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Effect of different intervals of verbal motivation during dispatcher-assisted CPR: A randomized controlled simulation trial

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ABSTRACT

Aim of the study: High quality chest compressions are essential for survival and good neurological outcome in out-of-hospital cardiac arrest (OHCA). Dispatcher- assisted CPR (DA-CPR) has led to increased survival in OHCA. Recently, additional verbal motivation has shown positive effects on CPR quality. The present randomized and controlled simulation trial investigates the effect of different intervals of verbal motivation during DA-CPR.
Methods: 159 medical laypersons performed eight minutes of CPR on a simulator after randomization into one of three study groups: 1) "DA-CPR" 2) "DA-CPR + motivation every 30s" 3) "DA-CPR + motivation every 60s". Verbal motivation consisted of "push harder, do not relent. Additionally, a metronome beat was audible via telephone in the motivation groups. Primary endpoint was the difference in median chest compression depth during the eight-minute CPR compared between the study groups.
Results: There were significant differences in median compression depth between the three study groups ($p = 0.002$). However, only the group "DA-CPR + motivation every 60s" showed a significant difference in compression depth compared to standard DA-CPR and was within the recommended range. Compressions with adequate depth ($p = 0.009$) and median compression rate ($p < 0.001$) were significantly elevated in both motivational groups compared to the "DA-CPR"-group.
Conclusion: Verbal encouragement every 30 or 60 s combined with a metronome beat led to a significant augmentation of chest compression depth compared to standard DA-CPR.
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1. Introduction

Over decades, out-of-hospital cardiac arrest (OHCA) has remained one of the leading causes of cardiovascular related deaths around the globe [1]. In order to avoid a poor neurological outcome or even death in OHCA, basic life support (BLS) needs to be performed as early as possible, e.g. by bystanders until professional care arrives [2-6]. Since laypersons are often overburdened with providing sufficient chest compressions, dispatcher-assisted CPR via telephone (DA-CPR) was introduced over 40 years ago [7]. Due to its beneficial effects on bystander CPR rates [8,9] as well as on patient survival and neurological outcome [10-12], DA-CPR has been recommended by the European Resuscitation Council guidelines since 2010 [13]. High quality CPR defined by a compression rate of 100 to 120 min^{-1} and a compression depth of 50 to 60 mm is associated with higher defibrillation success, increased rate of return of spontaneous circulation (ROSC), an increased rate of survival and better neurological outcomes [14-18]. New findings suggest that CPR quality during DA-CPR can be further improved through changes in protocols used for DA-CPR, e.g. by giving continuous instructions to the bystander during CPR [19,20]. Previous studies have shown that average compression depth in bystander CPR usually was lower than recommended [21]. In a recent study, compression depth was significantly elevated by simply giving verbal motivation every 20 s during the DA-CPR [22]. The objective of this study was to investigate the effect of different verbal motivational intervals on chest-compression quality. We primarily hypothesized that an interval of 30 s will result in chest compressions with optimized depth compared to an interval of 60 s. Secondarily, we tested the hypothesis that verbal motivation decreases the number of compressions with insufficient depth and increases the number of compressions with adequate depth.

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2. Methods

2.1. Study design and approval

This study was approved by the local Ethics Committee (Ethik-Kommission An Der Medizinischen Fakultät Der RWTH Aachen, EK 492/21, approved 9th of February 2022 by Prof. Dr. med. G. Schmalzing) and was registered at the German Clinical Trials Register (DRKS00027060) prior to inclusion of the first participant. During this three-armed, non-blinded, randomized controlled study, 159 participants performed eight minutes of chest compressions on a simulation manikin (AmbuMan® Advanced, Ambu A/S, Ballerup, Denmark) in a compression-only approach. Depending on study group assignment, participants received additional acoustic feedback. Reporting was carried out in accordance with the CONSORT reporting guidelines [23].

