Error of Exercise Heart Rate Estimated by Palpation of Post-exercise Pulse Rate Among Young Adults

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Abstract

When no heart rate monitor is available, palpating the recovery pulse rate immediately after exercise is considered to be useful to estimate the exercise heart rate that has reached a steady state. However, when one uses a certain equation proposed for the public to estimate their exercise heart rate, the individual's calculated heart rate can be far different from the actual heart rate because of the difference in recovery rate among individuals. In this investigation, forty three young male Japanese adults were tested with two popular equations, Yamaji's and Ikegami's, to examine how the errors of estimation distribute. The number of the participants whose difference in the exercise heart rate between the estimated and actual ones was 6 or more beats/min was 20.9% in Ikegami's method and 30.2% in Yamaji's; the number of participants having a difference of 10 or more beats / min was 4.7% and 9.3%, respectively.

Key words: heart rate palpation, estimated exercise heart rate, recovery heart rate

BACKGROUND

Knowing the exercise heart rate is critical in order to commit safe and effective fitness activities and exercise regimens. When a heart rate monitor is not available, palpation immediately after exercise can be useful to estimate the corresponding exercise heart rate because palpating the heart rate during exercise can be difficult. The trials to estimate exercise heart rate based on palpated heart rate immediately after exercise have been conducted (Yoshida et al., 1979 ; Yamaji & Nishida, 1984 ; Arimoto & Sasaki, 1985 ; Sonobe et al, 1995 ; Devan et al., 2005 ; Kajiyama et al., 2005). Ikegami (1987) proposed to estimate exercise heart rate by adding 10 to an acquired heart rate (beats / min) by palpation of heart beats for ten seconds as soon as possible after exercise. Yamaji et al. (1984, 2013) proposed to multiply the heart rate (beats / min) gained through palpation for 20 seconds by 1.1. The purpose of this examination is to examine previous findings and also to grasp the individuals' difference in the recovery rate.

When a heart rate monitor is not available, it seems useful to use a proposed method to estimate an exercise heart rate. However, as recovering heart rates vary among different individuals, estimated exercise heart rates can be far from the actual heart rate. These errors might not be opposed if the size of errors are small enough to be ignored, but the distributions of these errors have rarely been discussed. Hence, the purpose of this investigation is to apply Ikegami's method and Yamji's method to the cases of 43 young male Japanese adults, and clarify the distribution of the errors so that the two methods can be evaluated.

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METHOD

Participants

Forty three healthy male college students (18 - 22 yrs) whose heart rates reached a steady state during the final stage of a graded exercise test were recruited in this investigation. The mean and standard deviation of their height and body weight were 172.7 ± 5.55cm and 64.3 ± 10.83kg respectively. They were instructed to be abstinent from eating, smoking, and vigorous physical activities for at least 2 hours before the test. The study was approved by the Human Rights Committee at Yokohama College of Commerce.

Graded exercise test and measurement

This graded exercise test was conducted with a bicycle ergometer (Combi 232 - C®, Combi, Tokyo, Japan) and measured not only heart rate but also other physiological parameters including oxygen uptake and others. With a respiratory mask on the face and electrodes on the chest, the subjects pedaled from the bicycle ergometer seat, as their heart rates were continuously measured with an electrocardiogram machine (Life Scope G®, Nihon - Koden). The duration of each stage of pedaling was 3 minutes during the first and second stage, and 4 minutes for the final stage. Workloads (watts) were set for each individual, and the numerical value of the workload was determined to be equivalent to the numerical value of the subject's body weight (kg) for the first stage, 150% of the bodyweight for the second stage, and 200% for the final stage. The subjects pedaled steadily at 50 rpm to an assigned metronome.

