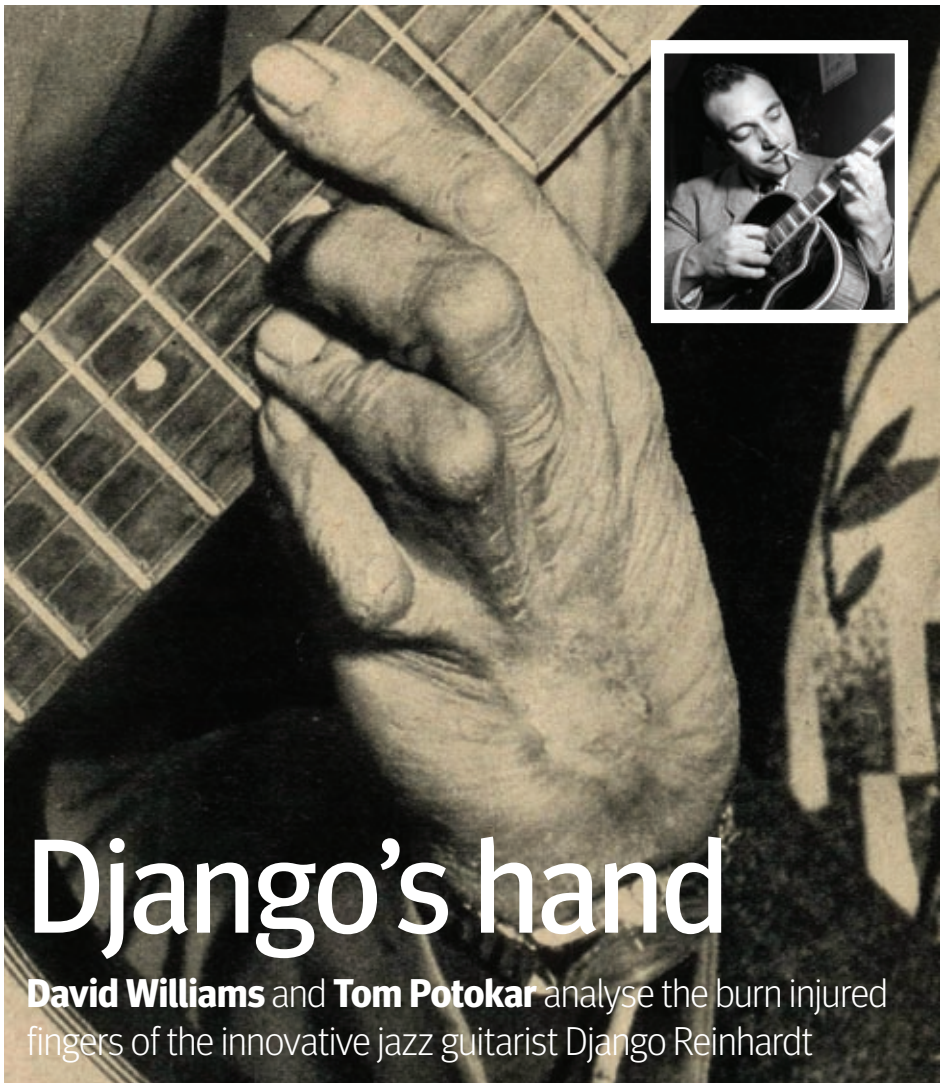
Nellie knows what to sing to keep rhythm while carrying out CPR, see p 1429 and vote on bmj.com

MUSICAL INTERLUDE

Django's hand

David Williams and **Tom Potokar** analyse the burn injured fingers of the innovative jazz guitarist Django Reinhardt



MICHEL DESCAMPS, 1950. INSET: WILLIAM GOTTLIEB/REDFERNS/GETTYIMAGES

Django's left hand showing dorsal scarring and contractures

Jean-Baptiste Reinhardt, better known by his gypsy name "Django" meaning "I awake," was a Manouche Gypsy born in a "roulotte," a wooden caravan, near Liberchies, Belgium, on 23 January 1910. He was the son of a travelling musician and learnt to play the violin aged 9 before teaching himself to play a banjo guitar, with which he soon supplemented the family income by playing the popular accordion "musette" waltzes. He had exceptional natural talent and a promising future as a professional musician. Although almost illiterate and unable to read music, he had an incredible ability to play a tune perfectly after hearing it once, and could improvise tirelessly for hours at a time.

