EMJ Online First, published on November 2, 2011 as 10.1136/emermed-2011-200187

PRESS RELEASE

Achy breaky makey wakey heart? A randomised crossover trial of musical prompts

Malcolm Woollard,[1,2] Jason Poposki,[2] Brae McWhinnie,[2] Lettie Rawlins,[3] Graham Munro,[2] Peter O'Meara[1,2,4]

[1]Pre-hospital, Emergency and Cardiovascular Care Applied Research Group, Faculty of Health and Life Sciences, Coventry University, Coventry, UK
[2]School of Biomedical Sciences, Charles Sturt University, Bathurst, New South Wales, Australia
[3]School of Medicine, Birmingham University, Edgbaston, Birmingham, UK
[4]La Trobe University, Melbourne, Victoria, Australia

Correspondence to
Professor Malcolm Woollard, Pre-hospital, Emergency and Cardiovascular Care Applied Research Group, Faculty of Health and Life Sciences, Coventry University, Room 304, Richard Crossman Building, Priory Street, Coventry CV1 5FB, UK; malcolm.woollard@btinternet.com

A copy of the trial protocol is available from the chief investigator, Professor M Woollard, malcolm.woollard@coventry.ac.uk

Accepted 11 September 2011

ABSTRACT

Objective Compared with no music (NM), does listening to 'Achy breaky heart' (ABH) or 'Disco science' (DS) increase the proportion of prehospital professionals delivering chest compressions at 2010 guideline-compliant rates of 100–120 bpm and 50–60 mm depths?

Methods A randomised crossover trial recruiting at an Australian ambulance conference. Volunteers performed three 1-min sequences of continuous chest compressions on a manikin accompanied by NM, repeated choruses of ABH and DS, prerandomised for order.

Results 37 of 74 participants were men; median age 37 years; 61% were paramedics, 20% students and 19% other health professionals. 54% had taken cardiopulmonary resuscitation training within 1 year. Differences in compression rate (mode, IQR) were significant for NM (105, 99–116) versus ABH (120, 107–120) and DS (104, 103–107) versus ABH ($p<0.001$) but not NM versus DS ($p=0.478$). Differences in proportions of participants compressing at 100–120 bpm were significant for DS (61/74, 82%) versus NM (48/74, 65%, $p=0.007$) and DS versus ABH (47/74, 64%, $p=0.007$) but not NM versus ABH ($p=1$). Differences in compression depth were significant for NM (48 mm, 46–59 mm) versus DS (54 mm, 44–58 mm, $p=0.042$) but not NM versus ABH (54 mm, 43–59 mm, $p=0.065$) and DS versus ABH ($p=0.879$). Differences in proportions of subjects compressing at 50–60 mm were not significant (NM 31/74 (42%); ABH 32/74 (43%); DS 29/74 (39%); all $p>0.5$).

Conclusions Listening to DS significantly increased the proportion of prehospital professionals compressing at 2010 guideline-compliant rates. Regardless of intervention more than half gave compressions that were too shallow. Alternative audible feedback mechanisms may be more effective.

The UK incidence of out-of-hospital cardiac arrest from cardiac causes is 123 per 100 000 per year in those under 76 years of age.[1] Starting cardiopulmonary resuscitation (CPR) as soon as possible after out-of-hospital cardiac arrest significantly increases survival rates,[2] and bystander-administered CPR can nearly triple discharge rates (OR 2.98, 95% CI 2.07 to 4.29) if commenced before emergency services arrive.[3]

The International Liaison Committee on Resuscitation 2010 consensus recommends a compression rate of 'at least 100 per minute' at a depth of 'at least 5 cm' highlighting that there is insufficient evidence to recommend a specific upper limit for either variable,[4] and the Australian Resuscitation Council guidelines for adult basic life support 2011 recommend a compression rate of 'approximately 100', highlighting the lack of evidence for an advantage with compression rates over 120, and that 'The lower half of the sternum should be depressed approximately one-third of the depth of the chest with each compression. This equates to more than 5 cm in adults…'.[5] Resuscitation Council (UK) 2010 adult basic life support guidelines include less open-ended recommendations, indicating that the chest should be compressed to a depth of 5–6 cm at a rate of 100–120 per min, and this was the rationale for the selection of the upper limits for these variables in the current study's analysis.[6]