Exercise heart rate and steady state

Exercise heart rate in this examination refers to the heart rate in the last minute of the final stage which was being calculated through R - R intervals by the machine. According to YMCA protocol (Lawrence, 2000 ; ACSM, 2006), 'steady state' is defined as a condition that the difference in heart rate, which is recorded during the final 15 seconds of every minute and is between the third and fourth minute is within five beats / min or less.

Recovery heart rate and palpated pulse rate

Recovery heart rate immediately after exercise was successively measured using the electrocardiogram. For the recovery rate, heart rates (beats / min) were identified by the electrocardiogram as the heart rates (beats / min) in each duration of between 0 - 10 sec, 0 - 15 sec, 0 - 20 sec, 5 - 15 sec, 5 - 20 sec, and 5 - 25 sec just after the final stage ends. Corresponding to the measurement taken for 10, 15 and 20 seconds, each recorded heart rate by the electrocardiogram was divided by 6, 4, or 3, and rounded off numbers less than 1, and then multiplied by 6, 4, or 3 to determine the palpated pulse rate, which is the way to gain the 'palpated pulse rate,' which indicates all of the recovering heart rate gained and is as the same rate as one counts the pulse beats without mistakes.

RESULTS

Table 1. Mean and standard deviation of palpated pulse rate and lowering rate (%)

Measurement	M ± SD (bpm)	Lowering rate (%)
Exercise HR	150.6 ± 12.48	
PPR 0-10 s	146.5 ± 13.87	2.7
PPR 0-15 s	144.4 ± 13.60	4.1
PPR 0-20 s	142.5 ± 13.50	5.4
PPR 5-15 s	141.3 ± 13.75	6.2
PPR 5-20 s	140.2 ± 13.58	6.9
PPR 5-25 s	138.4 ± 13.62	8.1

Table Note : PPR indicates palpated pulse rate (bpm). PPR 0 - 10 s indicates pulse rate palpated between 0 sec and 10 sec. The lowering rates were calculated by lowering beats divided by the exercise heart rate.

Distribution of the exercise heart rate and recovery pulse rate in this investigation is shown in Table 1 and Figure 1. The mean and standard deviation of the exercise heart rate was 150.6 ± 12.48 bpm, the highest heart rate is 177 bpm, and the lowest heart rate is 130 bpm. The lowering pulse rate immediately after stopping pedaling showed that the later and the longer palpation is, the larger lowering rate appears and the lower pulse rate is gained.

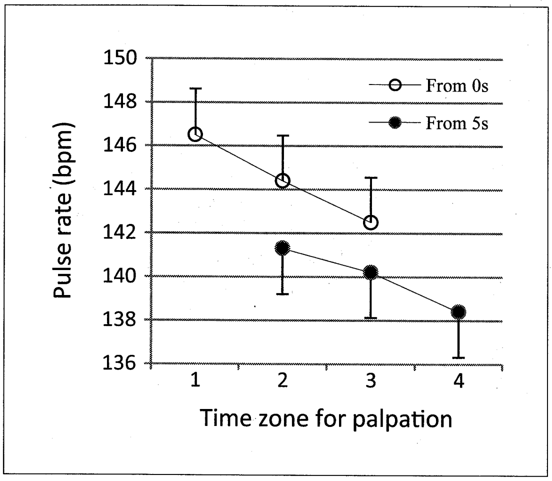

Fig. 1. Mean and 1/√43*SD of Palpated pulse rate after exercise

Note : The recovery pulse rates were operationally identified with the durations of 10, 15, and 20 seconds. In the X axis, for the white circles (○), 1, 2, and 3 indicate 0 - 10 sec, 0 - 15 sec, and 0 - 20 sec, for the black circle (●), 2, and 3, and 4 indicate 5 - 15 sec, 5 - 20 sec, and 5 - 25 sec, respectively.

