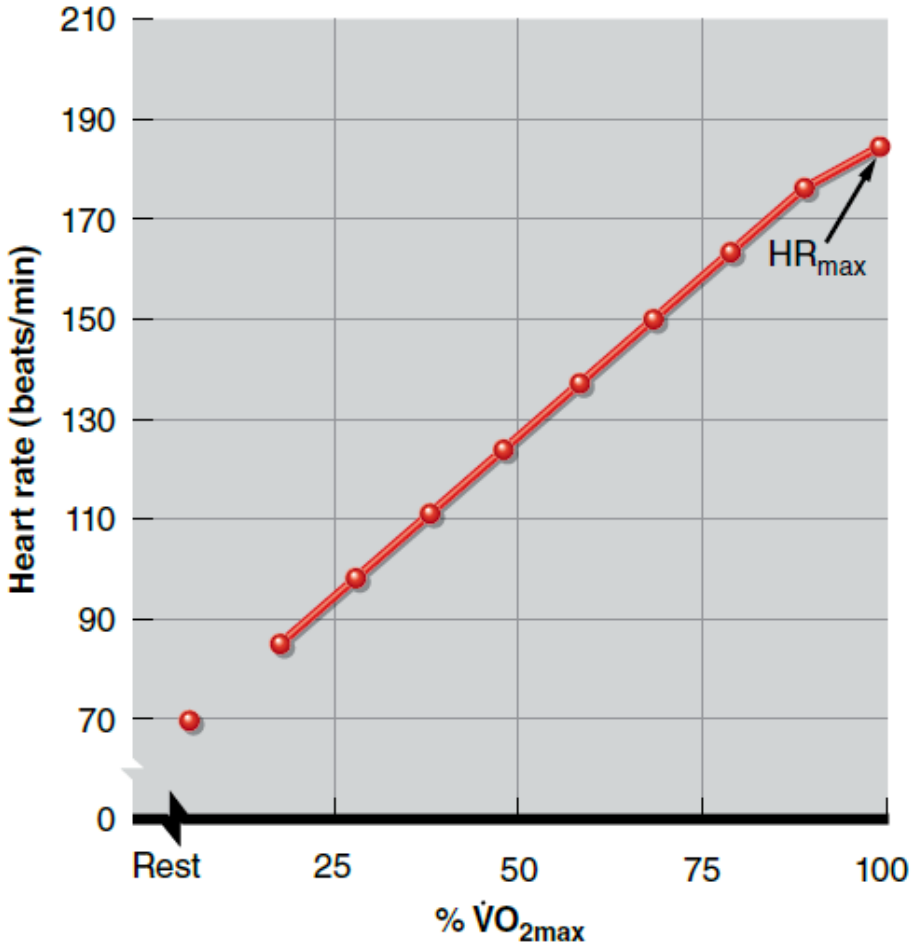
$\dot{V}O_2max$

Alternatives

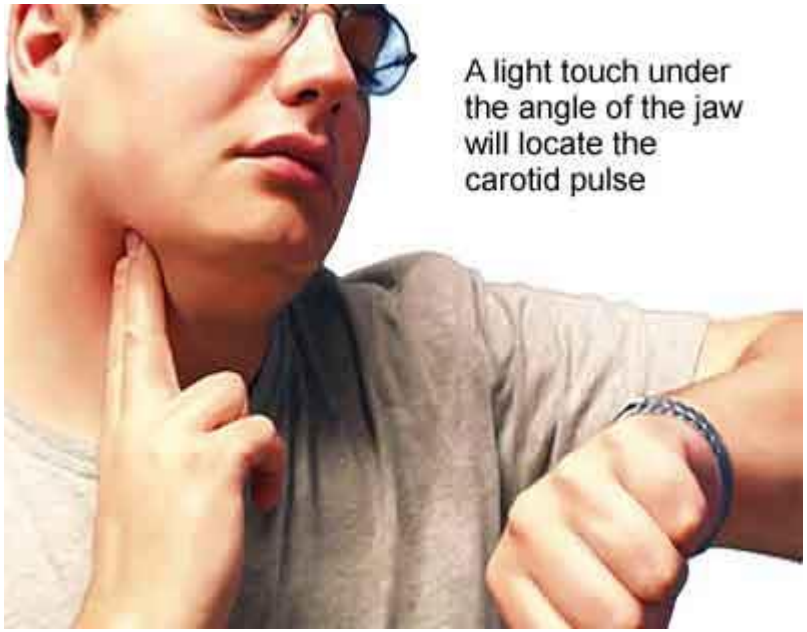
- **Heart Rates**
  - Maximal Heart Rate (**HR_{max}**) Method
  - Heart Rate Reserve (**HRR**) Method

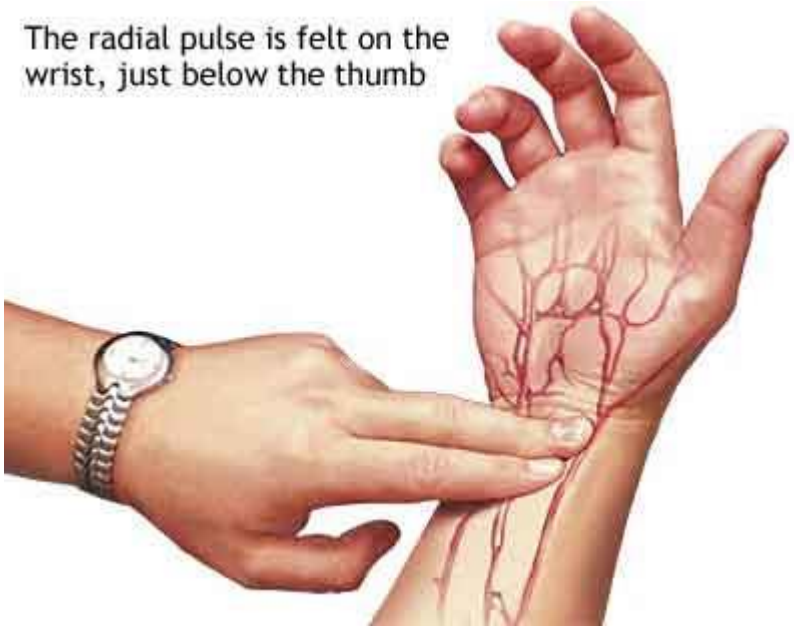
Heart Rates (HR)

- **HR** increases **directly** in proportion to the increase in exercise intensity (i.e., **%$\dot{V}O_2$max**) until near-maximal exercise is achieved.
- As **maximal** exercise intensity is approached, **HR** begins to **plateau** even as the exercise workload continues to increase.



