

https://dspace.org/

A prospective study assessing the quality of chest compressions delivered by anaesthetists during Cardiopulmonary Resuscitation

Witt, Jonathan

2021
https://hdl.handle.net/10539/32350

Downloaded from a DSpace repository. https://dspace.org/

A prospective study assessing the quality of chest compressions delivered by anaesthetists during Cardiopulmonary Resuscitation

Dr Jonathan Witt

0417981Y

A research report submitted to the Faculty of Health Sciences,
University of the Witwatersrand, Johannesburg,
in the partial fulfilment of the requirements for the degree of
Master of Medicine in the branch of Anaesthesiology

Johannesburg, 2021

Declaration

I, Jonathan Witt, herewith declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Medicine at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



_____

Signed

On this 17th day of June 2021

Presentations and publications from this research project

Not submitted

Abstract

Background

Cardiopulmonary resuscitation (CPR) is an important skill taught to laypeople and medical professionals alike. As peri-operative care physicians, anaesthetists are required to be proficient in CPR and the skills thereof. The success of CPR delivered to patients in cardiac arrest is dependent on the provision of high-quality chest compressions including adequate depth and rate. We aimed to measure the quality of chest compressions delivered by anaesthetists working in an academic department.

Methods

This was a prospective, descriptive, manikin-based study which utilised a CPR manikin fitted with a chest compression feedback device to record CPR quality. Each participant was asked to perform uninterrupted chest compressions for 3 minutes. The data was then captured and processed using regression modelling to assess the rate, depth, and decay of compressions over time. The impact of age, sex, training level, and previous attendance at formal CPR training courses on chest compression quality was also assessed.

Results

One hundred and forty-two participants performed 49348 chest compressions over the period of 407 minutes. The overall quality of compressions was found to be very poor with only 1% (IQR: 0 to 14%) delivered adequately. The median rate of compressions was 123 compressions per minute (cpm) [IQR:122 to 123cpm], with only 19% (IQR: 1 to 68%) of compressions being within the optimal range. The median depth of compression was 4.9cm [IQR:4.7 to 5.3cm], with the median depth slipping below the 5cm lower bound after 75 seconds of compressions. The demographic variables of male sex and body mass index (BMI) were found to be weakly significant in improving the quality of compressions delivered over time.

Conclusion

This study's findings suggest that the chest compression quality delivered by anaesthetists, as per ILCOR guidelines, is generally poor. The real-life consequences of this are a reduced rate of CPR success and return of spontaneous circulation (ROSC). Based on our findings, which are in line with similar research, it may be prudent to consider the use of individuals with increased muscle mass, normal to raised BMI, and/or of male sex to perform compressions where possible. In addition, feedback devices could assist in improving chest compression quality and overall CPR.

Acknowledgements

Dr Jacob Moutlana and Dr Ryan Campbell

Professor Peter Kamerman

Thank you to the Department of Anaesthetics, Wits University

Thank you to the Departments of Anaesthesia at Charlotte Maxeke Johannesburg Academic Hospital, Chris Hani Baragwanath Academic Hospital, Helen Joseph Hospital, and Rahima Moosa Mother and Child Hospital

Thank you to all study participants

Thank you to my wife, Brenda, for her ongoing support

Table of Contents

Declaration ii

Presentations and publications from this research project iii

Abstract iv

Background iv

Conclusion v

Acknowledgements vi

List of Figures viii

List of Tables ix

List of Appendices x

List of Abbreviations xi

Draft article 1

Introduction 2

Methods 3

Results 6

Discussion 16

Limitations 18

Conclusion 18

Disclosures 19

Conflict of interest 19

References 20

Appendices 25

List of Figures

Figure 1. Box-and-whisker plots of the compression rate (compressions per minute, cpm) every one second for 180s (3 minutes). 8

Figure 2. (A) Box-and-whisker plots of the average compression rate (compressions per minute, cpm) for each minute of compressions. 9

Figure 3. Box-and-whisker plots of the compression depth (centimetres, cm) every one second for 180s (3 minutes). 11

Figure 4. (A) Box-and-whisker plots of the average compression depth (centimetres, cm) for each minute of compressions. 13

Figure 5. Proportion of compressions for male (orange circles) and female (blue circles) participants that occurred in the desired range (5 to 6cm) for each second of the 180s (3 minute) trials 15

List of Tables

Table 1. Demographic characteristics of the 142 participants..... 6

List of Appendices

Appendix 1: Proposal 25

Appendix 2: Human research ethics committee clearance certificate 54

Appendix 3: Postgraduate approval letter 55

Appendix 4: Plagiarism/ turnitin report cover page 56

Appendix 5: Journal guidelines to authors 59

Appendix 6: Permission letter by the Head of Department of Anaesthesiology 66

List of Abbreviations

BMI:	Body mass index
CPR:	Cardiopulmonary resuscitation
CPM:	Compressions per minute
ILCOR:	International Liaison Committee on Resuscitation
IQR:	Interquartile range
ROSC:	Return of spontaneous circulation
Wits:	University of the Witwatersrand

Draft article

A prospective study assessing the quality of chest compressions delivered by anaesthetists during Cardiopulmonary Resuscitation

AUTHORS

Dr Jonathan Witt, BA Hons. (Wits), MBBCh (Wits), Dip PEC (SA), DA (SA), FCA (SA)
Department of Anaesthesiology, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand

Dr Hlamatsi Jacob Moutlana, MBChB (UP), DA (SA), FCA (SA), MMed (Anaesth) (Wits)
Charlotte Maxeke Johannesburg Academic Hospital
Department of Anaesthesiology, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand

Dr Ryan Campbell, BSc (Wits), MBBCh (Wits), DA (SA), FCA (SA), MMed (Anaesth) (Wits)
Chris Hani Baragwanath Academic Hospital
Department of Anaesthesiology, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand

Corresponding author
Dr Jonathan Witt
Department of Anaesthesiology, Charlotte Maxeke Johannesburg Academic Hospital, University of the Witwatersrand
7 York Road, Parktown, 2193
Contact number: +27 92 908 8032
Email: wittjon@gmail.com

Keywords: Cardiopulmonary resuscitation, chest compressions, quality, anaesthetists.

Introduction

Cardiopulmonary resuscitation (CPR) is a commonly used and widely taught skill to both the medical fraternity and the general public worldwide. More than six decades of research have contributed to the broader understanding of which skills contribute to the successful performance of CPR.[1]

Amongst the components of which CPR is comprised, high quality chest compressions have been repeatedly shown to be a fundamental aspect which contribute to return of spontaneous circulation (ROSC).[2] Ever since it was noted in the 1950's that forceful and rhythmic pressure to the sternum was able to maintain cerebral blood flow[3], chest compressions have been a mainstay of the approach to the resuscitation of cardiac arrest victims.[4,5] Further research has proven the crucial role of chest compressions in the initial minutes after cardiac arrest, also referred to as the circulatory phase[6], and the importance of adequate chest compressions in maintaining coronary perfusion pressure as well as improving the chance of successful defibrillation in order to achieve ROSC.[7,8]

The 2015 International Liaison Committee on Resuscitation (ILCOR) guidelines recommended that compressions be delivered at a rate of between 100 – 120 per minute at a depth of > 5 centimeters (cm) but not more than 6 cm while allowing full chest recoil.[9] A compression rate of 100 – 120 is associated with improved ROSC[10] whilst lower rates provide inadequate perfusion and higher rates cause a deleterious drop in compression depth.[11] It is however not clear whether rescuers in general perform chest compressions at a consistent rate and depth, with some data showing that up to 90% of compressions are less than the required minimum of 5cm.[11] CPR quality in both the in-hospital and out of hospital setting has been shown to be highly variable.[12] Data on CPR quality in South Africa could not be identified. We aimed to investigate whether anaesthetists in an academic department were capable of performing high quality chest compression.

Methods

This study was performed using a prospective, descriptive, manikin based research design with the intention of assessing the quality of chest compressions delivered by anaesthetists in a simulated environment. Ethics approval was applied for and received from the Human Research Ethics Committee (Medical), Faculty of Health Sciences, University of the Witwatersrand (PROTOCOL NO: M190926). Participants were invited to take part in the study and informed consent was obtained.

The primary endpoint of the study aimed to measure the adequacy of both depth and rate of chest compressions delivered by anaesthetists, as per international guidelines.[13] The secondary endpoint aimed to describe the influence of demographic variables (age, sex, BMI, training level, and formal CPR training) as well as the effect of decay on the performance of high quality chest compressions. The study used purposive sampling of doctors employed by the Department of Anaesthesia across its 4 primary teaching sites (Charlotte Maxeke Johannesburg Academic Hospital; Chris Hani Baragwanath Academic Hospital; Helen Joseph Hospital; Rahima Moosa Mother and Child Hospital). Exclusion criteria were anaesthetists who did not consent to take part in the study, those unable to perform continuous chest compressions due to a physical limitation, and doctors on leave during the study period. At the time of the study this population consisted of 208 doctors of varying experience and as such we calculated a required sample size of at least 136 participants to achieve a margin of error of less than or equal to 5%, and a confidence interval of 95%.

The study was conducted in vacant rooms nearby the theatre complex at each hospital site. Consented participants had their weight and height measured, and completed a demographic data collection sheet which collected participant age, sex, height (cm), weight (kg), level of training and formal CPR training course history. A CPR manikin fitted with Zoll CPR-D Training padz® attached to a Zoll X series monitor was used for the study. The site for compressions was clearly marked by a red cross and participants were allowed time to position themselves on a foam kneepad next to the manikin. Participants were asked to perform 3 minutes of continuous chest compressions in the same way as they might be expected to during the

resuscitation of a patient in cardiac arrest. Each individual was advised that they could stop at any time if they were too tired to continue.

The monitor screen was not visible to the participant and all voice/feedback prompts were disabled. During the period of compressions, the principal researcher left the room in order to eliminate observer bias. The data captured was uploaded onto the Rescuenet Code Review software (Zoll Medical, Chelmsford, Massachusetts, USA) which allowed for isolation and analysis of compression depth and rate. Demographic data was uploaded onto a password protected Microsoft Excel® document.

All frequency data are reported as proportions or percentages. To select independent variables, we performed correlations (Spearman's or Pearson's correlation depending on the nature of the variables) to find highly correlated variables. Doing so, we identified age, sex, and body mass index (BMI) as the independent variables to include in our models. The dependent variables in our models were generated by calculating the number of valid compressions per second for each individual over the three-minute trial.

Criteria for valid compressions were based on international guidelines and included compressions of 5 to 6cm chest displacement for depth of compression, 100 to 120 compressions per minute for compression rate, and the combination of valid depth and rate for high-quality compressions (depth: 5-6cm and rate: 100-120cpm). The 3 minute time period was chosen because the current 2 minute guideline is largely based on timing of defibrillation rather than data on the optimal compression period relative to fatigue.[14, 15] Both the recommended 2 minute compression period and the study's 3 minute period were taken into account when calculating the results.

Data were modelled using mixed-model logistic regression with compression validity as the binary dependent variable (valid compression versus invalid compression), and time, age, sex, and BMI as independent variables. For each of the dependent variables (rate, depth, overall quality), we constructed two models. The first model included the independent variables as main effects only, while the second model include interaction between time and the other three independent variables. These models were compared using a likelihood ratio test, and

if the test was statistically significant, the model describing interactions with time was reported, otherwise the simpler main effects only model was reported. All statistical analyses were performed using R statistical software (v3.6.3), and statistical significance was set at $p < 0.05$.

Results

A total of 142 participants each completed up to a maximum of 3 minutes of continuous chest compressions, resulting in a total of 49348 compressions being recorded over 407 minutes.

Table 1. Demographic characteristics of the 142 participants

Variable	**Values**
Sex [Female, n (%)]	88 (62%)
Age [years, median (IQR*)]	34 (31 to 39)
BMI [kg/m^2, median (IQR*)]	24 (22 to 27)
Professional level [n (%)]	
Registrar	72 (51%)
Medical officer	22 (15%)
Consultant	48 (34%)
Time elapsed since last CPR course (BLS/ACLS/PALS) completed [months, median (IQR*)]	> 24 (12-24 to > 24)

* IQR: Interquartile range

Quality

Over the entire period of the 3 minute trial only a median of 1% (IQR: 0 to 14%) of compressions met the criteria for a high-quality compression defined as a compression with a depth of between 5cm and 6cm delivered at a rate of 100 to 120 compressions per minute. Similarly, in the initial 2 minutes only a median of 1% (IQR: 0 to 17%) of compressions met the criteria for a high quality compression.

For the mixed-model logistic regression analysis, the model with interaction between time and age, sex, and BMI was not a significantly better fit than the model with no interaction between main effects [likelihood ratio test: $\chi 2(df=3) = 1.8$, p-value = 0.61], so we only report

on the simpler model. This main effects only model detected a significant effect of time [odds ratio = 0.97 (95%CI: 0.96 to 0.98), z-statistic = -5.16, p-value < 0.001], but no significant effect of age [odds ratio = 0.91 (95%CI: 0.47 to 1.76), z-statistic = -0.28, p-value = 0.78], BMI [odds ratio = 0.54 (95%CI: 0.27 to 1.09), z-statistic = -1.71, p-value = 0.09], or sex [odds ratio = 1.03 (95%CI: 0.25 to 4.18), z-statistic = 0.04, p-value = 0.97] on the proportion of compressions that met the criteria for being quality compressions. The findings for age and sex when isolating the initial 2 minute period were not significantly different however there was both a significant effect of time [odds ratio = 0.96 (95%CI: 0.95 to 0.98), z-statistic = -4.49, p-value < 0.001], and BMI [odds ratio = 0.48 (95%CI: 0.23 to 0.97), z-statistic = -2.03, p-value = 0.042].

