Human Centered Training: Perceived Exertion as Main Parameter for Training Adaption

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Abstract
Regular physical activity is important for a healthy lifestyle. The physical activity should be performed with the right individual intensity. Today it is common to use the heart rate as indicator for the optimal individual training intensity, but the subjective intensity of the trainee is not considered. In this paper we present an approach which focuses on the perceived exertion of the trainee and helps to reach and keep a user-defined intensity level.

Author Keywords
Perceived Exertion, Borg, RPE, Training, Intensity

ACM Classification Keywords
H.5.2. [User Interfaces]: Input devices and strategies

Introduction
It is well known that regular physical activity is an important key aspect for healthy living. Besides the frequency of the physical activity, the intensity is also a very important factor for a healthy training. However, during the training it is hard to keep the right intensity, especially for untrained people with no or little experience. Today it is common to use the heart rate as

RPE	perceived exertion
6	no exertion at all
7	extremely light
8	
9	very light
10	
11	light
12	
13	somewhat hard
14	
15	hard
16	
17	very hard
18	
19	extremely hard
20	maximal exertion

Figure 1: Borg-RPE-Scale

indicator for the optimal training intensity, to avoid overexertion or a too low intensity. For using them, a minimum and a maximum heart rate has to be measured or calculated by the user, to allow the watch e.g. to alarm her/him if the optimal heart rate corridor is left. This method does not take into account the perceived exertion of the trainee. While this parameter naturally cannot be measured and only inaccurately estimated, there are several scales which allow trainees Borg-RPE-Scale (RPE: "Rating or Perceived Exertion") which is used to adjust the training of trainees, e.g. in cardiac rehabilitation. Within certain limits, their target training intensity gets adapted based on their reports about their subjective exertion. In this paper, we present an approach, which focuses on the perceived exertion instead on measured parameters. We designed an unobtrusive as possible algorithm which encourages users to reflect their subjective exertion regularly but avoids a too high frequency when asking them.

Related Work

The perceived exertion is a good indicator for the intensity of a training. To measure the perceived exertion, the Borg-RPE-Scale was developed by Gunnar Borg [2]. It is visualized in Figure 1. The Borg-RPE Scale ranges from 6 to 20, so 6 equals no exertion at all and 20 is the maximum exertion a trainee can experience. Though the perceived exertion as response to physical activity shows an exponential increase [2], the Borg-RPE-Scale is linear. The scale has descriptions for some values, which are listed in Figure 1. The descriptions are less detailed than the numeric scale, but allow expressing exertions in a more intuitive way. This information can then be used for reflecting the training, coaching the body awareness, and for adjustments regarding the intensity, so the trainee can do her or his training in a comfortable way. The points on the Borg-RPE-Scale, the heart rate and other physiological measures [5] show a strong correlation between 0.8 and 0.9 [4]. For healthy people who are between 30 and 40 years old, the Borg-RPE value can be computed by dividing their heart rate by ten [3]. Many parameters can influence the perception of the exertion. Trainees with cardiovascular diseases sometimes have a deranged perception because of anxiety of activity, but also environmental factors like temperature, humidity, and noise can influence the rating. Medication, but also e.g. caffeine intake [1] can lead to a deranged perception and to different load limits. Physical and mental load influence the physiological and perceptual response of the body.

Approach

Users should stay within their personal physical limits. In our approach, we support users to reach or stay at a previously chosen subjective exertion level on their own. Our goal is to raise the body awareness of users by asking for their perceived exertion and allowing them to reflect their training intensity instead of providing commands like slow down based on the heart rate. Thus we are targeting inexperienced users who are not doing this already resulting in a too intense training for them. To ask the user for reflecting their perceived exertion, we still use the heart rate as an indicator when the user has to be asked for the Borg RPE value. The whole algorithm we will describe in the following is visualized in Figure 2. In the beginning, the user chooses a target RPE level using the previously described Borg-RPE-Scale. The algorithm then estimates the heart rate corridor the user will be most likely reach with this RPE level. Since the Borg-RPE Scale is derived from the average heart rate, this is

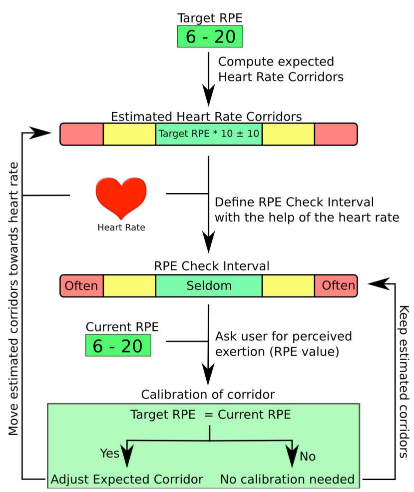

Figure 2: The expected heart rate corridor and the assessments of the perceived exertion get automatically adjusted according to the perceived exertion. This way, the system adapts to the individual user and avoids obtrusive queries of users whose heart rate does not correlate perfectly with their perceived exertion.

done by multiplying the target RPE level with 10 and using a tolerance of +/- 10 beats per minute. For example, if the user chooses a target RPE level of 12, the estimated heart rate corridor would be between 110 and 130 beats per minute. Using the measured heart rate and the estimated heartrate corridor, the algorithm defines the interval in which the user is asked to reflect and enter her or his exertion. If the heart rate lies in the optimal corridor, the system will ask the user the heart rate lies outside the optimal corridor, the system will shorten this interval. If the deviation is only a few beats per minute, the interval is lowered to three minutes. If the deviation is high, the interval is lowered to one minute.

