PIONEER OF WEARABLE SPORTS TECHNOLOGY

White Paper

Polar EnergyPointer

Research and Technology

April 5, 2008

CONTENTS

1. Introduction

This document describes the background and development of EnergyPointer (earlier Fat/Fit target zones), a novel feature that was first introduced as feature of the Polar FT40 heart rate monitor in 2008. This feature is called “EnergyPointer” and it helps training people to determine an intensity that corresponds to their individual target for each training session. When keeping the heart rate in the FAT zone, the main benefit of exercise is increased metabolism, particularly increased fat oxidation. In the FIT zone the main benefit is improved cardiovascular fitness.

Several studies have described the relationship between training intensity and fat oxidation. The intensity where fat oxidation is at a maximum in grams per minute has special importance for weight management programs, health-related exercise programs and endurance training (Jeukendrup and Achten 2001). In laboratory conditions, fat oxidation can be measured with respiratory gas analyzer. The determination requires quantification of the oxygen consumed and carbon dioxide produced in steady state exercise. As it is not possible to use laboratory devices in normal training, it is useful to find alternative ways for determining optimal intensities for fat oxidation and other exercise targets.

Heart rate can be used to determine suitable training intensity to improve or maintain cardiorespiratory fitness. The ACSM position stand (1998) states that fit individuals should exercise at an intensity of 55–65% to 90% of HR max. However, this description practically includes all kind of physical activities, and training at the low end of the given scale induces entirely different training stimulus from the high end. More detailed and individually determined training zones are needed.

Polar EnergyPointer provides individually defined target zones for fat oxidation and fitness improvement. This feature provides information on the effect of training intensity for the body. EnergyPointer limit is individually determined based on heart rate and its variability during exercise. The determination method has been developed in co-operation with Polar Electro Oy and international research groups. The decrease in HRV has been shown to be strongly linked to withdrawal of parasympathetic activation (Tulppo et al. 1996), and the point where HRV levels off marks the low end of fitness training zone.

Development of Polar EnergyPointer zones became possible as research revealed new ways to link heart rate variability to maximal fat oxidation during exercise. Research was done in Polar Electro Oy, Kempele, Finland in collaboration with Human Performance Laboratory in Birmingham, UK. The feature is based on heart rate and heart rate variability measured online during training. Age, gender, body height, and weight and fitness are also taken into account.

2. Background of development

Low intensity training increases fat oxidation and has several health benefits. Research has shown that there can be a large individual variation in the ability to oxidize fat during exercise. Moderate to high intensity training increases the metabolism, particularly carbohydrate oxidation. High intensity training is needed for optimal fitness development since temporary overloading is necessary for adaptations in the body. The aim of EnergyPointer is to define individually what is the limit between Fat and Fitness zones.

In human body, energy is produced aerobically from carbohydrates, fats and proteins. Since proteins are the least important energy source, they are usually left without attention. The mixture of carbohydrates and fats used as energy substrate differs depending on the intensity and duration of exercise. In absolute terms, carbohydrate oxidation increases proportionally to exercise intensity, whereas fat oxidation increases from very low to low intensities, but decreases again at higher intensities. Figure 1 illustrates the situation.

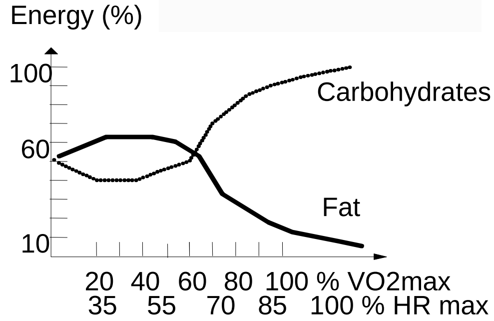

Figure 1. Energy sources during exercises at a variety of intensities. (Fogelholm 1997)

Referring to exercise intensity at maximal rate of fat oxidation in grams per minute, the term FatMax was introduced by Jeukendrup and Achten in 2001, see Figure 2. Venables et al. (2005) determined FatMax for 300 people. On an average, FatMax was reached at 48.3% of maximum oxygen consumption (VO2max) and 61.5% of maximum heart rate. Maximal fat oxidation capacity can vary largely between individual, depending on several factors that affect muscle cell metabolism. If men and women are compared, women are able to oxidize fat at higher intensities than men. Intra-individual differences are caused by changes in nutritional and training status, and menstrual cycle status in females. If exercise intensity is maintained, increased duration slightly increases fat oxidation.

