To analyze the ergonomic advantage in performing Cardiopulmonary Resuscitation (CPR): observational study

NIKHITA R. DODIYA, PRIYANSHU V. RATHOD

School of Physiotherapy, RK University, Rajkot, India

Corresponding author: dr.nikhitadodiya@gmail.com, priyanshu.rathod@rku.ac.in

Abstract

This study was aimed to analyze the ergonomic advantage in performing cardiopulmonary resuscitation (CPR). The subjects were selected from various city of Gujrat. 32 purposive subjects were taken according to selection criteria. Subject's written consent was taken. **Day: 1** Pre vital was taken like HR, BP, RR after that Half Subjects (n=16) were perform 1 man CPR for 2 min by assuming Position – A (Traditional position – kneeling) and another Half subjects (n=16) perform 1 man CPR for 2 min by assuming Position - B (Modified position - spine should be straight and HIP-KNEE 90-90*)) in **Day : 2** Reverse the Position and Perform 1 man CPR for 2 min**.** Pre and Post changes in vitals after performance of CPR were measure and energy expenditure were measured by HR based energy expenditure formula, Apple Watch series: 1. : Data was analysis by SPSS version 21 Normal Distribution of data was assessed by Shapiro Wilk Test, which saw the data was normally distributed. Therefore, Analysis of position wise pre and post changes in vitals was done by Paired sample t-Test and analysis of changes in mean of vitals and calories expenditure between Position - A and Position - B was done by Independent Sample t-Test. In position -B there is less vital changes and less number of calories burned as compared to position – A So, Present study concluded that there is a significant ergonomic advantage in performing cardiopulmonary resuscitation.

Keywords: *High Quality CPR, Posture, Energy Expenditure, Ergonomic Advantage*

Introduction

Ergonomic word is derived from Greek words: Ergo means work and Nomoi means natural laws Meaning of these is "The science of work and person's relationship to that work" [1] Ergonomics give information about human behavior and their abilities and limitations. Ergonomics is the study of people at work scientifically. [3] Ergonomics works on to reduce stress and eliminate injuries and disorders related to overuse of muscle due to bad posture and repeated task. This is done by proper designing of work area and utilization of proper biomechanics of the body. Any physical activity needs energy to perform it. [4] Energy expenditure is the total number of energies that a person wants to do any physical activity like walking, running, bathing even our body's physiological system also required energy to

perform their work. [5]

The amount of energy expenditure is associated with the exertional level of activity and biomechanics of posture. Use of science to evaluate the biomechanics of posture is known as ergonomics. Energy is measured in calories or kilocalories. The number of calories we utilize every day is known as Total daily energy expenditure (TDEE). TDEE is varied for all peoples. It depends on BMI, Height, Weight, Nutritional level, Gender etc. [6]. The energy on our body is produced in the form of heat. There are various methods to calculate energy expenditure in the form of calories like Accelerometer is a device which calculates active calories burned. There is one formula-based calculator given by American Council which measure energy expenditure directly by Heart Rate. Now a day's various devices are also available which calculate energy expenditure like Fitness Band, Digital Watches of a various company etc. [7]

CPR (Cardiopulmonary resuscitation) is an exertional activity its required lots of energy to perform. the total number of energies required to perform any physical activity depends on the physical health of a person and use of biomechanics of body. [8] The performance of high quality and adequate chest compression is one of the essential elements of the "chain of survival" of cardiac arrest patient. High quality CPR (Cardiopulmonary Resuscitation) creates blood flow which delivers oxygen to brain. [9, 10] CPR is a series of events. It consists of 2 phases of Compression and Breathing. The ratio between these two is 30:2 and Rate of compression is 100-120/min and Depth of compression is 5 cm for adult and for children and 4 cm for infants. [11,12] It is an early model of treatment in a patient with cardiac arrest either patient is inside or outside a hospital. [6,7] Survival of patient is depending on Time within CPR is given and Quality of CPR maintain thought CPR cycle. [13, 14, 15]

As CPR is a high exertional activity and it is required lots of energy so there is a need to find does change in position of CPR provider has any impact in energy expenditure which may lead to a reduction in exertion level of provider and may save the energy and maintain the quality of CPR

Material and Methods:

