Comparative Study of Heart Rate Training Versus Power Training for Cycling Performance

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***Abstract: Relative comparison between HR and Power training to see which one was more effective. Purpose: To make a comparative study and determine the more effective methodology of cycling training. Methods: 10 amateur cyclists used different training metric devices i.e. HR Monitor or Power Meters to see the difference in performance after a training period of one month. FTP tests were conducted; results were measured and recorded before and after the 1 month training plan. The percentage improvement in FTP in one month was recorded after the athletes completed their training using Heart Rate training metrics and subsequently Power Training metrics. This sample data was used to calculate mean percentage improvement for HR and Power Training methodologies. Results: Mean percentage improvement for Power training samples was 5.70% and mean percentage improvement for HR training samples was 2.20%. Conclusion: Power training is more effective than HR training for cyclists in terms of training intensity*.**

Keywords: FTP, Heart rate, Periodization, Power.

1. INTRODUCTION

Over the years cycling has evolved as one of the most exciting competitive sports across Europe, America and parts of Asia. In the later 1800's, cycling inside velodromes had become one of the most attractive spectator sports in America. As track cycling was evolving so quickly, road cycling became a parallel sport of attraction across Europe in the early 1900's. The most prestigious cycling race of all time 'Tour de France' was found in the year 1903. There were many more races that eventually came to existence globally. A few examples of famous road cycling races are Paris-Roubaix, Giro d'Italia, Milan San Remo, World Championships and many more. Cycling was eventually recognized as an Olympic Sport.

In the recent years, there was a lot of money and effort being put into identifying the most effective method of training for competitive cycling [1]. Athletics were constantly evolving and track records were being broken. The evolution of science technology has been helping the development of cycling by providing precise statistic data. This made it easier to track the development and performance of cyclists in terms of numeric data. This invited variety in coaching methods by facilitating them with the usage of technology. The amount of money being put into cycling allowed sponsorships from various business establishments. The few effective methods of cycling training include HR (Heart Rate) Training, Power Training and RPE (Rate of Perceived Effort) [2].

RPE is the most basic way to express training intensity; however it carries great value and helps athletes keep in touch with their individual bodies [2]. RPE does not give any value or determination of the physiological body stress or the work done by the body. It is generally used by rookie cyclists. It expresses the intensity that an individual experiences on a scale of 1-10. It is a beneficial methodology to recognize the physical limitations of the body through proprioception [2].

Heart Rate Training is a fairly advanced methodology for training and it is widely used amongst all amateurs globally. Heart Rate is a direct indicator of training intensity on a physiological level. It shows the effort done during cycling, however it doesn't determine the mechanical performance of a cyclist [2].
The lack of information provided by RPE makes HR Training and Power Training as preferred training methodologies [2].

HR Training is a methodology which gives a numeric record of HR in units of bpm (beats per minute). The heart rate is directly proportional to training intensity; it increases with increase in training intensity and vice versa. It provides details on the adaptation of the heart with varying training intensity and physiological stress that athletes undergo [1, 3, 4, 5, 6, 7].

Uli Schrober was a German engineer who discovered the Power Meter, 10 years after the Heart Rate Monitor was discovered. The purpose of designing a power meter was to have an accurate measurement of performance intensity. The evolution of cycling from a barely technical endurance sport, to the most technical sport is due to the invention of the power meter. It helped the sport enter a new dimension [2].

Power Training has helped revolutionize cycling training into one of the most technical forms of sports training [1]. Power training takes a measure of force that is applied on the pedals and the speed at which pedals are turned [2]. Pedal force and pedal speed are termed as "torque" and "cadence" respectively. The combination of torque and cadence is given in watts (unit of power) [2]. Power training helps in giving statistical data of the work done by athletes while training and it is preferred over HR training. The power numbers drop to 0 watts as soon as a cyclist stops pedaling however HR takes some time to recover and hold constant values independent of the cadence [1]. This makes data more accurate and efficient however it cannot give a value of biological stress, unlike HR training. Power data facilitates the calculation of FTP (Functional Threshold Power). FTP represents an athlete's ability to sustain highest possible power output over a period of 8 minutes, 20 minutes or 1 hour [8].

Periodization plays an essential role in the training cycle of a cyclist. The various phases of periodization are Base Period, Build Period, Peak Period and Race Period [9]. It essentially includes strategizing and formulating structured training plans in terms of training volume and training intensity. The training volume and intensities are distributed differently through different training periods, based on impact of training [9, 10, 11]. It is a necessity for cyclists to keep evolving and improve their performance so as to be competitive enough in their field [12].