In summary, the quality of the majority of compressions were sub-optimal. In the 2 minute period there was no association between the quality of compressions and age or sex, but there was an effect of time and BMI, with compression quality decreasing significantly over time for both variables. However, the effect of time was very weak, and the estimate of the effect of BMI was imprecise, with the upper limit of the 95% confidence interval indicating a weak effect. Over the entire 3 minute trial, there was no association between the quality of compressions and age, BMI, or sex, but there was an effect of time, with compression quality decreasing significantly over time. This effect of time was, however, very weak.

Rate

The median rate of compression was 123 compressions per minute (cpm) [IQR:122 to 123cpm], with only 19% (IQR: 1 to 68%) of compressions being within the optimal range of 100 to 120cpm over the 3 minute trial. Figure 1 summarises the compression rate every second for the 3 minute period of the trial, and compares it to the suggested rate (100 to 120 compression per minute).

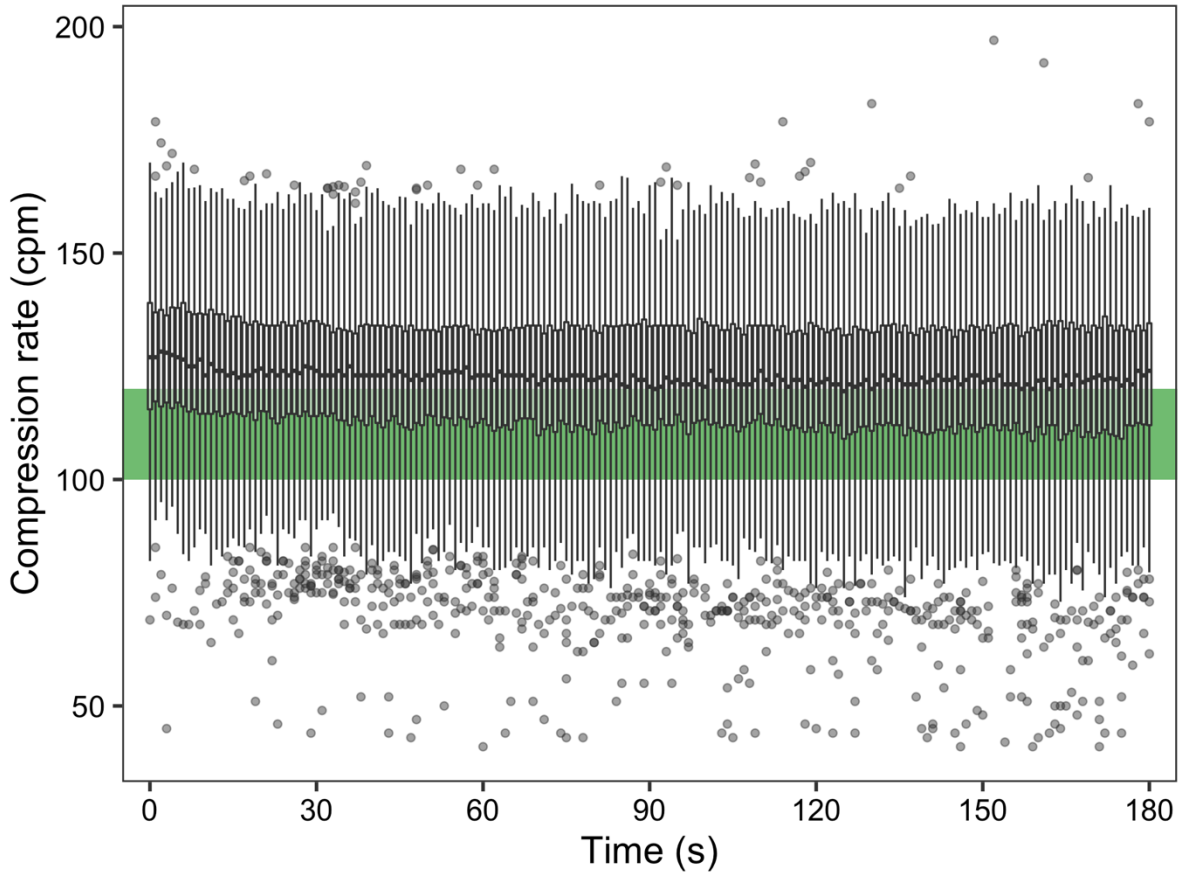


Figure 1. Box-and-whisker plots of the compression rate (compressions per minute, cpm) every one second for 180s (3 minutes). Each box shows the 25th percentile, median, and 75th percentile, while the whiskers show the range covered by 1.5 * interquartile range. Circles at the extremes show values lying outside of the range of the whiskers. The horizontal green bar shows the desired range of 100 to 120cpm.

In the initial 2 minutes the median rate of compression was equally 123cpm [IQR:122 to 124cpm], with only 20% (IQR: 1 to 69) of compressions being within the optimal range of 100 to 120cpm. Figure 2 summarises the average compression rate and proportion of compressions that are in the range of the desired rate for each minute of the trial. For each minute, the median compression rate (minute 1: 123cpm, minute 2: 121cpm, minute 3: 121cpm) was above the maximum recommended rate, and the percentage of compressions within the desired range of compressions per minute was consistently low for each minute (minute 1: 33%, minute 2: 37%, minute 3: 37%).

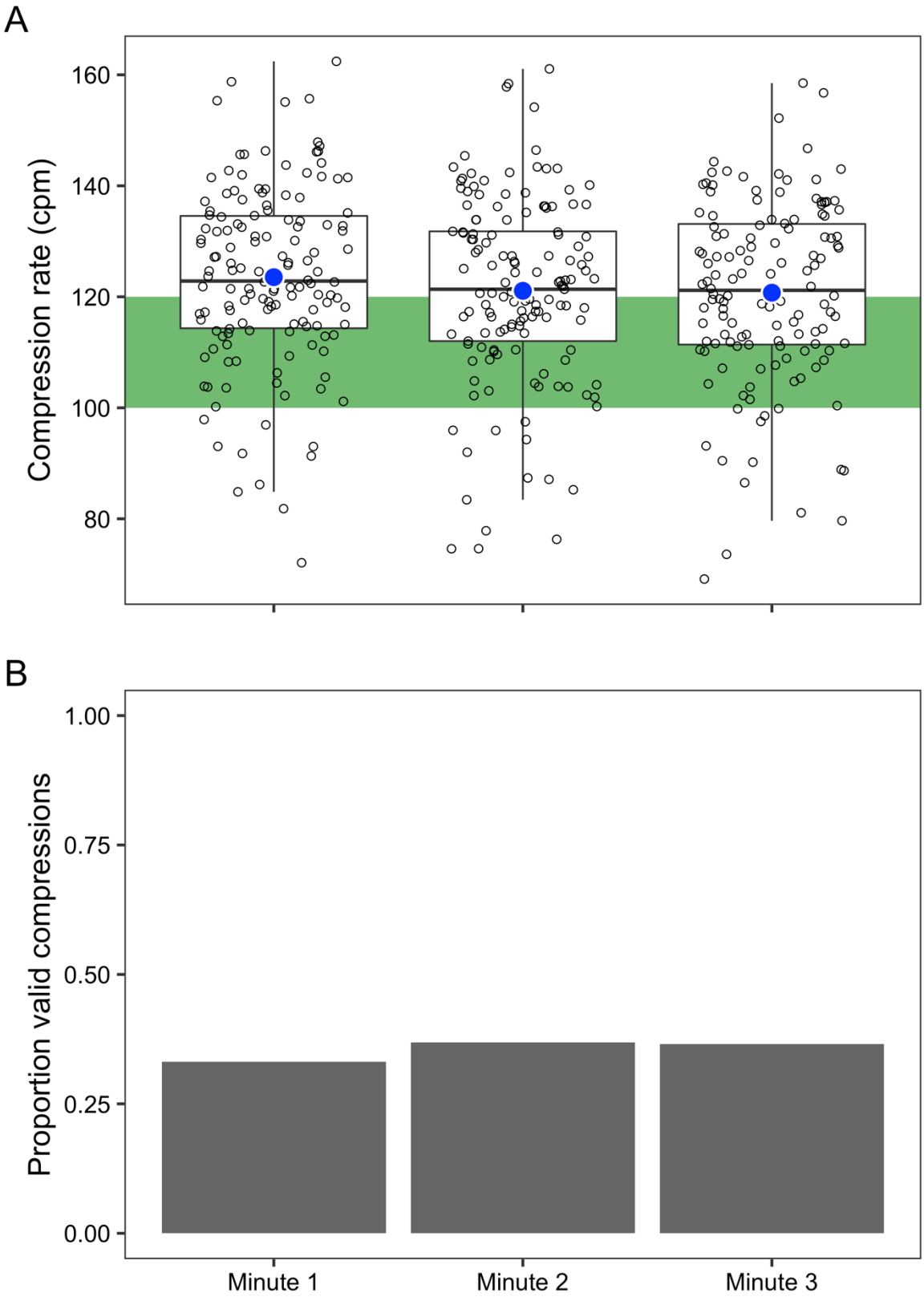


Figure 2. (A) Box-and-whisker plots of the average compression rate (compressions per minute, cpm) for each minute of compressions. Each

box shows the 25th percentile, median, and 75th percentile, while the whiskers show the range covered by 1.5 * interquartile range. The blue circle shows the mean value. Open circles show the minute average value for each individual (points are randomly scattered horizontally solely for visualization purposes). The horizontal green bar shows the desired range of compressions per minute (100 to 120cpm). (B) Proportion of compressions falling in the desired range of 100 to 120cpm for each minute of the trial.

For the mixed-model logistic regression analysis, the model with interaction between time and age, sex, and BMI was not a significantly better fit than the model with no interaction between main effects for 3 minutes [likelihood ratio test: $\chi2(df=3) = 2.59$, p-value = 0.46] or for 2 minutes [likelihood ratio test: $\chi2(df=3) = 2.61$, p-value = 0.46], so we report only on the simpler model. This model detected no effect of time [odds ratio = 1.00 (95%CI: 0.99 to 1.00), z-statistic = -1.16, p-value = 0.25], age [odds ratio = 0.90 (95%CI: 049 to 1.66), z-statistic = -0.33, p-value = 0.74], BMI [odds ratio = 0.59 (95%CI: 0.32 to 1.11), z-statistic = -1.63, p-value = 0.10], or sex [odds ratio = 1.03 (95%CI: 0.29 to 3.63), z-statistic = 0.04, p-value = 0.97] on the proportion of compressions in the 100 to 120cpm band during the 3 minute trial. Similar findings were evident when analysing the shorter 2 minute period, with no effect of time [odds ratio = 1.00 (95%CI: 0.99 to 1.01), z-statistic = 0.35, p-value = 0.73], age [odds ratio = 0.92 (95%CI: 0.48 to 1.75), z-statistic = -0.26, p-value = 0.79], BMI [odds ratio = 0.56 (95%CI: 0.29 to 1.08), z-statistic = -1.74, p-value = 0.10], or sex [odds ratio = 1.06 (95%CI: 0.28 to 3.96), z-statistic = 0.08, p-value = 0.93] on the proportion of compressions in the 100 to 120cpm band.

In summary, the rate of the majority of compressions were sub-optimal, with the rate, on average, being above the recommended range. There was no association between the rate of compressions and age, BMI, or sex, and there was no change in the rate of compression over time.

Depth

Over the period of the 3 minute trial, the median depth of compression was 4.9cm [IQR:4.7 to 5.3cm], with the median depth slipping below the 5cm lower bound for the first time after

75 seconds of compressions. Figure 3 summarises the depth of compression every second for the 3 minute period of the trial, and compares it to the optimal depth (5 to 6cm).

