original article

Effect of respiratory protection equipments wear on heart rate in different workload

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ABSTRACT

Aims: This study was done to evaluate the effect of three kinds of respiratory protective equipments (RPE) on the heart rate in light, moderate and heavy workload.

Materials and Methods: This study was performed on eleven healthy university students (male) under controlled thermal conditions in a climatic chamber. The mean (SD) of age, height and body mass index (BMI) were 24.1 (2.34) years, 172 (4.2) cm and 22.4 (1.1) Kg/m2, respectively. Subjects were participated in the four intermittent exercises experiments (without RPE, valve, half-face and full-face) on a treadmill in light, moderate and heavy workload. Duration of light, moderate and heavy activities was 30, 30 and 20 min, respectively. Heart rate was recorded every 5 min.

Results: The mean of heart rate in 11 subjects for without RPE trial in light, moderate and high workload was 93.5±13.1, 109.7±18.1 and 119.6±25.8 beats per min (bpm), for valve RPE was 102.8±9.7, 116.7±16.0 and 132.1±23.2 bpm, for half-face RPE was 102.4±11.42, 117.3±15.8 and 132.0±23.1 bpm and for full-face RPE was 109.3±14.7, 125±17.4 and 140.1±23.1 bpm, respectively. In three work load, significant differences between the mean of heart rate by using three kinds of RPE trials showed with without RPE trial were observed (P-value < 0.001). Also, mean of heart rate in three workload levels when using full-face RPE trial was significantly higher than valve and half-face RPE trials. In the valve and half-face RPE trials, significant differences were not detected

Conclusions: The results demonstrated that heart rate were significantly increased with wearing of three kinds of RPE. Full-face RPE have a higher effect on increasing heart rate than half-face RPE.

Keywords: Heart rate, Respiratory protective equipments, workload

INTRODUCTION

In many industrial, workers need to wear personal protective equipment to protect themselves from hazards.[1] Chemicals are the most important contaminants of workplace and the respiratory tract is the most important entrance way of these contaminants to the body, hence in many cases we are inevitably

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to use respiratory protection equipments.[2-5] Different types of the respiratory protective devices including air-purifying and air-supplying respirators are using in the work environment. Despite respirators can reduce contact with the pollutants, breathing load created by these devices has followed different side effects.[2,4,6,7] There are high cardio-respiratory strains in jobs that need to wear respiratory protective equipment.[8] White *et al*., did an experiment on the protective clothing and air-supplying respirator that increasing of heart rate and rectal temperature were the main reasons for stopping the experiment.[9] In the study of Louhevaara *et al*., on respiratory protection equipment, was found that the use of respiratory protection equipment can causes cardio-respiratory strain.[10] In a study at construction, foundry, shipyard and metal industries that regularly used such kinds of respiratory protective equipment, it was found that increase in mean heart rate when using the respiratory protective equipment is equivalent to aerobic strain of 12-57% $VO_{2\ max.}$ [11] Also, another study that examined the effect of wearing of respiratory protective equipment on heart rate, was determined that mean heart rate of subjects from 75-94 beats per min in the state without use of respirator was increased to 77-98 beats per min in the state of use of respirator in the work environment.[12] Previous studies mainly have been done on air-supplying respirators and few studies on air-purifying respirators have been conducted. Also in previous studies, the effect of different masks on heart rate has not been compared with each other. This study intended to assess and compare the effect of three kinds of respiratory protective equipment (valve, half-face and full-face) on heart rate at three levels of workloads (light, moderate and heavy) in neutral conditions.

MATERIALS AND METHODS

This study was performed under laboratory controlled conditions in climate chamber for two months from January to February (2011). Sampling method was simple random. Eleven healthy medical university students (male) from 18-30 years participated in the study, which was approved by the physician. Their physical characteristics mean (Standard Deviation) were: age 24.1 (2.34) years, height 172 (4.2)cm and body mass index 22.4 (1.1).

Inclusion criteria included lack of cardiovascular, respiratory, epilepsy, diabetes diseases and musculoskeletal disorders, subjects should not take medicines that affect on heart rate, and body mass index was in normal range (18.5-25). Exclusion criteria also include, on request of the subjects, if subjects suffered from fatigue during the experiments and were not able to continued, and if heart rate reach to maximum heart rate (220-age).

