Usefulness of an auditory aid to improve chest compression rate accuracy during cardiopulmonary resuscitation

Abstract

Objective – To assess compression rate accuracy amongst veterinarians and registered veterinary nurses (RVNs) without and with an audible aid.

Design – Prospective study with use of a canine CPR manikin.

Setting – Quiet room in small animal hospital.

Subjects – 36 participants (20 veterinarians and 16 RVNs).

Interventions – Each participant completed the first two-minute cycle of chest compressions without an auditory aid on a canine CPR manikin. Each participant was then randomized to one of three auditory aid groups (Group B: Bee Gees 'Stayin' Alive'; Group Q: Queen 'Another One Bites the Dust' or Group M: Traditional metronome) and then completed a second two-minute cycle of chest compressions with the instruction to synchronize their compression rate with the beat of the auditory aid. An accurate chest compression rate was defined as obtaining a rate between 100-120 compressions per minute (cpm).

Measurements and Main Results – Median cpm administered by participants during Cycle 1 for the 1st minute was 111 (range 88-140) and for the 2nd minute was 107 (range 80-151), with 25/36 (69%) participants obtaining an accurate chest compression rate. Median cpm administered during Cycle 2 for the 1st minute was 110 (range 76-125) and for the 2nd minute was 110 (range 72-125), with 34/36 participants (94%) obtaining an accurate chest compression rate. Participants were more likely to obtain an accurate chest compression rate when an auditory aid was present compared to without (McNemar's test; p=0.013). Subgroup analysis suggested the auditory aid was beneficial in Group Q and M but not Group B (Kruskal Wallis with Dunn's post-hoc testing; p=0.014, p=0.0455 and p=0.5637, respectively).

Conclusions – An auditory aid was associated with improved chest compression rate accuracy. However, as the auditory aid was not beneficial for Group B participants, our findings suggest that some some auditory aids are more helpful than others.

27

28 **Abbreviations**

29 cpm: compressions per minute

30 CPR: cardiopulmonary resuscitation

31 RECOVER: Reassessment Campaign on Veterinary Resuscitation

32 ROSC: return of spontaneous circulation

33 RVNs: registered veterinary nurses

Introduction

Basic life support encompasses recognition of cardiopulmonary arrest, delivery of chest compressions and airway management with provision of ventilation.[1-3] The quality of basic life support is associated with return of spontaneous circulation (ROSC) and survival in numerous studies.[4-6]

Appropriate chest compression technique is the cornerstone of high-quality cardiopulmonary resuscitation (CPR).[1-3,7] This requires that all clinical team members have a theoretical knowledge and complete regular training for development of the necessary psychomotor skills for optimal performance.[8] Chest compressions are optimized by appropriate hand position, compression rate, compression depth and chest wall recoil.[1-3,7] Current CPR guidelines advise a compression rate of 100-120 compressions per minute (cpm), based on a high-quality experimental canine study which identified that a compression rate of 120 cpm was associated with a higher rate of ROSC and 24-hour survival compared to a compression rate of 60 cpm.[1-3,7]

Despite increasing awareness of recommended compression rates during CPR, these may be difficult to achieve in reality. A clinical observational study of human cardiac arrest patients reported a compression rate compliance of only 28%.[9] A study assessing the ability of veterinary students without prior CPR experience to deliver a compression rate of 100 cpm on a canine manikin found that 53% of participants were successful.[10] A clinical study by Hoehne et al. documented a compression rate compliance of 76% in a prospective study involving 219 CPR events.[11] This study reported cpm administered by veterinarians in practice but the study was not specifically focused on assessing chest compression rate adequacy, limited further by compression rates being self-reported and not objectively measured. Additionally, the clinical nature of the study meant that no members of the resuscitation team underwent formal training within a predefined time frame of the CPR events occurring.