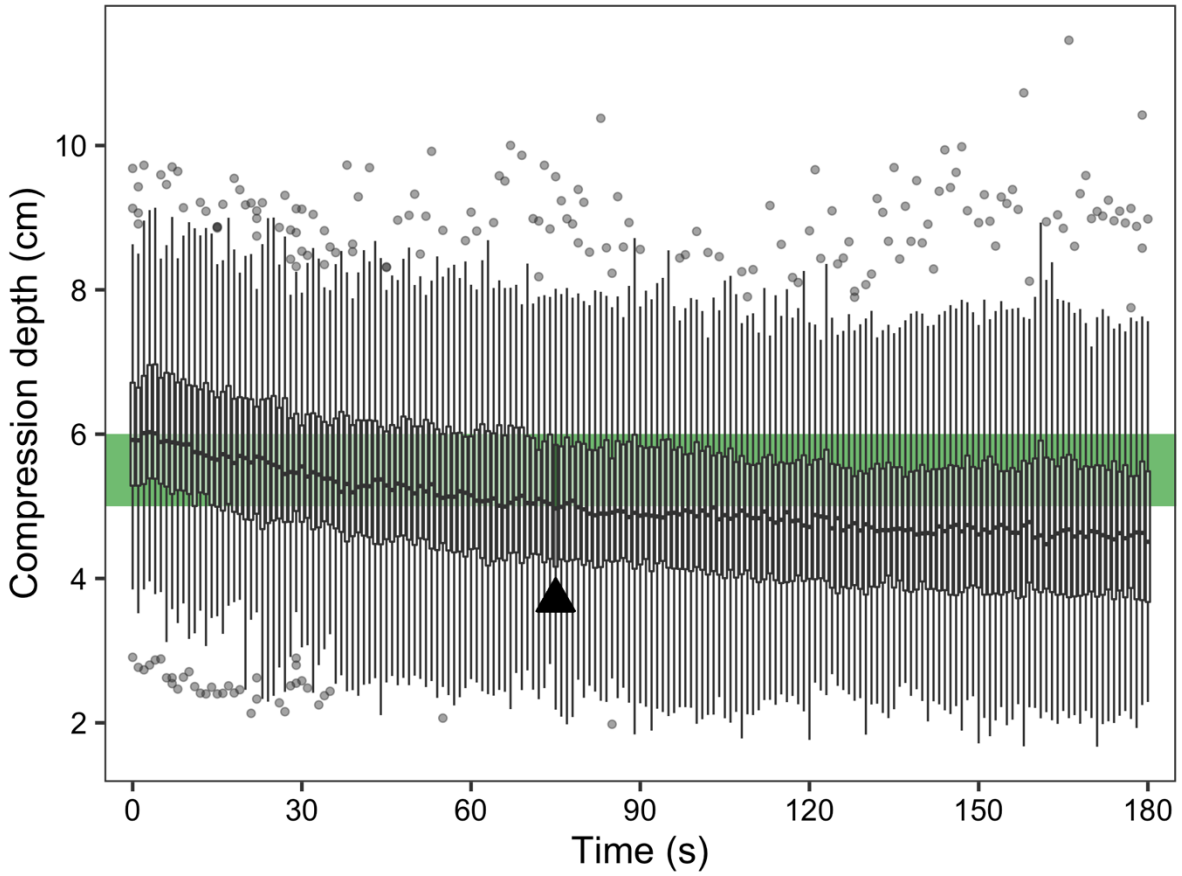


Figure 3. Box-and-whisker plots of the compression depth (centimetres, cm) every one second for 180s (3 minutes). Each box shows the 25th percentile, median, and 75th percentile, while the whiskers show the range covered by 1.5 * interquartile range. Circles at the extremes show values lying outside of the range of the whiskers. The horizontal green bar shows the desired depth of compressions (5 to 6cm). The black triangle marks the time (75s) at which the median compression depth first dropped below the lower bound of the desired range of compression depths (5cm).

During the initial 2 minutes, the median depth of compression was 5.2cm [IQR:4.9 to 5.5cm]. Overall, only 20% (IQR: 5 to 42%) of compressions during the 3 minute trial and 23% (IQR: 5 to 49%) of compressions during the initial 2 minutes were within the optimal depth range of 5 to 6 cm. Figure 4 summarises the average compression depth and proportion of

compressions that are in the optimal range of compression depths for each minute of the trial. For each minute, the mean and median compression depth progressively fell, starting within the middle of the suggested range (5 to 6cm) for minute 1 (mean: 5.6cm, median: 5.5cm), and falling to the lower limit of the optimal range for minute 2 (mean: 5.1cm, median: 5.0cm), and falling below the lower limit of the optimal range for minute 3 (mean: 4.8cm, median: 4.7cm). The percentage of compressions within the desired range of compression depths followed a similar downward trend to the compression depth data (minute 1: 33%, minute 2: 26%, minute 3: 21%).

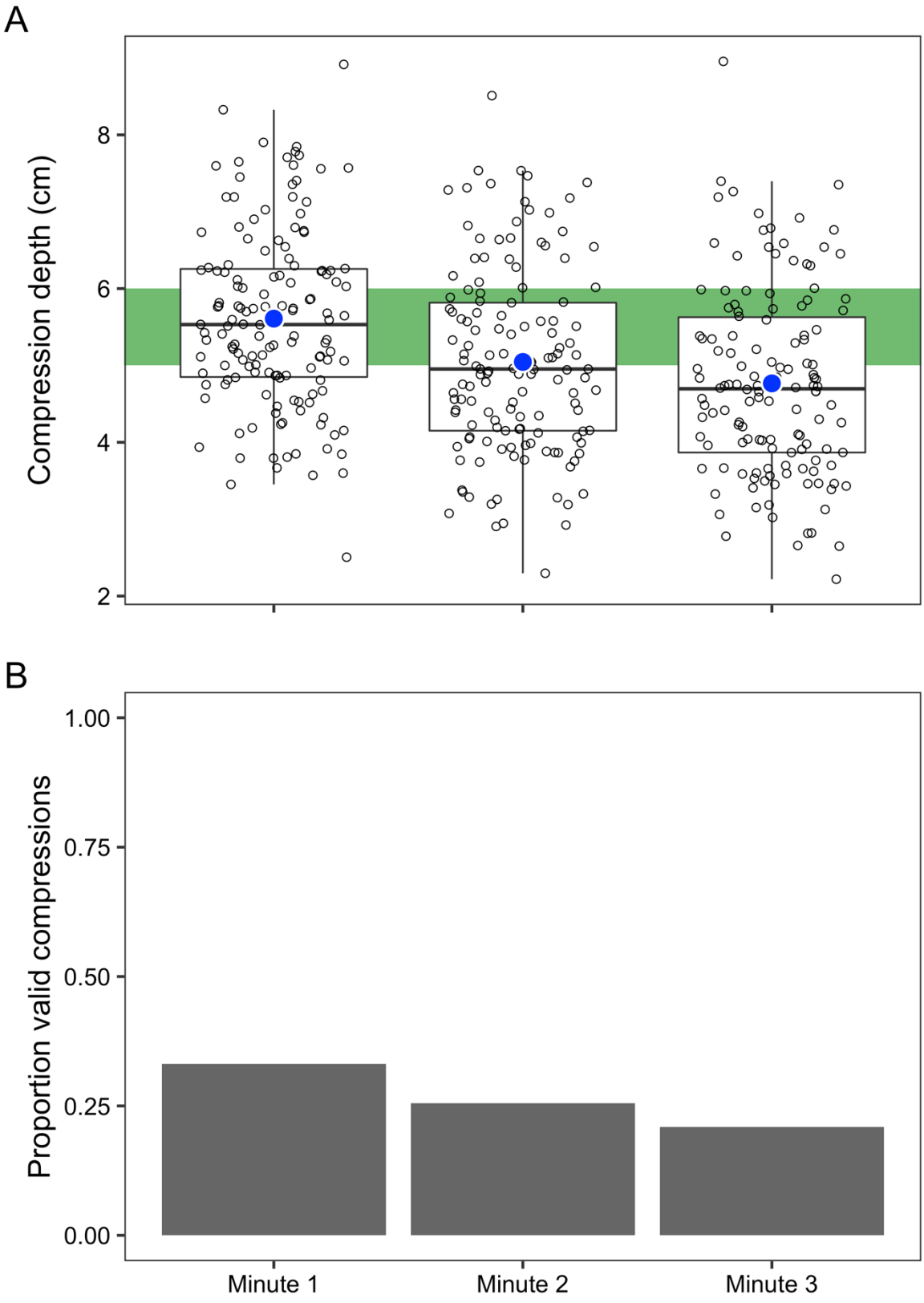


Figure 4. (A) Box-and-whisker plots of the average compression depth (centimetres, cm) for each minute of compressions. Each box shows the

25th percentile, median, and 75th percentile, while the whiskers show the range covered by 1.5 * interquartile range. The blue circle shows the mean value. Open circles show the minute average value for each individual (points are randomly scattered horizontally solely for visualization purposes). The horizontal green bar shows the desired depth of compressions (5-6cm). (B) Proportion of compressions falling in the desired range of 5 to 6cm for each minute of the trial.

For the mixed-model logistic regression analysis, the model with interaction between time and age, sex, and BMI was a significantly better fit than the model with no interaction between main effects for 3 minutes [likelihood ratio test: $\chi 2(df=3) = 11.85$, p-value = 0.008] or for 2 minutes [likelihood ratio test: $\chi 2(df=3) = 10.04$, p-value = 0.018]. Over the 3 minute period there was no significant interaction between time and BMI [odds ratio = 1.01 (95%CI: 1.00 to 1.02), z-statistic = 1.53, p-value = 0.13] or time and age [odds ratio = 1.00 (95%CI: 0.99 to 1.01), z-statistic = -0.24, p-value = 0.81], but there was significant interaction between time and sex [odds ratio = 1.04 (95%CI: 1.01 to 1.06), z-statistic = 3.11, p-value = 0.002], such that women showed a greater drop-off in performance than did men over the course of the three minute trial. This time versus sex interaction is shown in Figure 5. In the initial 2 minute period there was no significant interaction between time and age [odds ratio = 0.99 (95%CI: 0.98 to 1.01), z-statistic = -0.78, p-value = 0.43] but there was significant interaction between time and sex [odds ratio = 1.03 (95%CI: 1.01 to 1.06), z-statistic = 2.39, p-value = 0.02], and time and BMI [odds ratio = 1.01 (95%CI: 1.00 to 1.03), z-statistic = 2.13, p-value = 0.03].

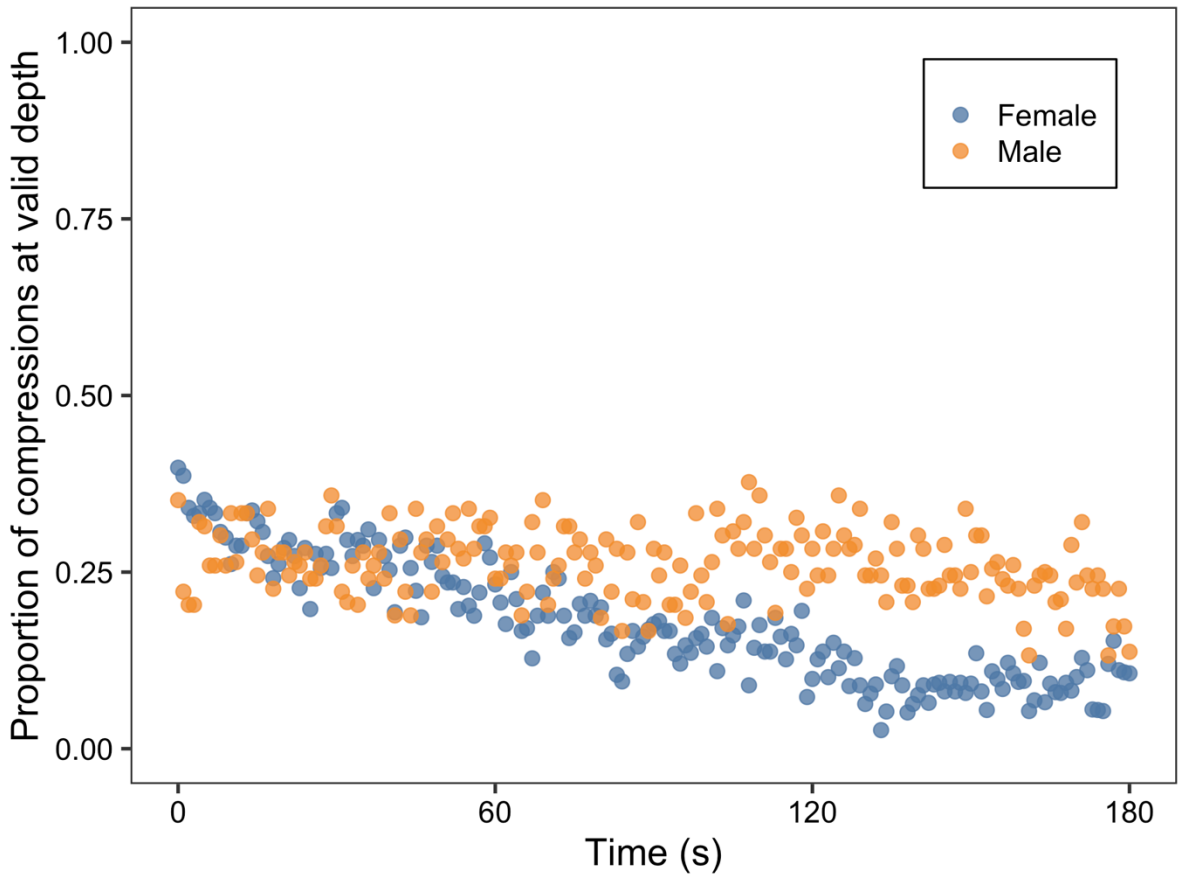


Figure 5. Proportion of compressions for male (orange circles) and female (blue circles) participants that occurred in the desired range (5 to 6cm) for each second of the 180s (3 minute) trials.

In summary, the depth of the majority of compressions were sub-optimal. There was significant interaction between time and sex, such that males had a greater odds of administering valid compressions over time than did females in both the 2 and 3 minute time periods. However, based on the 95% confidence interval of the odds ratios for the sex and time interaction, the effect was weak. Moreover in the initial 2 minute period there was interaction between time and BMI, such that greater BMI was associated with having a greater odds of administering valid compressions over time. Again, like the sex and time interaction, the interaction between BMI and time was very weak.