Failure to maintain adequate chest compression rates and to minimise interruptions to compressions is associated with a reduced chance of survival.[7] However, the quality of CPR is often poor, even when delivered by trained health professionals.[8 9]

The authors of a pilot study that encouraged healthcare workers to mentally recall the song 'Stayin' alive' by the Bee Gees while performing CPR reported that participants felt this helped them to deliver compressions in accordance with the then extant 2005 American Heart Association resuscitation guidelines of 100 bpm,[10] although the group's mean CPR rate was 113 bpm.[11] In the UK the children's tune 'Nellie the elephant' by Ralph Butler has similarly been proposed as helping learners maintain a rate of 100 compressions per minute, as recommended in the Resuscitation Council (UK) 2005 guidelines.[12] Research has reported that listening to Nellie did indeed increase the proportion of previously untrained lay responders compressing at a rate of 95–105 per minute compared with no music (42/130 (32%) vs 15/130 (12%), $p<0.0001$). However, it also determined that a greater proportion of compressions were delivered at too shallow a depth when participants listened to Nellie compared with no music (56 vs 47%; $p=0.022$).[13] The authors consequently suggested that Nellie the elephant should no longer be used as a CPR training aid.

This randomised crossover trial sought to test the hypothesis that alternative tunes with more pronounced beats might increase the proportion of prehospital health professionals delivering chest compressions at the correct rate and depth in comparison with CPR without musical prompts.

METHODS

Study design

This prospective randomised crossover trial assessed chest compression performance using a resuscitation manikin (Laerdal Resusci Anne simulator attached to a laptop computer running the Laerdal PC skill reporting system; Laerdal New Zealand Limited, PO Box 11952, Ellerslie, Auckland 1542, New Zealand). Participants were asked to perform three 1-min sequences of continuous chest compressions (ventilations being omitted for simplicity and in anticipation of potential resuscitation guideline changes)[4 14] with a rest interval of 1 min between each sequence. The three sequences were carried out without musical accompaniment (no music; NM); repeated choruses of 'Achy breaky heart' (ABH), sung by Billy Ray Cyrus (written by Don Von Tress, PolyGram/Mercury, 1992); or an edited section of 'Disco science' (DS) by Mirwais (Naive records, 1999) via headphones in accordance with a prerandomised order generated by the chief investigator using an Excel spreadsheet. This was concealed until recruitment started. The nature of the study meant it was impossible to blind the subjects and investigators as to which intervention was being used during each sequence of chest compressions.

Both songs were analysed using MixMeister BPM Analyser (MixMeister Technology LLC, Fort Lauderdale, Florida, USA) to verify the tempo of the songs (which were 121 bpm for ABH and 105 bpm for DS), and were edited using WavePad Sound Editor (NCH Software Inc, Greenwood Village, Colorado, USA) so that relevant portions were repeated for an appropriate interval.

Study population and setting

Individuals attending an Australian College of Ambulance Professionals conference in Auckland, New Zealand, were invited to participate on an opportunistic basis by the study's researchers if they were health professionals trained in CPR, working in the prehospital setting, and aged over 18 years.

Ethics approval

Ethics approval was obtained through the Charles Sturt University School of Biomedical Sciences research ethics committee and written informed consent was obtained from all participants.

Outcome measures

Primary outcome measure

Between-intervention paired differences in average compression rates.