Even if the correlation between the heart rate and the RPE is high for every human, every body reacts differently to physical activity. The interpretation of the different RPE levels is also individually and can differ. To address these issues, the algorithm uses the regularly user-entered RPE values to adjust the estimated heart rate corridors and in conjunction also the interval of user queries. This calibration is done if the actual RPE the user entered equals the target RPE the user entered in the beginning. In this case, the user has reached her or his defined target intensity which is the overall goal. If the estimated heart rate corridors do not reflect this, they have to be adjusted. The algorithm does this slowly to avoid too big adjustments caused by temporal effects like a shortly raised heart rate not caused by physical activity. We chose to adjust the estimated heart rate corridors by a maximum of 5 beats per minute per adjustment. As an example, let the target RPE 12 and the estimated heart rate corridor between 110 and 130 beats per minute. If the heart rate is 100 and the user enters 12 as current RPE, the algorithm will adjust the estimated heart rate corridor to 105 and 125 beats per minute. This will not change the query interval the first time, but the second time, the heart rate corridor will be reduced to 100 and 120 and match the actual heart rate. These adjustments can be limited to avoid adjusting to obvious misinterpretation of the Borg-RPE Scale. In such a case, a hint to the user could be given that heart rate and perceived exertion do not match and an explanation of the Borg-RPE-Scale could be displayed.

If the actual RPE the user entered does not equal the target RPE, no calibration is done and the current estimations are kept. We decided to do this, because it is hard to estimate the heart rate the user will have when the target RPE is reached. Instead, it is possible to give the user hints to adjust the training because the target RPE is not reached. These can be easy hints like “walk slower” or “walk faster”, or simple messages informing the user that the target RPE was e.g. 12 and the current RPE is only 9. This will finally lead to a convenient interval for each user, even if the heart rate does not correlate with the Borg-RPE values as expected. This allows users to reflect their perceived exertion regularly while avoiding an obtrusive system not tailored to their needs.

Use case example

The presented algorithm is currently implemented within a navigation application developed in the project HealthNavigator. The goal of the HealthNavigator is to allow users to adapt a hike according to their physical abilities and physiological status. The HealthNavigator e.g. allows shortening a hiking route when the users seem to be too exhausted to walk the whole route. The HealthNavigator app implements the presented

igure 3: Sony Smartwatch displaying heart ate and input screen for Borg-RPE value.

algorithm to allow the assessment of the perceived exertion and to adapt the hiking based on it. Besides the navigational elements which are presented on a smartphone, a Sony Smartwatch 2 is used to present the heart rate and to assess the perceived exertion using the Borg-RPE-Scale. Both screens are depicted in Figure 3.

Our algorithm needs the target Borg-RPE value of the user. In this context, this gets entered by the user in the beginning of the application, besides entering other information about the fitness level and how exhausting the path should be. When the hike begins, the input and output of our algorithm happens through the smartwatch. Based on the algorithm, the user is asked regularly to enter her/his current rating of perceived exertion. The need for a new entry is hinted by a vibration of the smartwatch. Depending on the entered value, the device gives further instructions. If the perceived exertion is lower than the target exertion, the smartwatch shows a hint to walk faster. If the perceived exertion is higher than the target exertion, a hint to walk slower is displayed. Otherwise, as described before, the query interval for the perceived exertion is adapted to the user.

Conclusion

Physical training should be performed within certain limits. The often used heart rate is an objective parameter for training intensity. It lacks the ability to reflect the perceived exertion of a trainee, though. In this paper, we presented an approach where the perceived exertion is in the focus for the adaption of the training. Our algorithm uses a target exertion to compute an estimated heart rate corridor. The interval between user queries for the perceived exertion is based on this estimated corridor. Over time, our algorithm uses the user input to adapt to a certain user and change the estimated heart rate corridor. This allows adequate query intervals for users whose perceived exertion does not correlate with their heart rate as expected. This way, our system allows the usage of perceived exertion as main parameter for training adaption and ensures a positive training experience for the user. In future work, we will verify our algorithm with user studies to optimize the training experience. Further, we will identify how often and especially in which way users want to report their perceived exertion. Our current input technique allows easily entering the perceived exertion on the Borg-RPE Scale when standing still or walking. During other physical activities, these input methods may have to be simpler to allow user input without distraction. We will look into different input techniques for the Borg-RPE value to reach a satisfying solution.

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