Heart Rate provides the athletes with a measure of physiological factors which helps them recognize their physical limitations while working out. Heart Rate training predominantly helps cyclists to attain the best results without overtraining. Power is the most accurate measure of training intensity and heart rate is relatively easier to track. There are limitations to heart rate training such as varying heart rate with different positions on the bike at a certain training intensity. The biggest limitation for Heart Rate Training is the rate of change of heart rate with respect to time, termed as the ‘cardiac drift’. The cardiac drift can drastically affect the relationship between heart rate and exercise intensity, especially in high altitudes or high surrounding temperature [13].

Heart rate is more effective in determining the stress undergone by the body, whereas power is more effective in giving a measure of exercise intensity. Hence it is vital to understand if one is interested in measuring total body stress or exercise intensity. Heart rate training is very useful as it helps in early detection of overtraining [13].

As mentioned above Power Training is the most accurate methodology for determining training intensity whereas Heart Rate Training has limitations. Power is calculated by measuring the force applied on the pedal (Torque) and the pedal speed (Cadence). Cadence and torque are combined together to give Power, which is expressed in Watts [2].

Athletes need to constantly monitor their training intensity to assess their performance; therefore it is necessary to have intensity reference points. As per research, “Aerobic Threshold” and “Anaerobic Threshold” are the most commonly used reference points in terms of physiological factors. An athlete attains Aerobic Threshold at 3 or 4 on the RPE scale, or simply at 65 percent of maximal heart rate. Anaerobic Threshold is attained at 7 on the RPE scale. This point is also termed as the “Lactate Threshold”. Road Cycle racing involves most cyclists who spend most of the time period with intensity between Aerobic and Anaerobic threshold, however the race results are decided by the performance that occurs beyond the Anaerobic Threshold i.e. when the RPE is greater than 7 out of 10. Thus competitive cycling emphasizes on the importance of High-Intensity Training.

Training intensities always lay in relativity with the two thresholds i.e. Aerobic and Anaerobic. Race specific training involves training beyond the anaerobic threshold point to attain a result. Seasoned cyclists weigh a lot of importance on Race Specific Training. One of the most vital reference points for cyclists is, Functional Threshold [1].

Functional Threshold in terms of Heart Rate (FTHR) is the sustained average heart rate that a cyclist can maintain over a certain period of time. The time can be 1 hour, 20 minutes, 8 minutes, or 5 minutes [8]. It is essentially a physiological reference flag [1] that enables a cyclist to recognize individual Heart Rate Zones. Tests that have a time period less than 20 minutes are not very accurate for determining FTHR.

Functional Threshold in terms of Power (FTP) is defined as the maximum power sustained by a cyclist in a nearly steady state [8]. Theoretically FTP is calculated by multiplying 95 percent with the average power output over a certain period of time. They essentially help in forming Power Zones for the cyclist.

As per research, optimal performance in cycling needs training periodization [9]. Base period, build period, peak period, race period and transition period form the building blocks of performance specific training.

Base period does not focus on a race. It essentially helps an athlete prepare for the physiological stress in the Building period. The purpose of Build Period is to prepare a cyclist for the physiological stress of racing. A cyclist bears maximum fatigue during this period of training due to high volume of training. This period includes event specific training. The Peak Period is aligned to race specific training. However the training volume reduces whereas the intensity remains the same. The agenda of the peak period is to give the body some time to recover after a hard building period. This helps the cyclist to become race ready gradually. The Race Period is further aligned to race specific training with really less training volume but high training intensity. The workout durations are a bare minimum. The agenda of this phase is complete recovery from the fatigue gained in the previous phases. The Transition Period is the phase that has really low training intensity as well as training volume. The agenda of this phase is to allow full recovery immediately after a race [9, 11].

With each athlete having varying fitness levels, factors like Aerobic Threshold, Anaerobic threshold and Functional Threshold are different for each athlete. Heart Rate Training and Power Training prove to be very useful in the development of an athlete’s performance [12]. There have been other research tests conducted to evaluate the relationship between power output and heart rate during a race [14].

The literature reveals major development towards designing and constructing various devices such as Heart Rate Monitors, Bike Computers and Power Meters [1]. These devices help in statistical analysis of training. Moreover, the computed analysis can be used to modify and update respective training plans. The debate to evaluate Heart Rate Training or Power Training as the superior form of training has been ongoing since many years and hence an experiment was conducted upon amateur cyclists with varying demography to evaluate whether Power Training or Heart Rate Training was more effective for competitive cycling. The objective of this survey is to study Heart Rate Training and Power Training methods to improvise performance of competitive cyclists. The resource utilized for the experiment was a smart indoor cycling trainer and the budget was minimal.

