WHOOP

PERCEIVED VS. OBJECTIVE STRAIN IN THE WHOOP POPULATION

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Abstract

Elite athletes need to adapt to ever-increasing performance demands. The constant evolution in sport is driven by better physical and mental performers, and modifications in training to achieve new, improved results are what most organizations are striving towards.

In an era where performance and training decisions are arbitrated by data, it is imperative that this data is measured accurately and objectively.

While one of the widely used metrics for capturing exercise intensity – rate of perceived exertion (RPE) – offers some insight into the physical load of a given workout (Alexiou, 2008), **it is neither accurate nor precise**, and thus can prompt the athlete or his coach to make inappropriate training decisions. Moreover, subjectively rating different types of activities of different durations on a single scale is particularly prone to biases.

The WHOOP Strain Score is an objective and consistent measure of cardiovascular strain that enables an athlete or coach to correctly assess the physiological stress of training through individualized strain measurements. Hence, it provides the information necessary to plan recovery, nutrition and future training in an optimal way, leading to improved performance levels and decreased risk of injury.

Rate of Perceived Exertion (RPE)

Tracking training loads through subjective scoring of physical exertion by athletes and their training staff is a common practice at all levels of competition. The aim of this practice is to determine whether an athlete is training at an appropriate intensity level so as to prevent overtraining, a physiological state that may increase the risk of athletic injuries (Anderson et al., 2003). Even through low-tech subjective scoring, a coach is provided with valuable clues as to when an athlete may need an adjustment to his recovery and nutrition plans. A popular scale on which to quantify physical effort is the Borg Scale of Perceived Exertion, diagramed below.

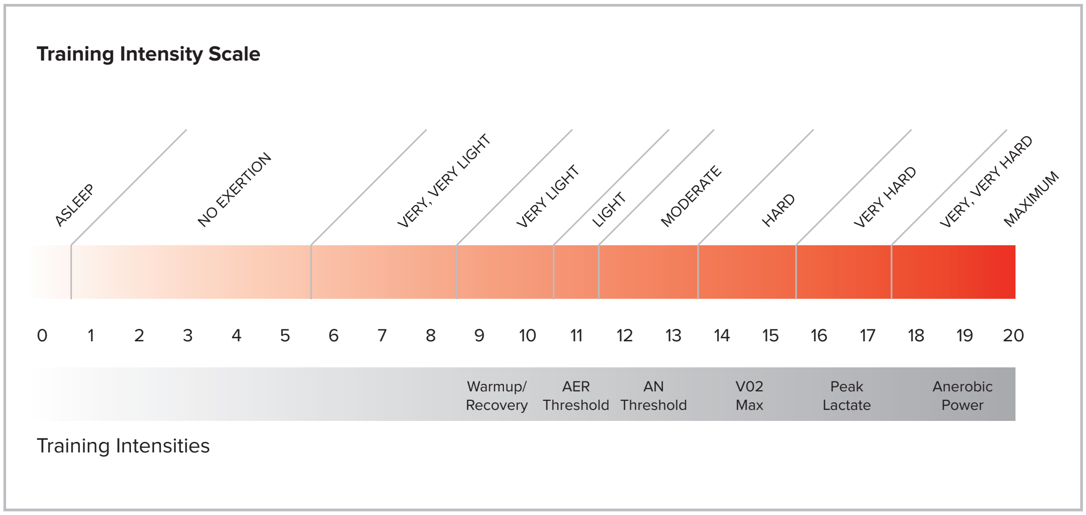
Training Intensity Scale
ASLEEP
NO EXERTION
VERY, VERY LIGHT
VERY LIGHT
LIGHT
MODERATE
HARD
VERY HARD
VERY, VERY HARD
MAXIMUM
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Warmup/ Recovery
AER Threshold
AN Threshold
V02 Max
Peak Lactate
Anerobic Power
Training Intensities

Figure 1: The Borg Scale of Perceived Exertion

This scale, developed by Gunnar A. V. Borg at the University of Stockholm in 1970, ranges from 0 to 20, with each score roughly equating to the average heart rate of a workout that would yield that level of perceived exertion for 30 to 50-year-old subjects. For example, an athlete exercising in the 160 BPM range is said to be likely to rate that workout a 16 on the Borg scale. As Borg himself noted though, this relationship was not to be taken too seriously; the actual correlation between heart rate and strain is dependent upon age, type of exercise, environment, anxiety, and other factors (Borg, 1982).