One method to improve compression rate accuracy during CPR is to use an auditory aid for guidance.[8-10,12-20] The auditory aid provides a tempo for compression rate administration and has been shown to improve compression rate accuracy when used during training and clinical practice of both lay persons and human medical personnel. [8-10, 12-20] Additionally, auditory aids have been found to help prevent deterioration of chest compression rate associated with fatigue over time.[8,12,15]

A traditional metronome is a low-cost and readily available device, which may be used as an auditory aid,.[9,14,16,18,21] The traditional metronome produces clear beats set at a specific rate as determined by the operator with the rescuer instructed to deliver compressions at the same rate to that of the metronome. Alternatively, several popular songs with beat counts between 100-120 per minute may be used as an auditory aid with the beat of the song providing a cadence for compression rate administration by rescuers.[8-10,12-20,22] Human guidelines are supportive for the use of auditory guidance during CPR to aid adherence and delivery of high-quality CPR, however, at present, there is no consensus, on the optimal auditory aid rate, type, and if using a popular song, it is unknown which is preferred.[2,23]

Popular songs with beat counts between 100-120 per minute can inspire recall for the rate of compressions, even when not audible.[8,10,15,22,24] Rescuers can think of these songs whilst delivering compressions to aid compression rate accuracy. In this capacity, the popular song acts as a mental metronome. A study evaluating the utility of a song as a mental metronome concluded that veterinary students were more likely to achieve an appropriate compression rate when using a mental metronome compared to veterinary students who were only instructed to administer chest compressions at a rate of 100 beats per minute.[10] To the author's knowledge, this is the only study assessing the utility of an auditory aid (traditional metronome or popular song audible or as mental metronome) within the veterinary literature. At present, it is unknown if chest compression rate

accuracy is improved with the use of an auditory aid by veterinary clinical members and hence the current Reassessment Campaign on Veterinary Resuscitation (RECOVER) guidelines make no recommendation relating to their use in CPR. The aim of this study was to assess compression rate accuracy amongst veterinarians and registered veterinary nurses (RVNs) without and with an audible aid (music or traditional metronome). A secondary aim was to assess the frequency and utility of use of a mental metronome to aid rate of chest compressions by veterinarians and RVNs. We hypothesized that the use of an audible aid would increase compression rate accuracy but there would be no significant difference between the use of a music or traditional metronome.

Materials and Method

The study protocol was approved by the institution's Veterinary Ethical Review Committee. All veterinarians and RVNs working within the small animal teaching hospital were eligible for study inclusion. Participants were recruited on a voluntary and informed basis via an email sent to hospital staff. Each interested individual was asked to sign a consent form for participation and then asked to attend one session based on their convenience. Each participant enrolled was allocated to one 30 minutes slot, with 4 participants enrolled in each 2-hour session. Each participant was evaluated on a 1:1 basis, with only one study participant and one study investigator present at any one time during a session. The sessions took place in a quiet room, away from clinical activities, in the small animal hospital.

There were three auditory aid study groups. Group B utilized the music aid Bee Gees, ''Stayin' Alive'' (103 beats per minute), Group Q utilized the music aid Queen, ''Another one bites the dust'' (110 beats per minute) and Group M utilized a traditional metronome set at a rate of 110 beeps per minute from a smart phone app.[a] For Group B and Group Q, a 2-minute clip of each song was made to ensure that each participant heard the same clip of the song.

A 5-minute video was developed by the study investigators to demonstrate how to perform optimal chest compressions using a canine manikin.[b] This video demonstrated optimal hand placement, locking of elbows, patient positioning, chest compression rate and importance of chest wall recoil. An optimal compression rate of 100-120 cpm was advised based on current RECOVER guidelines.[7] Optimal compression depth was not emphasized given the difficulty in achieving this on a manikin. All participants performed chest compressions on the same manikin[b] as used in the video. Each participant watched the video at the start of their session and then had the opportunity to practice chest compressions (up to 10 minutes) before initiating the first cycle (Cycle 1) of studied CPR. Participants did not receive feedback from a study investigator on their practice chest

compressions. If a participant did want to practice their compressions, a 5-minute break between practice and Cycle 1 of chest compressions was given.