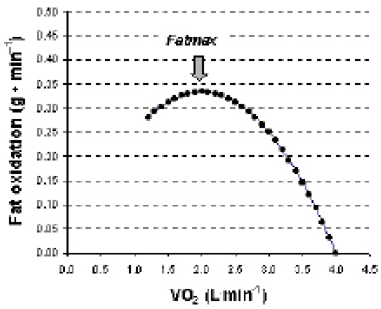

Figure 2. Fat oxidation and oxygen consumption in progressively increasing exercise intensity. (Jeukendup & Achten 2001).

A novel finding utilized in Polar EnergyPointer is that higher beat-to-beat variability during low intensity training indicates better ability to oxidize fat.

3. How EnergyPointer is determined?

Polar determines individual limit between Fat oxidation and Fitness target zones. The method finds the limit by using heart rate and heart rate variability measured online and personal characteristics (age, gender, body height, weight, HR max, VO2max) that can be input to the HRM. Polar has applied for a patent for this novel method**.**

From the user point of view, the determination is an automated process that runs in HRM. If a person stays in Fat zone, the previously determined limit is shown on the HRM (Display 1). When user selects this feature into use the first time, the limit is estimated based on the user's characteristics. If heart rate variability indicates that the EnergyPointer limit is approaching soon or has been crossed, the limit will be updated on the display. The heart symbol on the display will indicate if the person is training in the Fat Zone (Display 2) or the Fitness Zone (Display 3).

Display 1

Training in the Fat Zone: determining Fat/Fit-limit
Heart rate is 118 and the latest/estimated Fat/Fit-limit is 124 bpm. Fat/Fit-limit has not been reached during current exercise session so far.

Display 2

Training in the Fat Zone
The Fat/Fit-limit has been determined during this exercise session to be 128 bpm. The person is training in the Fat Zone.

Display 3

Training in the Fitness Zone

The heart symbol indicates that the person is currently training in the Fitness Zone.

At the end of training the user gets the result for his/her training session: how much time was spent and how many calories burned in each zone, and the percentage of calories that were oxidized from fat.

The lowest possible Fat/Fit limit is set to 100 bpm. The highest possible Fat/Fit limit is 80% HR max, because 80% HR max can be associated with Fitness enhancing physical activity with certainty, even if the person has an exceptionally good fat oxidation ability at high intensities. This limit is in alignment with ACSM recommendations for exercise prescription for vigorous intensity.

4. Benefits of EnergyPointer

Facilitation of fat metabolism is important in both health-related and performance-oriented exercise. The Fat/Fit feature can be used as part of health-related exercise, weight management, and endurance training.

Changes in fat metabolism are beneficial for a variety of clinical conditions, for example, diabetes. An increased amount of training can be used to serve weight management targets, either on its own or more usually together with diet. When exercise is the most essential part of weight management, the goal is usually more specifically to reduce body fat. The ability of an athlete to mobilize and oxidize fat is an important part of endurance performance. This ability is most likely achieved by specific training. (Jeukendup & Achten 2001)

In order to achieve optimal fitness improvement, it is important to exercise at higher intensities as well. Exercising at the Fitness Zone, i.e. moderate and high intensities, improves cardiovascular capacity. Fitness Zone challenges human body in a different way from Fat Zone: it transiently increases oxygen need in exercising muscles leading to increased ventilation, blood flow, blood pressure, and increased sweating. As long-term results of training, vascular tissue becomes more flexible, capillary blood flow improves and cardiac muscle becomes stronger, especially the left ventricle, which increases the stroke volume of the heart. Together, training adaptations lead to improved performance and lower heart rates at rest and during sub-maximal training.

5. Validity, reliability, and repeatability

To assess the validity of Polar EnergyPointer zones, we determined individual fat oxidation ability and its relation to heart rate variability in 300 individuals. More specifically, we analyzed the heart rate level at which fat oxidation falls below 90% of individually determined maximal fat oxidation rate (FatMax). Figure 3 illustrates how EnergyPointer limit associates with individually determined FatMax.

