

Appendix 3

**Kent Fire & Rescue Service**

**Physiological Report on Ship  
Firefighting Test**

**20<sup>th</sup> March 2009**

**by Eddie Fletcher MSc**

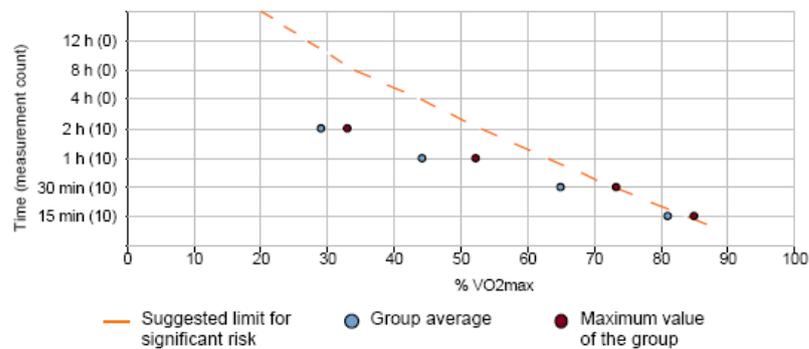
**Sport & Exercise Physiologist**

## 1. Summary

- 1.1 All participants performed the equivalent of a hard aerobic training session (so beyond normal exercise).
- 1.2 Each participant, and therefore the Group as a whole performed within an acceptable risk range. Over the most intense 30 minutes and 15 minutes periods of the exercise the duration and intensity was close to the 'line' for presenting a 'significant risk to health'.

**Figure 1 – All Group Risk Chart**

**Physical Workload Risk Chart**



Average (blue dots) and maximum (red dots) workload intensities in the group. Time indicates the length of measurement segment selected from the measurement.

- 1.3 The software equalises performances from the individual data by producing a **Recovery Index (Training Effect)** so there is a readily understood single number which ranges from 1 to 5 (calibrated in 0.1 increments up to 4.9 – level 5 just continues upwards. The level reached indicates the time needed to fully recover from the training (or exercise).

### Scale of Recovery Index

(Recovery time – depends on the time spent at each level):

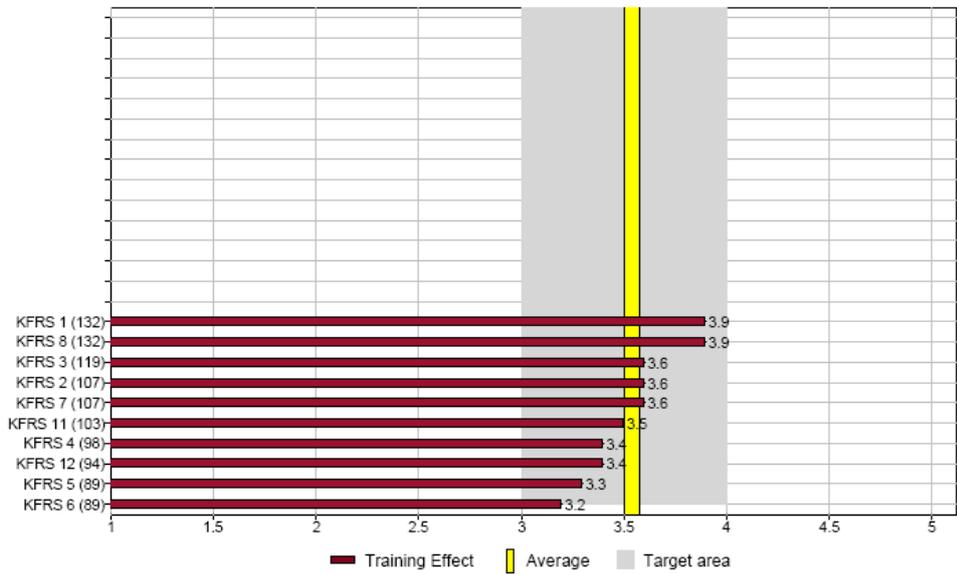
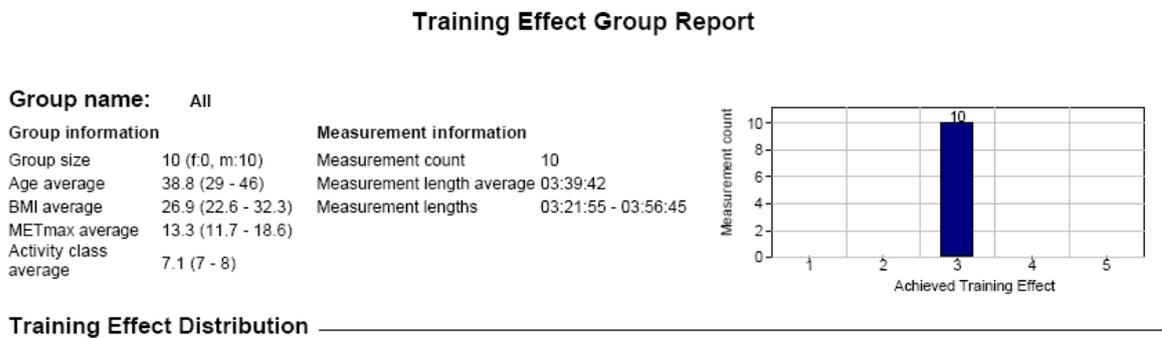
Scale	Recovery time in hours/days
1-2	3 hours to 1 day
2-3	1 to 2 days
3-4	1 to 4 days
4-5	2 to 7 days
5	7 days +