Measurement of HR





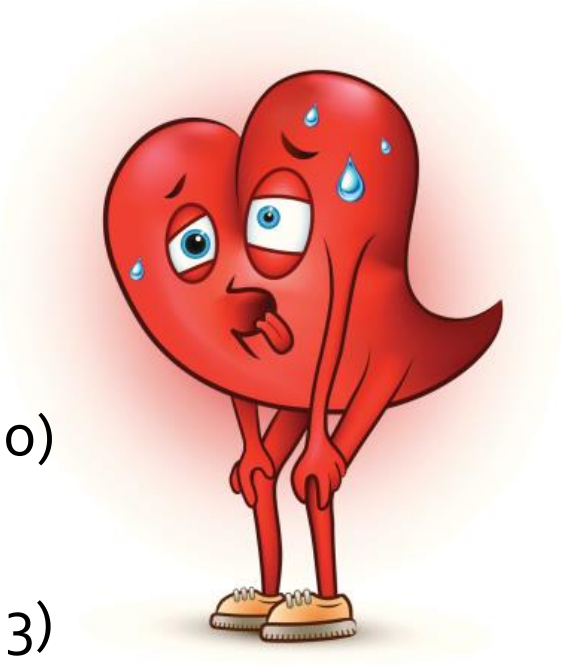
Measurement of HR

HR_{max}

Kenney, Wilmore & Costill (2015)

- **Maximal heart rate** (**HR_{max}**) is the **highest HR** value achieved in an **all-out effort** to the point of volitional fatigue.
- **Once accurately** determined, **HR_{max}** is a highly reliable value that remains constant from day to day.
- A slight but **predictable** decrease of about **one beat per year** beginning at **10 to 15** years of age.

HR_{max}



Swain et al. (1994)

- **$\%HR_{max}$** for **Men**
  $= (0.643 \pm 0.010)\%\dot{V}O_2max + (36.8 \pm 1.0)$
- **$\%\ HR_{max}$** for **Women**
  $= (0.628 \pm 0.014)\%\dot{V}O_2max + (39.0 \pm 1.3)$
- The value of **$\%\ HR_{max}$** for **women** averaged **1 percentage** point higher than **men** at **each** exercise intensity. However, the **F ratio** for a **sex effect** was **not** significant.

HR_{max}

National Council on Strength & Fitness

% VO_2max	% HRmax	Speed
50%	70%	Very Slow (warm up, cool down, recovery)
60%	75%	Slow Running (early measure of a long run, recovery day)
70%	82%	Steady Running (off-season; maybe challenging for LIT runs)
80%	88%	Half Marathon Pace; Just above Marathon Pace
90%	95%	10K Speed
95%	98%	5k Speed
100%	100%	3K Speed
110%	100%	1500 Speed

Measurement of HR_{max}

Direct Measurement during Maximal Work

- Provide the most accurate value.
- Require access to expensive laboratory equipment and skilled personnel.

Alternatives

- Age-prediction equations
  e.g., HR_{max} = 220 – Age

Age–prediction Equations for HR_{max}

Most Popular in Textbooks and Research Papers

- **HR_{max} = 220 – Age**

Sharkey & Gaskill (2013)

- However, **HR_{max}** is highly variable, with a **standard deviation** (SD) of **12 bpm**.
  - **68%** of subjects fall within **±1 SD**, **95%** of subjects fall within **±2 SD**, and **99%** of subjects fall within **±3 SD**.
  - **1 in 100** subjects of **40 years old** will have a **HR_{max} below 144** or **above 216 bpm**.

Age–prediction Equations for HR_{max}

Robergs & Landwehr (2002)

- **No published** record of research for this equation.
- The origin of the formula is a **superficial estimate**, based on **observation**, of a linear best fit to a series of raw and mean data compiled by **Fox and Haskell (1971)**.
- There remains **no** formula that provides **acceptable** accuracy of **HR_{max}** prediction.

v$\dot{V}O_2$max

- **$\dot{V}O_2$max** is considered a good performance predictor in **heterogeneous** groups where members possess a **wide variety** of aerobic capacities.
  - Athletes possessing higher values of **$\dot{V}O_2$max** generally have better performances, or vice versa.
- However, it is **not** the case with **homogeneous** groups, such as a group of **elite** long distance runners.
  - Athletes possessing similar values of **$\dot{V}O_2$max** may vary greatly in performances, or vice versa.

$v\dot{V}O_2max$

- **Noakes (2013)**

Athlete	VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	Marathon Time
Gary Tuttle	82.7	2:17:00
Graig Virgin	81.1	2:10:26
Joan Benoit	78.6	2:24:52
Bill Rodgers	78.5	2:09:27
Don Kardong	77.4	2:11:15
Alberto Salazar	76.0	2:08:13
Amby Burfoot	74.3	2:14:28
Kenny Moore	74.2	2:11:36
Grete Waitz	73.0	2:25:42
Buddy Edelen	73.0	2:14:28
Zithulele Sinqe	72.0	2:08:05
Frank Shorter	71.3	2:10:30
Willie Mtolo	70.3	2:08:15
Derek Clayton	69.7	2:08:34

$v\dot{V}O_2max$

Billat & Koralsztein (1996)

- **$v\dot{V}O_2max$** , introduced by **Daniels et al.** in 1984, refers to the **velocity** at **$\dot{V}O_2max$**.
- It is the **lowest** running speed which elicits a **$\dot{V}O_2$** equal to **$\dot{V}O_2max$**.
- **$v\dot{V}O_2max$** is a useful variable that combines **$\dot{V}O_2max$** and **running economy** into a **single** factor which can explain individual differences in performance that **$\dot{V}O_2max$** or **running economy alone** cannot.

Running Economy

Saunders et al. (2004)

- **Running economy** (RE) is typically defined as the energy demand for a given velocity of **submaximal** running.
- Runners with good **RE** use **less energy** and therefore **less oxygen** than runners with poor **RE** at the **same** velocity.
- There is a strong association between **RE** and distance running performance, with **RE** being a better predictor of performance than $\dot{V}O_2max$ in **elite** runners who have a similar $\dot{V}O_2max$.