However, on 26 October 1928 disaster struck. A carelessly dropped cigarette ignited a bunch of highly flammable celluloid flowers, turning Django's roulotte into an inferno. He grabbed a blanket to shield himself from the flames and managed to escape, but sustained burns to the left side of his body as well as to his left hand, which had been holding the blanket.

He was admitted to the Hôpital Lariboisière in Northern Paris, but fearing that the doctors would amputate his leg, on 22 November he fled back to the gypsy encampments where he was treated with traditional remedies. His wounds became infected and he was admitted to the Hôpital Saint-Louis on 23 January 1929 for debridement and cautery with silver nitrate under chloroform anaesthesia.[1-6]

The burns slowly healed, but resulted in severe contractures of the left ring and little fingers which made conventional guitar technique impossible. Despite these devastating injuries Django painstakingly re-learnt the guitar during an 18 month convalescence.

His novel technique, combined with influences from musette, flamenco, bebop and swing jazz, as well as classical influences from the composers Bach, Debussy, and Ravel, defined a new genre of music known as "Gypsy Jazz" that has influenced many generations of classical and popular musicians since then.[7-9] Django returned to public performance in 1930 and from this point he enjoyed worldwide acclaim as a musical pioneer and performer until his untimely death from a cerebral haemorrhage in the picturesque village of Samois-sur-Seine on 16 May 1953. He was aged only 43.

Only a few minutes of film footage of Django's playing exist,[5 10-17] but analysis of this gives us some insight into the innovative techniques that he developed to overcome the limitations imposed by his injuries.

Musical technique

Django devised a highly efficient system of three note chord shapes, each of which encompassed inversions of several different chords. He developed unorthodox techniques to play these, including the use of his left thumb to fret the lower one or two strings, one fingered "double stops"—where two strings are fretted simultaneously by placing the tip of one finger midway between both strings—and employed his contracted ring and little fingers on the upper strings, where they acted like a single finger. The last technique particularly suited ninth or minor sixth chords rather than the more conventional major or minor chords of the time, and introduced his audience to a new range of tonal colours.

It is difficult to play standard scales with just index and middle fingers, so Django adopted an arpeggio-based rather than modal approach to soloing. He adapted arpeggios so that they could be played with two notes per string patterns which ran horizontally up and down the fret board instead of the usual vertical "box" patterns, enabling him to move around the fret board with great speed and fluidity. Influenced by his childhood violin lessons, he often oriented his left hand so that these fingers

were almost parallel to the strings instead of perpendicular to the fret board. His injuries also defined his phrasing and ornamentation—he often incorporated open strings into his solos, along with his trademark chromatic glissando runs, for which he used his middle finger braced by the index finger—and the considerable strength that he had to develop in these fingers enabled him to achieve wide string bending and vibrato effects.

As a result of the relative immobility of his hand, Django often moved fixed shapes up and down the fret board which produced intervallic cycling of melodic motifs and chords, and played octave runs with the index and middle or ring fingers—a technique subsequently popularised by Wes Montgomery.

Computer model of Django's hand illustrating the deformity and effect of contractures

Anthropometric analysis

Django's technique was only possible because of the remarkable length and span of his index and middle fingers.[18] Photographs show that he could play a "barre" across the full width of the fret board using just the distal two phalanges of his index finger,[19] and a half barre with the distal phalanx of his middle finger[20]; and analysis of film footage[11] shows that he could effortlessly span a distance of at least 120 mm between the tips of his index and middle fingers.