Cycle 1

Participants were asked to perform 2 minutes' worth of chest compressions on the CPR canine manikin[b] as described within the video without an auditory aid. The manikin[b] was positioned in lateral recumbency on a table which could be height adjusted. Each participant was instructed to assess the table height and adjust as necessary prior to starting compressions. A camera was used to record participant efforts for data quality assurance. Only one study investigator was present, being responsible for video recording, timing the 2-minute cycle with a stopwatch and communicating the start and end time of the 2-minute period to each study participant. The video recording was started prior to the start of the cycle and stopped after the end of the cycle. No study investigator counted the number of compressions live during the cycle and all evaluations were based on the video recordings.

Questionnaire and Group Assignment

During recovery, each participant was asked to complete a 5-minute questionnaire, which had questions relating to participant demographics, frequency each participant performed CPR, date of last CPR training and whether they had completed any RECOVER CPR training. Each participant was also asked whether they used a mental metronome during Cycle 1, and if they did, they were asked to state the mental metronome used. Each participant was then informed of their study group allocation and had the opportunity to have 10 minutes to practice their chest compressions based on their group assignment. Participants were instructed to synchronize their compressions with the beat of the auditory aid. Each auditory aid was played from a tablet at a 2-meter distance away from the manikin[b] and at the same volume each time.

Cycle 2

Each participant was asked to complete a second round of chest compressions on the CPR canine manikin[b] in lateral recumbency at the same table height as Cycle 1, with the assigned auditory aid playing. Again, a camera was used to record all sessions and no study investigator counted the number of compressions during the cycle. The same study investigator again started the video recording and then timed the 2-minute cycle with a stopwatch, communicating the start and end time of the cycle to the study participant.

Compression rate assessment

Following recruitment of all participants, both study investigators independently assessed the video recordings of each participant to count the number of compressions administered during Cycle 1 and Cycle 2. For each cycle, the number of compressions administered during the 1st and 2nd minute was recorded. Each video was evaluated twice by both study investigators and then the results were reviewed. If there was a disagreement (defined as anything but the same exact same number), the senior investigator reviewed the videos on a third occasion and the values obtained during that review were used. Investigators were not blinded to the study group the participant was assigned to.

Statistical Analyses

Continuous data was assessed for normality using a Shapiro-Wilk test and all data was non-normally distributed. Quantitative parameters were expressed as medians and range (minimum – maximum). Chi squared test was used to assess categorical data from independent groups. Kruskal-Wallis testing was used to assess the median compression rates between groups. Post hoc testing with Dunn's multiple comparison test was performed to identify significant variables between individual groups. A Wilcoxon matched pairs signed rank test was used to compare compression rates between the 1st and 2nd minute of cycle 1 and cycle 2 and to compare compression rate without and with an auditory aid for each participant. McNemar's test was used to assess the successful compression rate of individuals without and with an auditory aid. All statistical analyses were performed using a commercially available program.[c] Significance was set at p value < 0.05.

To achieve a power of 80% and a level of significance of 5% (two sided) for detecting an effect size of 0.8 between pairs (without and with an auditory aid), a sample size of 16 participants was determined to be needed.

Results

A total of 36 participants (20 veterinarians and 16 RVNs) were successfully enrolled within the study. Twelve participants were enrolled into each auditory aid group. Participant demographics for each study group can be found in Table 1. There were no significant differences among the groups. When comparing participant demographics based on profession (i.e., veterinarian versus RVN), a significantly higher number of RVNs worked primarily within ECC compared to veterinarians (p= 0.006) but no other significant differences were identified (number of years qualified, p = 0.7016; frequency CPR performed, p = 0.5136; date of last CPR training, p = >0.9999; completion of any RECOVER training, p = 0.1914).