2.2. Participants

2.2.1. Recruitment

Participants were randomly recruited on the Campus of the University Hospital of the RWTH University Aachen, Germany and the emergency operations center of the German Red Cross (Prüm, Germany) through leaflets, online announcements, media communications and face-to-face interactions. Every participant was informed about the purpose following a standardized protocol and gave written informed consent prior to inclusion. Data privacy for all participants was obtained and only pseudonymized data was used for further analyses. Personal data including age, gender etc. was obtained using a standardized questionnaire. The experiments were carried out at the Aachen University Hospital and the emergency operations center Prüm.

2.2.2. Inclusion and exclusion criteria

Inclusion criteria were voluntary participation and age between 18 and 75 years. Exclusion criteria included pregnancy, medical related education or profession (nurses, physicians, medical students, paramedics), persons who are in a dependent or employment relationship with auditor and simultaneous participation in another clinical trial.

2.2.3. Randomization

A randomization list was generated by Microsoft® Office Excel® 2016 (Microsoft Corporation, Washington, USA) using the randomization function (RAND) with subsequent preparation of envelopes. Participants were enrolled by a different member of the study team to avoid selection bias.

2.3. Interventions

Experiments were carried out between July 2022 and December 2022. As a scenario, participants would find themselves in a simulated, standardized, single rescuer emergency situation of witnessed cardiac arrest with following simulated DA-telephone CPR. While being introduced to the simulation environment and the simulated emergency situation, every individual was instructed on how to use the cordless telephone (Alcatel-Lucent, Boulogne-Billancourt, France), including the activation of the loudspeaker function. The duration of the CPR was set to eight minutes which is a common time interval for EMS to arrive on scene in Germany [24]. By receiving the simulated emergency call, the dispatcher gave standardized instructions to all participants. Thereby, three modified DA-CPR protocols were used for the three study groups based on the standard protocol of the Cologne Emergency Medical Service Dispatch Center (see DA-CPR protocols in the supplements). Besides standard DA-CPR instructions, members of study group 1 did not receive any further support or feedback. The verbal motivation in the study groups 2 and 3 started 60 s after commencement of chest compressions and consisted of the command “Push harder, do not relent!” given every 30 s in group 2 or 60 s in group 3. Additionally, a metronome set to 110 min^{-1} was provided to study groups 2 and 3 from the beginning until the end of the experiment. The metronome was played using the Ambu CPR Application (Manikin Management Module V1.2.1, Ambu GmbH, Bad Nauheim, Germany). Chest compression parameters were continuously recorded by the simulation manikin with a rate of 40 Hz by the initial chest compression.

2.4. Outcomes

The primary outcome parameter was the median compression depth. Secondary outcome parameters (across 8 min and minute wise) were total number of chest compressions, time to first chest compression, number of chest compressions with correct, too deep and insufficient depth, compressions with correct hand position and correct chest release, number of effective chest compressions, compression rate, cumulative no-flow time, differences of performance between the participants regarding sex, age, BMI, physical fitness and time since last CPR training. Exact definition of parameters and the original questionnaire can be found in the supplements (Definition of primary and secondary outcome parameters; Participants questionnaire). The data set and software are available in the repository (10.18154/RWTH-2024-08024).

2.5. Statistics and sample size

Based on a previous study [22], a change in median compression depth of at least 8 mm was considered a relevant difference. Sample size was calculated in cooperation with the Institute for Medical Statistics of the University Hospital of the RWTH University, Aachen, Germany using nQuery (version 8.7, Statsols, Boston, USA). With statistical power of 80 %, effect size of 0.25 and two-sided alpha level of 0.05, numbers of participants in each group were found to be 53. Normally distributed data is presented as mean ± standard deviation (SD). Quantitative data not following normal distribution is presented as median and interquartile range (IQR). Primary and secondary endpoints were analyzed using a one-way analysis of variance (ANOVA). For post hoc analysis, the Tukey test was used. Frequencies of categorical variables are given as absolute and relative numbers. Univariate and multiple linear regression analysis were performed to determine influences of the participant's personal characteristics on chest compression depth. A p-value <0.05 was considered to indicate significant deviation from the respective null hypothesis. For statistical analysis, IBM SPSS Statistics (version 29, IBM, New York, USA) was used. The corresponding syntax can be found in the repository (10.18154/RWTH-2024-08024). The participant's questionnaires were obtained in paper from and transferred into digital format.