2. METHODOLOGY

In order to have more detailed study, an experiment was conducted on a group of 10 athletes. These athletes underwent a training program for 1 month [15] with Heart Rate training methodologies and then a 1 month training program with Power training methodologies. Furthermore, a Functional Threshold Power Test (FTP Test) [8] was conducted for a period of 20 minutes to measure the percentage improvement in the performance of individual methods.

The major parameter measured was FTP. Based on the FTP, the coach prepared customized training plans [16, 17] for each athlete, keeping their training phase in mind [9, 11]. The training statistics (Heart Rate or Power) were used to make a comparative analysis.

Athletes while using Power Training Metrics were assigned the name ‘SP’ and while using Heart Rate Training Metrics were assigned the name ‘SH’; where SP and SH denote Sample Power and Sample Heart respectively. There were 10 samples which underwent 1 month of training with Heart Rate metrics as well as 1 month of training with Power metrics to achieve better performance in competitive cycling. FTP was considered as the control point of the experiment so as to determine percentage improvement in performance. Thus, relevant comparison of performance between Heart Rate and Power training metrics for the same set of samples was possible. The FTP numbers of each athlete were measured and recorded before the 1 month period commenced and ended. This data was used in calculating the percentage improvement and mean improvement in FTP. As a result, it would help to decide the superior form of training between HR and Power Training. For the same, the results are presented in Table 1 and Table 2. Comparative analysis is presented in Figure 1, Figure 2 and Figure 3.

3. RESULTS

Table I : Comparative FTP Results for HR Samples

HR SAMPLES	FTP 1	FTP 2	PERCENT IMPROVEMENT
SH1	144 W	148 W	2.77%
SH2	183 W	185 W	1.10%
SH3	212 W	211 W	-0.40%
SH4	127 W	132 W	3.90%
SH5	246 W	258 W	4.90%
SH6	199 W	201 W	1.00%
SH7	155 W	159 W	2.50%
SH8	178 W	181 W	1.60%
SH9	163 W	164 W	0.60%
SH10	187 W	194 W	3.70%
Mean Improvement	2.20%		

As depicted in Table 1, SH3 shows decrease in performance, while SH5 shows maximum improvement. SH1, SH4, SH10 show moderate improvement while the rest of the sample shows minimal improvement in FTP Mean percentage improvement for Heart Rate samples is 2.20%.