Cycle 1: Without an auditory aid

The median (range) number of compressions administered by participants during the 1st and 2nd minute of chest compressions was 111 (range 88-140) and 107 (range 80-151), respectively (Figure 1). There was no significant difference of the number of compressions administered by each participant during minute 1 and minute 2 (p=0.2519).

A total of 25/36 (69%) participants successfully performed compressions at a rate within the recommended 100-120 cpm range for both minute 1 and minute 2 of Cycle 1 (Figure 2). Of the 11 individuals who were outside this range, 9 (82%) did not perform compressions in the range of 100-120 during the entire cycle while 1 (9%) performed compressions faster in minute 1 and 1 (9%) slower in minute 2. A significantly higher number of veterinarians compared to RVNs administered compressions outside the 100-120 cpm target (p=0.0091) (Table 2). No other significant demographic differences were found between participants delivering appropriate compared to inappropriate compression rates (Table 2). There was no significant difference among the three study groups in number of individuals administering appropriate compression rates compared to inappropriate compressions (p = 0.072).

206

207 The median compression rates administered within each group for minute 1 and minute 2
208 can be found in Figure 3. There was no difference in median compression rate prior to study group
209 randomization (p=0.8665). There was also no difference in median compression rate between the 1st
210 and 2nd minute for individuals within each group (Group B, p = 0.5186; Group Q, p = 0.3125; Group
211 M, p = 0.0586).

212

213 A mental metronome was self-reported to have been used by 28/36 (78%) participants
214 during Cycle 1 of chest compressions. The mental metronomes used were Bee Gees' "Stayin' Alive"
215 (n=20), Queen ''Another One Bites the Dust'' (n=4), Nellie the Elephant (n=1) and 3 participants did
216 not state what mental metronome they used. Participants utilizing a mental metronome were not
217 more likely to be successful at administering compressions within the rate of 100-120 per minute
218 than those who did not (p = 0.3884).

219

220 ***Cycle 2: With an auditory aid***

221 The median number of compressions administered during the 1st and 2nd minute for all
222 individuals was 110 (range 76-125) and 110 (range 72-125), respectively (Figure 1). Participants had
223 a higher compression rate during minute 1 compared to minute 2 of the cycle (p = 0.0164). A total of
224 34/36 (94%) participants successfully administered a compression rate within the recommended
225 100-120 cpm for both minute 1 and minute 2 of the cycle (Figure 2). All individuals in Group Q and M
226 had appropriate compression rates during the entire cycle of CPR while 2 individuals in group B had
227 inappropriate compression rates during the entire cycle, however, this did not reach statistical
228 significance (p=0.1203).

229

230 The median compression rates administered by the participants among each group for
231 minute 1 and minute 2 can be found in Figure 3. When assessing individuals among the 3 study

groups, a significant difference in the number of compressions administered during the cycle was identified (p = 0.0001) (Figure 3). Post hoc analysis identified that Group B participants administered a significantly lower number of compressions compared to participants in Group Q and Group M. No differences between Group M and Group Q were found. There was no difference in median compression rate between the 1st and 2nd minute for individuals within each group (Group B, p = 0.0781; Group Q, p = 0.584; Group M, p = 0.1328) (Figure 3).

Comparing compressions without and with auditory aid

The number of compressions administered by each participant during Cycle 1 and Cycle 2 were not significantly different (p=0.3996 and 0.4629, respectively). However, subgroup analysis identified that participants in Group B had a significantly higher cpm rate during both minute 1 and minute 2 of Cycle 1 compared to minute 1 and minute 2 of Cycle 2 (p = 0.022 and 0.0273, respectively). No significant differences in cpm rates were found between minute 1 and minute 2 of Cycle 1 and Cycle 2 for participants in Group Q and Group M (p=0.9453, 0.8945, 0.6382, 0.6587, respectively).