The age, training level and previous attendance of study participants at formal CPR training courses were not statistically correlated with any outcome.

Discussion

CPR is a skill taught to laypeople and healthcare professionals alike. Anaesthetists, as peri-operative specialists, are required to maintain this skill as a core competency and have long been thought of as being leaders in the area of resuscitation.[16] Current international CPR guidelines require that chest compressions be administered within a narrow band of recommended depth and rate. Our findings suggest that anaesthetists across an academic circuit are however poor at delivering quality chest compressions (1% over both 2 and 3 minutes) without any form of feedback. It is reasonable to assume that our findings are externally valid insofar as they raise questions about CPR competency amongst other medical professionals, specialists, and the public at large. Since any possibility of survival from a cardiac arrest is highly dependent on the quality of CPR provided, our results are of significant concern.

Our research found severe deficiency by the study population to administer the correct depth and rate of chest compressions. This compounded into the resultant finding of poor chest compression quality overall. Manikin based studies have previously been performed with the intention of assessing CPR quality and the various components thereof. These studies concluded that the depth of in-hospital chest compressions are generally insufficient and the overall quality of CPR is suboptimal.[17,18] Our findings support these notions. The addition of a fixed upper limit to chest compression depth (6cm) in 2015 remains significant given that previous guidelines merely recommended rescuers push hard and fast together, with a minimum chest compression threshold (5cm). Evidence has however shown a significant increase in injuries at a compression depth exceeding 6cm – including rib fractures (13 – 97%), sternal fractures (1 – 43%), intra-thoracic / intra-abdominal lacerations as well as haemorrhage, which helped inform the change.[19,20] In this study the depth of compressions was either too deep or too shallow with a minority in the 5 – 6cm band as per ILCOR guidelines. When depth of compressions was isolated over the initial 2 minutes the median depth fell within the recommended range (5.2cm) but only 23% of all compressions in this time period were in range. Of note is that males had greater odds of administering a valid compression than females over time, a finding which is even further amplified if the 6cm upper limit is removed. We believe this to be a function of muscle mass, a finding supported

by similar research which concluded that anthropometric variables are linked to improved CC quality.[21]

The rate of compressions administered were only in the correct band 19% of the time over the 3 minutes, and 20% of the time over 2 minutes. Of note is that the median rate for all participants was 122.5, consistently over the recommended upper limit of 120. The real world effect of this is a reduction in ventricular filling times as well as diastolic perfusion time, resulting in decreased cardiac output and suboptimal coronary perfusion, with ultimately lowered chances of ROSC.[22] Since rate was not correlated with any other variable, including time, it would seem as if participants compensated for fatigue by reducing depth whilst maintaining their compression rates. The focus therefore needs to be on both aspects during performance of CPR even though the common tendency during resuscitation is to favour compression rate versus depth, as the former is far easier to visually monitor than the latter.

Decay in compression depth and rate over time due to rescuer fatigue is a known issue and has been well investigated.[23,24] Whilst current guidelines recommend swapping compressors every 2 minutes several studies have shown that significant fatigue sets in within 2 minutes of commencing CPR and as early as 60 seconds into resuscitation efforts.[25,26] This is based on various factors including sex which has been one variable shown to have an effect on adequate rate and depth of chest compressions over time.[27,28] Our data weakly supports these findings specifically with regards to superior male performance and compression depth, whereby the median drops below 5cm at 75 seconds. Given this information it may be prudent to allocate individuals with specific characteristics to the performance of chest compressions, and look to swap rescuers prior to 2 minutes.

In order to perform 'high quality CPR' several variables need to be performed to an adequate standard. Our assessment of quality which combined rate and depth simultaneously performed as per the guidelines showed a dismal 1% of compressions performed correctly with only a small association to BMI. Increasing BMI in our data was however weakly correlated with achievement of better depth compressions, which is in keeping with previous studies showing improved depth and effectiveness of CPR when performed by those with higher body weights and individuals with increased BMIs.[29-31]

Given the narrow band of requirements within which chest compressions are required be delivered, a number of real-time feedback devices have been developed for both training and clinical use. These have been shown to significantly improve CPR quality when in use, which suggests a place and need for them in the clinical setting.[32-34] It is our view based on the results of this study and others that feedback devices may also play a significant role in improving the CPR delivered to patients.

Limitations

This was a manikin study which can result in uncertainties of measurement when considering a manikin versus the diversity of human patients, however clinical findings on manikins are often converted into clinical practice.[35] The influence of the Hawthorne effect[36] and the inability to accurately replicate real emergent resuscitation events, which likely result in a sympathetic response amongst compressors, can play a role in simulated studies. In addition BMI is a broad anthropometric variable which is not able to directly indicate level of fitness, a more accurate predictor of aerobic fatigue. Patients who go into cardiac arrest may also have monitoring such as EtCO2 and/or intra-arterial blood pressure which does allow for compression feedback.

Conclusion

High quality CPR, and more specifically high quality chest compressions, is one of the few interventions proven to result in ROSC and improved patient outcomes following cardiac arrest.[2,13,37] The most important aspect of this is the delivery of minimally interrupted chest compressions at the correct rate and depth.[38,39] Our study aimed to investigate whether Anaesthetists working in the Department of Anesthetics at the University of the Witwatersrand are proficient in providing high quality chest compressions, as per international guidelines. We assessed the quality (rate; depth) of chest compressions

delivered by anaesthetists and found them to be exceptionally poor with both sex of compressor and decay in quality over time being significant variables. Based on our findings it may be prudent to consider the use of individuals with increased muscle mass, normal to raised BMI, and/or of male sex to perform compressions where possible. It is suggested that more frequent and ongoing training may improve CPR, and that where available CPR feedback devices could also be considered to guide adequate rate and depth of chest compressions.

Disclosures

This research was completed as partial fulfilment of a Masters in Anaesthesiology degree at the University of the Witwatersrand. Assistance with funding of this research has been provided by the South African Society of Anaesthesiologists (SASA) through a grant from the Jan Pretorius Research Fund. A CPR manikin, Zoll CPR-D Demo Electrodes / Pads, and a Zoll X Series monitor was loaned by Stat-Tiakeni PTY (LTD) for the period of data collection. Statistical support and advice have been provided by Professor Peter Kamerman, School of Physiology, University of the Witwatersrand. The results of this study and its findings have been shared with the Wits Department of Anaesthesia.

Conflict of interest

None.

References

1. Witt J. CPR: ABC or CAB. Afr Fam Pr. 2019;61(2):S1–46.

2. Cheng A, Brown LL, Duff JP, Davidson J, Overly F, Tofil NM, et al. Improving Cardiopulmonary Resuscitation With a CPR Feedback Device and Refresher Simulations (CPR CARES Study): A Randomized Clinical Trial. JAMA Pediatr. 2015 Feb 1;169(2):137.

3. Hurt R. Modern cardiopulmonary resuscitation--not so new after all. J R Soc Med. 2005 Jul 1;98(7):327–31.

4. Mitka M. Peter J. Safar, MD. JAMA. 2003 May 21;289(19):2485.

5. Marsch S, Tschan F, Semmer N, Zobrist R, Hunziker P, Hunziker S. ABC versus CAB for cardiopulmonary resuscitation: a prospective, randomized simulator-based trial. Swiss Med Wkly [Internet]. 2013 Sep 6 [cited 2019 Sep 1]; Available from: http://doi.emh.ch/smw.2013.13856

6. Weisfeldt ML, Becker LB. Resuscitation After Cardiac Arrest: A 3-Phase Time-Sensitive Model. JAMA. 2002 Dec 18;288(23):3035.

7. Steen S, Liao Q, Pierre L, Paskevicius A, Sjöberg T. The critical importance of minimal delay between chest compressions and subsequent defibrillation: a haemodynamic explanation. Resuscitation. 2003 Sep;58(3):249–58.

8. Edelson DP, Abella BS, Kramer-Johansen J, Wik L, Myklebust H, Barry AM, et al. Effects of compression depth and pre-shock pauses predict defibrillation failure during cardiac arrest. Resuscitation. 2006 Nov;71(2):137–45.

9. Nolan JP, Hazinski MF, Aickin R, Bhanji F, Billi JE, Callaway CW, et al. Part 1: Executive summary. Resuscitation. 2015 Oct;95:e1–31.

10. Idris AH, Guffey D, Aufderheide TP, Brown S, Morrison LJ, Nichols P, et al. Relationship Between Chest Compression Rates and Outcomes From Cardiac Arrest. Circulation. 2012 Jun 19;125(24):3004–12.

11. Stiell IG, Brown SP, Christenson J, Cheskes S, Nichol G, Powell J, et al. What is the role of chest compression depth during out-of-hospital cardiac arrest resuscitation?*: Crit Care Med. 2012 Apr;40(4):1192–8.

12. Vadeboncoeur T, Stolz U, Panchal A, Silver A, Venuti M, Tobin J, et al. Chest compression depth and survival in out-of-hospital cardiac arrest. Resuscitation. 2014 Feb;85(2):182–8.

13. Perkins GD, Travers AH, Berg RA, Castren M, Considine J, Escalante R, et al. Part 3: Adult basic life support and automated external defibrillation. Resuscitation. 2015 Oct;95:e43–69.

14. Kolarova J, Ayoub IM, Yi Z, Gazmuri RJ. Optimal timing for electrical defibrillation after prolonged untreated ventricular fibrillation: Critical Care Medicine. 2003 Jul;31(7):2022–8.

15. Wik L, Hansen TB, Fylling F, Steen T, Vaagenes P, Auestad BH, et al. Delaying Defibrillation to Give Basic Cardiopulmonary Resuscitation to Patients With Out-of-Hospital Ventricular Fibrillation: A Randomized Trial. JAMA. 2003 Mar 19;289(11):1389.

16. Baskett PJ, Strunin L. Resuscitation. Br J Anaesth. 1997 Aug;79(2):149–50.

17. Sato H, Komasawa N, Ueki R, Yamamoto N, Fujii A, Nishi S, et al. Backboard insertion in the operating table increases chest compression depth: a manikin study. J Anesth. 2011 Oct;25(5):770–2.

18. Semark B, Årestedt K, Israelsson J, von Wangenheim B, Carlsson J, Schildmeijer K. Quality of chest compressions by healthcare professionals using real-time audiovisual feedback during in-hospital cardiopulmonary resuscitation. Eur J Cardiovasc Nurs. 2017 Jun;16(5):453–7.

19. Hellevuo H, Sainio M, Nevalainen R, Huhtala H, Olkkola KT, Tenhunen J, et al. Deeper chest compression – More complications for cardiac arrest patients? Resuscitation. 2013 Jun;84(6):760–5.

20. Kim MJ, Park YS, Kim SW, Yoon YS, Lee KR, Lim TH, et al. Chest injury following cardiopulmonary resuscitation: A prospective computed tomography evaluation. Resuscitation. 2013 Mar;84(3):361–4.

21. Bibl K, Gröpel P, Berger A, Schmölzer GM, Olischar M, Wagner M. Randomised simulation trial found an association between rescuers' height and weight and chest compression quality during paediatric resuscitation. Acta Paediatr. 2020 Sep;109(9):1831–7.

22. Wallace SK, Abella BS, Becker LB. Quantifying the Effect of Cardiopulmonary Resuscitation Quality on Cardiac Arrest Outcome: A Systematic Review and Meta-Analysis. Circ Cardiovasc Qual Outcomes. 2013 Mar;6(2):148–56.

23. Ashton A, McCluskey A, Gwinnutt CL, Keenan AM. Effect of rescuer fatigue on performance of continuous external chest compressions over 3 min. Resuscitation. 2002 Nov;55(2):151–5.

24. Berg RA, Hemphill R, Abella BS, Aufderheide TP, Cave DM, Hazinski MF, et al. Part 5: Adult Basic Life Support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010 Nov 2;122(18_suppl_3):S685–705.

25. Badaki-Makun O, Nadel F, Donoghue A, McBride M, Niles D, Seacrist T, et al. Chest Compression Quality Over Time in Pediatric Resuscitations. PEDIATRICS. 2013 Mar 1;131(3):e797–804.

26. McDonald CH, Heggie J, Jones CM, Thorne CJ, Hulme J. Rescuer fatigue under the 2010 ERC guidelines, and its effect on cardiopulmonary resuscitation (CPR) performance. Emerg Med J. 2013 Aug;30(8):623–7.

27. Shin J, Hwang SY, Lee HJ, Park CJ, Kim YJ, Son YJ, et al. Comparison of CPR quality and rescuer fatigue between standard 30:2 CPR and chest compression-only CPR: a randomized crossover manikin trial. Scand J Trauma Resusc Emerg Med. 2014 Dec;22(1):59.

28. Contri E, Cornara S, Somaschini A, Dossena C, Tonani M, Epis F, et al. Complete chest recoil during laypersons' CPR: Is it a matter of weight? Am J Emerg Med. 2017 Sep;35(9):1266–8.

29. Krikscionaitiene A, Stasaitis K, Dambrauskiene M, Dambrauskas Z, Vaitkaitiene E, Dobozinskas P, et al. Can lightweight rescuers adequately perform CPR according to 2010 resuscitation guideline requirements? Emerg Med J. 2013 Feb;30(2):159–60.