Adding to the inaccuracy of this method is the well-documented subjectivity of human generated evaluation. In a study conducted by Borg, subjects driving a car at 50 miles/h were instructed to decrease the speed until they perceived it to be half the starting value. The actual speed they reached on average was 35 miles/h or 40% over the target value (Borg, 1982). Such distortions between perception and reality are not limited to speed. More relevant to exercise physiology, in a controlled study, Bjorn Ekblom and Alberto Goldbarg found that the RPE was instead correlated with the blood lactate level (which is a source of exercise-induced muscle pain) and had relatively high variance for exercises with the same target heart rate, depending on the group of muscles performing the task (Ekblom, 1971).

The unreliability and subjectivity of the RPE metric has also been confirmed using constant physiological monitoring with WHOOP data. After each workout, WHOOP provides its athletes with the opportunity to answer an optional four-question survey. One of the questions asks the users to report their RPE on a discrete 21-point scale. This survey question is asked of the users before they are shown the WHOOP-calculated objective Strain Score in order to avoid biasing the reports. We note that WHOOP does not use the reported RPE values or any other subjective information in calculating the Strain Score. The analysis in this report focuses on the objective WHOOP Strain Scores and the user-reported RPE values from an NCAA Division I Track and Field Team. The distribution of the difference between the objective WHOOP Strain Score and RPE in this population is shown in **Figure 2**.

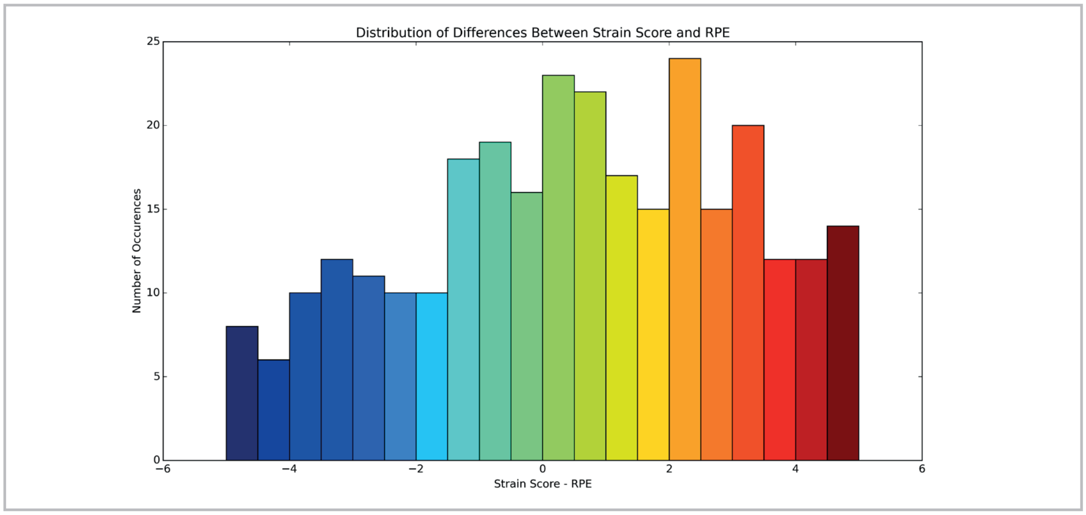

Figure 2: (Strain Score – RPE) during training for a NCAA Division 1 Team

Notice that although most athletes reported RPEs that are consistent with the objective Strain Score provided by WHOOP, some differences are significant.

Overestimated RPE

Overestimated RPEs (the negative values in Figure 2) can be a symptom of overtraining, muscle fatigue, lack of sleep, dehydration, or improper nutrition (Oliver et al., 2009). By comparing an athlete's objective and subjective measures of strain, he or she can be alerted that one of the aforementioned physiological imbalances may be distorting his or her perception. This creates an important opportunity to course-correct, thereby reducing the probability of negative side effects.

Underestimated RPE

Underestimated RPEs (the positive values in Figure 2) can be a symptom of nearing peak physical fitness (Oliver et al., 2009). Seeing this is tantamount to giving athletes an incentive to push themselves even harder in subsequent training sessions.

Subjective vs. Objective Data

The WHOOP Strain Score builds on Borg's work, as this has become the "standard" that most coaches and athletes understand. However, it offers significantly more insight as each score is computed from heart rate data, which is then algorithmically processed in a personalized way that accounts for inter-individual differences. Athlete-specific markers of fitness, such as resting heart rate and maximum heart rate, affect the weight carried by each recorded heart rate. This process assures that the resulting score reflects that athlete's personal level of cardiovascular strain no matter the power output or type of activity performed.