Participants were significantly more likely to administer chest compressions within the recommended range of 100-120 cpm when an auditory aid was present compared to without an auditory aid (p=0.013). When specifically evaluating groups, participants in group Q (p = 0.014) and group M (p = 0.0455) were significantly more likely to achieve a compression rate within 100-120cpm when an auditory aid was present, but the auditory aid did not improve compression rate accuracy for Group B participants (p = 0.5637).

Discussion

The findings of this study suggest that the use of an auditory aid during chest compressions may help improve chest compression rate accuracy when performed on a canine manikin.[b] Without the presence of an auditory aid, 69% of participants successfully administered chest compressions within the recommended range of 100-120 cpm, with this number increasing to 94% when an auditory aid was present.

Several studies have evaluated chest compression rate accuracy delivered by human medical personnel during CPR in relation to CPR guidelines in both simulator and clinical settings, with accuracy rates ranging from 15% - 80.3% having been documented.[9,13,14,25,26] To the authors knowledge, there are only two studies evaluating chest compression rate accuracy in accordance with RECOVER guidelines in dogs and cats.[10,11] The chest compression accuracy rate of 69% within our study is encouraging and similar to the 76% reported in a prospective, clinical study.[11] However, direct comparison of results is difficult acknowledging that this previous study was not specifically focused on assessing chest compression rate accuracy with compression rates not being objectively measured. Additionally, as only one compression rate was recorded for each CPR event, there was no consideration for potential variability in compression rate during each CPR cycle and amongst team members. Our accuracy rate is higher than the 53% accuracy rate reported by Kneba et al for a group of veterinary students enrolled in a manikin study, which can likely be explained by most of our participants having at least some prior CPR experience.[10]

Profession of the participant was the only significant difference in participant demographics when comparing those who were successful compared to unsuccessful at administering a chest compression rate in the range of 100-120 cpm during Cycle 1. RVNs were more likely to achieve a compression rate within this range compared to veterinarians more likely to be outside the range.

283 This finding may be related to there being a significantly greater number of RVN participants
284 primarily working in ECC compared to veterinarians. However, with no differences between the
285 veterinarian and RVN participants in relation to frequency CPR performed, date of last CPR training
286 or completion of RECOVER training to offer further explanation, this finding may purely be
287 coincidental and related to the small participant number of the study.
288
289 Most of our participants (78%) stated that they used a mental metronome during Cycle 1 to help
290 set a tempo. However, there was no difference in compression rate accuracy for those who used a
291 mental metronome compared to those who did not. Kneba et al. identified that the accuracy of
292 chest compression rate decreased approximately 10 weeks following initial training with an auditory
293 aid, with 72% participants successfully delivering compressions at a rate of 100-120 cpm compared
294 to 50% participants who had not received any training with an auditory aid.[10] The absence of a
295 beneficial effect of use of a mental metronome within this study may be the result of a
296 heterogenous population in relation to date of last training, potential differences in CPR training or
297 due to the majority of participants using 'Stayin' Alive' as a mental metronome which the results
298 reported here suggest may be an inferior auditory aid.
299
300 A number of popular songs have been reported to help aid chest compression rate accuracy by
301 acting as an auditory aid, with perhaps the most well-known being the Bee Gee's aptly named
302 'Stayin' Alive'. A 2021 systemic review concluded that the use of songs as auditory aids should be
303 considered when teaching CPR, however, it was not able to make any formal recommendations
304 relating to the optimum song/s nor the optimum song beats per minute.[27] We chose to use 'Stayin'
305 Alive' and Queen's 'Another One Bites the Dust' as auditory aids in this study as both songs have a
306 rate within the 100-120 beats per minute range and are well known songs commonly used as part of
307 CPR training within our hospital. Matlock et al. first suggested use of Bee Gee's 'Stayin' Alive' as an
308 aid to help pace chest compressions following the finding that 15 healthcare professionals