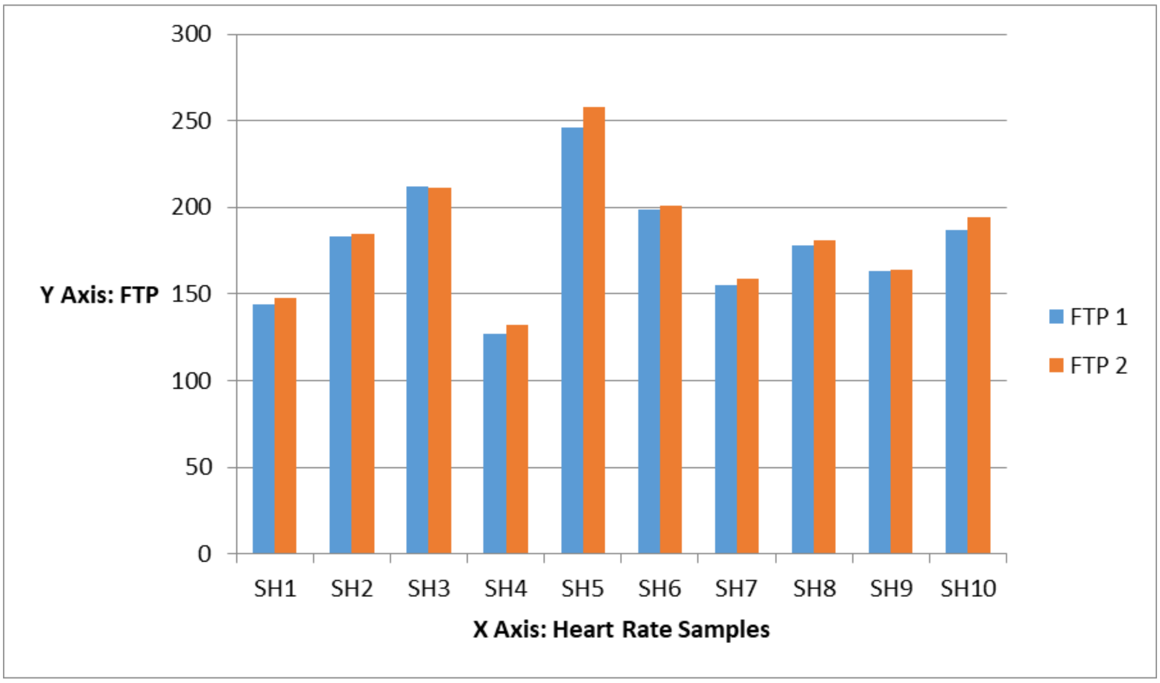

Fig.1 Comparative FTP Results for HR Samples

The graph shown in Figure 1, depicts the FTP data of the athletes who used Heart Rate Training Metrics. The X-axis denotes the samples and the Y-axis denotes the FTP. The blue bars (FTP 1) refer to the FTP data of the athletes before the one month period commenced, and the orange bars (FTP 2) refer to the FTP data post the training period.
The percentage improvement in FTP was calculated using the formula [18], Percent Improvement= {(Latest FTP- Previous FTP)/ (Previous FTP)} X100.

Table II : Comparative FTP Results for Power Samples

POWER SAMPLES	**FTP 1**	**FTP 2**	**PERCENT IMPROVEMENT**
SP1	148 W	159 W	7.40%
SP2	185 W	186 W	0.50%
SP3	211 W	224 W	6.20%
SP4	132 W	152 W	15.20%
SP5	258 W	266 W	3.10%
SP6	201 W	214 W	6.50%
SP7	159 W	167 W	5.00%
SP8	181 W	189 W	4.40%
SP9	164 W	171 W	4.20%
SP10	194 W	202 W	4.10%
Mean Improvement	5.70%		

As depicted in Table 2, SP3 shows positive improvement with Power training unlike the HR training results, which indicates better effectiveness of Power Training in terms of performance intensity. SP1, SP4 and SP6 show huge improvement while the rest of the sample shows moderate improvement. SP2 shows minimal improvement. Mean percentage improvement for Power samples is 5.70%

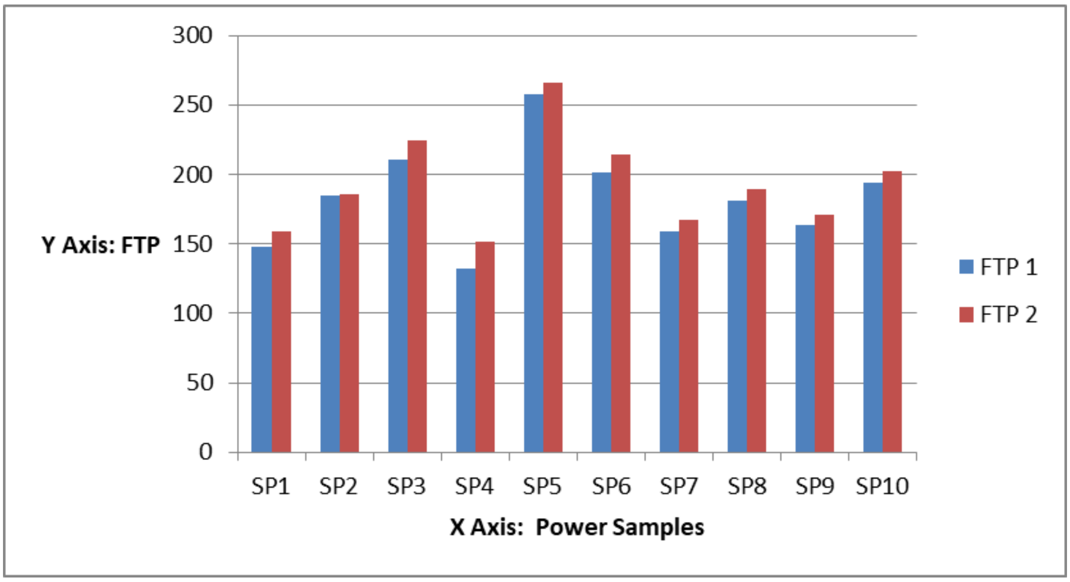

Fig. 2 Comparative FTP Results for Power Samples

The graph shown in Figure 2 similarly shows the statistics of athletes who underwent Power Training and their improvement in FTP results. The X-axis denotes the samples and the Y-axis denotes the FTP. The blue bars (FTP 1) refer to the FTP data of the athletes before the one month period commenced, and the orange bars (FTP 2) refer to the FTP data post the training period. The percentage improvement is similarly calculated using the above formula [18].