- Mannequin (3 bscientiic.com), Measure Tap (SMI)
- Mask, Stethoscope (Diamond), Stop Watch (Racer)
- Apple Mac book pro Core I9 9th Gen, Sphygmomanometer (Diamond)
- Apple watch series -1, Consent Form and Assessment form
- Pen, Paper

Methodology:

- **Study Design**: Observational study
- **Study Setting**: Gujrat
- **Study Population**: BLS certified provider
- **Sampling Technique**: Purposive Sampling Technique

- **Sample Size**: 32
- **Study duration**:6 Months

Criteria for selection of samples:

Inclusion criteria:

- People with certified as a BLS provider
- Both male and female

Procedure:

First Ethical approval was from Institutional Ethical Committee (IEC) , SPT, RKU and CTRI registration was done once after approval arrives from IEC,SPT,RKU After that Total of 32 purposive participants was taken According To selection The subjects in the study were prior informed about the risks and the written consent forms were taken. After that in Day:1 all subject's pre vitals (Heart rate, Respiratory rate, and Blood pressure as taken) then First Half subjects (n=16) were perform 1 man CPR for 2 min by assuming Position – A (Traditional Position – Kneeling) and Second Half subjects (n=16) were perform 1man CPR for 2 min by assuming Position – B (Modified position – spine should be straight and Hip-Knee at 90-90*) after that post vitals was taken and energy expenditure in form of calories as measure by Heart rate based formula and Apple watch series-1 on Day-2 Reverse the position First Half subjects (n=16) were perform 1 man CPR for 2 min by assuming Position – B (Modified position – spine should be straight and Hip-Knee at 90-90*) and Second half subjects (n=16) were perform 1 man CPR for 2 min by assuming Position – A (Traditional Position – Kneeling) pre and post changes in vitals and energy expenditure in form of calories were measure.

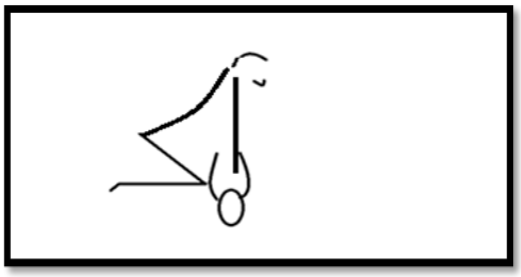


Figure 1.1 Position - A (Traditional position- Kneeling)

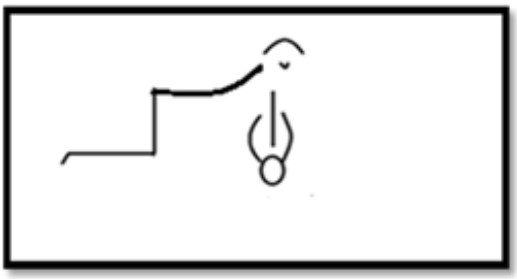


Figure 1.2 Position - B (Modified position - spine straight, HIP-KNEE at 90-90*)

Outcome measures:

- **Vitals**

- Blood pressure, Heart Rate, Respiratory Rate
- Average Range for above mentioned vitals for an adult is Blood pressure is 100-120/80-90mm/hg, Heart Rate is 60-100 bpm and Respiratory rate is 12-20 rpm[17]

- **Energy expenditure**

There are various methods to calculate energy expenditure among them; these two are the most reliable method.

- Apple Watch series-1 [25, 26]
- Heart Rate based energy expenditure formula[27,28]
- **Formula For males:**

- C = ((-55.0969+(0.6309*HR)+(0.1988*W)+(0.2017*A)) /4.184)*60*T

- **Formula For females:**

- C = ((-20.4022+(0.4472*HR) - (0.1263*W)+(0.074*A)) /4.184)*60 *

C = Calories, HR = Heart Rate, W = Weight (kg), A = Age, T = Time

- **Results and statistical analysis**

The present study was carried out to find out the effect ergonomic advantage in performing Cardiopulmonary Resuscitation. Data was analyzed using SPSS software version 20 and Microsoft Excel 2019. Level of significance was kept at **≤0.05** and confidence interval **95%** before applying statistical tests, data was screened for normal distribution.

