Development and Evaluation of Polar OwnZone Feature

The OwnZone determination in Polar heart rate monitors is based on heart rate variability (R-R-interval) measurement during exercise and it is a result of an extensive research co-operation between Polar Electro Oy and international research groups. Heart rate variability (HRV) has traditionally been referred only in medical research in patients. Polar got interested in HRV in the beginning of 1990 when a Russian scientist presented his findings to the Polar R&D department. In 1993 Polar started research co-operation with the Merikoski Rehabilitation and Research Center, Oulu, Finland, to find out if HRV could be useful also in healthy subjects at rest and during exercise.

The first study projects were done with sedentary subjects and with top athletes at rest. The athletes had higher HRV at rest than the sedentary subjects (unpublished). Preliminary research was also done during acute stress and anxiety on adults. Even though HRV was related to stress, no notable results for the use of Polar Electro were found. HRV was further investigated in athletes before and after resting (2 months) and training (16 weeks) periods (Mäkikallio et al. 1996). In this phase of co-operation, the division of Cardiology at the University of Oulu joined the project to ensure experienced medical advice.

The next research project was a 3 months training study with relatively sedentary subjects. The results did not show any changes in the resting HRV after training (unpublished). However, in this project the systematic repeatability in the HRV decrease during graded exercise was found. A quantitative Poincaré plot analysis method for HRV analysis was adopted (Huikuri et al. 1996). A large bicycle exercise study with 110 men started (Tulppo et al. 1996a,b). An additional trial with atropine medication (parasympathetic blockade) was performed. It was shown that the Poincaré plot method can be used as a reliable analysis method of HRV during exercise (Tulppo et al. 1996a,b). On the average, the HRV "plateau" (Poincaré plot, SD1) was found at 50-55% of maximal aerobic power (VO_{2max}) or at about 61-65% of the maximum heart rate (HR_{max}). In this phase Polar and Merikoski started co-operation with the Cooper Institute for Aerobics Research in Dallas, Texas, USA. Another large sample of 120 adult men and women was studied during treadmill exercise to ensure the previous finding of HRV plateau during exercise (Tulppo et al. 1996c, Wilkinson et al. 1996a,b, 1997, 1999). The plateau occurred at somewhat higher percentage of the maximal aerobic power on the least fit subjects (57%) compared to the most fit ones (53%) (Wilkinson et al. 1996c). The HRV measures were shown to be independent of the absolute heart rate (Thompson et al. 1997). Because all aforementioned studies concluded that the HRV measures could serve as reliable markers of exercise intensity, Polar adopted the method for technical development. This resulted in the OwnZone function.

After the basic research described above, several other study projects have been carried out in co-operation with the Merikoski Center from 1997 on. A large sample of 110 males was further analyzed and age was shown to explain the HRV at rest and physical fitness during exercise (Tulppo et al. 1997a,b, 1998a). One study has been conducted on the repeatability of the HRV measures. In this work every subject was measured on four consecutive days (two days between each) to detect possible day-to-day variation in HRV during exercise (Tulppo et. al. 1998a). Another study has been done on bicycle and on treadmill both at steady-state and during interval exercise to detect possible differences between exercise modes. The results showed that the HRV plateau, as expressed in percentages of maximal aerobic power, is well repeatable, and the changes in the autonomic modulation of HR were comparable during arm and leg exercise (Tulppo et al. 1999) Three of the aforementioned studies (Tulppo et al. 1996b, 1998a, 1999) have been discussed also in the doctoral dissertation by Mikko Tulppo on December 1998 (Tulppo 1998b).

In the early phase of the OwnZone development, a controlled trial with a SmartEdge heart rate monitor simulator was done in the laboratory. The OwnZone determination developed was consistent (unpublished). SmartEdge prototypes were used in a field validation study on 50 adults to study if the field determination of the OwnZone done by slow to fast walking-jogging warm-up protocol is consistent with the HRV plateau measured in the laboratory. The lower and the upper OwnZone target heart rate limits determined by SmartEdge were (mean±SD) 121±8 and 154±9 bpm and corresponded to 64±4% and 82±5% of maximal heart rate, respectively (Laukkanen et al. 1998).

In a field study on ten adults, the OwnZone determination test (incremental warm-up) was done twice a day for a month (unpublished). In this group 90% of the subjects achieved the HRV-based OZ determination (OZV) with an individual variation of 5-10 bpm. The OZ values tended to be 3-5 bpm lower when the test was done in the morning (within 2 hours from waking up) than those determined in the evening (after 6 p.m.). The lowest HR limits were obtained in cycling, and the highest in cross-country skiing. The values in walking-jogging were in between. A resting period (several days without physical activity) as well as long-duration, low-intensity recovery-type exercise seemed to increase the OZ heart rates slightly, whereas bad sleep and stress feelings tended to decrease the heart rates.

The reproducibility of individual training heart rate determined by Polar SmartEdge HR monitor has proven to be good (Kinnunen et al. 1998). In this study on healthy males the OwnZone determinations were repeated four times with four days of recovery in between. In a study on 50 obese men and women (mean BMI 37 kg/m^2) the lower and upper OwnZone HR limits determined by the SmartEdge corresponded to 118 bpm (68% HR_{peak}) and 150 bpm (86% HR_{peak}) on the average (Byrne et al. 1999). On 50 non-medicated hypertensive males and females (mean age 45 years) the lower and upper HR limits determined by the SmartEdge corresponded to 113 bpm (66% HR_{peak}) and 147 bpm (85% HR_{peak}) on the average (Byrne et al., submitted). On 58 keep-fit middle-aged marathon runners, men and women, the OwnZone lower limit corresponded to 117 bpm (65% HR_{max}) and the uppr limit to 147 bpm (83% HR_{max}) on the average (Virtanen et al. 2000).

The latest position stand of American College of Sports Medicine (ACSM 1998) for the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory fitness in healthy adults recommends 55/65-90 % of maximum heart rate for the intensity of training. The results obtained on Polar OwnZone indicate that it can be used for feasible target heart rate zone determination in adults.

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