30. Sayee N, McCluskey D. Factors influencing performance of cardiopulmonary resuscitation (CPR) by Foundation Year 1 hospital doctors. Ulster Med J. 2012 Jan;81(1):14–8.

31. Gianotto-Oliveira R, Gonzalez MM, Oliveira GG, Zanocelo TM, Munhoz BD, Quilici AP, et al. Influence of body mass index in the quality of cardiopulmonary resuscitation. Resuscitation. 2010 Dec;81(2):S49.

32. Sugerman NT, Edelson DP, Leary M, Weidman EK, Herzberg DL, Vanden Hoek TL, et al. Rescuer fatigue during actual in-hospital cardiopulmonary resuscitation with audiovisual feedback: A prospective multicenter study. Resuscitation. 2009 Sep;80(9):981–4.

33. Yeung J, Meeks R, Edelson D, Gao F, Soar J, Perkins GD. The use of CPR feedback/prompt devices during training and CPR performance: A systematic review. Resuscitation. 2009 Jul;80(7):743–51.

34. Majer J, Jaguszewski MJ, Frass M, Leskiewicz M, Smereka J, Ładny JR, et al. Does the use of cardiopulmonary resuscitation feedback devices improve the quality of chest compressions performed by doctors? A prospective, randomized, cross-over simulation study. Cardiol J. 2019;26(5):529–35.

35. De Luca A, Sall FS, Sailley R, Capellier G, Khoury A. Reliability of manikin-based studies: an evaluation of manikin characteristics and their impact on measurements of ventilatory variables. Anaesthesia. 2015 Aug;70(8):915–21.

36. Chen LF, Vander Weg MW, Hofmann DA, Reisinger HS. The Hawthorne Effect in Infection Prevention and Epidemiology. Infect Control Hosp Epidemiol. 2015 Dec;36(12):1444–50.

37. Cunningham LM, Mattu A, O'Connor RE, Brady WJ. Cardiopulmonary resuscitation for cardiac arrest: the importance of uninterrupted chest compressions in cardiac arrest resuscitation. Am J Emerg Med. 2012 Oct;30(8):1630–8.

38. Ewy GA, Kern KB. Recent Advances in Cardiopulmonary Resuscitation. J Am Coll Cardiol. 2009 Jan;53(2):149–57.

39. Stiell IG, Brown SP, Nichol G, Cheskes S, Vaillancourt C, Callaway CW, et al. What Is the Optimal Chest Compression Depth During Out-of-Hospital Cardiac Arrest Resuscitation of Adult Patients? Circulation. 2014 Nov 25;130(22):1962–70.

Appendices

Appendix 1: Proposal

A prospective study assessing the quality of chest compressions delivered by anaesthetists during Cardiopulmonary Resuscitation

Name: Dr Jonathan Witt

Student number: 0417981Y

Degree: Masters of Medicine, Anaesthesiology

Supervisors: Dr Jacob Moutlana
Department of Anaesthesia
Chris Hani Baragwanath Academic Hospital
University of the Witwatersrand

Dr Ryan Campbell
Department of Anaesthesia
Chris Hani Baragwanath Academic Hospital
University of the Witwatersrand

Index

1. Introduction
2. Problem Statement
3. Aims
4. Objectives
5. Research Assumptions and Definitions
6. Demarcation of Study Field
7. Ethical Considerations
8. Research Methodology
    1. Study Design
    2. Population
    3. Sampling
        1. Size
        2. Method
    4. Inclusion and Exclusion Criteria
    5. Data Collection
        1. Demographics
        2. Skill Assessment
    6. Data Analysis
9. Significance of the Study
10. Validity and Reliability
11. Limitations
12. Time Frame
13. Financial Plan
14. References
15. Appendices
    1. Appendix A – Participant Information Sheet
    2. Appendix B – Participant Consent Form
    3. Appendix C – Demographic Data Collection Sheet
    4. Appendix D – Data Collection Table
    5. Appendix E – Participant Skill Instructions
    6. Appendix F – Letter to HOD

1. Introduction

Cardiopulmonary resuscitation (CPR) is a commonly used and widely taught skill amongst both the medical fraternity and the general public worldwide. More than six decades of research have contributed to the broader understanding of which skills contribute to the successful performance CPR.[1]

Amongst the components of which CPR is comprised, high quality chest compressions have been repeatedly shown to be a fundamental aspect which contribute to return of spontaneous circulation (ROSC)[2]. Ever since Kouwenhoven in the late 1950's noted that forceful and rhythmic pressure to the sternum was able to maintain cerebral blood flow[3], chest compressions have been a mainstay of the approach to the resuscitation of cardiac arrest victims.

With Safar's publication of the 'ABC of Resuscitation' in 1957, and the subsequent publication of the first internationally recognized CPR guidelines in 1966, the step-wise approach to CPR became one of 'Airway-Breathing-Circulation' (ABC)[4]. This emphasis on rescue breathing as more important or equally important as compressions remained fixed dogma in almost every country across the world for several decades[5].

In 2005 following research which had shown compressions to be crucial to ROSC, especially during what is referred to as the circulatory phase (4 – 10 minutes after cardiac arrest)[6], the International Liaison Committee on Resuscitation (ILCOR) changed the CPR guidelines from a compression to ventilation ratio of 15:2 to that of 30:2[7]. This change emphasized the importance of chest compressions in maintaining coronary perfusion pressure and achieving ROSC[8] as it takes approximately 40 – 45 seconds of continuous uninterrupted chest compressions before the best possible level of perfusion is reached[9].

In 2010 ILCOR again adjusted their recommendations and suggested a 'Compressions-Airway-Breathing' (CAB) approach as a preferred method for the approach to CPR[10]. This is because mouth-to-mouth ventilation produces significant interruptions in chest compressions, reducing survival with poorer neurological outcomes[11]. The CAB approach has also been

shown to shorten the delay to starting chest compressions, and reduce the time required to complete a full cycle of CPR[12, 13].

Both the 2005 and the 2010 ILCOR changes emphasized the greater importance of chest compressions in relation to ventilation, with airway management being downplayed should such measures risk interfering with the delivery of high quality and minimally interrupted chest compressions[14].

In the 2015 ILCOR guidelines it was recommended that compressions be delivered at a rate of between 100 – 120 per minute at a depth of > 5 centimeters (cm) but not more than 6 cm[15]. A compression rate of 100 – 120 is associated with improved ROSC[16] whilst lower rates provide inadequate perfusion and higher rates cause a deleterious drop in compression depth[17]. The change to compression depth is significant because it is the first time there has been a fixed upper limit to compression depth. Previous guidelines recommended rescuers push hard and fast however evidence has shown a significant increase in injuries at a compression depth exceeding 6cm – including rib fractures (13 – 97%), sternal fractures (1 – 43%), intra-thoracic / intra-abdominal lacerations as well as haemorrhage[18, 19].

A further concern is the decay in compression depth and rate due to rescuer fatigue[20]. Whilst current guidelines recommend swapping every 2 minutes several studies have shown that significant fatigue sets in within 2 minutes of commencing CPR and as early as 60 seconds into resuscitation efforts[21]. This is based on various factors including gender which has been one variable shown to have an effect on adequate rate and depth of chest compressions over time[22].

It is however not clear whether rescuers in general perform chest compressions at a consistent rate and depth, with some data showing that up to 90% of compressions are less than the required minimum of 5cm[17]. CPR quality in both the in-hospital and out of hospital setting has in some studies been shown to be variable[23]. Given the narrow band of requirements within which chest compressions are required be delivered a number of real-time feedback devices have been developed for both training and clinical use. These have

been shown to improve CPR quality, which suggests a place and need for them in the clinical setting[24, 25].

Manikin studies have previously been performed with the intention of assessing CPR quality and the various components thereof. These have thus far concluded that the depth of in-hospital chest compressions are generally insufficient and the overall quality of CPR is suboptimal[26, 27].

2. Problem Statement

High quality CPR, and more specifically high quality chest compressions, is one of the few interventions proven to result in ROSC and improved patient outcomes following cardiac arrest[9, 28, 2]. The most important aspect of this is the delivery of minimally interrupted chest compressions at the correct rate and depth[29, 30]. Anaesthetists working in the Department of Anesthetics at the University of the Witwatersrand (Wits) are required to know and provide CPR as part of their duties, however their proficiency in providing high quality chest compressions, as per the international guidelines, is not known.

3. Aims

The aims of the study are to:

- Assess the quality (rate; depth) of the compressions delivered by anaesthetists in the Wits Department of Anaesthesia when performing CPR
- Assess how selected demographic variables influence the quality of compressions delivered during the performance of CPR

4. Objectives

The objectives of this study are to:

- Describe the adequacy of the depth of chest compressions delivered by anaesthetists as per international guidelines when performing CPR
- Describe the adequacy of the rate of chest compressions delivered by anaesthetists as per international guidelines when performing CPR
- Describe the influence of demographic variables on the performance of high quality chest compressions
- Describe the decay in the quality of compressions delivered by anaesthetists over time, when performing CPR
- Describe any difference which exists in in the quality of compressions delivered by senior anaesthetists compared to junior anaesthetists

5. Research Assumptions and Definitions

Anaesthetist: Any qualified doctor who has completed their internship training and is currently employed by the Wits Department of Anaesthesia. This includes medical officers, anaesthetic registrars, and consultant anaesthesiologists.

Career Medical Officer: An anaesthetist who has a postgraduate Diploma in Anaesthesia (DA) and has been practicing for 10 years or more.

Chest Compressions: The act of interlacing the fingers of both hands and placing the heel of the bottom hand over the sternum of a patient, after which the chest is compressed to a recommended depth of 5 – 6cm, and then released before repeating the action[15].

Consultant (Cons.): An anaesthetist who has completed the required exams to become a Fellow of the College of Anaesthetists (FCA) with the Colleges of Medicine of South Africa (CMSA).

Compression Decay: The effect of fatigue on the ability of rescuers to continue to perform compressions according to the correct rate and depth as recommended by the guidelines[15].

Junior Anaesthetist: Medical officers and registrars in their first or second year of their registrar programme.

Medical Officer (MO): A doctor working as an anaesthetist in the Department of Anaesthesia who does not have an anaesthetic qualification or has held a DA for less than 10 years.

Registrar (Reg.): A doctor who is in a four year training programme to become a Fellow of the College of Anaesthetists (FCA) with the Colleges of Medicine of South Africa (CMSA).

Senior Anaesthetist: Consultants and registrars in their third or fourth year of their registrar programme.

6. Demarcation of Study Field

The study will take place in the offices at the three main sites (CMJAH; CHBAH; HJH) of the Department of Anaesthesia, University of the Witwatersrand.

7. Ethical Considerations

Approval to conduct the study will be obtained from the Human Research Ethics Committee (Medical) and the Postgraduate Office, Faculty of Health Sciences, University of the Witwatersrand.

Participants, all employees of the Department of Anaesthesia, will be invited to take part in the study. Those who agree will be given an information letter and be asked to sign informed consent (Appendix A and Appendix B).

Confidentiality will be maintained at all times. Each participant's data will be assigned a unique code which will be identifiable to the researcher only.

8. Research Methodology

8.1 Study design

A prospective, descriptive, manikin based research design will be used in this study.

A prospective study design measures variables during the time in which the study takes place. The quality of compressions delivered on a CPR manikin will be measured and recorded at the time of this study.

A descriptive study is designed to describe the distribution of one or more variables in a given population. This can be an observed finding or a behavior[31]. This study will describe the quality of chest compressions delivered by anaesthetists in a simulated environment.

A manikin based study utilizes a manikin to accurately simulate a skill which would normally be performed on a human subject. Clinical findings on manikins are often converted into clinical practice[32]. This study will use a CPR manikin fitted with a compression feedback device to assess the quality of chest compressions performed.

8.2 Population

The study population will include:

Doctors working in the Wits Department of Anaesthesia, who are practicing anaesthesia and are required to be able to perform CPR as one of their core competencies.

8.3 Sampling

8.3.1 Size

The sample size of this study is calculated based on the population size of the Anaesthetic Department. This is comprised of 31 medical officers, 114 registrars and 85 consultants – a total of 230 people. The formula is as follows:

$$\text{Sample size} = \frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p\,(1-p)}{e^2 N}\right)}$$

N = population size
e = Margin of error
z = z-score

Given a population of 230 people and calculating a sample with a margin of error of less than or equal to 5%, and a confidence interval of 95%, the final result is a study sample of 145 participants.

8.3.2 Method

The intention of this study is to assess the specific skill of chest compressions performed by a selected population (anaesthetists). The study will therefore utilize a non-probability purposive sampling-based method. Purposive sampling deliberately chooses participants based on the qualities they possess. This involves identification and selection of individuals or groups of individuals that are proficient and well-informed with regards to a subject or skill of interest[33].

8.4 Inclusion and Exclusion Criteria

The inclusion criteria for this study will be:

- Anaesthetists working on the Wits Department of Anaesthesia circuit at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), Chris Hani Baragwanath Academic Hospital (CHBAH), and Helen Joseph Hospital (HJH).

The exclusion criteria for this study will be:

- Anaesthetists who do not consent to take part in this study
- Anaesthetists who are unable to perform continuous chest compressions due to a physical limitation
- Interns rotating in the Department and doctors on leave during the study period

8.5 Data collection

Data collection will take place over 2 full weeks during which 15 participants will take part per day so as to reach the sample size of 145.