Secondary outcome measures

Between-interventions paired difference in proportions of:
Compressions too shallow
Compressions too deep
Compressions with incomplete hand release
Compressions with incorrect hand position
Compressions at the correct depth
Participants delivering compression rates within the range of 100–120 per minute
Participants delivering compression depths between 50 and 60 mm
Between-interventions paired differences in:
RR for compression rate of 100–120
Numbers needed to treat (NNT) to achieve a compression rate of 100–120
RR for compression depth of 50–60 mm
NNT to achieve a compression depth of 50–60 mm

Demographic data were collected on age, gender, occupational grade (professional qualification) and the interval since previous CPR training, using an anonymised data collection sheet.

Quantitative data on chest compression performance was obtained from the laptop computer running the Laerdal PC skill reporting system by the researchers immediately after each 1-min sequence.

Sample size

Based on previous research that reported a SD of 13.125 for a paired difference in mean compression rates,[13] it was estimated that 64 subjects would be required to detect a mean paired difference between any two interventions of five compressions per minute with a power of 0.85 and an α of 0.05.

Statistical methods

PASW statistics software (version 17.0.2) was used to calculate descriptive statistics and p values using Wilcoxon's rank sum test to compare differences in compression rates and median proportions of correct compressions, compressions too shallow, compressions too deep, compressions with incomplete hand release, compressions with incorrect hand position and compressions at the correct depth; and Spearman's correlation coefficient for the relationship between compression rate and average compression depth for each intervention. StatsDirect software (version 2.7.8) was used to calculate p values and 95% CI for paired between-interventions comparisons of the respective proportions of participants delivering average compression rates within the range of 100–120 per minute, average compression depth within the range 50–60 mm, and RR and NNT for a compression rate of 100–120 and a depth of 50–60 mm; and within-interventions comparisons of the proportion of participants with averaged compression depth too shallow versus the proportion with averaged compression depth too deep.

RESULTS

Participant flow

Figure 1 shows the participant flow through the study.

Demographics

Of 74 subjects, 37/74 (50%) were men, and the median age was 37 years (IQR 27–43). With respect to professional qualifications, 26/74 (35%) were intensive care paramedics, 19/74 (26%) were paramedics, 15/74 (20%) were students and 14/74 (19%) were other qualified healthcare professionals. CPR training had been undertaken by 40/74 (54%) of participants in the previous year.