Running Economy

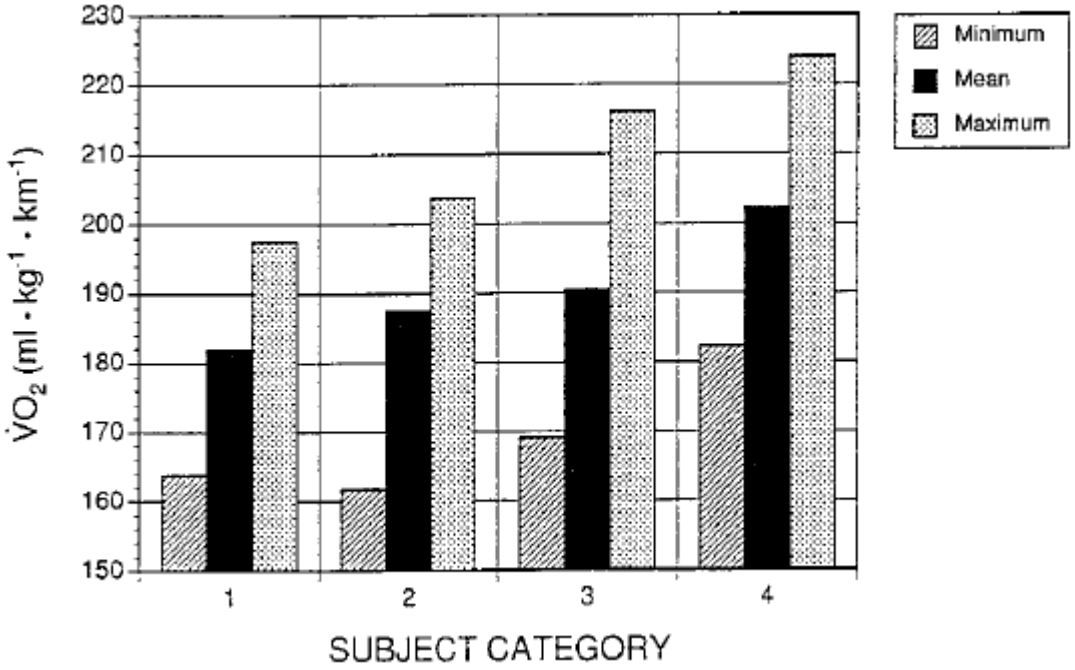
Karp (n.d.)

- **RE** is the volume of oxygen consumed at **submaximal** running speeds.
  - If two runners have the same **VO_2max**, but **Runner A** uses **70%** and **Runner B** uses **80%** of that **VO_2max** while running at **7:00** pace, the pace feels easier for **Runner A** because **Runner A** is **more economical**.
  - **Runner A** can run at a **faster pace** before feeling the **same amount** of fatigue as **Runner B**.

Running Economy

Bassett & Howley (2000)

- Elite runners had a better **RE** than the other groups of runners.
- All running groups were better than the group of untrained subjects.

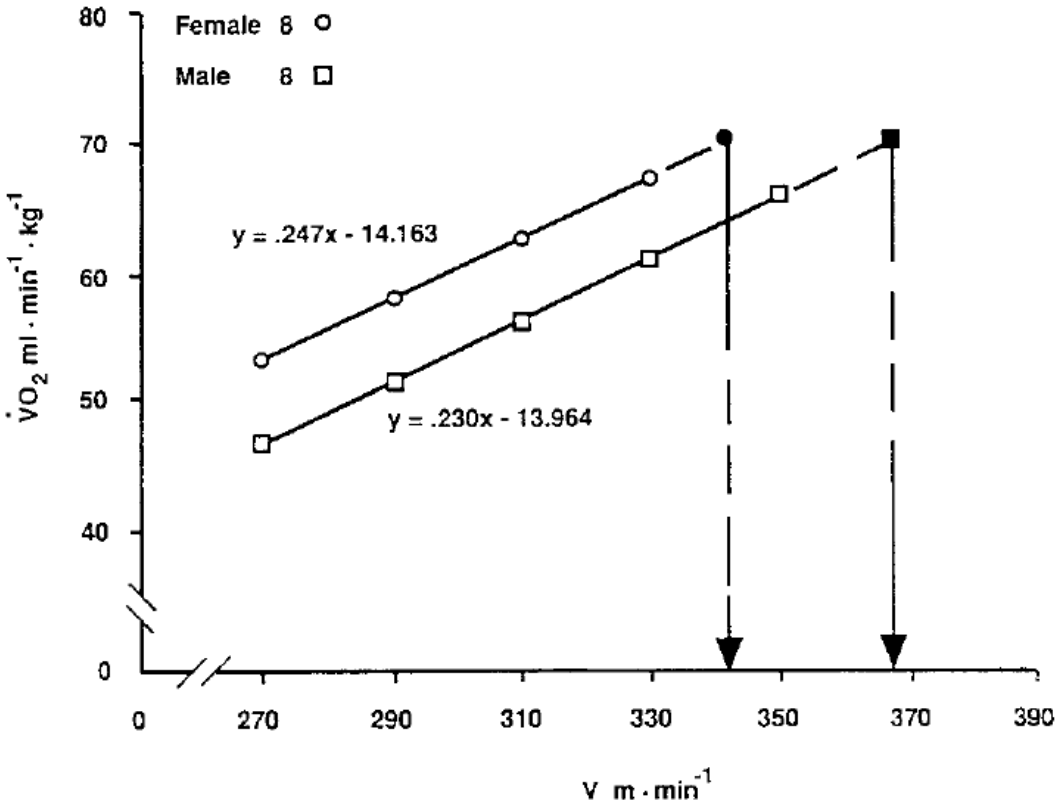


Minimum, mean, and maximum aerobic demand values for elite runners (Category 1), sub-elite runners (Category 2), good runners (Category 3), and untrained subjects (Category 4).

Running Economy

Bassett & Howley (2000)

- The difference in **RE** resulted in a clear difference in the speed that could be achieved if that race were run at $\dot{V}O_2max$.



A plot of male and female runners equal in terms of VO_2max, but differing in running economy.

Running Economy

Karp (n.d.)

- Factors influencing **RE** include:
  - biomechanics, muscle fiber type, leg mass, clothing, shoe weight, wind, air resistance, terrain, …
- Runners tend to be most economical at the speed they train most, so **athletes should train at race pace to improve economy at race pace**.

v$\dot{V}O_2$max & Running Events

Denadai et al. (2006)

- **v$\dot{V}O_2$max** has been used with success in prescribing exercise intensities for middle and long distance runners.

Joyner & Coyle (2008)

- Much of the 42-Km marathon is run at approximately **75-85% $\dot{V}O_2$max**.
- 10 Km is performed at **90-100% $\dot{V}O_2$max**.
- 5 Km at **close to $\dot{V}O_2$max**.

v$\dot{V}O_2$max & Running Prescription

Denadai et al. (2006)

- 5000 m at **90-95% $\dot{V}O_2$max**.
- 1500 m at **105-115% $\dot{V}O_2$max**.