Of these six measurement conditions, the palpated pulse rates for 10 seconds and for 20 seconds from 5 seconds after stopping the pedaling and corresponding exercise heart rates were distributed in Figure 2. The regression equation with the palpated pulse rates and the exercise heart rates were [Y = 0.863X + 28.60] in the 10 second method and [Y = 0.864X + 30.97] in the 20 second method, which are another expression of the data distribution. The palpated pulse rates of these conditions were finally adopted to examine the two equations, Ikegami's and Yamaji's, the reason for this is shown in the next paragraph.

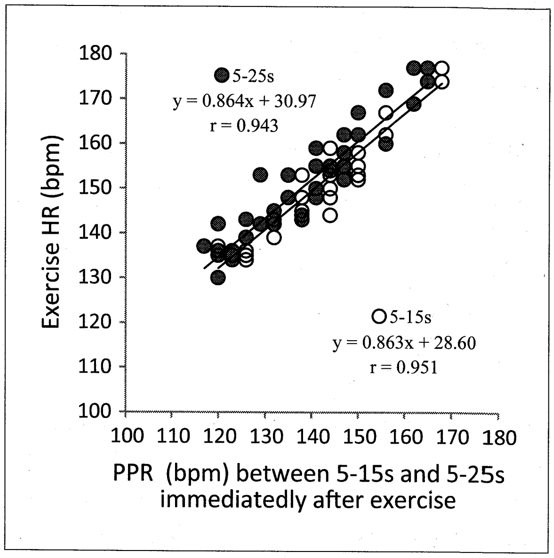

Fig. 2. Relationship between palpated pulse rate and exercise heart rate.

Note : N = 43. The white circles (○) indicate the palpated pulse rate (PPR, bpm) between 5 and 15 sec after exercise and the actual exercise heart rate. The black circles (●) indicate PPR (bpm) palpated between 5 and 25 sec. after exercise and the actual heart rate.

Ikegami's method (PPR + 10) was applied to the pulse rate palpated for 10 seconds and Yamaji's method (PPR × 1.1) was applied to the pulse rate palpated for 20 seconds. Both Ikegami and Yamaji have mentioned that the sooner one starts counting, the better. To make sure which condition produces less size of the error from 0 or from 5, the calculation for each method was applied to the two conditions, counting heart beats from 0 seconds and 5 seconds after stopping exercise to determine their palpated heart rates. As a result, estimated errors, that is, the distance from the actual exercise heart rate to the estimated heart rate, tends to be smaller when counting from 5 seconds rather than from 0 seconds (Table 2).

Table 2. The mean and Maximum of the absolute value of the difference between the real exercise HR and its estimated HR (bpm)

Measurement sec.	PPR × 1.1 Mean (Max)	PPR + 10 Mean (Max)
PPR 0-10		6.5 (12)
PPR 0-20	6.7 (13)	
PPR 5-15		3.1 (12)
PPR 5-25	4.3 (12)	

Note : PPR indicates 'palpated pulse rate.' The difference is expressed in heart beats. PPR × 1.1 means Yamaji's method and PPR + 10 is Ikegami's method applied to estimate the exercise heart rate in this investigation.

Next, the distribution of sizes of the estimation error was further examined. In order to clarify how many participants had an error of estimation which cannot be ignored, the number of participants whose error of estimated exercise heart rate were 6 or more and 10 or more. This was counted respectively in the case of which palpation started at 5 seconds after exercise.

Table 3. Difference between the estimated exercise heart rate and the actual exercise heart rate

Measurement	Mean (Max)	6≤ n (%)	10≤ n (%)
PPR [5-15s] + 10	3.1 (12)	9 (20.9%)	2(4.7%)
PPR [5-25s] × 1.1	4.3 (12)	13 (30.2%)	4(9.3%)

Note : The numbers and the percentages of 6 ≤ include the net number and percentage of 10 ≤, respectively.