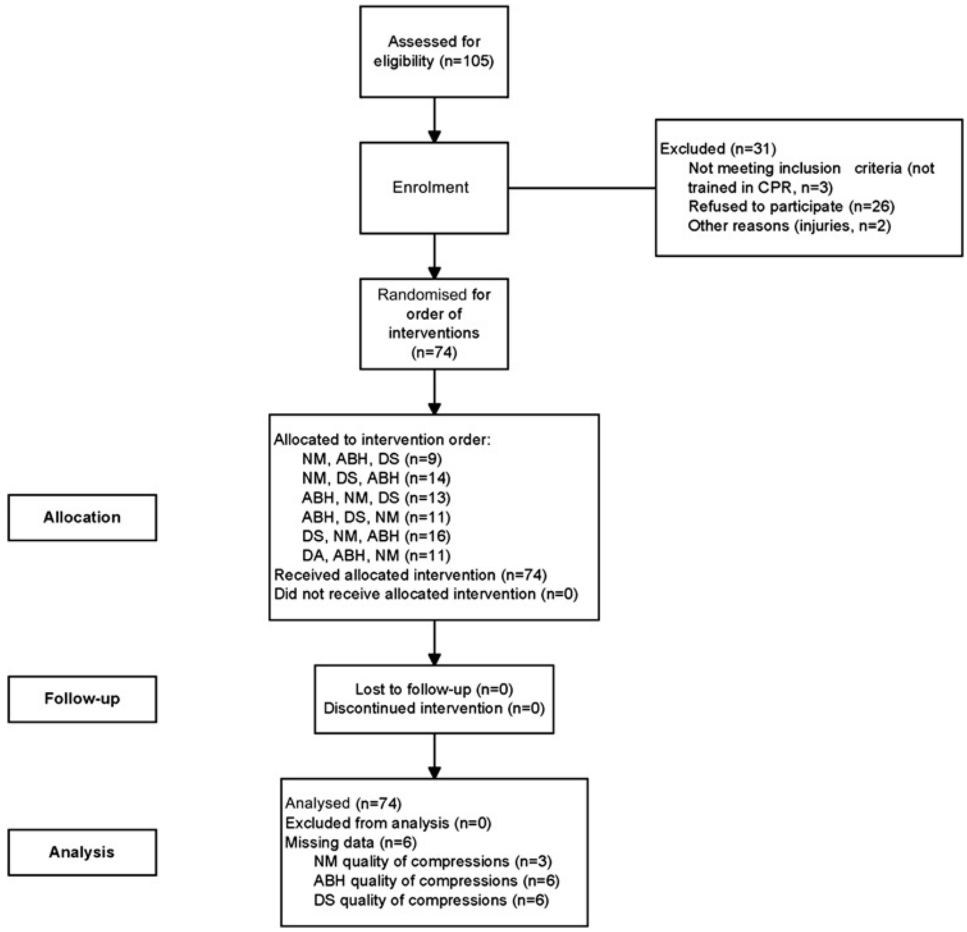
Main results

All analysis was by 'intention to treat'.

Table 1 compares compression rate and depth performance for each intervention.

Differences between interventions in average (modal) compression rates were significant for NM versus ABH and DS versus ABH ($p<0.001$) but not NM versus DS ($p=0.478$). Differences in the proportion of participants achieving average compression rates of 100–120 were significant for DS versus NM ($p=0.007$, 95% CI for difference +6% to +29%) and DS versus ABH ($p=0.007$, 95% CI +6% to +31%) but not for NM versus ABH ($p=1$, 95% CI −12% to +15%). The RR of achieving a compression rate of 100–120 was 1.27 (95% CI 1.05 to 1.57) for DS versus NM with a NNT of six (95% CI 4 to 30), and for

Figure 1 Participant flow (modified CONSORT flowchart). ABH, 'Achy breaky heart'; CPR, cardiopulmonary resuscitation; DS, 'Disco science'; NM, no music.



DS versus ABH was 1.30 (95% CI 1.07 to 1.61) with a NNT of six (95% CI 4 to 22): RR and NNT were not statistically significant for NM versus ABH.

Differences between interventions in average (modal) compression depths were significant for NM versus DS (p=0.042) but not for NM versus ABH (p=0.065) and DS versus ABH (p=0.879). Differences in the proportion of participants achieving average compression depths of 50–60 mm were not significant for NM versus ABH (p=1, 95% CI −12% to +9%), DS versus NM (p=0.824, 95% CI −15% to +9%) or ABH versus DS (p=0.581, 95% CI −6% to +14%). The RR and NNT of achieving a compression depth of 50–60 mm were not statistically significant for any comparison of interventions.

Table 2 compares the error rates for chest compressions with each intervention. Missing data were due to a technical error with the manikin software.

The variations between interventions did not reach statistical significance, with the exception of the difference in the median proportion of compressions with incomplete hand release for NM versus ABH (p=0.007).

The within-intervention differences in proportions of participants with an average compression depth that was too shallow as opposed to too deep was significant for NM (difference 20%, 95% CI for difference +5% to +34%, p=0.010), ABH (24%, +9% to +38%, p=0.002) and DS (28%, +13% to +42%, p<0.001).

Faster compression rates were weakly correlated with greater average compression depth for NM (Spearman's ρ=0.262, p=0.027) and DS (Spearman's ρ=0.305, p=0.011) but this correlation was not statistically significant for ABH (Spearman's ρ=0.120, p=0.329).