8.5.1 Demographics

A demographic data collection sheet will be used to collect data from all anaesthetists who participate in the study (Appendix C). The data collected will be as follows:

- Age
- Gender
- Height (measured using a standard measuring tape from crown to heel)
- Weight (measured using a calibrated scale, fully clothed without shoes)
- Level of training
- Formal CPR training

8.5.2 Skill Assessment

The study will be conducted and set-up in a location nearby to the theatre complex at each hospital site. In the room where the study will be conducted there will be a Zoll CPR-D Demo Manikin which will have Zoll CPR-D Demo Electrodes / Pads attached onto it. The pads contain a Food and Drug Administration (FDA) approved force transducer and accelerometer which sits over the sternum and directly under the compressor's hands. The technology is able to measure chest compression fraction, depth, rate, and rate of recoil. The site for compression is clearly marked by a red cross.





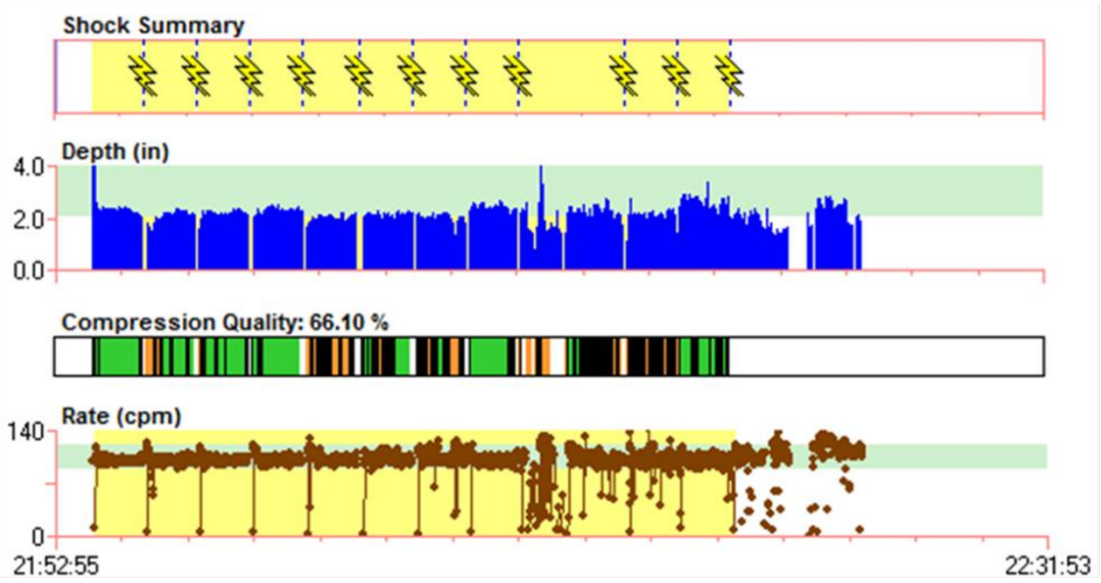
Anaesthetists will be asked to participate in the study during their breaks, or in between cases. The estimated time for each participant is approximately 5 minutes and as such minimal disruption will be caused to their work duties.

Once completing the demographic sheet participants will be given an instruction sheet (Appendix E) which will explain to them that they are required to perform continuous chest compressions for a period of 3 minutes. The participant will be allowed time to position themselves on a foam kneepad next to the manikin, and a single whistle will sound to indicate that they may start compressions. A double whistle will sound after 3 minutes to indicate that compressions should be stopped.

The CPR-D Demo Electrodes will be connected to a Zoll E/X Series monitor which will capture the depth and rate of each compression. The instantaneous values reflecting compression quality will not be visible to the participant. The data captured on the device will be downloaded daily and will be kept on a drive with at least 64-bit encryption.

8.6 Data analysis

Demographic data will be recorded in Microsoft Excel® spreadsheet and analysed using descriptive and inferential statistical tests. All data from the Zoll monitor will be uploaded onto the Rescuenet Code Review software (Zoll Medical, Chelmsford, Massachusetts, USA) which allows for isolation and analysis of compression depth and rate, as well as providing a combined value for compression quality, which is calculated based on the correct performance of both variables over the time specified.



The software also allows for analysis of minute-by-minute data (as shown below) which will be used to assist in calculating compression decay over the 3-minute cycle.

CPR Performance Summary Data

Export...

Minute	Sec. w/o Comp.	Vents	Vents CO2	Vents Leads	Comp. Count	Mean Comp. Depth	Comp. Rate	Mean Releas Vel.	Comp. Fraction	Unanl. Sec.	Comp. In Target Depth	Comp. In Target Rate	Comp. in Target	Mean CO2
1	25	0	18	0	63	2....	108	472	58.3...	0	12.70...	36.51...	11.11...	3...
2	37	0	28	0	39	3....	101	671	38.3...	0	0.00 %	17.95...	0.00 %	3...
3	31	0	28	0	52	3....	107	534	48.3...	0	11.54...	36.54...	0.00 %	3...
4	35	0	30	0	42	3....	100	621	41.6...	0	2.38 %	7.14 %	0.00 %	3...
5	28	0	11	0	59	3....	110	631	53.3...	0	1.69 %	5.08 %	0.00 %	3...

Numeric and graphical summaries of the data will be presented using mean (SD) for normally distributed data, median (IQR) for non-parametric data, and percentages for proportions. The primary outcome will be analysed using linear regression with percent correct compressions as the dependent variable and demographics variables as independent variables. The secondary outcome, change in the percentage of correct compressions over time, will be analysed using linear mixed models. All analysis will be performed using the statistical programming language R (v3.5).

9. Significance of the Study

Previous international studies evaluating the performance of CPR by anaesthetists and other healthcare providers both in and out of hospital have shown that it is generally performed poorly[23, 26, 27]. Poor quality CPR reduces the occurrence of ROSC and leads to poorer neurological outcomes in those patients who do achieve ROSC[8, 16, 24, 28]. Current guidelines recommend a chest compression rate of 100 – 120 and a compression depth of 5 – 6 cm[15]. It is unknown whether anaesthetists in South Africa are able to deliver reliably high quality chest compressions. Further research suggests the use of feedback devices may be helpful in improving CPR quality and outcomes[2, 24, 27]. This is a significant factor as these devices are not readily available in our hospitals and this study could form part of a justification for access to such equipment.

10. Validity and Reliability

The validity of a study refers to whether a "measurement instrument actually measures what it is meant to measure", and the reliability of a study refers to the "degree of similarity of the results obtained when the measurement is repeated"[34].

The validity and reliability of this study will be ensured by the following:

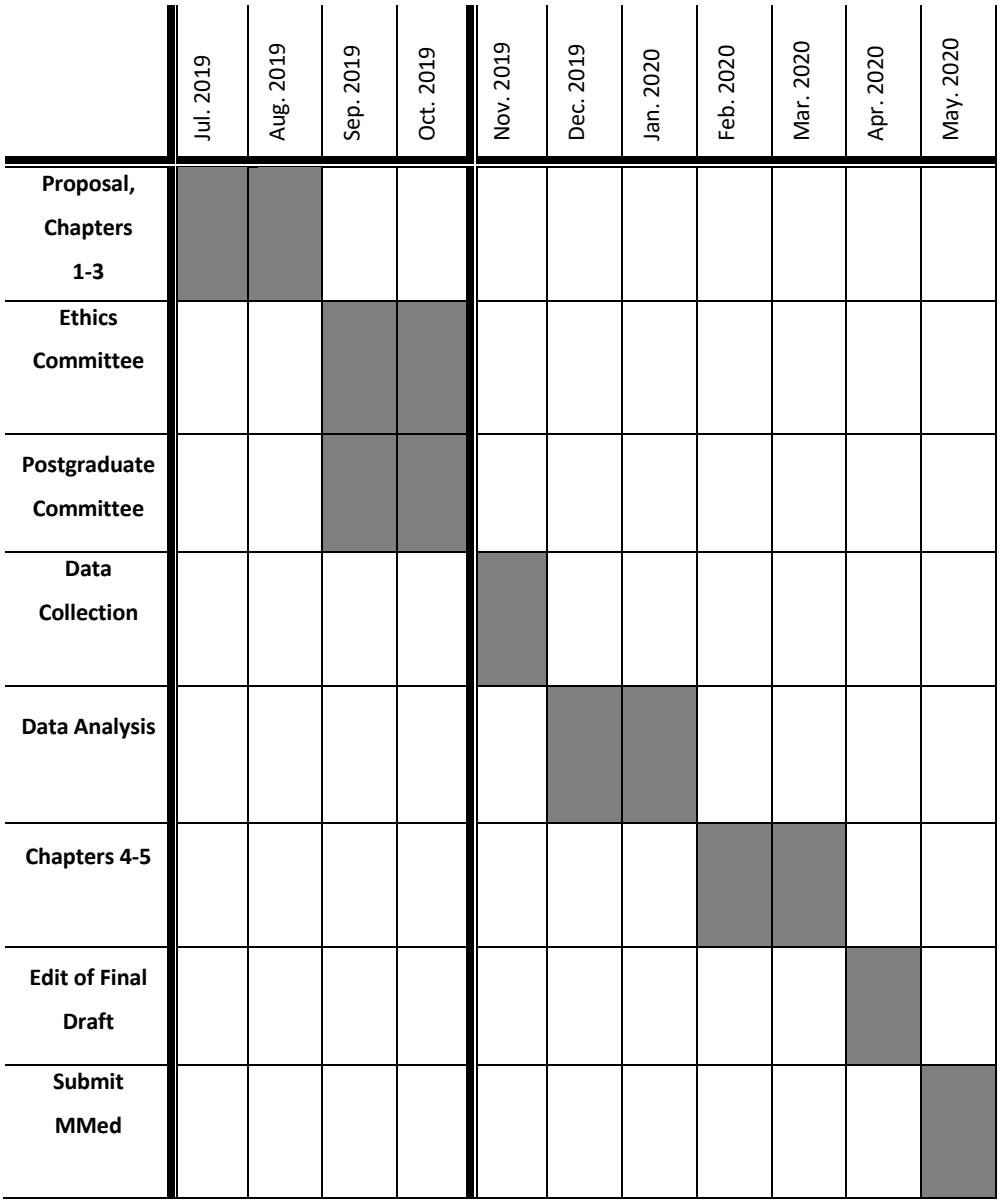
- Use of an appropriate study design and data gathering techniques
- One researcher will be responsible for collecting all data, ensuring consistency
- Use of the correct sample size relative to the population being studied
- Adherence to the CPR guidelines as set out by ILCOR
- Calibration of all electronic equipment being utilised

11. Limitations

Due to the use of purposive sampling, which is not randomized, there is the possibility of researcher bias. In addition, the contextual nature of the study in one specific Anaesthetic

Department means its findings may not be applicable or generalizable to other centres. There is also a very real possibility of the Hawthorne effect[35], whereby participants in the research change their behavior, in this instance their performance of chest compressions, because they know their skill is being watched and recorded. As this is a manikin study the participant may behave differently given that it is not a human. The chest stiffness and damping may also be different from that of some cardiac arrest patients which would could skew the compression depth data.

12. Anticipated Time Frame



13. Financial Plan

The Zoll CPR-D manikin and the Zoll E/X series monitor will be supplied by Stat-Tiakeni Medical (PTY) LTD. Further costs for the study are detailed below:

Description	Price per item	Number of items	Total
Printing			
- Proposal	0.60	100	R 60.00
- Data Collection	0.60	600	R 360.00
Equipment			
- Zoll CPR D-Padz	2500	1	R 2500.00
- Digital Scale Rental	280	10	R 2800.00
Travel Expenses			
- Fuel	1100	1	R 1100.00
Research Report Preparation	120	3	R 360.00
Total			R 7180.00

These costs will be self-funded.

14. References

1. Witt J. ABC or CAB. S Afr Fam Pract 2019;61(2):S1-S46.

2. Cheng, A., Brown, L. L., Duff, J. P., Davidson, J., Overly, F., Tofil, N. M., … Nadkarni, V. M. (2015). Improving Cardiopulmonary Resuscitation With a CPR Feedback Device and Refresher Simulations (CPR CARES Study). JAMA Pediatrics, 169(2), 137.

3. Hurt R. Modern cardiopulmonary resuscitation—not so new after all. J R Soc Med. 2005 Jul; 98(7): 327-331.

4. Mitka M. Peter J. Safar, MD: "father of CPR," innovator, teacher, humanist. JAMA. 2003 May 21;289(19):2485-6.

5. Marsch S, Tschan F, Semmer NK, Zobrist R, Hunziker PR, Hunziker S. ABC versus CAB for cardiopulmonary resuscitation: a prospective, randomized simulator-based trial. Swiss Med Wkly. 2013 Sep 6;143:w13856.

6. Weisfeldt ML, Becker LB. Resuscitation after cardiac arrest: a 3-phase time-sensitive model. JAMA 2002;288(23):3035-8.

7. Handley, A. J., Koster, R., Monsieurs, K., Perkins, G. D., Davies, S., & Bossaert, L. European Resuscitation Council Guidelines for Resuscitation 2005. Resuscitation, 67, S7–S23.