administered a mean compression rate of 109.1 cpm during training when this song was playing and felt utilizing music helped them improve their ability to provide CPR in accordance with the then current guidelines.[24] Since then, 'Stayin' Alive has been found to be beneficial when used as a mental metronome, aiding both short and long term recall of optimal chest compression rate, however, there is a scarcity of evidence evaluating its role on chest compression rate accuracy when playing.[10,15,22] The positive lyrics of 'Stayin' Alive' are in stark contrast to those of Queen's 'Another One Bites the Dust' and likely the reason why the authors are not aware of any prior studies which have assessed the utility of this song as a CPR aid in either a training or clinical setting. The use of a traditional metronome as an auditory aid is reported to have a beneficial effect on compression rate accuracy when used by both medical personnel and bystanders, however, this may be a less effective memory aid.[8,9,14,16,18,21]

Group B participants had significantly lower compression rates compared to those in Group Q and Group M during Cycle 2. This can be explained by the lower beats per minute rate of the song 'Stayin' Alive' (103 bpm) compared to 'Another One Bites the Dust' and the metronome both being at 110 beats per minute. Assessing number of participants who achieved a compression rate between 100-120 per minute with an auditory aid is likely a more clinically useful way to assess the usefulness of auditory aids during chest compressions compared to the compression rate itself. When an auditory aid was present, compression rate accuracy was 94% for all participants, indicating that an auditory aid was helpful to pace compressions in this study. Subgroup analysis suggested an improved compression rate accuracy for participants in Group Q and Group M when an auditory aid was present, but no beneficial effect was found for Group B. Further evaluation of these findings identified the two participants who were not successful at achieving a compression rate of 100-120 cpm with an auditory aid were both in Group B and likely explains why the Group B auditory aid was not beneficial. The authors hypothesize that the beat of the song 'Stayin' Alive' may not be as discernable compared to the other auditory aids to offer an explanation for this finding. However,

despite two individuals not achieving the optimal compression rate in Group B, the clinical relevance should be considered. The recommended 100-120 cpm is based on the results of an experimental study which identified a higher rate of ROSC with compressions at 120 per minute compared to 60 per minute.[7] Therefore, the individual who administered chest compression rates below 100 cpm in this study may have administered chest compressions so low that it would be clinically relevant and potentially detrimental. In contrast, one participant achieved a compression rate just above the recommend range and the clinical impact of this is unknown at present. These findings provide preliminary evidence that some auditory aids are more beneficial than others. Our results suggest that an auditory aid with a beat that lies well within the RECOVER recommended 100-120 cpm may be more beneficial than one that barely lies within this range.

The 2012 RECOVER guidelines do not provide any guidance on the use of auditory aids during CPR, and current human guidelines suggest that an auditory aid may be useful but are not able to make recommendations on the most appropriate form or tempo.[2,23,28] Our study results indicate that compression rate accuracy may be influenced by the auditory aid used and suggest that a traditional metronome or 'Another One Bites the Dust' may be used as an auditory aid following documentation of improved compression rate accuracy with these auditory aids. Perhaps in a clinical setting, the authors speculate that the use of a traditional metronome would be most appealing. In addition to many defibrillator units now having an inbuilt metronome, a traditional metronome would eliminate the potential need for familiarization of songs and ability to discern the beat from within the song. There is also the potential concern for loss of professionalism associated with use of a music aid, especially in a clinical setting, which would be eliminated if a traditional metronome were used.

Despite no studies evaluating optimal timing of CPR cycles in dogs and cats, the 2012 RECOVER guidelines advise that chest compressions should be performed in 2- minute cycles without