3. Results

3.1. Recruitment and baseline data

Fig. 1 presents the flow diagram. In total, 159 volunteers were recruited, randomized and included in our trial. There were no dropouts (Fig. 1). Data collection started in July 2022 and ended in December 2022 after achieving the calculated number of participants. Participants characteristics can be found in Table 1. Primary and secondary outcome parameters can be found in Table 2. Neither adverse events nor unexpected findings occurred.

3.2. Compression depth

The median compression depth was 42.9 mm in the first group, 48.1 mm in group 2 and 51.7 mm in group 3 (Fig. 2), showing a significant difference between the three groups ($p = 0.002$) (Table 2). The pairwise comparisons revealed significant differences between group 1 and group 3 ($p = 0.001$), but not between group 1 and group 2

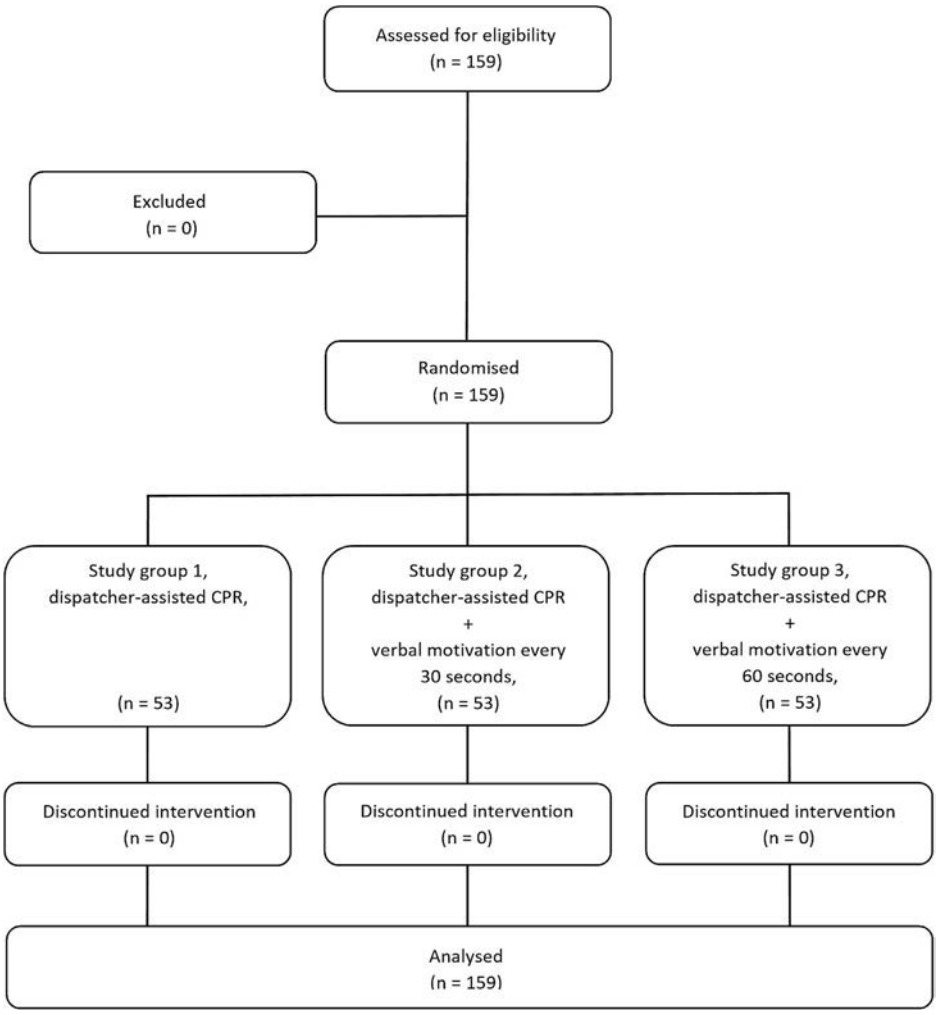

Fig. 1. Study flow diagram.