As shown in Table 3, 4.7% of all the participants had an estimation error with 10 or more beats and 20.9% – including the previous 4.7% – of all the participants had an estimation error with 6 or more in Ikegami's method. The number of participants in Yamaji's method was 9.3% and 30.2% as well. Incidentally, when the equations come from these 44 participants were applied to the pulse rate palpated for 10 seconds, there were 5 participants (11.6%) who had the errors of more than 5 beats.

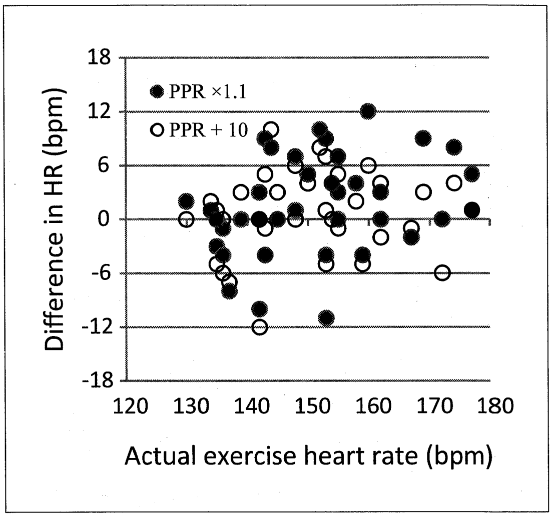

Fig. 3. Difference in heart rate (bpm) between the estimated heart rate and the actual heart rate.
Note : The X axis reads the actual exercise heart rate, and the Y axis reads the difference between the estimated exercise heart rate and the actual heart rate. The white circles (○) are the data gained with Ikegami's method (PPR + 10). The black circles (●) are gained with Yamaji's method (PPR × 1.1).

DISCUSSION

Equations commonly proposed to estimate exercise heart rate should give values as approximate to actual ones as possible, but it is impossible to avoid some errors of estimation including errors that should not be overlooked. As a matter of fact, two common equations applied to the 43 participants in this investigation revealed that 20.9% and 30.2% of all the participants' estimated heart rate deviated more than 5 beats from the actual one, as well as the regression equation from these participants resulted in a 11.6% deviation of more than 5 beats. These kind of errors come from deviations from the regression line. People should know if their recovery speed in their heart rate is average.

It is not a simple matter of judging if a certain equation is useful. If someone calculates an estimated exercise heart rate which is actually more than 10 beats different from actual one, the equation cannot be recommended to be used. What if it is 6 beats more than the actual? Some may, and some may not be able to allow it. Those who have certain chronic diseases and are involved in a specific exercise regimen cannot allow it (ASCM, 2014).

Take maximal heart rate reserve, for instance. If the resting heart rate is 70 beats / min and the maximal heart rate is 190 beats / min, 10 beats correspond to 8.3% of maximal heart rate reserve and 6 beats correspond to 5% of the one. If the resting heart rate is 70 beats / min and the maximal heart rate is 170 beats / min, 10 beats and 6 beats correspond to 10% and 6% maximal heart rate reserve, respectively. If the situation is of exercise prescription, these percentages are seemingly serious.

It is clear that still 70 - 80% of healthy young adults could use common equations without any problem, but how can people know if they are one of these people? Furthermore, in this investigation, the palpated recovery pulse rates were determined with the electrocardiogram, but there is a problem on palpation per se, in general. The problem is if people are accustomed to palpating and if they put the fingers on the radial artery or temporal artery, instead of palpating the carotid artery, which seems common place to palpate in the public, might cause heart rate reduction, which is still controversial (McArdle et al., 2007). This is why an individual approach is recommended for every health and fitness program. If people want to use the palpating method to determine heart rate, they need to understand the proper relationship between the exercise heart rate and recovering heart rate, which should be provided during the process of exercise testing and exercise prescription.

CONCLUSION

The error of estimation for calculating exercise heart rate using palpation after exercise happens often and in a relatively wide range of heart rate. If people want to know a more precise exercise heart rate without using a monitoring device, they should be prepared to use the equation that fits oneself best.

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