The authors used Luthiers' blueprints of Django's guitars to find the fret and fingerboard widths at each point on the necks of his instruments.[21-23] By using these values for reference and comparing them with 14 rare archive photographs and images captured from video footage, it was possible to derive rough measurements of Django's left hand. Corresponding measurements from the right hand were also taken to confirm the measurements where appropriate. Software (Adobe Photoshop CS2, Adobe Systems Incorporated, California) was used to correct for the effects of perspective and scale, but it was impossible to fully compensate for distortion because of parallax or the focal length of the original camera lenses. These data were compared with anthropometric reference data,[24-26] and used in combination with 3D modelling software (Poser 6, Curious Labs, California) and texture map rendering of scar tissue (Photoshop CS2) to create a virtual model for visualisation.

Listen to the music of Django Reinhardt and other gypsy jazz musicians
www.last.fm/music/Django+Reinhardt
www.7digital.com/artists/django-reinhardt
www.live365.com/stations/hotclubdepott

Discussion

It is reported that Django had extensive full thickness burns "from knee to chest," and that his hand was "grotesquely charred."[2-4] However, from the mechanism and records of his injuries,[1] the reality is that he probably sustained mixed thickness burns of 7% to 15% body surface area.

The instinctive response when threatened by assault or fire is to protect the face by raising the arms, which exposes the dorsum of the hands to injury. The thin subcutaneous tissue and superficial tendons in this region make it vulnerable to subsequent deformity.

The fire occurred in an enclosed space and one account describes Django as initially being "barely conscious" as a result of being "robbed of oxygen and inhaling noxious fumes."[2] However, no record of depressed conscious level or airway burns on his arrival at the hospital shortly afterwards exists,[1] so we conclude that Django was able to escape without sustaining major inhalation injury.

In the acute phase of severe hand burns, swelling occurs which can result in compartment syndrome and irreversible damage to the intrinsic muscles of the hand. This was unlikely in Django's case, as shown by the remarkable agility and span of his index and middle fingers.

Django initially stayed in hospital for 28 days,[1 11] by which time any areas of superficial partial thickness injury would have healed. Early excision and grafting of burn injuries was not practised in this era, but debridement was often performed to remove necrotic tissue and reduce the risk of infection. This was a very painful procedure, requiring general anaesthesia with chloroform or ether, and the granulating tissue would bleed profusely, requiring cautery. In Django's case this procedure was performed nearly three months after the original injury, which indicates that these areas had sustained deep, almost certainly full thickness, burns.

As a result of conservative management, Django was left with an ovoid mass of scar tissue on the dorsum of his left hand measuring about 30 mm by 20 mm, overlying zone six of the tendons of the ring and little fingers, and fixed contractures of these fingers. Film archives show no evidence of contracture or limitation of movement at the elbow, wrist, thigh, or knee, and so it is likely that these areas healed completely.

Delayed healing of a burn wound often results in chronic recurrent infection. Although the traditional remedies Django received would have included antiseptic herbal poultices ("drab"),[27 28] these would not have been sufficiently potent to treat this. The violinist Stephane Grappelli, who toured with Django for many years, observed that Django's hand never properly healed and ". . . would sometimes fester and weep and look very sore . . . preventing him from playing."[29]

Hand injuries can be devastating for musicians, for whom music is their means of self expression and livelihood.[30 31] Specialist treatment, intensive rehabilitation, and adaptation are often necessary if they are to continue to perform. Adaptation may include the use of splints or prostheses, modification of the instrument or technique, and adoption of a completely different musical style or instrument.[30 32-34] Where possible, management should be conservative with early mobilisation and return to playing. Surgical management should prioritise reconstruction of the playing position over the anatomical "position of function" or cosmetic appearance.[30]

Conclusions

Disaster can also be a positive catalyst for innovation. Modern reconstructive surgery would have dramatically improved the function and cosmetic appearance of Django's hand, but would have perhaps changed the course of jazz music forever. The enduring popularity of Django's music is testament to his innate genius and determination.

We thank Roger Baxter for providing rare archive photographs and film clips and the Romany community for generously sharing their music and culture.