According to this study Power Training methodologies are more effective (in terms of performance intensity) than Heart Rate Training Methodologies as the percent improvement for samples using Power Training is higher.

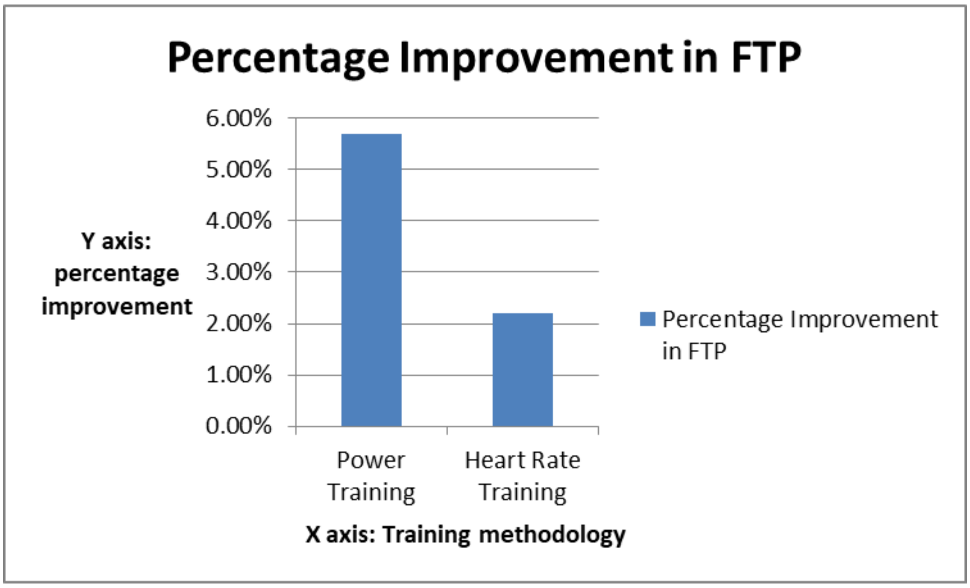

Fig. 3 Percentage Improvement in FTP

4. DISCUSSION

The purpose of this investigation was to make a comparative study of Heart Rate versus Power Training methods. Based on the results from international cycle racing, power training is proven to be as the most effective methodology of training for elite level cyclists [7]. Statistics and performances changes are primarily measured in terms of watts (Power unit) [3] whereas Heart Rate measurement during a race is considered as a secondary parameter. However, Heart Rate Training methodologies have been extremely effective in calculating parameters such as exercise intensity, OBLA (Onset of blood lactate accumulation) [6, 10], Lactate threshold [13], VO2 max (Rate at which the heart effectively uses oxygen) [5] and TSS (Total Stress Score) [3]. These parameters help in defining the limitations of individual athletes and customizing their training intensities in accordance. The athletes considered in this investigation were 10 amateur level athletes in different phases of training. The percent improvement in the FTP data does not directly indicate the cycling capabilities of the athlete on a general note. This is justified by difference in training phases. The various phases of training include base building, sport specific training, tapering, peaking and recovery [5, 22]. Athletes in build phase or peaking phase did not improve by a big margin because they underwent maximum training fatigue and maximum performance capabilities are achieved in the course of peaking phase [2]. FTP test was conducted for 20 minutes because the data for functional threshold Heart Rate (FTHR) is reliable over a long duration of time (greater or equal to 20 minutes) [8]. Samples SH2, SH6, SH8, SH9 and SP2 belonged to the peaking phase which justified the minimal percentage improvement in FTP results. The samples showing maximum percentage improvement (SH4, SH5, SH10, SP1, SP4) belonged to the transition phase from base building to specific phase. The transition from base building phase to specific phase has a big scope of improvement due to constantly improving fitness levels. The samples showing moderate improvement were in the specific phase with minor improvements in fitness levels directed towards the peaking phase. The mean percentage improvement for Power samples was 5.70%, on the other hand mean percentage improvement for HR samples was 2.20%. While studies [6, 7, 8, 19] suggest that power training is the superior methodology for elite level cyclists, this experiment comprised of pure amateur samples belonging to different training phases. The primary control points of the investigation were physical limitations of individual athletes belonging to separate training phases and their FTP. This indicated that Power Training is more effective and accurate for athletes who aim for higher performance intensity, even in a group with varying training phases, fitness level and demography, as compared to Heart Rate Training. The resources for the experiment were very limited and the budget was minimal, the calculations were recorded with the help of indoor cycling trainers. The data of 10 samples was used to generalize the survey results over a large population of cyclists.

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