Coaching with a WHOOP Strain Score

The WHOOP Strain Score is a valuable tool for coaches as it provides meaningful, individualized data based on each athlete's unique physiology. As such, athletes going through identical training sessions and delivering the same power output can receive significantly different Strain Scores, reflecting their different levels of bio-energetic fitness. This information can then be used by the coach to alter subsequent training sessions in line with the athlete's potential at a given moment in time.

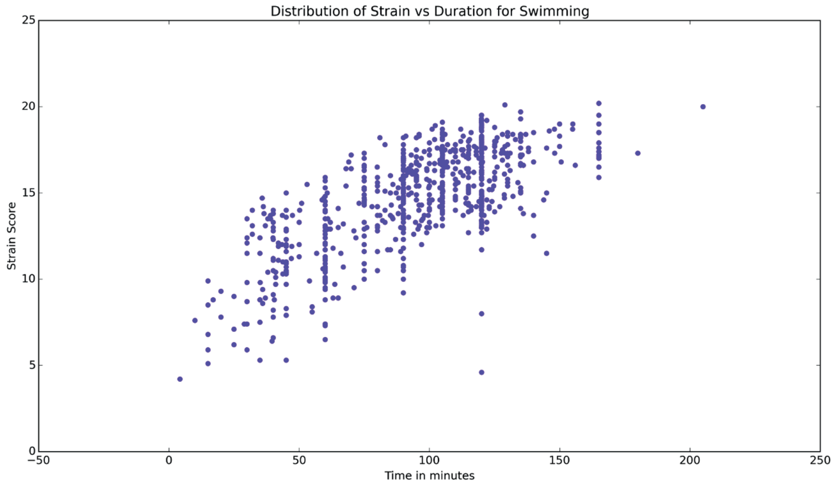

Figure 3: distribution of Strain Scores for athletes of an NCAA Division 1 Swimming Team plotted against the duration of the workout.

The conspicuous vertical lines at the 60, 90, 120 and 180 minute marks represent the distribution of scores for the standard training sessions that all athletes completed. Notice how the range of these distributions is more than significant (averaging 5 points), suggesting that while all athletes completed the same exercise regimen, the amount of strain they placed on their bodies is notably different. Analyzing the trends in the Strain Score for similar training sessions over time can yield valuable information about short-term fitness levels allowing athletes to peak on game day and avoid overtraining.

Owing to it's objectivity, the WHOOP Strain Score can accurately quantify different activities of different durations under the same scale as pictured below in **Figure 4**.

Notice here that walking, running, cycling, swimming, and weight lifting activities are evaluated on the same scale. By extending this model, we are also able to evaluate the strains associated with non-workout activities such as errands, household chores, or waking a dog in order to produce an aggregate Day Strain Score that incorporates the totality of a day's cardiovascular strain, regardless of the sources.

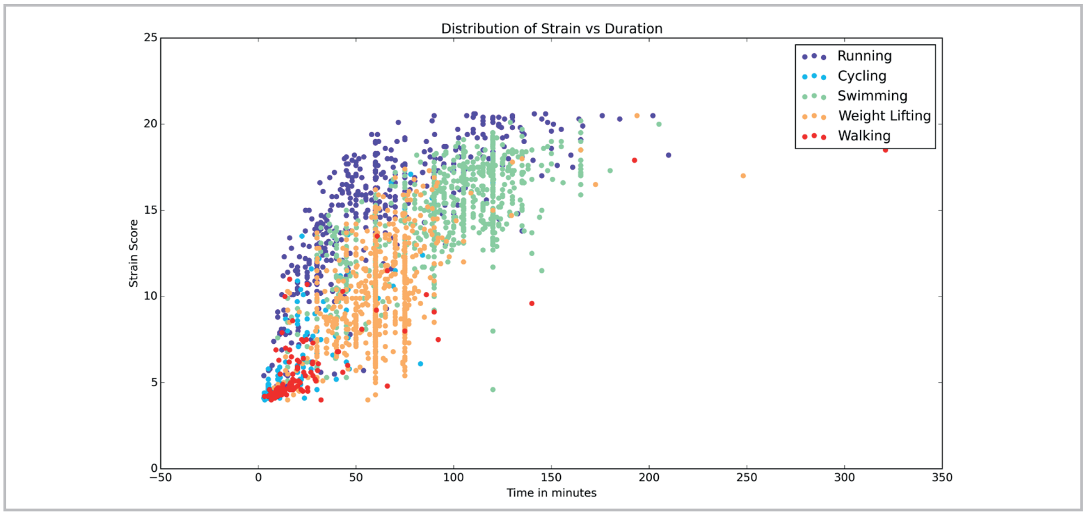

Figure 4: Different Activities of Different Durations Compared For Strain Score

Conclusion

The analysis presented here shows that an objective and consistent Strain Score is a more actionable and reliable option for measuring physical exertion in athletes.