Table: 1.1 Demographic distributions of Subjects

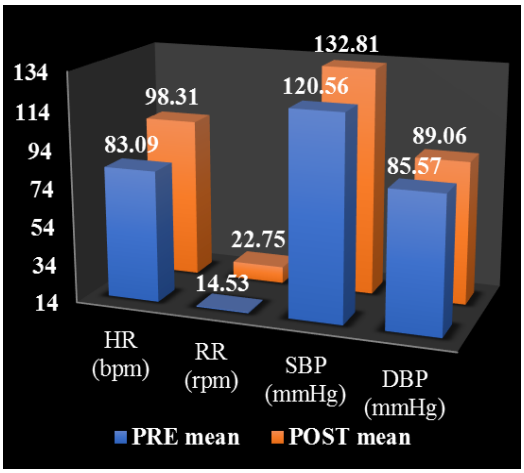
Total Subjects	**32**
Males	**15**
Females	**17**
Mean Age (years)	**24.41**

Table: 2.1 Analysis of pre and post changes in vitals by paired t-test for Position: A Traditional position assume by CPR provider)

Parameters	**PRE**		**POST**		**t- Value**	**'p' Value**
	Mean	**±SD**	**Mean**	**±SD**		
HR (bpm)	**83.09**	**6.49**	**98.31**	**10.93**	**-11.22**	**0.000**
RR (rpm)	**14.53**	**3.28**	**22.75**	**3.80**	**-21.76**	**0.000**

SBP (mmHg)	**120.6**	**9.33**	**132.8**	**9.85**	**-14.32**	**0.000**
DBP (mmHg)	**85.57**	**8.68**	**89.06**	**9.34**	**-4.847**	**0.000**

Interpretation: In position – A all Vitals are significant changes with p-value < (0.05) after CPR performance

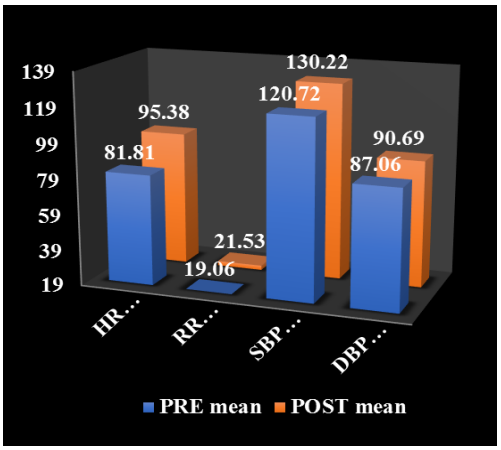


Graph: 1.1 Comparison of Pre and Post changes in mean of vitals for Position: A (Routine position assume by CPR provider)

Table: 2.2 **Analysis of Pre and Post changes in vitals by paired t-test for Position: B (Modified Position -Spine should be straight& Hip-Knee 90-90*)**

Parameters	**PRE**		**POST**		**t- Value**	**'p' Value**
	Mean	**±SD**	**Mean**	**±SD**		
HR (bpm)	**81.81**	**4.25**	**95.38**	**9.99**	**-9.002**	**0.001**
RR (rpm)	**19.06**	**3.22**	**21.53**	**3.99**	**-18.91**	**0.000**
SBP (mmHg)	**120.72**	**6.93**	**130.2**	**6.83**	**-12.67**	**0.001**
DBP (mmHg)	**87.06**	**7.57**	**90.69**	**6.59**	**-8.004**	**0.000**

Interpretation: In position – B all Vitals are significantly changing with p-value < (0.05) after CPR performance

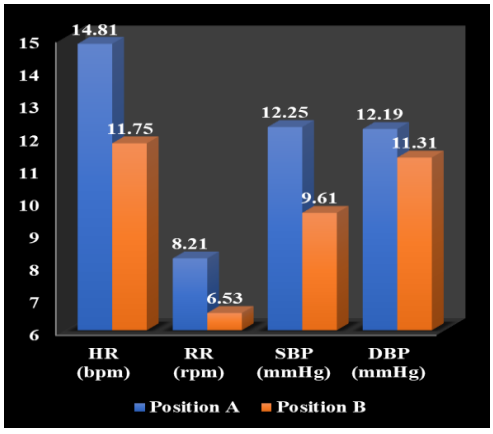


Graph: 1.2 Comparison of Pre and Post changes in mean of vitals for Position: B (Traditional position - Spine should be straight& Hip-Knee 90-90*)

Table 2.3 Analysis of changes in vitals by Independent sample t-test (Between Position – A and Position - B)