Mean heart rate was measured using a heart rate monitor (Polar RS100, Electro, Finland).This heart rate monitor was used in different researches [11-13]. Wet Bulb Globe Temperature index was measured using a Microtherm WBGT (Casella cel, U.K). We used three kinds of respiratory protection equipments valve type (Filtration class FFP2, JFY1021 model, manufacture by APASCIANI), half-face mask (included two cartridge, made of rubber, Duetta P3 model, manufacture by APASCIANI), full-face mask (TR2002/BN model, made of rubber, with a large filter, manufacture by APASCIANI). These respiratory protection equipments typically are used in Iran workplaces [Figure 1].

Before the first experiment, the subjects were required to read an information sheet, on which the purpose, method, and risks of the study were described, and then sign a consent form. Then the experimental schedule was communicated to each subject and was informed has adequate rest the night before of exercise and avoids coffee or alcohol drinks and fatty foods.

Every subject on arrival to climatic chamber wore a sport clothe. Then heart rate monitor closed on the chest and wrist, and subject has to rest in the climatic chamber for 15 min. At the end of 15 min, resting heart rate was recorded. After rest the subject was started three exercises on a treadmill. The exercise consisted of walking on a treadmill at a speed of 1.34 m/s with no grade at the light (30 min) workload and with 5 and 10% grade at the moderate (30 min) and the high (20 min) workload, respectively. Each exercise followed by 15 min rest period. During these exercises heart rate were recorded every 5 min. All these steps were performed in four conditions including: without RPE, valve RPE wear, half-face RPE wear and full-face RPE wear. All subjects carried out the experiments on four different days with one day off between the experiment days. The experimental protocol was approved by the Institution's Ethical Committee of Investigations Involving Human Subjects.[13]

Analysis of the data was performed by using repeated measurement ANOVAs and paired *t*-test in software SPSS16.

RESULTS

Mean (SD) heart rate of subjects for without RPE wear trial in light, moderate and heavy workloads were 93.5 (13.1), 109.7 (18.1), 119.6 (25.8) bpm respectively, for valve RPE trial were 102.8 (9.7), 116.7 (16.0), 132.1 (23.2) bpm, for half-face RPE trial were 102.4 (11.42), 117.3 (15.8), 132.0 (23.1) bpm and for full-face RPE trial were 109.3 (14.7), 125 (17.4), 140.1 (23.1) bpm, respectively.

Figure 1: Respiratory protection equipments used in this study; (a) Valve (b) Half-face and (c) Full-face

Repeated measure ANOVAs showed that mean heart rate among four trial (without RPE, valve RPE, half-face RPE and full-face RPE) in three levels workloads were a significant difference ($P < 0.001$). Value of F for light, moderate and heavy workloads obtained 74.31, 75.58 and 92.23 respectively. Paired *t*-test showed significant differences among mean heart rate in without RPE trial and three kinds of RPE trials ($P < 0.001$). Pair wise comparisons among valve, half-face and full-face RPE in three levels workloads showed mean heart rate for full-face RPE wear is higher than for valve and half-face RPE but no significant differences were observed between valve and half-face REP in three levels workloads that the *P* value for light, moderate and heavy workloads were 0.599, 0.427 and 0.959, respectively.

In Figures 2-4 mean heart rate changes for four trials in three workloads were compared.

DISCUSSION

The experimental results showed heart rates significantly are affected by wearing three kinds of RPE. In other words, mean heart rate in valve, half-face and full-face RPE wear trials are higher than without RPE trial in all workloads. The additional heart rate caused by wearing valve RPE in light, moderate and high workloads was 7, 9 and 13 bpm, respectively. For half-face RPE was 9, 8 and 13 bpm and for full-face RPE was 16, 16 and 21 bpm, respectively. Laird *et al*., studied the effect on heart rate of half-face mask air-filtering respirator, in this study 12 New Zealand workers, while working were examined that the results showed use of respiratory mask additions to mean heart rate by 2-4 bpm.[12] Another study found the physiological load of working with N95 half-face mask in two different workload (40W and 85W) was associated with additional heart rate ranged from 8.3 to 10.8 bpm.[14] Results of these studies were similar to our findings. However, Scanlan were measured physiological effects of S10 full-face respirator on four healthy men that found the mean heart rate when using of mask was less than unmask condition but this difference was not significant.[15] Mean heart rate in full-face mask wearing condition was higher than valve and half-face masks in all three workloads. James *et al*., were measured physiological responses caused by wearing half-face and full-face masks in both moderate and high workloads that found mean heart rate of full-face mask was more than half-face mask.[16] Result of this study was similar to our finding. One of the reasons that heart rate is higher for full-face RPE, is breathing resistance in full-face RPE is higher than valve and half-face RPE. As studies is express high breathing resistance made it difficult for the subject to breathe and take in sufficient oxygen. Shortage of oxygen stimulates the sympathetic nervous system and increases heart rate.[17] Perhaps higher weight of full-face RPE than valve and half-face RPE is effective in increasing heart rate. Hooper *et al*., compared the mean heart rate between use of two types light weight and conventional self-contained breathing apparatus and found mean heart rate was significantly lower in lightweight breathing protection