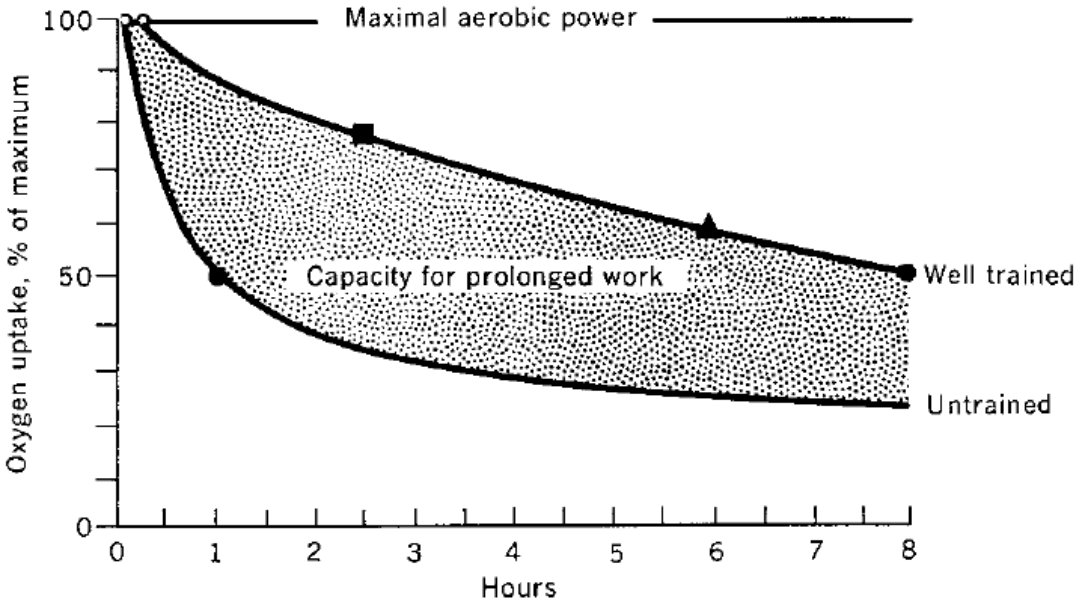
Bragada et al. (2010)

- 3000 m running velocity ranged **between 97 and 101%** (mean = **100%**) **$\dot{V}O_2$max**.
- Determination of **v$\dot{V}O_2$max** provides an important tool which can be used in training.
  - e.g., as a **speed** suitable for use during **interval training**.

v$\dot{V}O_2$max & Running Prescription

Bassett & Howley (2000)

- **Trained** individuals functioned at **higher %$\dot{V}O_2$max** than **untrained** subjects for the **same** duration of time.



Approximate percentage of a subject's VO_2max during work of different duration and how this is affected by training state (Astrand & Rodahl, 1970).

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

- Since **Billat & Koralsztein (1996)** pointed out that the average value of **time limit** at **100% $v\dot{V}O_2max$** is **close to 6 minutes**, it is reasonable to conduct a **6-minute all out run** to estimate the **$v\dot{V}O_2max$** (i.e., the minimum speed that elicits **$\dot{V}O_2max$**.
- With reference to **Bragada et al. (2010)**, **Denadai et al. (2006)**, and **Joyner & Coyle (2008)**, runners should emphasize training at the speeds **close to** and **slightly above** the **%$v\dot{V}O_2max$** of their **major** running events.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

Major Distance Running Events	Training Speed (% $v\dot{V}O_2max$)
1,500 m, 1 mile (1,609 m), 2K (2,000 m)	100 to 115%
3K (3,000 m), 5K (5,000 m)	95 to 105%
10K (10,000 m), 15K (15,000 m)	90 to 100%
Half Marathon (21,097 m)	85 to 95%
Marathon (42,195 m)	75 to 85%

Remarks:

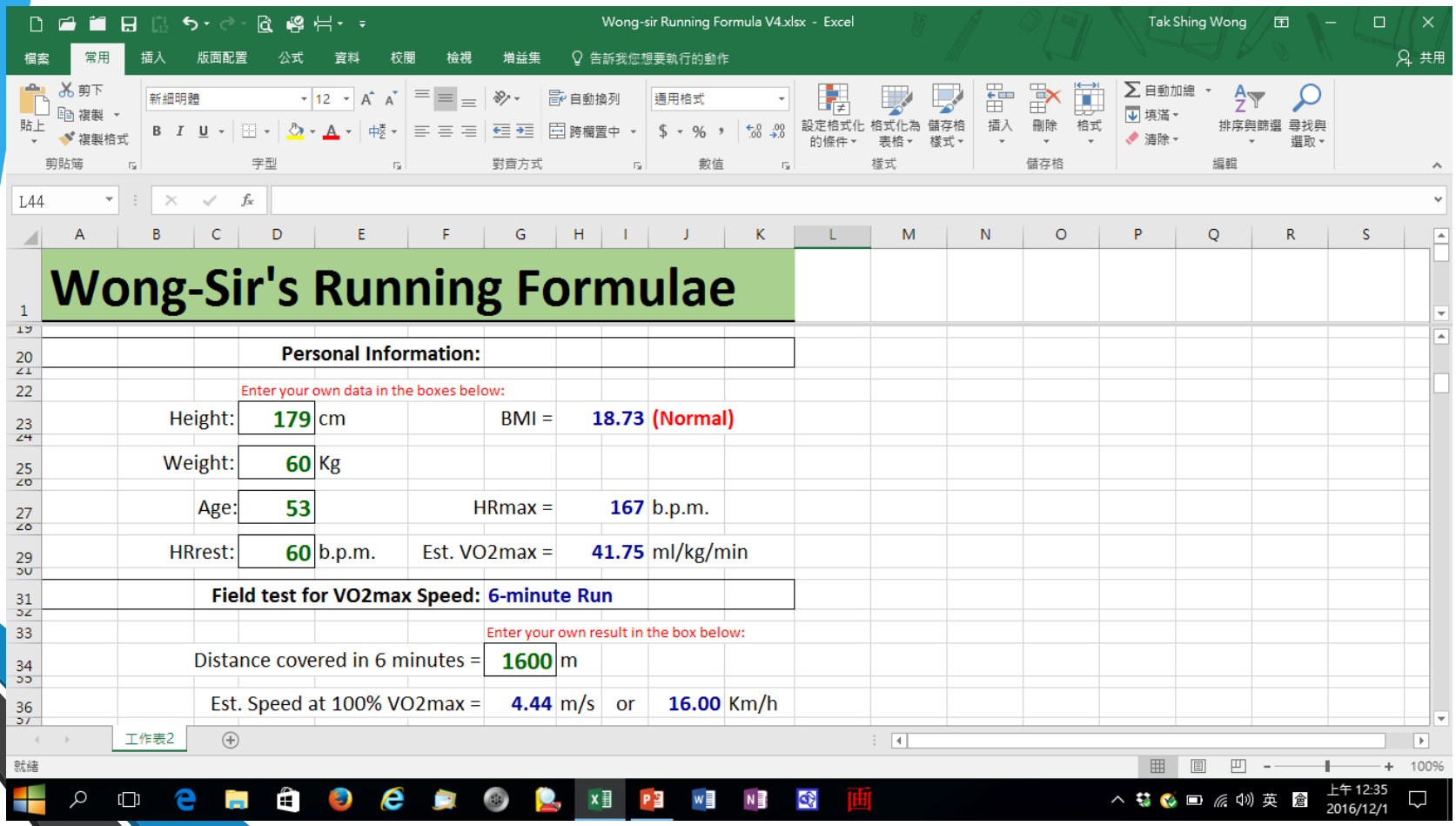
1. *Data adjusted (by me) for local runners.*
2. *3000 m is considered as running close to 100% for elite runners.*