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Competing interests: David Williams and Tom Potokar are dedicated guitarists, and members of the gypsy jazz trio "Swing Bohème"..

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Effect of listening to *Nellie the Elephant* during CPR training on performance of chest compressions by lay people: randomised crossover trial

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Abstract

Objectives To determine whether listening to music during cardiopulmonary resuscitation (CPR) training increases the proportion of lay people delivering chest compressions of 100 per minute.

Design Prospective randomised crossover trial.

Setting Large UK university.

Participants 130 volunteers (81 men) recruited on an opportunistic basis. Exclusion criteria included age under 18, trained health professionals, and CPR training within the past three months.

Interventions Volunteers performed three sequences of one minute of continuous chest compressions on a skill meter resuscitation manikin accompanied by no music, repeated choruses of *Nellie the Elephant* (Nellie), and *That's the Way (I like it)* (TTW) according to a pre-randomised order.

Main outcome measures Rate of chest compressions delivered (primary outcome), depth of compressions, proportion of incorrect compressions, and type of error.

Results Median (interquartile range) compression rates were 110 (93-119) with no music, 105 (98-107) with Nellie, and 109 (103-110) with TTW. There were significant differences within groups between Nellie *v* no music and Nellie v TTW (P<0.001) but not no music *v* TTW (P=0.055). A compression rate of between 95 and 105 was achieved with no music, Nellie, and TTW for 15/130 (12%), 42/130 (32%), and 12/130 (9%) attempts, respectively. Differences in proportions were significant for Nellie *v* no music and Nellie *v* TTW (P<0.001) but not for no music *v* TTW (P=0.55). Relative risk for a compression rate between 95 and 105 was 2.8 (95% confidence interval 1.66 to 4.80) for Nellie *v* no music, 0.8 (0.40 to 1.62) for TTW *v* no music, and 3.5 (1.97 to 6.33) for Nellie *v* TTW. The number needed to treat for listening to Nellie *v* no music was 5 (4 to 10)—that is, the number of cardiac arrests required during which lay responders listen to Nellie to facilitate one patient receiving compressions at the correct rate (*v* no music) would be between four and 10. A greater proportion of compressions were too shallow when participants listened to Nellie *v* no music (56% *v* 47%, P=0.022).

Conclusions Listening to *Nellie the Elephant* significantly increased the proportion of lay people delivering compression rates at close to 100 per minute. Unfortunately it also increased the proportion of compressions delivered at an inadequate depth. As current resuscitation guidelines give equal emphasis to correct rate and depth, listening to *Nellie the Elephant* as a learning aid during CPR training should be discontinued. Further research is required to identify music that, when played during CPR training, increases the proportion of lay responders providing chest compressions at both the correct rate and depth.

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WHAT IS ALREADY KNOWN ON THIS TOPIC

Mentally "singing" the song *Nellie the Elephant* is sometimes recommended during CPR training in the UK because of its appropriate tempo to help individuals keep a rate of 100 compressions per minute

WHAT THIS STUDY ADDS

Listening to *Nellie the Elephant* significantly increased the proportion of lay people achieving compression rates of 95-105 a minute compared with no music

Unfortunately it also increased the proportion of compressions delivered at an inadequate depth

As current resuscitation guidelines give equal emphasis to correct compression rate and depth the use of *Nellie the Elephant* as a learning aid during CPR training cannot be recommended

Introduction

Cardiopulmonary resuscitation (CPR) is an important life saving technique that can be effectively taught to most people.[1] It is important that skills are taught well so that bystanders feel confident enough to use them. Resuscitation Council (UK) guidelines for adult basic life support recommend a compression rate of 100 per minute, with a repeating sequence of 30 compressions followed by two rescue breaths.[2 3] It is important to maintain chest compression rates and reduce interruptions to compressions as failure to do so is associated with a reduced chance of survival.[4]

Estimating a rate of 100 beats per minute (bpm) can be difficult. A pilot study involving listening to the song *Stayin' Alive* by the Bee Gees while performing CPR has suggested this helps health professionals maintain a compression rate of around 100 bpm.[5] Traditionally in the UK mentally "singing" the children's nursery tune *Nellie the Elephant* has been suggested during CPR training to help learners maintain a rate of 100 compressions a minute because of its appropriate rhythm and tempo. We carried out a randomised crossover trial to test whether listening to *Nellie the Elephant* during training helps lay people to improve their performance of chest compressions during CPR compared with no music or a second tune with a similarly appropriate tempo.