361 interruption based on several high-quality prospective and retrospective human studies.[29,30] These
362 studies concluded that uninterrupted cycles of basic life support of 2 minutes resulted in better
363 survival and neurological outcomes than shorter cycle, however, some other studies suggest that
364 rescuer fatigue may decrease quality of chest compressions after only 1 minute.[31] To the authors
365 knowledge, this is the first study to attempt to assess cpm during the first and second minute of a 2-
366 minute CPR cycle, with and without an auditory aid, in veterinary medicine. We did not demonstrate
367 compressor fatigue between minute 1 and minute 2 of Cycle 1, with no difference in cpm being
368 found when an auditory aid was not present (Cycle 1). When assessing the whole study population
369 with an auditory aid, participants were found to have a significantly higher cpm rate during the 1st
370 minute compared to the 2nd minute of Cycle 2, but this significant difference was lost when assessing
371 participants in each study group. The exact significance of this is unknown and is unlikely of clinical
372 relevance but further studies are required to evaluate further. Comparing number of cpm of Cycle 1
373 to that of Cycle 2 was not significantly different for all participants, suggesting that there was no
374 evidence of compressor fatigue and that participants had ample time for recovery between cycles.
375 However, participants in Group B were found to have a significantly lower cpm rate during Cycle 2
376 compared to Cycle 1. This can be explained by the finding that the BPM of 'Stayin' Alive' is lower
377 than the median cpm documented in Cycle 1 at 110.5 cpm for minute 1 and 105.5 cpm for minute 2.
378 No significant differences in cpm by each participant during minute 1 or minute 2 of Cycle 1 or Cycle
379 2 for participants in group Q or M were found.
380
381 This study has several limitations. Chest compressions were carried out on a manikin,[b] in an
382 artificial environment, without the noise and stress typically associated with resuscitation efforts,
383 and so it is unknown how transferable these results are to a clinical setting. The implementation of
384 an auditory aid during CPR must be in addition to a primary focus on providing high quality basic life
385 support, which includes chest compression depth, adequate chest recoil and chest compression
386 point. The stiff nature of the canine CPR mannequin used within this study precluded our ability to

assess compression depth accuracy. Some human studies have suggested that although an auditory aid may improve compression rate accuracy, compression rate depth decreased. [13,15-17,21] Further studies are required to assess the impact of the use of an auditory aid on compression depth in veterinary patients.

Additional limitations include this study being carried out in one referral hospital and so it is unknown if our results are representative of other settings. This study recruited participants on a volunteer basis and so may have inadvertently selected for certain personality types (e.g., more confident individuals). The small sample size should be considered when interpreting the significant finding that the auditory aid in Group B did not improve chest compression accuracy rate, especially as this finding appeared to be driven by data from only 2 participants. Participants were also always asked to complete chest compressions without an auditory aid first, potentially leading to either a learned effect or increasing likelihood of fatigue for Cycle 2. This was however intentional as we wanted to assess compression rate accuracy of the clinical staff members without an auditory aid to begin with and tried to mitigate the effect of fatigue by providing participants with recovery time akin to what would be similar in real life CPR efforts. Finally, the practice periods of 10 minutes prior to recording Cycle 2 of chest compressions could furthermore have led to a learned effect of how to best optimize use of the auditory aid.

In conclusion, an auditory aid was found to be of value at increasing the likelihood of participants administering compressions within the targeted range amongst a population of veterinarians and RVNs. This study provides preliminary evidence that auditory aids with higher underlying beats (110bpm) may be more beneficial to help rescuers reach the target compression rates of 100-120 per minute than auditory aids with a beat at the lower end of this spectrum (103 for ‘Stayin’ Alive’). Our results suggest that a music aid or traditional metronome may be considered, but the authors speculate that a traditional metronome may be preferred to maintain

413 professionalism in a clinical setting and eliminate need for song familiarization, but further studies

414 must be conducted to determine the most valuable auditory aid.

415

Table 1: Participants were assigned to one of three study groups where they performed chest compressions on a canine CPR manikin with the song 'Stayin' Alive' (Group B), 'Another One Bites the Dust' (Group Q) or a traditional metronome (Group M) as an auditory aid. Participant demographics are shown along with results of statistical analyses of study group comparisons (Chi-squared test) . A p value < 0.05 was considered statistically significant.