($p = 0.212$) and not between group 2 and group 3 ($p = 0.146$). Further, only in group 3 the median compression depth was within the recommended range of 50 to 60 mm (Fig. 2). Regarding the number of chest compressions with correct compression depth, group 1, 2 and 3 showed median numbers of $n = 30$ (8.2 %), $n = 180$ (20.6 %) and $n = 177$ (19.1 %) respectively. Further details can be found in Table 2. Additionally, we analyzed eight intervals of 60s each. At the beginning, the uninstructed group 1 showed a decline in median compression depth. After 120 s until the end, median compression depth stayed below 50 mm. In contrast, study group 3 remained within the recommended range until the seventh minute. After an initial increase, study group 2 fell below 50 mm of median compression depth at minute 5. From minute 2 until the end, there was a significantly higher median compression depth in study group 3 compared to group 1 (Fig. 3). Between study group 2 and 3, no significant difference was observed across any of the eight intervals (Table A.1). The median number of insufficient chest compressions was highest in group 1 (79.4 %) and lowest in group 3 (35.4 %) (Table 2). The rate of too deep chest compressions remained below 10 % in every group (Table 2).

3.3. Compression rate

The median compression rate in study group 2 and 3 was 109.1 min^{-1} and 85.7 min^{-1} in study group 1, showing a significant difference ($p < 0.001$) (Table 2). Further, in the post hoc analysis there were significant differences between study group 1 and 2 ($p < 0.001$) and between group 1 and group 3 ($p < 0.001$). In the minute-wise analysis, the median chest compression rate of group 2 and 3 remained

Table 1
baseline data, data shown as median (25th percentile – 75th percentile).

	group 1 (no motivation) $n = 53$	group 2 (motivation every 30s) $n = 53$	group 3 (motivation every 60s) n = 53	overall	p-value
Gender (female), n/%	32/60	34/64	28/53	94/59	0.488
Age [years]	50 (40.5–59.5)	51 (31.5–59.5)	53 (42–59.5)	52 (40–59)	0.555
body mass index (BMI)	25.5 (23.5–27.9)	25.2 (22.5–28.4)	25.4 (22.4–29.2)	25.4 (22.8–28.2)	0.735
Time since last CPR training [years]	3 (2–3)	3 (2–3)	3 (3–3)	3 (2–3)	0.051
Physical fitness [1–10]*	7 (5.5–8)	7 (5–8)	7 (5–8)	7 (5–8)	0.679

* 1 = subjective minimal fitness, 10 = subjective maximal fitness.

Table 2
primary and secondary outcomes, data shown as median (25th percentile – 75th percentile), *p*-value from Tukey-Test.