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

Wong-Sir's Running Formulae

- This is absolutely **not** an earthshaking invention.
- Simply conduct a **6-minute time trial** first, and then input the result (e.g., **1600 m**) and other data (optional) into the **Excel spreadsheet**.
- Based on the **predicted $\dot{V}O_2max$ speed** using the **6-minute time trial** (e.g., **1600 m ÷ 360 s = 4.44 m/s** or **16 km/h**), calculate the speeds for the different percentages of **$\dot{V}O_2max$** with the **Excel spreadsheet**.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription



Wong-Sir's Running Formulae

Rationales:

(Billat & Koralsztein, 1996; Bragada, et al., 2010; Donadai, et al., 2006; Joyce & Coyle, 2008; Uth et al., 2004)

1. **Percent VO2max speed of different running events:**
   1,500 m, 1 mile (1,609 m), 2K (2,000 m) = 100 to 115% VO2max
   3K (3,000 m), 5K (5,000 m) = Near 100% VO2max
   10K (10,000 m), 15K (15,000 m) = 90 to 100% VO2max
   Marathon (42,195 m) = 75 to 85% VO2max

2. **The average value of time limit at 100% vVO2max is close to 6 minutes.**

3. **Predicted 3000 m Speed = 0.646 + 0.626 x V4 Speed + 0.416 x vVO2max Speed**
   (All speeds measured in Km/h)

4. **Mass-specific VO2max = 15*(HRmax/HRrest)**
   (in ml/kg/min)

Personal Information:

Enter your own data in the boxes below:

Height: 179 cm BMI = 18.73 (Normal)

Weight: 60 Kg

Age 53 HRmax = 167 b.p.m.

HRrest: 60 b.p.m. Est. VO2max = 41.75 ml/kg/min

Field test for VO2max Speed: 6-minute Run

Enter your own result in the box below:

Distance covered in 6 minutes = 1600 m

Est. Speed at 100% VO2max = 4.44 m/s or 16.00 Km/h

Optional test for V4 Speed: 3000-m Time Trial

Enter your own result in the boxes below:

Time to finish 3000 m = 12 min 0 s

Average speed = 4.17 m/s or 15.00 Km/h

Est. V4 (i.e., lactate threshold) Speed = 12.30 Km/h

Percent VO2max at V4 Speed = 76.86 %

At	115	% VO2max speed, or	5.11	m/s,	or	18.40	Km/h
Time to run	100	m =	19.6	s, or	0	min	19.6 s
Time to run	200	m =	39.1	s, or	0	min	39.1 s
Time to run	300	m =	58.7	s, or	0	min	58.7 s
Time to run	400	m =	78.3	s, or	1	min	18.3 s
Time to run	600	m =	117.4	s, or	1	min	57.4 s
Time to run	800	m =	156.5	s, or	2	min	36.5 s
Time to run	1000	m =	195.7	s, or	3	min	15.7 s
Time to run	1200	m =	234.8	s, or	3	min	54.8 s
Time to run	1600	m =	313.0	s, or	5	min	13.0 s
Time to run	2000	m =	391.3	s, or	6	min	31.3 s

At	110	% VO2max speed, or	4.89	m/s,	or	17.60	Km/h
Time to run	100	m =	20.5	s, or	0	min	20.5 s
Time to run	200	m =	40.9	s, or	0	min	40.9 s
Time to run	300	m =	61.4	s, or	1	min	1.4 s
Time to run	400	m =	81.8	s, or	1	min	21.8 s
Time to run	600	m =	122.7	s, or	2	min	2.7 s
Time to run	800	m =	163.6	s, or	2	min	43.6 s
Time to run	1000	m =	204.5	s, or	3	min	24.5 s
Time to run	1200	m =	245.5	s, or	4	min	5.4 s
Time to run	1600	m =	327.3	s, or	5	min	27.3 s
Time to run	2000	m =	409.1	s, or	6	min	49.1 s

At	105	% VO2max speed, or	4.67	m/s,	or	16.80	Km/h
Time to run	100	m =	21.4	s, or	0	min	21.4 s
Time to run	200	m =	42.9	s, or	0	min	42.9 s
Time to run	300	m =	64.3	s, or	1	min	4.3 s
Time to run	400	m =	85.7	s, or	1	min	25.7 s
Time to run	600	m =	128.6	s, or	2	min	8.6 s
Time to run	800	m =	171.4	s, or	2	min	51.4 s
Time to run	1000	m =	214.3	s, or	3	min	34.3 s
Time to run	1200	m =	257.1	s, or	4	min	17.1 s
Time to run	1600	m =	342.9	s, or	5	min	42.9 s
Time to run	2000	m =	428.6	s, or	7	min	8.6 s

At	100	% VO2max speed, or	4.44	m/s,	or	16.00	Km/h
Time to run	100	m =	22.5	s, or	0	min	22.5 s
Time to run	200	m =	45.0	s, or	0	min	45.0 s
Time to run	300	m =	67.5	s, or	1	min	7.5 s
Time to run	400	m =	90.0	s, or	1	min	30.0 s
Time to run	600	m =	135.0	s, or	2	min	15.0 s
Time to run	800	m =	180.0	s, or	3	min	0.0 s
Time to run	1000	m =	225.0	s, or	3	min	45.0 s
Time to run	1200	m =	270.0	s, or	4	min	30.0 s
Time to run	1600	m =	360.0	s, or	6	min	0.0 s
Time to run	2000	m =	450.0	s, or	7	min	30.0 s

At	95	% VO2max speed, or	4.22	m/s,	or	15.20	Km/h
Time to run	100	m =	23.7	s, or	0	min	23.7 s
Time to run	200	m =	47.4	s, or	0	min	47.4 s
Time to run	300	m =	71.1	s, or	1	min	11.1 s
Time to run	400	m =	94.7	s, or	1	min	34.7 s
Time to run	600	m =	142.1	s, or	2	min	22.1 s
Time to run	800	m =	189.5	s, or	3	min	9.5 s
Time to run	1000	m =	236.8	s, or	3	min	56.8 s
Time to run	1200	m =	284.2	s, or	4	min	44.2 s
Time to run	1600	m =	378.9	s, or	6	min	18.9 s
Time to run	2000	m =	473.7	s, or	7	min	53.7 s

At	90	% VO2max speed, or	4.00	m/s,	or	14.40	Km/h
Time to run	100	m =	25.0	s, or	0	min	25.0 s
Time to run	200	m =	50.0	s, or	0	min	50.0 s
Time to run	300	m =	75.0	s, or	1	min	15.0 s
Time to run	400	m =	100.0	s, or	1	min	40.0 s
Time to run	600	m =	150.0	s, or	2	min	30.0 s
Time to run	800	m =	200.0	s, or	3	min	20.0 s
Time to run	1000	m =	250.0	s, or	4	min	10.0 s
Time to run	1200	m =	300.0	s, or	5	min	0.0 s
Time to run	1600	m =	400.0	s, or	6	min	40.0 s
Time to run	2000	m =	500.0	s, or	8	min	20.0 s