DISCUSSION

Principal findings

The proportion of subjects providing compressions within the rate range of 100–120 was significantly higher while they listened to DS compared with ABH or NM. However the

Table 1 Between-interventions paired comparison of chest compression rate and depth

	NM (n=74)	ABH (n=74)	DS (n=74)
Mode for compression rate (IQR, range)	105 (99 to 116, 58 to 157)	120 (107 to 120, 57 to 127)	104 (103 to 107, 60 to 124)
Proportion of participants compressing at a rate of 100–120	48/74 (65%)	47/74 (64%)	61/74 (82%)
Mode for compression depth (IQR, range) (recommended depth 50–60 mm)	48 mm (46 to 59 mm, 34 to 65 mm)	54 mm (43 to 59 mm, 29 to 64 mm)	54 mm (44 to 58 mm, 30 to 65 mm)
Proportion of participants compressing at an average depth of 50–60 mm	31/74 (42%)	32/74 (43%)	29/74 (39%)

ABH, 'Achy breaky heart'; DS, 'Disco science'; NM, no music.

Table 2 Between-interventions paired comparison of chest compression error rates

	NM (n=71)*	ABH (n=68)†	DS (n=68)†
Median, mode for proportion of compressions incomplete hand release (IQR, range)	8%, 0% (0 to 94%, 0 to 100%)	34%, 0% (1 to 97%, 0 to 100%)	25%, 0% (0 to 94%, 0 to 100%)
Median, mode for proportion of compressions with incorrect hand position (IQR, range)	52%, 0% (0 to 99%, 0 to 100%)	71%, 0% (0 to 98%, 0 to 100%)	63%, 0% (2 to 97%, 0 to 100%)
Proportion of participants with averaged compression depth too shallow (%, 95% CI)	27/71 (38%, 27 to 50%)	26/68 (38%, 27 to 51%)	29/68 (43%, 31 to 55%)
Proportion of participants with averaged compression depth too deep (%, 95% CI)	13/71 (18%, 10 to 29%)	10/68 (15%, 7 to 25%)	10/68 (15%, 7 to 25%)

*Data missing for three subjects.
†Data missing for six subjects.
ABH, 'Achy breaky heart'; DS, 'Disco science'; NM, no music.

average (modal) compression rate fell within the 2010 guidelines regardless of intervention. The modal compression depth was too shallow when no musical prompt was provided, but although this fell within the recommended range for both ABH and DS only the latter was statistically significantly different from NM. The proportion of subjects compressing at the correct depth did not differ significantly between the three interventions, and over a third of compressions were delivered at too shallow a depth.

Incorrect hand position was recorded for over half of compressions across all interventions, and incomplete hand release was noted for a quarter of compressions in the DS intervention and for over a third for ABH, although only the latter was statistically greater than with NM.

A pilot non-randomised observational study has previously investigated the effect of listening to Stayin' alive by the Bee Gees on compression rates performed by healthcare professionals, but had a small sample size of 15 and has only been published as an abstract.[11] The investigators reported that the medical students and resident physicians enrolled delivered compression at a mean rate of 109 bpm while listening to the music and at 113 bpm 5 weeks later when asked to give CPR while 'remembering' the tune. It was reported that the participants felt that 'utilising' the music helped them deliver CPR in accordance with the then extant American Heart Association guidelines of 100 compressions per minute although the objectively measured results did not support this conclusion.

A previous study by some of the authors of the current paper evaluated the effect of lay members of the public listening to the children's tune Nellie the elephant and the disco song 'That's the way (I like it)' (TTW) on their ability to perform a sequence of 100 compressions at then recommended rate of 100 per minute.[13] This found that listening to Nellie conferred a statistically significant advantage on modal compression rates (106 vs 109 for TTW vs 111 for no music). Furthermore, a greater proportion of participants delivered compressions within an 'acceptable' range of 95–105 bpm when Nellie was played (42/130 (32%)) than with TTW (12/130 (9%)) and no music (15/130 (12%)). Disappointingly, however, it was determined that listening to a song about an elephant leaving home was not the panacea that it first appeared, as it also resulted in an increase in the proportion of compressions delivered at too shallow a depth—56% with Nellie versus 47% with no music, $p=0.022$.