WHOOP's objective approach maintains the individualized nature of the subjective RPE method while increasing accuracy and providing a framework for rating different activities of different durations on the same scale. In doing so, the Strain Score helps athletes and coaches prevent overtraining, stay on top of recovery, and maximize performance.

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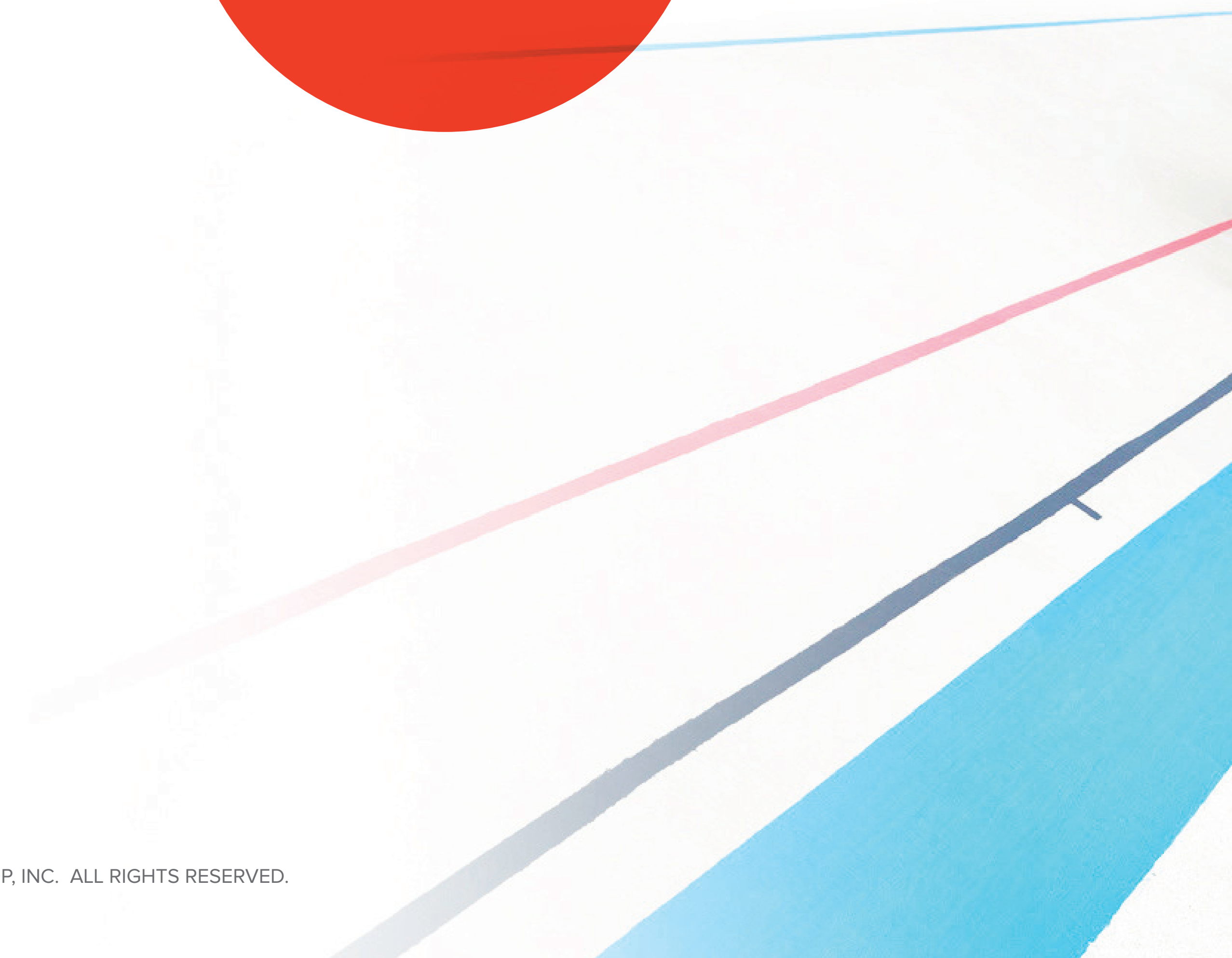

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