At	85	% VO2max speed, or	3.78	m/s,	or	13.60	Km/h
Time to run	100	m =	26.5	s, or	0	min	26.5 s
Time to run	200	m =	52.9	s, or	0	min	52.9 s
Time to run	300	m =	79.4	s, or	1	min	19.4 s
Time to run	400	m =	105.9	s, or	1	min	45.9 s
Time to run	600	m =	158.8	s, or	2	min	38.8 s
Time to run	800	m =	211.8	s, or	3	min	31.8 s
Time to run	1000	m =	264.7	s, or	4	min	24.7 s
Time to run	1200	m =	317.6	s, or	5	min	17.6 s
Time to run	1600	m =	423.5	s, or	7	min	3.5 s
Time to run	2000	m =	529.4	s, or	8	min	49.4 s

At	80	% VO2max speed, or	3.56	m/s,	or	12.80	Km/h
Time to run	100	m =	28.1	s, or	0	min	28.1 s
Time to run	200	m =	56.3	s, or	0	min	56.3 s
Time to run	300	m =	84.4	s, or	1	min	24.4 s
Time to run	400	m =	112.5	s, or	1	min	52.5 s
Time to run	600	m =	168.8	s, or	2	min	48.8 s
Time to run	800	m =	225.0	s, or	3	min	45.0 s
Time to run	1000	m =	281.3	s, or	4	min	41.3 s
Time to run	1200	m =	337.5	s, or	5	min	37.5 s
Time to run	1600	m =	450.0	s, or	7	min	30.0 s
Time to run	2000	m =	562.5	s, or	9	min	22.5 s

At	75	% VO2max speed, or	3.33	m/s,	or	12.00	Km/h
Time to run	100	m =	30.0	s, or	0	min	30.0 s
Time to run	200	m =	60.0	s, or	1	min	0.0 s
Time to run	300	m =	90.0	s, or	1	min	30.0 s
Time to run	400	m =	120.0	s, or	2	min	0.0 s
Time to run	600	m =	180.0	s, or	3	min	0.0 s
Time to run	800	m =	240.0	s, or	4	min	0.0 s
Time to run	1000	m =	300.0	s, or	5	min	0.0 s
Time to run	1200	m =	360.0	s, or	6	min	0.0 s
Time to run	1600	m =	480.0	s, or	8	min	0.0 s
Time to run	2000	m =	600.0	s, or	10	min	0.0 s

At	70	% VO2max speed, or	3.11	m/s,	or	11.20	Km/h
Time to run	100	m =	32.1	s, or	0	min	32.1 s
Time to run	200	m =	64.3	s, or	1	min	4.3 s
Time to run	300	m =	96.4	s, or	1	min	36.4 s
Time to run	400	m =	128.6	s, or	2	min	8.6 s
Time to run	600	m =	192.9	s, or	3	min	12.9 s
Time to run	800	m =	257.1	s, or	4	min	17.1 s
Time to run	1000	m =	321.4	s, or	5	min	21.4 s
Time to run	1200	m =	385.7	s, or	6	min	25.7 s
Time to run	1600	m =	514.3	s, or	8	min	34.3 s
Time to run	2000	m =	642.9	s, or	10	min	42.9 s

At	65	% VO2max speed, or	2.89	m/s,	or	10.40	Km/h
Time to run	100	m =	34.6	s, or	0	min	34.6 s
Time to run	200	m =	69.2	s, or	1	min	9.2 s
Time to run	300	m =	103.8	s, or	1	min	43.8 s
Time to run	400	m =	138.5	s, or	2	min	18.5 s
Time to run	600	m =	207.7	s, or	3	min	27.7 s
Time to run	800	m =	276.9	s, or	4	min	36.9 s
Time to run	1000	m =	346.2	s, or	5	min	46.2 s
Time to run	1200	m =	415.4	s, or	6	min	55.4 s
Time to run	1600	m =	553.8	s, or	9	min	13.8 s
Time to run	2000	m =	692.3	s, or	11	min	32.3 s

At	60	% VO2max speed, or	2.67	m/s,	or	9.60	Km/h
Time to run	100	m =	37.5	s, or	0	min	37.5 s
Time to run	200	m =	75.0	s, or	1	min	15.0 s
Time to run	300	m =	112.5	s, or	1	min	52.5 s
Time to run	400	m =	150.0	s, or	2	min	30.0 s
Time to run	600	m =	225.0	s, or	3	min	45.0 s
Time to run	800	m =	300.0	s, or	5	min	0.0 s
Time to run	1000	m =	375.0	s, or	6	min	15.0 s
Time to run	1200	m =	450.0	s, or	7	min	30.0 s
Time to run	1600	m =	600.0	s, or	10	min	0.0 s
Time to run	2000	m =	750.0	s, or	12	min	30.0 s

At	55	% VO2max speed, or	2.44	m/s,	or	8.80	Km/h
Time to run	100	m =	40.9	s, or	0	min	40.9 s
Time to run	200	m =	81.8	s, or	1	min	21.8 s
Time to run	300	m =	122.7	s, or	2	min	2.7 s
Time to run	400	m =	163.6	s, or	2	min	43.6 s
Time to run	600	m =	245.5	s, or	4	min	5.4 s
Time to run	800	m =	327.3	s, or	5	min	27.3 s
Time to run	1000	m =	409.1	s, or	6	min	49.1 s
Time to run	1200	m =	490.9	s, or	8	min	10.9 s
Time to run	1600	m =	654.5	s, or	10	min	54.5 s
Time to run	2000	m =	818.2	s, or	13	min	38.2 s

At	50	% VO2max speed, or	2.22	m/s,	or	8.00	Km/h
Time to run	100	m =	45.0	s, or	0	min	45.0 s
Time to run	200	m =	90.0	s, or	1	min	30.0 s
Time to run	300	m =	135.0	s, or	2	min	15.0 s
Time to run	400	m =	180.0	s, or	3	min	0.0 s
Time to run	600	m =	270.0	s, or	4	min	30.0 s
Time to run	800	m =	360.0	s, or	6	min	0.0 s
Time to run	1000	m =	450.0	s, or	7	min	30.0 s
Time to run	1200	m =	540.0	s, or	9	min	0.0 s
Time to run	1600	m =	720.0	s, or	12	min	0.0 s
Time to run	2000	m =	900.0	s, or	15	min	0.0 s

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For 1500 m to 2000 m Runners

- **Frequency:** 3 to 4 sessions per week
- **Intensity & Volume**
  e.g., For a runner with **100%$\dot{V}O_2$max speed** = **4.44 m/s**.
  - **At least 2 sessions** at **100 to 115% $\dot{V}O_2$max speed**.
    - **1:1 work/rest ratio or below** (mild **jogging** during rest period).
    - Each run should last from **100 m to 1000 m** (**30 s to 3 minutes**).
    - Repeat running for **1.5 to 2 times** the **racing distance**.