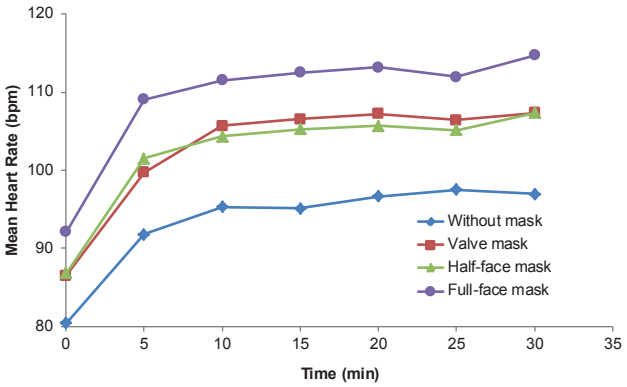

Figure 2: Heart rate changes due to wear respiratory protective equipments in light work load

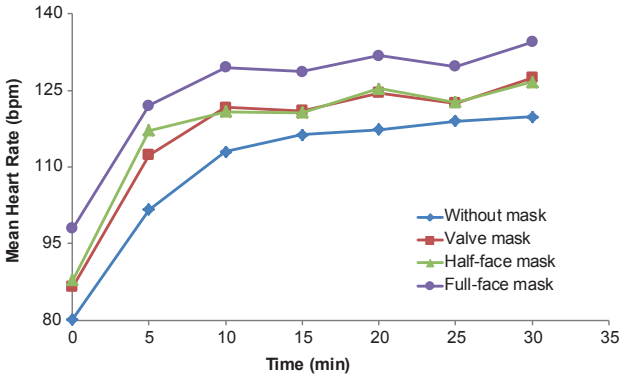

Figure 3: Heart rate changes due to wear respiratory protective equipments in moderate work load

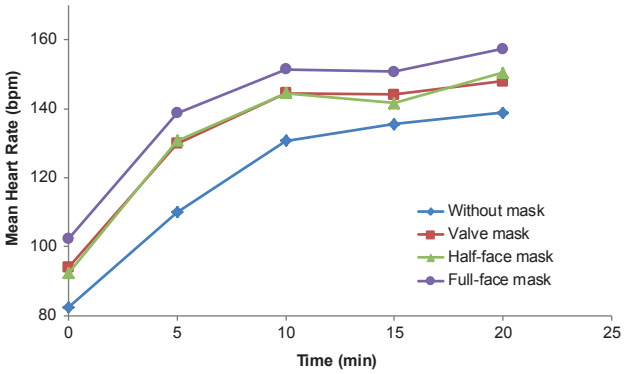

Figure 4: Heart rate changes due to wear respiratory protective equipments in heavy work load

device. Hooper study shows that weight of respiratory protection device is effective on heart rate.[18] However, weight factor is considered more about self-contained breathing apparatus. In our study, weight difference between half-face and full-face RPE was not high. No significant difference was observed between valve and half-face mask. Similar study, that these two kinds of RPE were compared, was not found. As Figures 2-4 demonstrate the pattern of changes in mean heart rate in three levels workloads amongst four trials (without RPE, valve RPE, half-face RPE and full-face RPE) are similar.

Also, when subjects do not wearing RPE have the lowest heart rate and when wearing full-face RPE have the highest heart rate. This study was conducted on men in the laboratory, it is suggested that similar studies in workplace on women and with more subjects be done.

CONCLUSIONS

Two principal conclusions emerge from the study. First, wearing respiratory protection devices in different work load produced a significant increase in heart rate. Secondly, full-face RPE have a higher effect on increasing heart rate than half-face RPE.

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