The increase in the recommended upper rate of compressions contained in the 2010 resuscitation guidelines suggests that listening to any of the music evaluated in the research literature should aid the delivery of compressions at the correct rate, both for lay people and health professionals. However, when the depth of compressions was measured, none of the studied tunes resulted in even half of the providers compressing at the correct depth, regardless of professional background.

A study using a metronome has reported an increase in the proportion of emergency medical technicians giving compressions at a target rate of 90–110 from three of 34 (9%) to 33/34 (97%) ($p<0.001$).[15] A similar study using a metronome with intensive care nurses reported a mean compression rate of 137 without versus 98 with a metronome ($p<0.001$), and a mean compression depth of 46.9 mm and 43.2 mm, respectively ($p=0.09$).[16] The provision of audible feedback from a modified defibrillator used in 'real' cardiac arrest cases increased the mean compression depth from 34 to 38 mm ($p<0.001$) and the median percentage of compressions with an 'adequate depth' (38–51 mm) from 24% to 53% ($p<0.001$).[17] Mean compression rates decreased from 121 to 109 ($p=0.001$). It would appear that using either a metronome or audible feedback prompts is at least as effective as listening to music in encouraging the correct rate for chest compressions, and more effective at facilitating the delivery of compressions at an appropriate depth.

Limitations

Opportunistic sampling could have led to responder bias, as those practitioners who perceived themselves as being competent in CPR may be more likely to participate in research, as might individuals with outgoing personalities. Selection bias may have occurred as recruitment was solely from attendees who had self-selected to attend an academic prehospital conference, and who therefore might be more motivated or have attained a higher level of education than those electing not to attend. The researchers may also have unconsciously approached individuals they perceived as more likely to take part. The study was carried out in public areas, which may have deterred potential volunteers and may have resulted in distractions for participants, although the use of headphones may have reduced this. Furthermore, the randomised crossover design of the study ensured that any differences between interventions were not due to the effects of the sequence in which they were performed; or differences in the skills, amount of practice, or fatigue of participants. Due to the limited period of access to the study participants we were unable to test if the tunes could be retained in the memory long enough to influence performance in the event a real cardiac arrest was encountered.

CONCLUSIONS

Perhaps not surprisingly listening to ABH was unhelpful, whereas listening to DS resulted in a higher proportion of subjects compressing within the range of 100–120 bpm in comparison with ABH and NM. Although DS resulted in a significantly greater modal depth of compressions, the proportion of subjects compressing within the recommended depth range was not statistically different between groups, and over a third of subjects compressed too shallowly regardless of the intervention. A half to two-thirds of subjects used an incorrect hand position regardless of musical accompaniment, and over a quarter had incomplete hand release when listening to either tune. High error rates suggest the possibility of reduced clinical efficacy and indicate a training need. When considering the combined importance of correct depth and rate, the authors are unconvinced that music provides any benefit in improving the quality of CPR compared with a metronome or audible feedback, and suggest that this interesting but unproductive area of resuscitation research should be discontinued.

Acknowledgements The authors gratefully acknowledge the contribution of the study participants and thank them sincerely for the commitment they displayed in volunteering to listen to Achy breaky heart for a whole 60 s. None was permanently harmed. The authors also thank the Australian College of Ambulance Professionals and Charles Sturt University for their cooperation and support.

Funding Financial support was provided by Charles Sturt University and the Australian College of Ambulance Professionals. Neither organisation played any role in the study design; in the collection, analysis and interpretation of data; in the writing of the manuscript; or in the decision to submit the manuscript for publication.

Competing interests None.

Ethics approval Ethic approval was obtained from the Charles Sturt University School of Biomedical Sciences research ethics committee.

Contributors MW conceived the study and conducted the statistical analysis; all authors contributed to the design, data collection, and drafting and approving the final manuscript for submission.

Provenance and peer review Not commissioned; internally peer reviewed.

