Influence of Physical Activity of the Rescuer on Chest Compression Duration and its Effects on Hemodynamics and Fatigue Levels of the Rescuer: A Simulation-based Study

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ABSTRACT

Background: Cardiopulmonary resuscitation (CPR) is a lifesaving skill performed during the cardiac arrest. Various factors of rescuer affect CPR quality, and rescuers physical fitness is one among the important factors needs to be explored for improved CPR quality. This study aimed to assess the physical activity (PA) levels of the health care providers (HCPs) who were trained in basic life support (BLS) and its relationship on chest compression duration, hemodynamic parameters, and fatigue levels of the rescuers.

Materials and methods: A single-center, cross-sectional study was conducted on 48 HCPs who were trained in BLS within one year. Eligible participants were contacted by email, and the responders’ level of PA was determined using the global physical activity questionnaire (GPAQ). The participants were recruited for chest compression-only cardiac arrest scenarios. Each subject performed continuous chest compression on the manikin until they perceived maximum fatigue. Heart rate (HR), blood pressure (BP), oxygen saturation (SpO₂), and fatigue level were assessed at baseline, immediately after and following two minutes of cessation of chest compressions. The total duration of chest compression was also documented.

Results: Most participants (24, 50%) reported high levels of PA while 22 (45.83%) and 2 (4.17%) reported moderate and low intensity of PA, respectively. The mean age of the 35 participants was 26.08 ± 4.60 years. The mean duration of chest compressions was 193.25 seconds with higher times reported for those with high PA when compared to those with moderate PA (p = 0.017). Similar findings were also observed for fatigue.

Conclusion: Rescuers who reported high PA had lower levels of fatigue and could perform longer duration of chest compressions.

Keywords: Cardiopulmonary resuscitation, Chest compression, Fatigue, Hemodynamic, Physical activity.

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INTRODUCTION

Cardiopulmonary resuscitation (CPR) is a lifesaving skill performed during the cardiac arrest. It combines the use of chest compressions and ventilation to maintain circulatory blood flow and oxygenation to vital organs.1 Following cardiac arrest, early initiation of CPR improves the chances of survival and reduces neurological manifestations.2 Cardiopulmonary resuscitation guidelines by the American Heart Association (AHA) recommends 5 cycles of CPR in 2-minute intervals with each cycle consisting of 30 effective chest compressions, up to a depth of at least 5 cm and providing two rescue breaths.3 In the presence of an advanced airway or airway adjuncts, continuous chest compression at a rate of 100–120 compressions per minute is recommended along with 10 breaths/ minute.3 Irrespective of the situation and duration, the emphasis is on a high-quality CPR.4,5

Factors such as knowledge of the rescuer, body weight, body position, age, underlying problems, physical fitness, and hemodynamic changes play a vital role in the quality of chest compressions.6–9 Manikin studies have demonstrated that physical fatigue occurs within a minute of initiating CPR which reduces effective chest compressions which is completely oblivious to the rescuer, while further altering hemodynamics of the rescuer after 5 or 10 cycles of CPR.8–11 Along with hemodynamic status, levels of physical activity (PA) have been found to vary across rescuers.12 Nevertheless, there is a paucity of data on the impact of PA levels of the rescuer on the duration of CPR, quality of chest compression, and hemodynamic alterations. Thus, we aimed to study the PA levels of the CPR-trained healthcare professional (HCP) and its effect on chest compression duration, hemodynamic parameters of the rescuers, and their fatigue level during the simulated chest compression-only CPR.

MATERIALS AND METHODS

The study was carried out on the participants aged between 18 years and 50 years after obtaining institutional ethical approval...
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Results

The distribution of participants in the study is illustrated in Flowchart 1. Of the 35 participants, 11 (31.43%) were males and 24 (68.57%) were females with an average age of 26 ± 4 years. The demographics, PA characteristics, and chest compression characteristics are summarized in the Table 1. A statistically significant difference was observed for chest compression duration provided by those with high PA than moderate PA levels (p = 0.017). Furthermore, males provided a significantly longer duration of chest compression than females (p < 0.001), irrespective of the PA levels (Table 1). No statistically significant difference was observed for chest compression duration provided by females (189.37 ± 60.73 seconds) and males (239.5 ± 74.36 seconds) among those with high PA levels (p = 0.144). Also, in moderate PA group, the chest compression duration provided by male participant was 220 seconds and females was 162.12 ± 32.94 seconds.

The overall hemodynamic changes during the study are represented in Table 2. Further analysis between moderate and high PA levels for the difference in HR, SBP, DBP, and SpO2 showed a statistically significant difference (p < 0.001) within the group. However, no differences were observed between these groups (p > 0.05) (Table 2). The difference between males and females in HR, SBP, DBP, and SpO2 within the group was statistically significant at p < 0.001 (Table 2). Furthermore, a significant difference was found in SBP and DBP between males and females (p < 0.05). Interestingly, the median RPE after chest compression was higher in moderate PA group when compared to the high PA group, 3 (2,3) vs 2 (2,3). The median hand pain score was 3 (3,5) across the participants.