1.4 The **Recovery Index** results for the group range are 3.2 to 3.9 with a mean of 3.5 so recovery 1 to 4 days (1 day at 3.2 and 4 days at 3.9).

See Also section 4 - RMSSD

Subsequent bouts of intense training during that recovery period will exacerbate fatigue and could lead to clinical over training in the long term or short term fatigue, illness, injury, lack of concentration etc. Light exercise in the 1-2 **Recovery Index** range will help overall recovery.

**Figure 2 – All Group Recovery Index**



Training Effects' distribution and average. Darkened area displays the set exercise target area. The figure after the person's name indicates the achieved EPOC-level.

	<b>EPOC</b>	EPOC (Excess Post-exercise Oxygen Consumption) is a physiological measure of training load. EPOC peak is the general disturbance to homeostasis brought on by exercise.
	<b>Training Effect</b>	Training Effect is a measure of the fitness effects that the exercise is having to respiratoral and vascular organs.

- 1.5 At this level of exercise the ability to function effectively is close to maximum although all participants were in the target acceptable area – in a real situation a more measured rational response would be necessary to enable fire crews to make crucial decisions. It would be interesting to measure fire crews in real situations to see whether the intensity level is more or less than that experienced in the exercise.
- 1.6 It should be noted that that despite the acceptable overall duration and intensity of the exercise all participants performed at, or close to maximum heart rate in the first exercise and I suspect that this would also be repeated in a real firefighting situation.
- 1.7 The rapid rise in the recovery index in the individual charts is due in part to the heart rate being at a high level for some time. The link is duration-intensity-recovery where even a short duration at high heart rate can produce a long recovery period. This accounts for the high risk factor for 15 minutes in Figure 1 – All Group Risk Chart. The reluctance to use maximal fitness tests would therefore appear contradictory.
- 1.8 The second exercise later, whilst of a lower intensity is a compounding factor which extends the recovery period. It is further compounded by the lack of recovery between the exercises for some of the participants as evidenced by the individual RMSSD charts (see section 4).
- 1.9 The response of the participants in this exercise would have been heightened with some pre-test anxiety and the influence of heat and dehydration which would elevate heart rate and blood pressure.
- 1.10 The Chart below gives an overview for each participant of the time spent in each of three upper types of endurance classification classified as follows:

Type 3 > 30% of  $VO_{2max}$ , Type 4 > 50%  $VO_{2max}$ , Type 5 > 75% of  $VO_{2max}$

**Figure 3 – All Group Endurance Type Classification**

## Statistics

Name	Measurement duration	Endurance Training Classification					Heart Rate		Oxygen Consumption ml/kg/min (%VO <sub>2</sub> max)	
		Type 1	Type 2	Type 3	Type 4	Type 5	Average	Range	Average	Maximum
KFRS 1	3h 30min			22 min	28 min	25 min	123	92 - 191	13 (33%)	40 (98%)
KFRS 8	3h 30min			22 min	28 min	25 min	123	92 - 191	15 (33%)	45 (98%)
KFRS 3	3h 30min			12 min	15 min	27 min	113	72 - 194	14 (28%)	47 (95%)
KFRS 2	3h 24min			19 min	17 min	25 min	111	65 - 186	12 (28%)	40 (96%)
KFRS 7	3h 44min			18 min	28 min	15 min	117	72 - 202	12 (27%)	44 (97%)
KFRS 11	3h 21min			23 min	16 min	17 min	111	79 - 179	13 (29%)	43 (91%)
KFRS 4	3h 54min			13 min	18 min	19 min	105	62 - 197	11 (24%)	45 (98%)
KFRS 12	3h 56min			36 min	33 min	17 min	117	82 - 186	14 (32%)	41 (98%)
KFRS 5	3h 52min			16 min	19 min	12 min	113	76 - 201	11 (25%)	43 (98%)
KFRS 6	3h 52min			10 min	19 min	20 min	105	63 - 201	16 (24%)	63 (97%)
Average		0 min	0 min	19 min	22 min	20 min	114	75 - 193	13 (28%)	45 (97%)

Endurance training classification types are measurement specific.