	group 1 (no motivation) n = 53	group 2 (motivation every 30s) n = 53	group 3 (motivation every 60s) n = 53	Global significance (p-value)	Pairwise significance (p-value)
Median compression depth [mm]	42.9 (33.7–58.7)	48.1 (41.4–57.6)	51.7 (44.7–62.9)	p = 0.002	group 1 vs. group 2 = 0.212 group 2 vs. group 3 = 0.146 **group 1 vs. group 3 = 0.001**
Total number of compressions w. depth 50-60 mm [n] / percentage*	30 (0–239) / 8.2 %	180 (11–408) / 20.6 %	177 (43–399.5) / 19.1 %	p = 0.009	**group 1 vs. group 2 = 0.020** group 2 vs. group 3 = 0.998 **group 1 vs. group 3 = 0.023**
Median compression rate [min^{-1}]	85.7 (48–109.1)	109.1 (109.1–114.3)	109.1 (109.1–114.3)	$p < 0.001$	**group 1 vs. group 2 < 0.001** group 2 vs. group 3 = 0.983 **group 1 vs. group 3 < 0.001**
Total number of compressions with correct chest release [n] / percentage*	535 (311–788.5) / 100 %	873 (824–893.5) / 100 %	869 (834.5–888.5) / 100 %	p < 0.001	**group 1 vs. group 2 < 0.001** group 2 vs. group 3 = 0.994 **group 1 vs. group 3 < 0.001**
Total number of compressions with correct hand position [n] / percentage*	374 (182.5–684) / 86.8 %	720 (486–867) / 86.2 %	790 (514.5–862.5) / 95 %	$p < 0.001$	**group 1 vs. group 2 < 0.001** group 2 vs. group 3 = 0.708 **group 1 vs. group 3 < 0.001**
Cumulative no-flow time [s]	7.5 (0.7–38.8)	3 (0.2–8.3)	0.5 (0.2–5.1)	p < 0.001	**group 1 vs. group 2 < 0.001** group 2 vs. group 3 = 1.000 **group 1 vs. group 3 < 0.001**
Time to first compression [s]	98 (84–103.5)	93 (81.5–99)	92 (83–100.5)	$p = 0.209$	
Total number of compressions [n]	569 (345.5–802.5)	876 (864–898.5)	877 (847–890)	p < 0.001	**group 1 vs. group 2 < 0.001** group 2 vs. group 3 = 0.999 **group 1 vs. group 3 < 0.001**
Total number of compressions w. depth < 50 mm [n] / percentage*	308 (23.5–510.5) / 79.4 %	487 (152.5–798.5) / 58.8 %	307 (14–731.5) / 35.4 %	$p = 0.037$	**group 1 vs. group 2 = 0.035** group 2 vs. group 3 = 0.160 group 1 vs. group 3 = 0.781
Total number of compressions w. depth > 60 mm [n] / percentage*	0 (0–150.5) / 0 %	6 (0–285.5) / 0.7 %	54 (0–629.5) / 5.9 %	$p = 0.018$	group 1 vs. group 2 = 0.804 group 2 vs. group 3 = 0.090 **group 1 vs. group 3 = 0.018**
Total number of effective chest compressions [n] / percentage*	0 (0–5.5) / 0 %	125 (3.5–287) / 14.2 %	107 (10.5–233.5) / 12.3 %	p < 0.001	**group 1 vs. group 2 < 0.001** group 2 vs. group 3 = 0.978 **group 1 vs. group 3 < 0.001**

* Percentage shown as median value.

constantly within the recommended range of 100–120 min^{-1} after the first 60 s (Fig. 4).

3.4. Ancillary analyses

We found significant differences comparing the cumulative no-flow time ($p < 0.001$), the total number of chest compressions with correct hand position ($p < 0.001$) and correct chest release ($p < 0.001$) between the three study groups (Table 2). Results of the influences of the participants' characteristics can be found in the supplements (Table A.2 and Table A.3).

4. Discussion

4.1. General discussion

The present study provides evidence that in a DA-CPR scenario, the use of verbal encouragement every 60s lead to a significant increase in median chest compression depth compared to standard DA-CPR. The feedback provided either every 30 or 60 s combined with a metronome beat led to an increased number of compressions with adequate depth compared to standard DA-CPR. Median compression rate was significantly elevated in the two intervention groups. However, the number of insufficient compressions was significantly decreased when motivation was given every 30 s compared to the standard group. Cumulative no flow time, correct chest release and compressions with correct hand position were significantly increased in the motivation groups. Results of recent studies showed improved CPR quality in terms of augmented chest compression depth in bystander CPR through verbal encouragement [19,20,22,25], which underline the clinical relevance of our primary outcome. An adequate chest compression depth of 50 to 60 mm along with a compression rate of 100 to 120 min^{-1} resulted in higher defibrillation success, an increased rate of ROSC, increased rates of survival and better neurological outcomes [14-18]. One study [19] investigated the effects of different instructions during a ten-minute simulated DA-CPR scenario on CPR quality. The authors found that little changes in DA-CPR instructions with continuous verbal encouragement and questions about the CPR (for example “Are you pushing hard?”) every 20 to 30 s, resulted in improved chest compression rate and less hands-off time. However, there was a delay in onset of the first compression and chest compression depth did not differ significantly between standard and continuous DA-CPR instructions. In contrast, our results show significant differences regarding median compression depth between the two motivation groups and the standard DA-CPR group but not regarding the time until the first compression. Another simulation study reported that changes in the DA-CPR protocol in terms of wording and descriptions of how to perform CPR (verbal encouragement given every 15 s, addressing issues such as hand position, compression depth, rescuer position or time to arrival of paramedics) led to augmented compression depth and a higher rate of correct hand positioning [25]. Since multiple elements in the protocol were changed and evaluated simultaneously, one cannot draw conclusions about the effect of one specific intervention. In our current study, to our surprise, the study group with the 60 s time interval of verbal motivation showed (non-significant) higher levels of median compression depth compared to the group with a time interval of 30 s. A reason could be that an interval of 30 s distracts from the task the participants were focused on (optimizing compression depth, trying to synchronize to the metronome beat, etc.). The impact of a metronome beat was previously investigated by multiple studies [26-29]. Our results reinforce the existing consensus about the use of a metronome and the growing evidence of a positive impact of verbal