8. Steen S, Liao Q, Pierre L, Paskevicius A, Sjoberg T. The critical importance of minimal delay between chest compressions and subsequent defibrillation: a haemodynamic explanation. Resuscitation 2003;58:249–58.

9. Cunningham LM, Mattu A, O'Connor RE, Brady WJ. Cardiopulmonary resuscitation for cardiac arrest: the importance of uninterrupted chest compressions in cardiac arrest resuscitation. Am J Emerg Med. 2012 Oct;30(8):1630-8.

10. Hazinski MF, Nolan JP, Billi JE, Böttiger BW, Bossaert L, de Caen AR, Deakin CD et al. Part 1: Executive summary: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Circulation. 2010 Oct 19;122(16 Suppl 2):S250-75.

11. Kern KB, Hilwig RW, Berg RA, Sanders AB, Ewy GA. Importance of Continuous Chest Compressions During Cardiopulmonary Resuscitation: Improved Outcome During a Simulated Single Lay-Rescuer Scenario. Circulation. 2002;105:645–9.

12. Kobayashi M, Fujiwara A, Morita H, Nishimoto Y, Mishima T, Nitta M, et al. A manikin-based observational study on cardiopulmonary resuscitation skills at the Osaka Senri medical rally. Resuscitation. 2008;78:333-9.

13. Marsch S, Tschan F, Semmer NK, Zobrist R, Hunziker PR, Hunziker S. ABC versus CAB for cardiopulmonary resuscitation: a prospective, randomized simulator-based trial. Swiss Med Wkly. 2013 Sep 6;143:w13856.

14. Perkins GD, Olasveengen TM, Maconochie I, Soar J, Wyllie J, Greif R, et al. European Resuscitation Council Guidelines for Resuscitation: 2017 update. Resuscitation. 2018 Feb;123:43-50.

15. Nolan JP, Hazinski MF, Aickin R, Bhanji F, Billi JE, Callaway CW, Castren M et al. Part 1: Executive summary: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation. 2015 Oct;95:e1-31.

16. Idris AH, Guffey D, Aufderheide TP, Brown S, Morrison LJ, Nichols P, Powell J, Daya M, Bigham BL, Atkins DL, Berg R, Davis D, Stiell I, Sopko G, Nichol G; Resuscitation Outcomes Consortium (ROC) Investigators. Relationship between chest compression rates and outcomes from cardiac arrest. Circulation. 2012 Jun 19;125(24):3004-12.

17. Stiell IG, Brown SP, Christenson J, Cheskes S, Nichol G, et al. What is the role of chest compression depth during out-of-hospital cardiac arrest resuscitation? Critical Care Medicine, 40(4), 1192–1198.

18. Hellevuo, H., Sainio, M., Nevalainen, R., Huhtala, H., Olkkola, K. T., Tenhunen, J., & Hoppu, S. (2013). Deeper chest compression – More complications for cardiac arrest patients? Resuscitation, 84(6), 760–765.

19. Kim, M. J., Park, Y. S., Kim, S. W., Yoon, Y. S., Lee, K. R, et al. Chest injury following cardiopulmonary resuscitation: A prospective computed tomography evaluation. Resuscitation, 84(3), 361–364.

20. Berg, R. A., Hemphill, R., Abella, B. S., Aufderheide, T. P., Cave, D. M., Hazinski, M. F., … Swor, R. A. (2010). Part 5: Adult Basic Life Support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation, 122(18 suppl 3), S685–S705.

21. McDonald, C. H., Heggie, J., Jones, C. M., Thorne, C. J., & Hulme, J. (2012). Rescuer fatigue under the 2010 ERC guidelines, and its effect on cardiopulmonary resuscitation (CPR) performance. Emergency Medicine Journal, 30(8), 623–627.

22. Shin, J., Hwang, S. Y., Lee, H. J., Park, C. J., Kim, Y. J., Son, Y. J., … Hong, S. G. (2014). Comparison of CPR quality and rescuer fatigue between standard 30:2 CPR and chest compression-only CPR: a randomized crossover manikin trial. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 22(1).

23. Vadeboncoeur, T., Stolz, U., Panchal, A., Silver, A., Venuti, M., Tobin, J., … Bobrow, B. (2014). Chest compression depth and survival in out-of-hospital cardiac arrest. Resuscitation, 85(2), 182–188.

24. Sugerman, N. T., Edelson, D. P., Leary, M., Weidman, E. K., Herzberg, D. L., Vanden Hoek, T. L., … Abella, B. S. (2009). Rescuer fatigue during actual in-hospital cardiopulmonary

resuscitation with audiovisual feedback: A prospective multicenter study. Resuscitation, 80(9), 981–984.

25. Yeung, J., Meeks, R., Edelson, D., Gao, F., Soar, J., & Perkins, G. D. (2009). The use of CPR feedback/prompt devices during training and CPR performance: A systematic review. Resuscitation, 80(7), 743–751.

26. Sato, H., Komasawa, N., Ueki, R., Yamamoto, N., Fujii, A., Nishi, S., & Kaminoh, Y. (2011). Backboard insertion in the operating table increases chest compression depth: a manikin study. Journal of Anesthesia, 25(5), 770–772.

27. Semark, B., Årestedt, K., Israelsson, J., von Wangenheim, B., Carlsson, J., & Schildmeijer, K. (2017). Quality of chest compressions by healthcare professionals using real-time audiovisual feedback during in-hospital cardiopulmonary resuscitation. European Journal of Cardiovascular Nursing, 16(5), 453–457.

28. Perkins GD, Travers AH, Berg RA, Castren M, Considine J, Escalante R, et al. Part 3: Adult basic life support and automated external defibrillation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation. 2015;95:e43–e69

29. Ewy GA, Kern KB. Recent advances in cardiopulmonary resuscitation: cardiocerebral resuscitation. J Am Coll Cardiol 2009;53(2):149-57.

30. Stiell, I. G., Brown, S. P., Nichol, G., Cheskes, S., Vaillancourt, C., … Callaway, C. W. (2014). What Is the Optimal Chest Compression Depth During Out-of-Hospital Cardiac Arrest Resuscitation of Adult Patients? Circulation, 130(22), 1962–1970.

31. Aggarwal R, Ranganathan P. Study designs: Part 2 – Descriptive studies. Perspect Clin Res. 2019 Jan-Mar; 10(1): 34–36.

32. De Luca, A., Sall, F. S., Sailley, R., Capellier, G., & Khoury, A. (2015). Reliability of manikin-based studies: an evaluation of manikin characteristics and their impact on measurements of ventilatory variables. Anaesthesia, 70(8), 915–921.

33. Etikan I, Musa SA, Alkassim RS. Comparison of Convenience Sampling and Purposive Sampling. American Journal of Theoretical and Applied Statistics. Vol. 5, No. 1, 2016, pp. 1-4.

34. Joubert G, Ehrlich R. Epidemiology: A research manual for South Africa (third edition). Oxford Univeristy Press, 2014.

35. Chen, Luke & W Vander Weg, Mark & Hofmann, David & Reisinger, Heather. The Hawthorne Effect in Infection Prevention and Epidemiology. Infection control and hospital epidemiology. 36. 1-7. 10.1017/ice.2015.216.

15. Appendices

15.1 Appendix A – Participant Information Sheet

Consent to Participate in Research – Study Information Sheet

A prospective study assessing the quality of chest compressions delivered by anaesthetists during Cardiopulmonary Resuscitation

Hello, my name is Jonathan Witt. I am an anaesthetic registrar doing a research study in order to complete my Master of Medicine degree. My research study is on the quality of chest compressions delivered by anaesthetists, and I would like to invite you to take part.

My study will entail the following; Once you have finished reading this information sheet and consented to participate in the study, you will be asked to complete a demographic questionnaire. This will require you to complete basic questions about your age, gender, height, weight, level of training and recent CPR training. Thereafter you will be asked to complete 3 minutes of continuous chest compressions on a manikin in the same way as you would if this were a real patient in cardiac arrest. Your compressions will be recorded by a monitoring device and on completion of the 3 minutes you will be free to leave.

The Human Research Ethics Committee (number XXX-XXX) and the Postgraduate Committee of the University of the Witwatersrand have approved my study.

I do not believe that this will study endanger or harm you in any way. I will not record your name or any other information that can be used to identify you in any way. Only those directly involved in the study will see the individual results however group results may be disseminated and/or published in academic journals and presentations.

Poor quality CPR has a negative effect on patient outcomes. A better understanding of whether anaesthetist delivered chest compressions are of a high quality and why they are or aren't will help improve the knowledge in this subject and ultimately contribute to better patient care and resuscitation.

If you would like to discuss the study further, or have any questions, please do not hesitate to contact me on 082 908 8032. You may also contact the HREC at telephone number 011 717 1234 with any further queries.

Signing the consent form attached means that you agree to take part in this study. You will be given a copy of this form to keep.

Thank you for your time.

Kind regards

Dr Jonathan Witt

15.2 Appendix B – Participant Consent Form

Consent Form

I, _____
(Full name(s) and surname of participant)

hereby agree to participate in the prospective study assessing the quality of chest compressions delivered by anaesthetists during Cardiopulmonary Resuscitation.

I further confirm that:

- I have read and fully understood the information letter provided to me
- I understand that my participation in this research is voluntary and that I may withdraw from the study at any point if I do not wish to participate.
- I understand that ethical approval for this study has been obtained.
- I participate in this study on condition that all individual results will be treated with strict confidentiality
- I acknowledge that the results of this research project will be used for scientific and educational purposes
- I have had the opportunity to ask questions about the study and my participation

_____

Participant Name

_____ _____

Participant signature Date

15.3 Appendix C – Demographic Data Collection Sheet

Date: ____ / ____ / 20____ Participant number: _____

Please mark the applicable column with a tick

Consent obtained:	YES	NO

Does any injury preclude you from performing CPR:	YES	NO

Age:	21 – 30	
	31 – 40	
	41 – 50	
	51 – 60	
	> 60	

Gender:	Female	Male

Height (cm): _____

Weight (kg): _____

Training Level:	MO	Reg.	Cons. / Career MO

Year (if Reg.):	1st	2nd	3rd	4th

Most recent BLS / ACLS / PALS course:	< 6 months	
	6 months – 1 year	
	1 – 2 years	
	> 2 years	

Rescuenet file: _____

15.4 Appendix D – Data Collection Table

Participant Number	Age	Gender	Height (cm)	Weight (kg)	BMI	Training Level	CPR Training	Rescuenet
A1	2	1	168	54	19	2	3	001
D4	5	2	174	87	29	3	4	054
G7	1	1	170	71	25	1	1	102

15.5 Appendix E – Participant Skill Instructions

Thank you for your participation in this CPR study.

You are required to perform 3 minutes of chest compression on a manikin in the same way as you would in your clinical practice for a patient in cardiac arrest.

The manikin is fitted with a device which is able to measure compressions. You must please compress over this device which is denoted by a red cross.

When you are ready please place yourself at the side of the manikin ready to perform chest compressions.

A single whistle will sound and you can then begin performing chest compressions.

When 3 minutes have passed a double whistle will sound indicating that you can stop compressions.

If you become too fatigued to complete the full 3 minutes of compressions you may stop and advise the researcher.

Once you have completed the compressions you may leave the room and return to your activities.

Appendix F – Letter to HOD

Dr J Witt
Department of Anaesthesia
University of the Witwatersrand
wittjon@gmail.com
[date] 2019

For Attention: HOD – Department of Anaesthesia, University of the Witwatersrand

I am currently doing a research study in order to complete my Masters in Medicine degree. My research is aimed at determining the proficiency of anaesthetists in the Department of Anaesthesia at performing high quality chest compressions during CPR. This will entail the performance of 3 minutes of continuous chest compressions by medical officers, registrars and consultants in the Department. A specialized device will measure the quality of the chest compressions and this data will then be analysed. Other demographic factors including patient age, gender, height, weight, level of training, and CPR training will also be recorded.

I would request permission to conduct this study at the Wits Department of Anaesthesia and its various sites from 1-30 November 2019.

Thank you for your consideration of this proposal.