Set Training Effect target area

To appreciate how difficult maintaining exercise at these levels consider the following scale.

This scale generally describes the intensity of exercise as a percentage of **maximum oxygen uptake (VO<sub>2</sub>max)**.

- < 30% - daily physical activities, very light aerobic training
- < 50% - light to moderate pace, basic endurance training
- < 75% - moderate to hard pace, very hard endurance training
- > 75% - very hard **VO<sub>2</sub>max** training

1.11 Energy Expenditure during the exercise was

**Figure 4 – All Group Energy Expenditure**

## Energy Expenditure

	Average	SD	Range
Total energy expenditure (kcal)	1181	152	934 - 1480
Net energy expenditure during exercise	670	126	508 - 857
Net energy expenditure during everyday routines and tasks	87	33	56 - 149
Energy expenditure due to other causes	424	45	348 - 482
Estimated daily energy expenditure	2744	251	2257 - 3129

## 2. General

2.1 The data for participants 9 and 10 has been excluded (one Instructor and one where the data raises a number of questions about the individual) as has data for participants 13 and 14 due to HR belt transmission issues.

2.2 Out of 14 participants there are individual data for 12 participants and 10 included in the main analysis.

## 3. Participant data

3.1 The participant data is attached as appendix A with Individual Charts in appendix B.

Explanations:

### 3.2 Body Mass Index (BMI)

BMI is a straight forward relationship between a persons height and weight calculated from the formula  $\text{weight (kgs)}/\text{height (m)}^2$  – it should be used with caution and in conjunction with other occupational health information about the individual – whilst the normal BMI for men is 20-25, BMI can be equally a measure of lean body mass (muscle).

3.3 **Resting heart rate** is set at either at a rate given by the participants or at a rate observed during the exercise rest periods.

3.4 **Maximum heart rate** is a mixture of system default or maximum achieved in the exercise – they are reasonable values upon which to base the analysis – illustrates the issues around using maximum heart rate formulas.

3.5 **Forced Vital Capacity** is system generated.

3.6 **Maximal Oxygen Uptake ( $\text{VO}_{2\text{max}}$ )** is system estimated from the basic personal data of age, height and weight coupled with an assessment of 'fitness' level based on the participants ability to do the exercise. The resultant  $\text{VO}_{2\text{max}}$  may be higher or lower than actual – specific maximal or sub-maximal tests should be carried out to obtain actual figures.

$\text{VO}_{2\text{max}}$  has been shown as millilitres per kilogram of body weight and as absolute figures - for some tasks absolute  $\text{VO}_{2\text{max}}$  is the more appropriate measure.

It should be noted (see BMI) that simply losing weight will increase the  $\text{VO}_{2\text{max}}$  per kilogram of body weight.

**METs (maximum performance capability)** is  $\text{VO}_{2\text{max}}$  divided by 3.5 (3.5 ml/kg is the oxygen consumption at rest i.e. 1 MET).

3.7 **Activity Class** is an estimate of the 'fitness' level of a participant. Activity class has been set at a minimum of 7 which assumes that each participant undertakes a minimum of 3 hours physical activity per week (including work based activity).

3.8 All the Personal Settings are transferred into the **Suunto Training Manager** and **Firstbeat HEALTH** software to produce the Individual and Group reports.

3.9 The **Suunto Training Manager** software calculates individual **Recovery Index** (known as **Training Effect** in the software), **Ventilation Rate**, **Respiration Rate** and **Total Energy**.

3.10 **Firstbeat Health** produces the time spent above 30%, 50% and 75% of  $VO_{2max}$ , breaks the **Total Energy** down into segments and estimates **Total Daily Energy**. In addition Firstbeat Health produces all the individual Physical Workload, Training Effect, Energy Expenditure and statistical Analysis Reports.

#### **4. RMSSD**

4.1 **RMSSD** = Root Mean Square of Successive Differences – it is simply an index of recovery and can be used to determine recovery from physical workload. High values are related to recovery with low values indicating poor recovery.

4.2 During the day the value should be at least 15 but normally over 25. During the night the value should be at least 50 % higher (20-30) although athletes can have a value of several hundred. These limits are just guidelines; medication, heritage and training status also influence the level.

Research indicates that these limits may be associated with burn-out.

4.3 There are many lifestyle reasons why recovery may not take place so. It is important to establish an individual baseline values over a period of time for comparison purposes.

However it would be 'normal' to see recovery taking place in between the two exercises that were carried out on the 20<sup>th</sup> March 2009.

The Individual Charts of the participants are included as appendix B.

Recovery is present in the charts of participants – 3, 4, 6, 7, 10, and 12.

Under recovery is present in the charts of participants: 1, 2, 5, 8, 9, and 11.

No conclusions can be drawn from one chart but serve as a start point for further Occupational Health investigation.