Fig. 2. Compression depth of the three study groups. Grey dot: mean; grey bar: median.

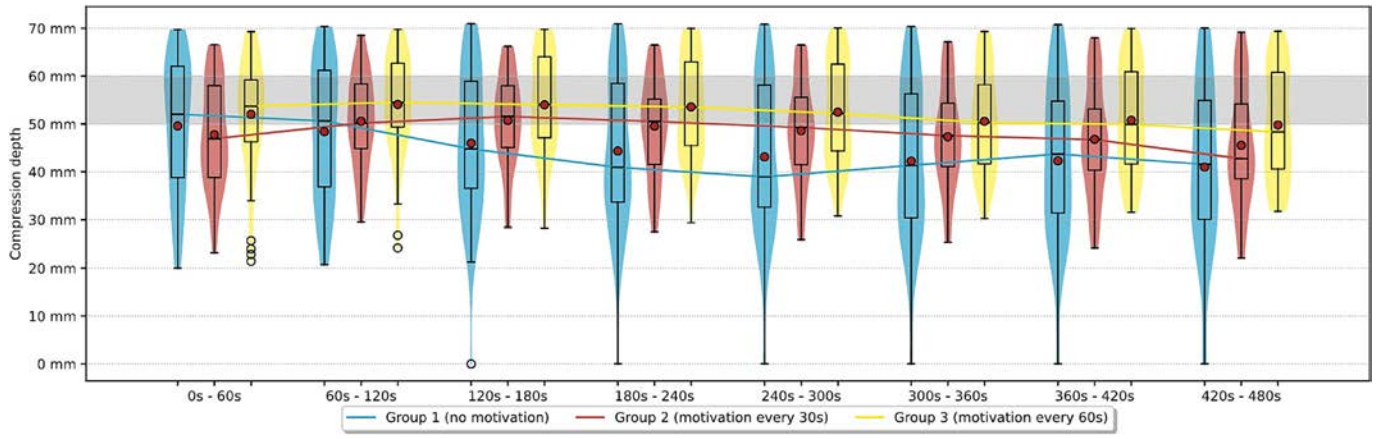

Fig. 3. Compression depth of the three study groups in one minute intervals over the study period of eight minutes. Red dot: mean; grey bar: median. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