REFERENCES

1. **Norris RM**; UK Heart Attack Study (UKHAS) Collaborative Group. Circumstances of out of hospital cardiac arrest in patients with ischaemic heart disease. *Heart* 2005;**91**:1537–40.
2. **Larsen MP,** Eisenberg MS, Cummins RO, *et al*. Predicting survival from out-of-hospital cardiac arrest: a graphic model. *Ann Intern Med* 1993;**22**:1652–8.
3. **Stiell IG,** Wells GA, DeMaio VJ, *et al*. Modifiable factors associated with improved cardiac arrest survival in a multicenter basic life support/defibrillation system: OPALS Study phase I results. Ontario Prehospital Advanced Life Support. *Ann Emerg Med* 1999;**33**:44–50.
4. **Sayre MR,** Koster RW, Botha M, *et al*; on behalf of the Adult Basic Life Support Chapter Collaborators. International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Part 5: Adult basic life support. *Circulation* 2010;**122**(Suppl 2):S298–324.
5. **Australian and New Zealand Resuscitation Councils,** . Guideline 6: Compressions. In: Australian and New Zealand Resuscitation Councils. *Index of Guidelines February 2011*. http://www.resus.org.au/policy/guidelines/section_6/compressions.htm (accessed 6 Apr 2011).
6. **Handley A,** Colquhoun M. Adult basic life support. In: Resuscitation Council (UK). *Resuscitation Guidelines 2010*. http://www.resus.org.uk/pages/bls.pdf (accessed 15 Apr 2011).
7. **Eftestol T,** Sunde K, Steen PA. Effects of interrupting precordial compressions on the calculated probability of defibrillation success during out-of-hospital cardiac arrest. *Circulation* 2002;**105**:2270–3.
8. **Mellor R,** Woollard M. Skill acquisition by health care workers in the Resuscitation Council (UK) 2005 guidelines for adult basic life support. *Int Emerg Nurs* 2010;**18**:61–6.
9. **Woollard M,** Smith A, McLean G, *et al*. *A randomised controlled trial comparing skill acquisition following standard CPR training or standard CPR training supplemented with a voice advisory manikin*. Ambulance UK, 2003;**18**:263–7.
10. **American Heart Association.** 2005 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Part 4: Adult basic life support. *Circulation* 2005;**112**(Suppl I):IV-19–IV-34.
11. **Matlock D,** Hafner JW Jr, Bockewitz EG, *et al*. "*Stayin' Alive*": a pilot study to test the effectiveness of a novel mental metronome in maintaining appropriate compression rates in simulated cardiac arrest scenarios (abstract). *Ann Emerg Med* 2008;**52**:S67–8.
12. **Resuscitation Council (UK).** *Adult Basic Life Support Guidelines (2005)*. http://www.resus.org.uk/pages/bls.pdf (accessed 10 Sep 2010).
13. **Rawlins L,** Woollard M, Williams J, *et al*. Effect of listening to Nellie the Elephant during CPR training on performance of chest compressions by lay people: randomised crossover trial. *BMJ* 2009;**339**:b4707.
14. **Sayre MR,** Berg RA, Cave DM, *et al*, American Heart Association Emergency Cardiovascular Care Committee. Hands-only (compression-only) cardiopulmonary resuscitation: a call to action for bystander response to adults who experience out-of-hospital sudden cardiac arrest: a science advisory for the public from the American Heart Association Emergency Cardiovascular Care Committee. *Circulation* 2008;**117**:2162–7.
15. **Kern KB,** Stickney RE, Gallison L, *et al*. Metronome improves compression and ventilation rates during CPR on a manikin in a randomized trial. *Resuscitation* 2010;**81**:206–10.
16. **Jäntti H,** Silfvast T, Turpeinen A, *et al*. Influence of chest compression rate guidance on the quality of cardiopulmonary resuscitation performed on manikins. *Resuscitation* 2009;**80**:453–7.
17. **Kramer-Johansen J,** Myklebust H, Wik L, *et al*. Quality of out-of-hospital cardiopulmonary resuscitation with real time automated feedback: a prospective interventional study. *Resuscitation* 2006;**71**:283–92.