Wong-Sir's Comments on v$\dot{V}O_2$max Running Prescription

For 1500 m to 2000 m Runners

- **Frequency:** 3 to 4 sessions per week
- **Intensity & Volume**
  e.g., For a runner with **100%$\dot{V}O_2$max speed** = **4.44 m/s**.
  - **At least 2 sessions** at **100 to 115% $\dot{V}O_2$max speed**.
    - **e.g. 1:** Training at **110% $\dot{V}O_2$max speed**.
      12-15 x **200 m** in **41 s**, jog **41 s** between each.
    - **e.g. 2:** Training at **100% $\dot{V}O_2$max speed**.
      4-5 x **600 m** in **2:15**, jog **2:15** between each.

Wong-Sir's Comments on v$\dot{V}O_2$max Running Prescription

For 1500 m to 2000 m Runners

- **Frequency:** 3 to 4 sessions per week
- **Intensity & Volume**
  e.g., For a runner with **100%$\dot{V}O_2$max speed** = **4.44 m/s**.
  - **At least 2 sessions** at **100 to 115% $\dot{V}O_2$max speed**.
    - **e.g. 3:** Training at **100% $\dot{V}O_2$max speed**.
      3-4 x **800 m** in **3:00**, jog **3:00** between each.
    - Intervals **longer** than **800 m**, which have exceeded **3 minutes** will **not** be very efficient to improve the **$\dot{V}O_2$max** of this runner.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For 1500 m to 2000 m Runners

- **Frequency:** 3 to 4 sessions per week
- **Intensity & Volume**
  e.g., For a runner with **100%$\dot{V}O_2max$ speed** = **4.44 m/s**.
  - **Other sessions** at **85 to 95% $\dot{V}O_2max$ speed** to improve **AT**.
    - **e.g. 1:** Training at **90% $\dot{V}O_2max$ speed**.
      3-4 x **1000 m** in **4:10**, jog **4:10** between each.
    - **e.g. 2:** Training at **85% $\dot{V}O_2max$ speed**.
      4000 m in **17:40**, i.e., **4:25/Km** pace.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For 3000 m to 5000 m Runners

- **Frequency:** 3 to 4 sessions per week
- **Intensity & Volume**
  - **1 to 2 sessions** at **100 to 115% $\dot{V}O_2max$ speed**.
    - **1:1 work/rest ratio or below** (mild **jogging** during rest period).
    - Each run should last from **200 m to 1000 m** (**30 s to 3 minutes**).
    - Repeat running for **up to 3 to 4 K**.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For 3000 m to 5000 m Runners

- **Frequency:** 3 to 4 sessions per week
- **Intensity & Volume**
  - **Other sessions** at **85 to 95% $\dot{V}O_2max$ speed** to improve **AT**.
    - **1:1 work/rest ratio or below** (mild **jogging** during rest period).
    - Use longer intervals (e.g., **600 m or above**).
      - Repeat running for **1 to 1.5 times** the **racing distance**.
    - **20 to 40 minutes Tempo Run** at **90% $\dot{V}O_2max$ speed or above**.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For 10000m (10 K) Runners

- **Frequency:** 3 to 4 sessions per week
- **Intensity & Volume**
  - **At least 1 sessions** at **100 to 115% $\dot{V}O_2max$ speed**.
    - **1:1 work/rest ratio or below** (mild **jogging** during rest period).
    - Each run should last from **200 m to 1000 m** (**30 s to 3 minutes**).
    - Repeat running for **up to 3 to 4 K**.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For 10000m (10 K) Runners

- **Frequency:** 3 to 4 sessions per week
- **Intensity & Volume**
  - **Other sessions** at **85 to 95% $\dot{V}O_2max$ speed** to improve **AT**.
    - **1:1 work/rest ratio or below** (mild **jogging** during rest period).
    - Use longer intervals (e.g., **1000 m, 2000 m, or above**).
      - Repeat running for **1 to 1.5 times** the **racing distance**.
    - **30 to 60 minutes Tempo Run** at **85-90% $\dot{V}O_2max$ speed** or above.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For Marathon Runners

- **Intensity & Volume** (Average Marathon time = **3:30**)
  - **Porter (1984), Grand et al. (1984), Holmich et al. (1989)**
    - On the **average** of **60 Km/week**.
    - 70% runners did **30 to 90 Km/week**.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For Marathon Runners

- **Intensity & Volume** (Average Marathon time = **2:40**)
  - **Holmich et al. (1988)**
    - 2/3 of the runners did **90-150 Km/week**, with only **one** training session per day.
    - 5 out of the total 60 runners did more than 150 Km/week and train more than 2 sessions per day.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For Marathon Runners

- **Intensity & Volume**
  - **Billat et al. (2001)**
    - **2:11 to 2:16** Marathon Time: **168 to 206 Km/week** (Men)
    - **2:32 to 2:38** Marathon Time: **150 to 166 Km/week** (Women)
  - **Karp (2007)**
    - **2:15 to 2:22** Marathon Time: **144 to 156 Km/week** (Men)
    - **2:40 to 2:48** Marathon Time: **113 to 136 Km/week** (Women)

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For Marathon Runners

- **Frequency:** 4 to 6 sessions per week
- **Intensity & Volume**
  - **Anderson (2013)**, "The Marathon is a Power Race."
  - **Men** Marathon Record – **2:02:57**
    - **Average speed:** 17.5 s/100 m or 1:10/400 m
  - **Women** Marathon Record – **2:15:25**
    - **Average speed:** 19.3 s/100 m or 1:17/400 m

Wong-Sir's Comments on v$\dot{V}O_2$max Running Prescription

For Marathon Runners

- **Frequency:** 4 to 6 sessions per week
- **Intensity & Volume**
  - **At least 1 session** at **100 to 115% $\dot{V}O_2$max speed**.
    - **1:1 work/rest ratio or below** (mild **jogging** during rest period).
    - Use longer intervals (e.g., **400 m to 1000 m**).
    - Repeat running for **up to 3 to 4 K**.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For Marathon Runners

- **Frequency:** 4 to 6 sessions per week
- **Intensity & Volume**
  - **1-2 sessions** at **80 to 90% $\dot{V}O_2max$ speed** to improve **AT**.
    - **1:1 work/rest ratio or below** (mild **jogging** during rest period).
    - Use longer intervals (e.g., **800 m or above**).
    - Repeat running for **up to 10 to 15 K**.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