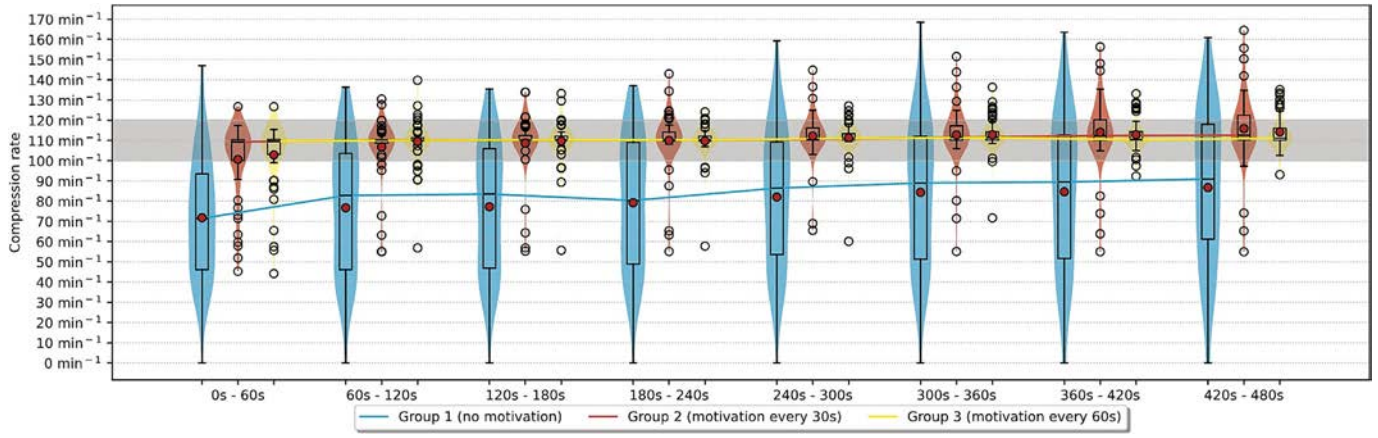

Fig. 4. Minute-wise analysis of the compression rate. Red dot: mean; grey bar: median. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

encouragement on CPR quality during DA-CPR. The mean time since the last CPR training of the participants was 3 years overall (Table 1), which is not representative for the population in Germany. It is possible that participants whose last first aid course was not so long ago were more likely to take part in the study. However, this does not diminish the overall validity of the study since all study groups had similar characteristics (Table 1). A prolonged no-flow time is known to be associated with a worse neurological outcome [30,31] and lower odds of initial shockable rhythms [32]. Our results show a significantly reduced median cumulative

no-flow time in study group 2 and 3 compared to study group 1 (Table 2). This was mainly caused by multiple compressions with insufficient depth of less than 20 mm for more than two seconds in study group 1, which contributed to cumulative no-flow time. Further, the use of verbal motivation and a metronome in group 2 and 3 did not delay the onset of CPR (Table 2). Even though the exact interval needs to be investigated under real world conditions, verbal feedback from a dispatcher in intervals of 30 to 60 s seems advantageous and easily achievable by modifying existing DA-CPR protocols.

4.2. Limitations

We recognize several limitations of our study. A simulated CPR does not represent a CPR under real conditions. Many confounding factors or influences like stress, unforeseen events, the surroundings or overwhelm during a CPR in real life can affect the obtained data. Due to the study design, participants were not surprised at being faced with an emergency situation and might remember elements of basic life support prior to beginning the experiment. Thus, immediate conclusions on clinical outcome cannot be drawn. Another limitation of the study is that the majority of participants were recruited from a single campus of a university hospital. While no participants with a medical-related profession were included, it is possible that they may have had more general knowledge and interest about health-related topics compared to the population as a whole, which could have influenced their performance in the study.

4.3. Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

5. Conclusion

Compared to standard DA-CPR, verbal encouragement combined with a metronome beat leads to a significant augmentation of chest compression depth and compression rate while lowering the cumulative no-flow time. DA-CPR algorithms should be modified in order to investigate the effect on real life CPR scenarios.

CRediT authorship contribution statement

Marcel Gehlen: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jörg Christian Brokman:** Writing – review & editing, Supervision, Resources, Project administration. **Rainer Röhrig:** Writing – review & editing, Visualization, Validation, Software, Formal analysis, Data curation. **Christian Hübel:** Writing – review & editing. **Jenny Unterkofler:** Writing – review & editing. **Christopher Plata:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Conceptualization.

Declaration of competing interest

All authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2024.11.091.

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Glossary

CPR: cardiopulmonary resuscitation
DA-CPR: dispatcher assisted cardiopulmonary resuscitation
OHAC: out-of-hospital cardiac arrest
BLS: basic life support
ROSC: return of spontaneous circulation