Parameters	Position – A		Position - B		t -Value	'p' Value
	Mean	±SD	Mean	±SD		
HR (bpm)	14.81	6.26	11.75	4.46	2.254	0.02
RR (rpm)	8.21	2.14	6.53	1.88	3.352	0.001
SBP (mmHg)	12.25	4.84	9.61	4.26	2.292	0.002
DBP (mmHg)	12.19	2.86	11.31	2.29	1.352	0.1

Interpretation: In position – B all vitals saws significantly less changes in vitals with p-value < (0.05) except DBP which is > (0.05) after CPR performance

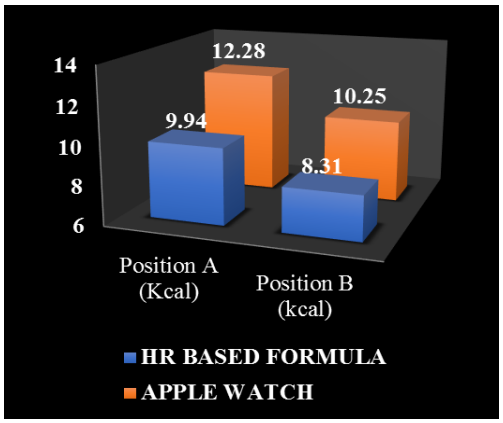


Graph: 1.3 Comparison of changes in mean of vitals (Between Position – A and Position - B)

Table: 2.4 Analysis of calories expenditure by Independent sample t-test (Between Position – A and Position - B)

Parameters (Kcal)	Position - A		Position - B		't' Value	'p' Value
	Mean	±SD	Mean	±SD		
HR based Formula	9.94	2.77	8.31	2.03	2.67	0.01
Apple watch	12.28	2.69	10.25	1.57	3.69	0.001

Interpretation: In Position -B there is a less calories expenditure as compare to Position- A with p-value (<0.05) after CPR performance



Graph: 1.4 Comparison of mean calories expenditure in CPR performance (Between Position – A and Position - B)

Discussion

The primary aim of the present study was to analyses the ergonomic advantage in performing cardiopulmonary resuscitation (CPR). Total 32 Subjects was included in this study and they have to perform 1-man CPR for 2 min in 2 Different positions. The result of the present study demonstrated that there is a significant effect of ergonomic advantage in performing cardiopulmonary resuscitation. That is why the alternative hypothesis of the present study is accepted.

The reason behind these can be expected that in any physical work first 30 seconds, there is an anaerobic energy expenditure which does not require oxygen. After 30 seconds in any work, there is an aerobic energy expenditure which required utilization of oxygen to release energy. [29] Amount of oxygen required to perform any physical activity is dependent upon the following factors.

Level of physical activity, type of activity, exertion level, utilization of biomechanics of joint,

number of muscle activation etc.

Now we will see Biomechanics of **Position A (Traditional Position)**

- Less Base of support (BOS) and Line of gravity (LOG) falls outsides the BOS
- Trunk and Hip-knee is in continuous flexion position
- Antigravity muscles like Trunk flexors, Gluteus Maximus, and Quadriceps are in continuously eccentrically contracted state
- Due to large oxidative muscle fibers continuously in eccentric contraction it early goes into fatigue
- Due to this there is more calories expenditure required to maintain this position.

Biomechanics of **Position – B (Modified position - Spine straight & Hip-Knee at 90-90*)**

- More Base of support (BOS) and Line of gravity (LOG) falls insides the BOS
- Spine is in neutral position and Hip-knee is also in 90-90* position
- Antigravity muscles like Trunk flexors, Gluteus maximus, and Quadriceps are in co-contracted
- Compression force is generated directly from the shoulder
- Provides gravity assisted movement for Compression and Allowed chest to recoil completely

- Calorie expenditure depends on heart rate so here it is considered that in position A there is more Heart rate so calories expenditure is also higher and in position B there is less heart rate, so calories expenditure is also less.[30]

M. P. DE LOOZE also conducted a study on Relationship between energy expenditure and positive and negative mechanical work in repetitive lifting and lowering was concluded that change in position in lifting and lowering has a significant impact on the reduction in energy expenditure. Which support the mechanism of the present study.

Conclusions

- This study concluded that change in position has an ergonomic advantage in performing cardiopulmonary resuscitation (CPR).
- Life-saving skills always matter while performing CPR. However, change in the position and taking ergonomic advantage to add value in the performance of CPR as well as longevity of execution.

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