Discussion

Knowledge of the PA levels among HCPs is very important to predict their capacity to provide high-quality CPR during the resuscitation. In our study, we found that the majority of BLS-trained HCPs were physically active with most having a moderate to high level of the PA. Majority of the male rescuers in the high PA group show that they are more conditioned for high PA with more muscle mass and upper extremity strength. The hemodynamic parameters were increased significantly from baseline to post-chest compression irrespective of the PA level. Interestingly, rest for two minutes of post-chest compression effectively reduced the hemodynamic parameters to baseline, so the emphasis on two-minute rest and rotation during the chest compression helps to normalize the hemodynamics of rescuer. The present study did not show a statistically significant difference in hemodynamic changes between high and moderate PA levels among HCPs, whereas Lucía et al. found a significant increase in heart rate in sedentary participants than in physically active participants.14 However, the absence of low PA participants in our study limited this differentiation of hemodynamic changes at rest and during the chest compression scenario. The mean age-predicted heart rate post-chest compression reached 50.7%, which shows participants could provide a longer duration of chest compression to reach their maximum exercise limit. Slightly higher mean maximum heart rate (61%) was found by Riera et al.15 The other interesting finding of this study is the gender difference in BP. The change in BP was significant (p < 0.05) between males and females during the study. Females had significantly lower baseline BP than males. Previous studies on the gender differences in BP have shown these results.16,17

Chest compression duration is another important factor to be considered. Termination and decreased quality of chest compression are indicative of fatigue,8,9,11 so obtaining an optimum duration of chest compression and the influence of PA on it helps to optimize the chest compression quality with less fatigue. The chest compression duration provided by high PA participants in our study was significantly higher than the moderate PA group, and similar results were found by Lucía et al.14

The high-quality chest compression is achieved by ensuring adequate depth and rate to better the chances of survival and early return of spontaneous circulation.5,18 Several studies have shown that compression depth decreases significantly after a minute of initiation of chest compression.2,10,11 We found a stable chest compression depth and rate during the study. The feedback for
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The overall chest compression duration provided by all the participants in our study was 193.25 ± 62.62 seconds. McDonald et al.20 and Ochoa et al.6 showed similar results. McDonald et al.20 observed maximum fatigue and reduced quality of CPR in rescuers at an average of 167 seconds of CPR, whereas Ochoa et al.6 observed at an average of 180 ± 84.1 seconds. The differences in the duration of chest compression were observed between men and women and between the levels of PA. Reasons for women achieving lower chest compression durations could be attributed to build muscle mass and cardiorespiratory fitness. These were, however, not assessed in this study, and therefore, no definite relation can be established. Nevertheless, the data suggest that in a simulated environment, continuous chest compression can be provided by all HCPs with moderate to high levels of PA.

The median RPE reported by moderately active participants was higher than that of the high PA group. Participants stopped chest compression after the maximum fatigue which is seen by the shorter duration of chest compression (167.88 ± 39.76 seconds vs 217.22 ± 71.43 seconds) and higher RPE score in moderate PA participants. This may be due to early-onset fatigue during the chest compression. Lopez-Gonzalez et al. observed rescuers’ muscle strength and arm strength exercises improve the quality of CPR.21 So screening HCPs for PA levels and advising routine exercises may help to overcome the fatigue in moderately low PA group HCPs during the CPR.24

**Limitations of the Study**

This was a time-bound study, and we faced the loss of participants after BLS certification. The PA levels were measured by GPAQ rather than by objective exercise testing. It is important in a study like ours to separate out strength vs endurance of the individuals performing CPR. The strength would be important for depth of

**Flowchart 1: Flow of participants into the study**

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Total number of BLS providers contacted (n = 244)

GPAQ filled participants (n = 48)

Participants classified according to perceived physical activity

High (n = 24)
Moderate (n = 22)
Low (n = 2)
Participated in Mankin study (n = 18)
Participated in Mankin study (n = 17)
Declined to participate in the Mankin study

Males (n = 10) Females (n = 8)
Males (n = 1) Females (n = 16)

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**Table 1: Demographics, PA, and chest compression characteristics of the participants**

| Demographic variables of the participants (n = 35) | Values |
|--------------------------------------------------|--------|
| Age (years) mean ± SD | 26.08 ± 4.60 |
| BMI (kg/m²) | 22.3 ± 3.15 |
| Gender, n (%) | Male 11 (31.43), Female 24 (68.57) |
| Overall MET.minute/week median (IQR) | 4,020 (1,830, 8,250) |
| MET.minute/week for different PA levels Moderate median (IQR) | 1,920 (1,200, 2,400) |
| High median (IQR) | 8,280 (6,040, 10,760) |
| Physical activity level after GPAQ analysis Moderate, n (%) | 17 (48.57) |
| High, n (%) | 18 (51.43) |
| Chest compression duration characteristics (n = 35) | |
| Overall duration of chest compression (second), mean ± SD | 193.25 ± 62.62 |
| Categories | Duration (second) | p value |
| Chest compression duration between PA levels (second), mean ± SD High PA, (n = 18) | 217.22 ± 71.43 | p = 0.017 |
| Moderate PA (n = 17) | 167.88 ± 39.76 |
| Chest compression duration between gender (second), mean ± SD Males (n = 11) | 241.3 ± 70.82 | p < 0.001 |
| Females (n = 24) | 171 ± 44.75 |
| Chest compression rate (range) (rate/minute) | (95–106) |
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The CPR while the endurance will decide how long the CPR can be given by the performer, but in the current study, we do not have this information. Also based on the current data, we cannot comment on the influence of the gender on the duration of CPR. Irrespective of the gender, the duration of chest compression was longer in high PA than in moderate PA. The absence of participants in the low PA group was an important limitation. The quality of chest compression was constant with metronome and depth monitored using click sounds, and the unclicked compressions were missed because of difficulty in the follow-up.

**Conclusion and Future Directives**

Fitness level of the HCP is an important factor to determine chest compression duration. Higher the PA, lower the fatigue level and longer duration of chest compression.

Further studies can consider changes in hemodynamics across different age groups, oxygen consumption levels, and exercises to promote overall physical fitness to improve the CPR.

**Disclosure Statement**

This study was presented as a scientific poster in CRITICARE 2018, 24th Annual Conference of Indian Society of Critical Care Medicine held in Varanasi, Uttar Pradesh, India.
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