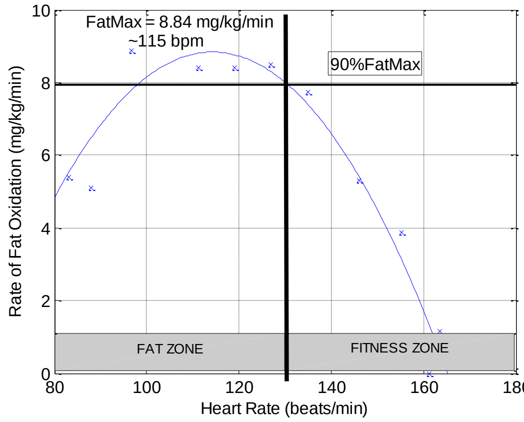

Figure 3. Fat oxidation during increasing training intensity. FatMax was determined by fitting an inverted parabola to Fat oxidation values. Adapted from Salmi 2007.

Polar EnergyPointer -feature determines fat and fitness zones based on heart rate variability and background variables. EnergyPointer corresponds to 69% HR max (in women 72% and in men 67%) on an average. Figure 4 shows that statistically significant correlation with individually determined maximal fat oxidation is reached.

Good repeatability of Polar EnergyPointer limits and individual fat oxidation capability was found in 12 women by Salmi, 2007 who repeated a similar exercise session seven times separated by one week from each other.

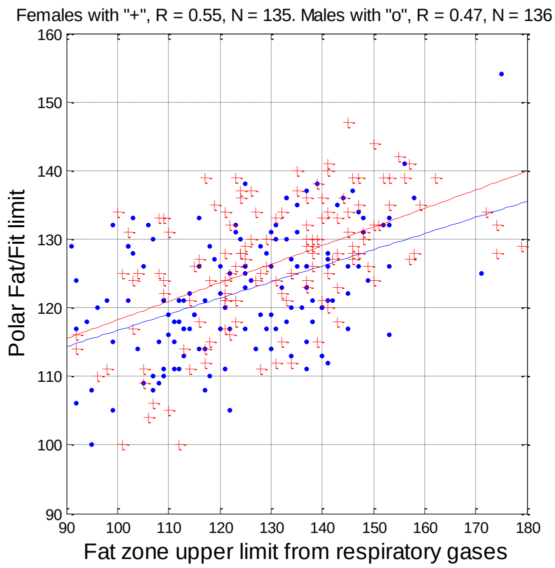

Figure 4. The Polar Fat/Fit limit associates with heart rate when fat oxidation has fallen 10% below individual maximal fat oxidation rate. Females with "+", N = 135, R = 0.55. Males with "o", N = 136, R = 0.47.

6. Limitations

The ability to oxidize fat during exercise is highly individual. Some people are able to oxidize fat significantly also at high intensities, e.g. above 80% HR max. Regardless of this, the Polar Fat/Fit limit was restricted to take place no higher than 80% HR max because significant fitness benefits are obtained at this intensity.

This feature does not count for slightly increased fat oxidation with increasing exercise duration. This is not a big problem because a longer training duration increases fat oxidation almost evenly at all intensities (Meyer et. al. 2007).

7. References

Fogelholm M. In book Lihavuus - ongelma ja hoito (Obesity problem and treatment). Eds Fogelholm et al. Duodecim 1997, p.130

Jeukendrup, A.E. 1997. Aspects of carbohydrate and fat metabolism during exercise. The University of Maastricht. Doctoral thesis.

Jeukendrup, A.E. & Achten, J. 2001. Fatmax: A new concept to optimize fat oxidation during exercise? European Journal of Sport Science, 1(5), 1–5.

McArdle, W.D., Katch, F. & Katch, V. 2001. Exercise physiology: energy, nutrition, and human performance. 5th edition. Lippincott Williams & Wilkins, Philadelphia.

Meyer T., Gässler N., and Wilfried Kindermann. 2007. Determination of “Fatmax” with 1 h cycling protocols of constant load. Appl. Physiol. Nutr. Meab. 32: 249–256.

Salmi, U. M. 2007. Daily variability of maximum fat oxidation rate (Fatmax) and determination of it by using heart rate variability. The University of Jyväskylä. Masters thesis.

Tulppo MP, Mäkikallio TH, Takala TES, Seppänen T & Huikuri HV. 1999. Quantitative beat-to-beat analysis of heart rate dynamics during exercise. Am J Physiol; 271 (Heart Circ Physiol 40): H244–H252.

Venables M.C., Achten, J. & Jeukendrup, A.E. 2005. Determinants of fat oxidation during exercise in healthy men and women: a cross-sectional study. Journal of applied physiology 98. 160–167