Kind regards
Dr Jonathan Witt
Registrar
Department of Anaesthesia
University of the Witwatersrand

Appendix 2: Human research ethics committee clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr J Witt

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M190926

NAME: (Principal Investigator)	Dr J Witt
DEPARTMENT:	School of Clinical Medicine Department of Anaesthesia Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	A prospective study assessing the quality of chest compressions delivered by anaesthetists during cardiopulmonary resuscitation
DATE CONSIDERED:	2019/09/27
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Drs J Moutlana and R Campbell
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2019/11/12

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the 3rd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **September** and will therefore reports and re-certification will be due early in the month of **September** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature _____ Date _____

PLEASE QUOTE THE CLEARANCE CERTIFICATE NUMBER IN ALL ENQUIRIES

Appendix 3: Postgraduate approval letter

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

06 September 2019
Person No: 0417981Y
PAG

Dr J Witt
P O Box 505
Melrose Arch
2000
South Africa

Dear Dr Jonathan Witt

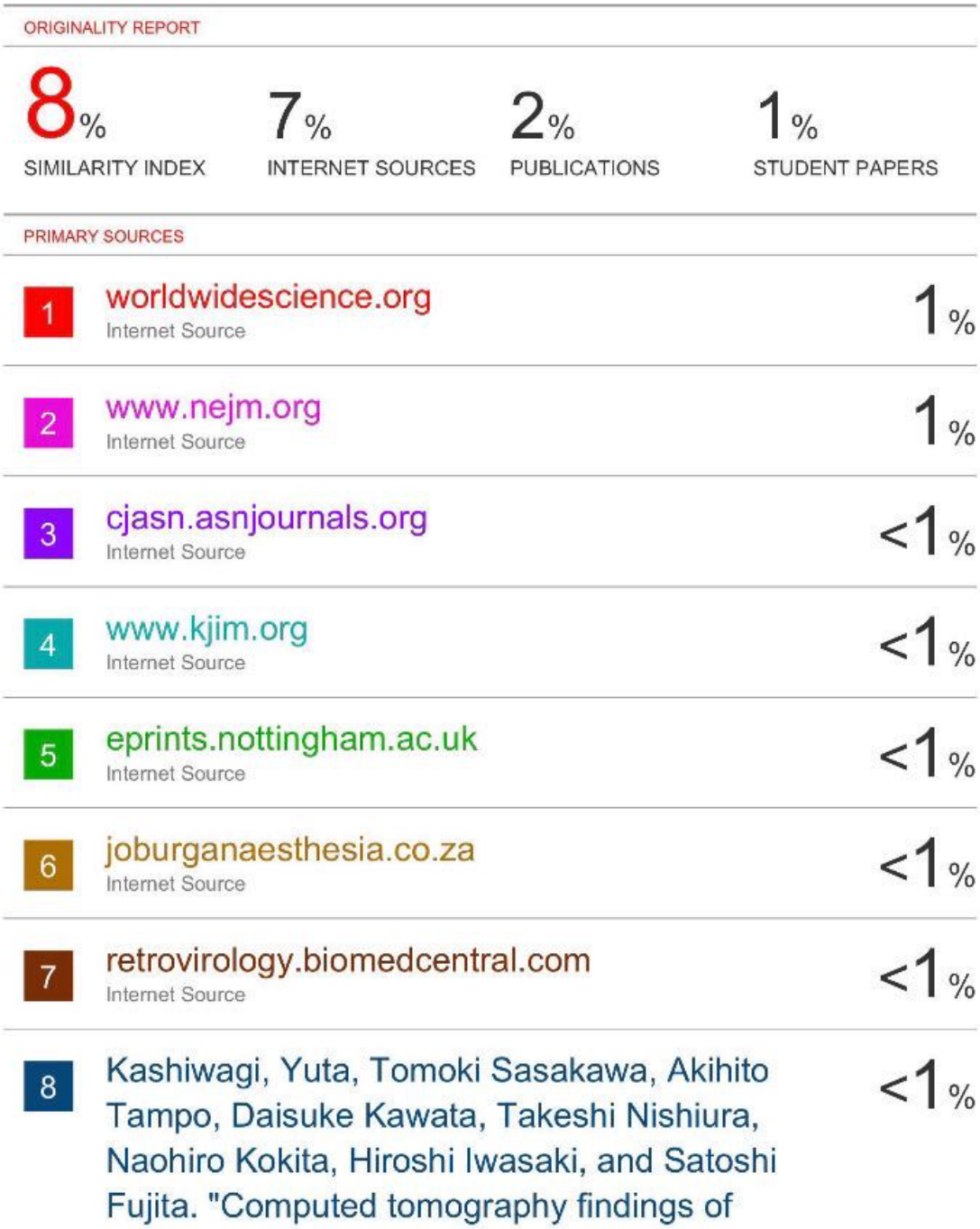
Master of Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *A prospective study assessing the quality of chest compressions delivered by anaesthetits during cardiopulmonary resuscitation.* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Appendix 4: Plagiarism/ turnitin report cover page



ORIGINALITY REPORT

8%	7%	2%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	worldwidescience.org Internet Source	1%
2	www.nejm.org Internet Source	1%
3	cjasn.asnjournals.org Internet Source	<1%
4	www.kjim.org Internet Source	<1%
5	eprints.nottingham.ac.uk Internet Source	<1%
6	joburganaesthesia.co.za Internet Source	<1%
7	retrovirology.biomedcentral.com Internet Source	<1%
8	Kashiwagi, Yuta, Tomoki Sasakawa, Akihito Tampo, Daisuke Kawata, Takeshi Nishiura, Naohiro Kokita, Hiroshi Iwasaki, and Satoshi Fujita. "Computed tomography findings of	<1%

	complications resulting from cardiopulmonary resuscitation", Resuscitation, 2015. Publication	
9	Claire-Louise Pfister, Sarisha Govender, Robert A. Dyer, Brian Rayner et al. "A Multicenter, Cross-Sectional Quality Improvement Project", Anesthesia & Analgesia, 2020 Publication	<1%
10	www.dovepress.com Internet Source	<1%
11	Submitted to Edge Hill College of Higher Education Student Paper	<1%
12	hdl.handle.net Internet Source	<1%
13	www.jrheum.org Internet Source	<1%
14	ccforum.biomedcentral.com Internet Source	<1%
15	adc.bmj.com Internet Source	<1%
16	Submitted to University of Witwatersrand Student Paper	<1%
17	Bradley S. Marino, Sarah Tabbutt, Graeme MacLaren, Mary Fran Hazinski et al.	<1%

	"Cardiopulmonary Resuscitation in Infants and Children With Cardiac Disease", Circulation, 2018 Publication	
18	doczz.net Internet Source	<1%
19	repub.eur.nl Internet Source	<1%

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		

Appendix 5: Journal guidelines to authors

Southern African Journal of Anaesthesia and Analgesia guidelines to authors

Article sections and length

The following contributions are accepted (word counts exclude abstracts, tables and references)

Original research (2800 – 3200 words/ 4-5 pages)

FULL AUTHOR GUIDELINES

Title page

All articles must have a title page with the following information and in this particular order: title of the article; surname, initials, qualifications and affiliation of each author; the name, postal address, e-mail address and telephonic contact details of the corresponding author and at least 5 keywords.

Abstract

All articles should include an abstract. The structured abstract for an Original Research article should be between 200 and 230 words and should consist of four paragraphs labeled: Background, Methods, Results, and Conclusions.
It should briefly describe the problem or issue being addressed in the study, how the study was performed, the major results, and what the authors conclude from these results. The abstracts for other types of articles should
be no longer than 230 words and need not follow the structured abstract format.

Keywords

All articles should include keywords. Up to five words or short phrases should be used. Use terms from the Medical Subject Headings (MeSH) of Index Medicus when available and appropriate. Key words are used to index the article and may be published with the abstract.

Acknowledgements

In a separate section, acknowledge any financial support received or possible conflict of interest. This section may also be used to acknowledge substantial contributions to the research or preparation of the manuscript made by persons other than the authors.

References

Cite references in numerical order in the text, in superscript format (Format> Font> Click superscript). Please do not use brackets or do not use the footnote function of MS Word.

In the References section, references must be typed double-spaced and numbered consecutively in the order in which they are cited, not alphabetically.

The style for references should follow the format set forth in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals (http://www.icmje.org) prepared by the International Committee of Medical Journal Editors.
Abbreviations for journal titles should follow Index Medicus format. Authors are responsible for the accuracy of all references. Personal communications and unpublished data should not be referenced. If essential, such material should be incorporated in the appropriate place in the text.

List all authors when there are six or fewer; when there are seven or more, list the first three, then "; et al."; When citing URLs to web documents, place in the reference list, and

use the following format: Authors of document (if available). Title of document (if available).URL (Accessed [date]).

The following are sample references:

1. Jun BC, Song SW, Park CS, Lee DH, Cho KJ, Cho JH. The analysis of maxillary sinus aeration according to aging process: volume assessment by 3-dimensional reconstruction by high-resolutional CT scanning. Otolaryngol Head Neck Surg. 2005 Mar;132(3):429-34.

2. Polgreen PM, Diekema DJ, Vandeberg J, Wiblin RT, Chen YY, David S, et al. Risk factors for groin wound infection after femoral artery catheterization: a case-control study. Infect Control HospEpidemiol [Internet]. 2006 Jan [cited 2007 Jan5]; 27(1):34-7. Available from: http://www.journals.uchicago.edu/ICHE/journal/issues/v27n1/2004069/2004069.web.pdf.

More sample references can be found at:
http://www.nlm.nih.gov/bsd/uniform_requirements.html"

Tables

Tables should be self-explanatory, clearly organised, and supplemental to the text of the manuscript. Each table should include a clear descriptive title on top and numbered in Roman numerals (I, II, etc) in order of its appearance as called out in text. Tables must be inserted in the correct position in the text. Authors should place explanatory matter infootnotes, not in the heading. Explain in footnotes all non-standard abbreviations.

For footnotes use the following symbols, in sequence: *, †, ‡, §, ||, **, ††, ‡‡

Figures

All figures must be inserted in the appropriate position of the electronic document. Symbols, lettering, and numbering (in Arabic numerals e.g. 1, 2, etc. in order of appearance in the text) should be placed below the figure, clear and large enough to remain legible after the figure has been reduced. Figures must have clear descriptive titles.

Photographs and images

If photographs of patients are used, either the subject should not be identifiable or use of the picture should be authorised by an enclosed written permission from the subject. The position of photographs and images should be clearly indicated in the text. Electronic images should be saved as either jpeg or gif files. All photographs should be scanned at a high
resolution (300dpi, print optimised). Please number the images appropriately.

Permission

Permission should be obtained from the author and publisher for the use of quotes, illustrations, tables, and other materials taken from previously published works, which are not in the public domain. The author is responsible for the payment of any copyright fee(s) if these have not been waived. The letters of permission should accompany the manuscript. The original source(s) should be mentioned in the figure legend or as a footnote to a table.

Review and action

Manuscripts are initially examined by the editorial staff and are usually sent to independent reviewers who are not informed of the identity of the author(s). When publication in its original form is not recommended, the reviewers' comments (without the identity of the reviewer being disclosed) may be passed to the first author and may include suggested revisions. Manuscripts not approved for publication will not be returned.

Ethical considerations

Papers based on original research must adhere to the Declaration of Helsinki on "; Ethical Principles for Medical Research Involving Human Subjects"; and must specify from which recognised ethics committee approval for the research was obtained.

Conflict of interest

Authors must declare all financial contributions to their work or other forms of conflict of interest, which may prevent them from executing and publishing unbiased research. [Conflict of interest exists when an author (or the author's institution), has financial or personal relationships with other persons or organizations that inappropriately influence (bias) his or her opinions or actions.]* *Modified from: Davidoff F, et al. Sponsorship, Authorship, and Accountability. (Editorial) JAMA 2001: 286(10). The following declaration may be used if appropriate: "I declare that I have no financial or personal relationship(s) which may have inappropriately influenced me in writing this paper."

Submissions and correspondence

All submissions must be made online at www.sajaa.co.za and correspondence regarding manuscripts should be addressed to:

The Editor, SAJAA, E-mail: toc@sajaa.co.za

Note: Ensure that the article ID [reference] number is included in the subject of your email correspondence.

Electronic submissions by post or via email

Authors with no e-mail or internet connection can mail their submissions on a CD to:
SAJAA, PO Box 14804, Lyttelton Manor, 0140, Gauteng, South Africa.

All manuscripts will be processed online. Submissions by post or by e-mail must be accompanied by a signed copy of the following indemnity and copyright form. CLICK HERE to download and save it to your computer.

Tips on Preparing your manuscript

1. Please consult the "Uniform requirements for manuscripts submitted to biomedical journals" at www.icmje.org

2. Please consult the guide on Vancouver referencing methods at: http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=citmed.TOC&depth=2

3. The submission must be in UK English, typed in Microsoft Word or RTF with no double spaces after the full stops, double paragraph spacing, font size10 and font type: Times New Roman.

4. All author details (Full names, Qualifications and affiliation) must be provided.

5. The full contact details of corresponding author (Tel, fax, e-mail, postal address) must be on the manuscript.

6. There must be an abstract and keywords.

7. References must strictly be in Vancouver format. (Reference numbers must be strictly numerical and be typed in superscript, not be in brackets and must be placed AFTER the full stop or comma.)

8. It must be clear where every figure and table should be placed in the text. If possible, tables and figures must be placed in the text where appropriate. If too large or impractical, they may be featured at the end of the manuscript or uploaded as separate supplementary files.

9. All photographs must be at 300dpi and clearly marked according to the figure numbers in the text. (Figure 1, Table II, etc.)

10. All numbers below ten, without percentages or units, must be written in words.

11. Figure numbers: Arabic, table numbers: Roman

<="" uk="" in="" proficient="" expert="" a="" by="" reviewed="" be="" must="">

Appendix 6: Permission letter by the Head of Department of Anaesthesiology

Signatures

Date 06/09/19 Applicant's Signature Jonathan Witt

WHO WILL SUPERVISE THE PROJECT? (Where applicable)

Name DR H.J MOUTLANA Department

Telephone No 0725551212 / 0614965676 Email hlamats@yahoo.com

Signature Date 5/9/19

HEAD RESEARCH COORDINATOR OF DEPARTMENT ENTITY IN WHICH STUDY WILL BE CONDUCTED (Where applicable) (Wits Students Academic HOD must sign)

Name P Motshabi Department Entity

Tel No 0114884344 Email Parlesa.motshabi@wits.ac.za

Signature Date 06/09/19