Energy-Aware Heart Rate Monitoring During Stair Climbing

Navid Amini, Mahsan Rofouei, William J. Kaiser, Majid Sarrafzadeh
University of California, Los Angeles

Stair climbing is one of the most energy-burning sports, requiring individuals to move their entire body weight vertically, instead of horizontally. Stair climbing exercise has been shown to be very effective in improving cardiovascular fitness, reducing cholesterol levels, decreasing body fat, and increasing the strength of the lower limbs. Besides the above mentioned benefits, being able to provide accurate estimates of the amount of energy expenditure during stair climbing motivated us to monitor the heart rate changes during ascending stairs. Although previous studies have determined the caloric cost of stair climbing, none of them has been conducted on an actual staircase with a large number of stairs. Accordingly, the purpose of this study is to determine the heart rate response during the stair climbing exercise for different intensities of constant-load exercise (see Figure 1). To this end, we used the stepmill (Figure 2) since it excellently performs like a real stair climbing exercise.

Two healthy male volunteers with an average level of cardiovascular fitness carried out two different intensities of exercise on a stepmill for three times in three different days and their heart rates were measured using a Bluetooth pulse oximeter (Figure 2). In this work, we attempted to fit the heart rate trends induced by constant exercise loads of different intensities to a second-order exponential function:

$$HR = \alpha_1(e^{\beta_1 t}) + \alpha_2(e^{\beta_2 t})$$  \hspace{1cm} (1)

Through employing the least-squares method in MATLAB we compared the results with fitting of the heart rate changes to first-order exponential curves. The second-order exponential function suitably fitted the heart rate responses induced by two different intensities of loads for stair climbing (see Figures 3 and 4): moderate (91.5 W: correlation coefficient, $r = 0.9732 \pm 0.01$), high (149.2 W: $r = 0.9684 \pm 0.02$). However, the first-order exponential curve to some extent fitted the moderate case only (91.5 W: correlation coefficient, $r = 0.8737 \pm 0.03$).

The presented results indicate that the second-order exponential function fitted the heart rate response for both the moderate and high loads and is more reliable than first-order exponential function to analyze the heart rate response during climbing stairs, however, this function includes many regression coefficients whose relation to factors like age and gender needs to be determined.