	Group B (N)	Group Q (N)	Group M (N)	P value
Participants: Vets RVNs	 6 6	 6 6	 8 4	 >0.99
Number of individuals primarily working within ECC	3/12	5/12	7/12	0.2636
Year qualified as veterinarian or RVN < 2 years ago 2-5 years ago 6-10 years ago 11-15 years ago 16 years +	 0 3 6 2 1	 3 3 3 1 2	 2 4 5 0 1	 0.2740
Frequency CPR performed At least once per week At least once per month At least once every 6 months At least once per year Less than once per year Never	 0 4 6 0 1 1	 1 3 5 1 1 1	 1 6 3 1 0 1	 0.4931
Date of last CPR training session Within past 3 months Within past 6 months Within past 12 months More than a year ago Never received any training	 1 3 4 4 0	 3 0 4 4 1	 2 2 6 1 1	0.4971
Completed any RECOVER training Yes None	 5 8	 9 5	 8 4	 0.9605

Abbreviations: BLS, basic life support; CPR, cardiopulmonary resuscitation; N, number of participants; RECOVER, Reassessment Campaign on Veterinary Resuscitation; RVN, registered veterinary nurse

425 **Table 2: During Cycle 1, participants performed 2 minutes' worth of chest compressions on a CPR**
426 **canine manikin without an auditory aid. They were instructed to obtain a rate of 100-120**
427 **compressions per minute. Participant demographics are shown for those who were successful and**
428 **unsuccessful at achieving this rate are shown along with results of statistical analyses comparing**
429 **these two groups (Chi-squared test). A p value < 0.05 was considered statistically significant.**
430

	Compression rate in range 100-120 cpm during Cycle 1 (N)	**Compression rate outside 100-120 cpm during Cycle 1 (N)**	**P value**
Participants: Vets RVNs	 10 15	 10 1	0.0091
Number of individuals primarily working within ECC	13/25	2/11	0.0769
Year qualified as veterinarian or RVN < 2 years ago 2-5 years ago 6-10 years ago 11-15 years ago 16 years +	 2 8 9 3 3	 3 2 4 1 1	0.4361
Frequency CPR performed At least once per week At least once per month At least once every 6 months At least once per year Less than once per year Never	 2 7 11 1 1 3	 0 6 3 1 1 0	0.4972
Date of last CPR training session Within past 3 months Within past 6 months Within past 12 months More than a year ago Never received any training	 4 5 8 6 2	 2 0 6 3 0	0.8838
Completed any RECOVER training			

Yes No	14 11	6 5	0.9355

Abbreviations: cpm, compressions per minute; CPR, cardiopulmonary resuscitation; N, number of participants; RECOVER, Reassessment Campaign on Veterinary Resuscitation; *RVN, registered veterinary nurse*

436 **Footnotes**

437 [a] MetroTimer app, Version 3.3.5, for Apple iPhone

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439 [b]Jerry K-9 CPR manikin, Rescue Critters, Simi Valley, CA

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441 [c] GraphPad Prism, Version 9.3.1(350) for Mac OS X, GraphPad Software, San Diego, CA.

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Figure 1: Box and whisker plots representing the median number of compressions per minute and interquartile range administered by the participants without an auditory aid (Cycle 1) and with auditory aid (Cycle 2). The whiskers represent the minimum and maximum number of compressions administered. The dashed lines indicate the upper (120 cpm) and lower (100 cpm) limits of the desired range.

Figure 2: Success rates of individuals achieving 100-120 compressions per minute (cpm) without an auditory aid (Cycle 1) and with an auditory aid (Cycle 2).

Figure 3: Box and whisker plots representing the median number of compressions per minute and interquartile range administered by the participants in each group without an auditory aid (Cycle 1) and with auditory aid (Cycle 2). A different auditory aid was used during Cycle 2 for participants assigned to each group: Stayin' Alive' (Group B), 'Another One Bites the Dust' (Group Q) and traditional metronome (Group M). The whiskers represent the minimum and maximum number of compressions administered. The dashed lines indicate the upper (120 cpm) and lower (100 cpm) limits of the desired range. Individual data points are also shown.