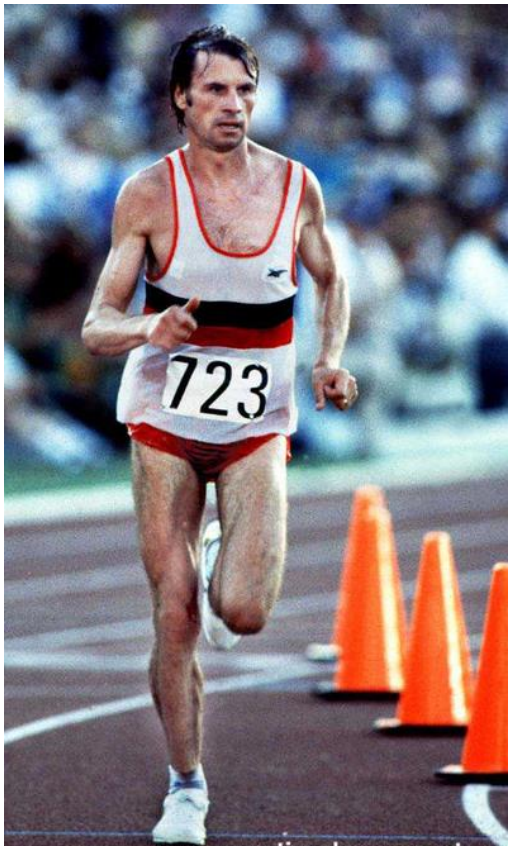
For Marathon Runners

- **Frequency:** 4 to 6 sessions per week
- **Intensity & Volume**
  - **Emil Zatopek**
    - 20 x 200 m,
      40 x 400 m,
      20 x 200 m,
      a **total** of **24 K**
      in one workout.

Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

For Marathon Runners

- **Frequency:** 4 to 6 sessions per week
- **Intensity & Volume**
  - **Carlos Lopes** (2:07:11)
    - 2 interval sessions per week
      - 15 x 400 m at 3000 m pace
      - 6 x 2000 m at 10000 m pace
    - 200-240 Km/week throughout the year



Wong-Sir's Comments on $v\dot{V}O_2max$ Running Prescription

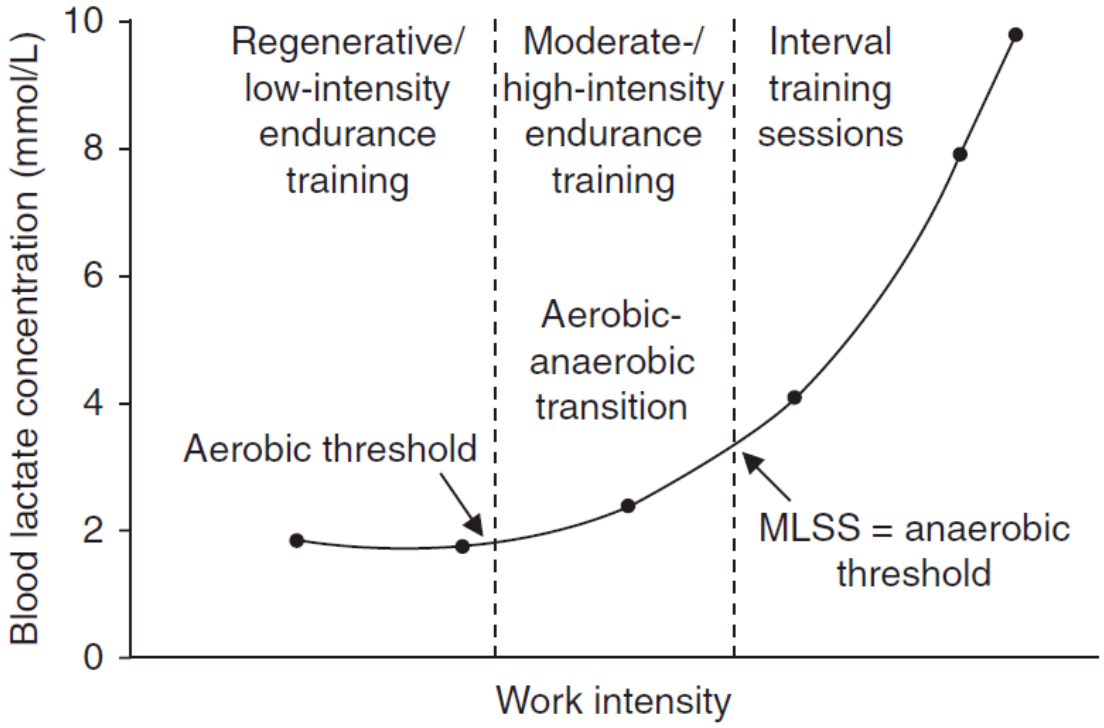
For Marathon Runners

- **Frequency:** 4 to 6 sessions per week
- **Intensity & Volume**
  - **Other sessions** at **75 to 85% $\dot{V}O_2max$ speed**.
    - Accumulating **up to 60 to 80 Km/week**, including all other sessions mentioned in this section for Marathon Runners before.

One More Thing…

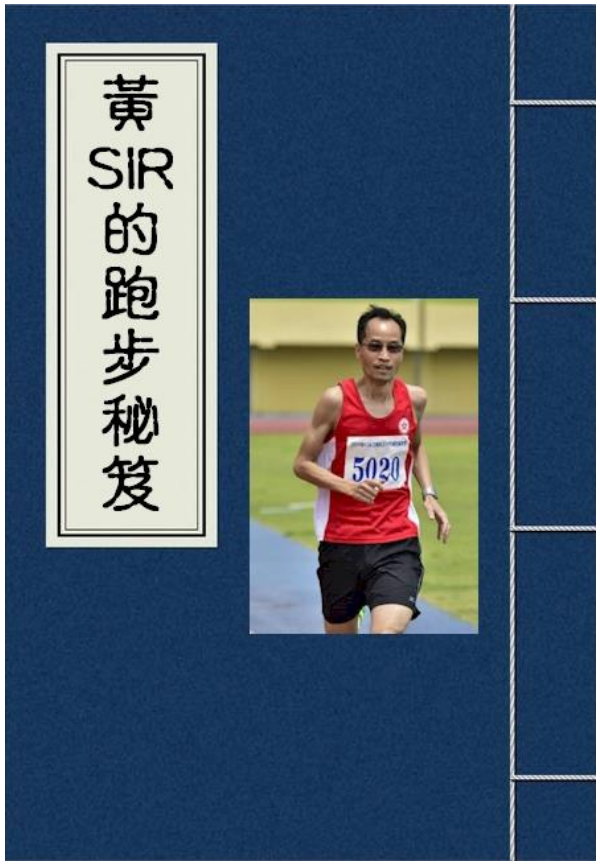
Anaerobic Threshold

- To be continued **next year…**
- **Thank you!!!**



Running Training Q&A

Want to know more...



http://www.tswongsir-runners.guide