Methods

Hypothesis and objectives—Our hypothesis was that listening to the songs *Nellie the Elephant* or *That's the Way (I like it)* during CPR training would increase the likelihood of lay people performing chest compressions at the recommended rate, compared with the absence of music.

Setting and participants—We invited staff or students aged over 18 at Coventry University to participate. We excluded healthcare students or professionals or those who had received CPR training within the previous three months. Participants were recruited on an opportunistic basis.

Table 1 | Comparison between interventions in performance of compression rate and depth

	No music	Nellie the Elephant	That's the Way (I like it)
Median compression rate (IQR, range)	110 (93-119, 43-146)	105 (98-107, 48-162)	109 (103-110, 53-157)
Proportion of subjects delivering compression rate 95-105/min (%, 95% CI)	15/130 (12%, 7% to 18%)	42/130 (32%, 24% to 41%)	12/130 (9%, 5% to 16%)
Median for proportion of compressions delivered at correct depth (IQR, range)	24% (0-62, 0-99)	14% (0-59, 0-97)	11% (0-65, 0-98)

Design—This community based prospective randomised crossover trial assessed performance of manikin based chest compression. All participants were given a brief demonstration on the use of a resuscitation manikin and had one minute to practise while listening to a metronome. Participants were then asked to perform three sequences of one minute of continuous chest compressions carried out without musical accompaniment, with repeated choruses of *Nellie the Elephant* (Nellie) by Little Bear (105 bpm), or with *That's the Way (I like it)* (TTW) by KC and the Sunshine Band (109 bpm) in a pre-randomised order.

Outcome measures—Our primary outcome measure was the paired differences in average compression rates between interventions. Secondary outcome measures comprised paired differences between interventions in proportions of correct compressions, 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 95-105 per minute, relative risk for compression rate of 95-105, and numbers needed to treat to achieve a compression rate of 95-100.

Results

Of the 130 participants, 81 (62%) were men. The median age was 21 (interquartile range 20-25, range 18-72), and 94 (72%) had no previous CPR training. All analysis was by intention to treat. Table 1 compares the performance of compression rate and depth with each intervention.

Differences between interventions in median compression rates were significant for Nellie *v* no music and Nellie *v* TTW (both P<0.001) but not for no music *v* TTW (P=0.055). Differences in the proportions of people delivering compressions at a rate of 95-105 were significant for Nellie *v* no music and Nellie *v* TTW (both P<0.001) but not for no music *v* TTW (P=0.55). Relative risk for a delivered compression rate of 95-105 was 2.8 (95% confidence interval 1.66 to 4.80) for Nellie *v* no music, 0.8 (0.40 to 1.62) for TTW *v* no music, and 3.5 (1.97 to 6.33) for Nellie *v* TTW. The number needed to treat for listening to Nellie *v* no music was 5 (4 to 10)—that is, the number of cardiac arrests required during which lay responders listen to Nellie to facilitate one patient receiving compressions at the correct rate (*v* no music) might be as many as 10 or as few as four. There were no significant differences between interventions in the proportion of compressions given at the correct depth (no music *v* Nellie P=0.084; no music *v* TTW P=0.095; Nellie *v* TTW P=0.378). Table 2 shows that there were no significant differences between interventions for the proportion of chest compressions given correctly, the proportion given too deeply, or the proportion given with an incorrect hand position. There was a significantly greater proportion of compressions given to an inadequate depth when participants listened to Nellie compared with no music, but this difference was not significant for no music *v* TTW or Nellie *v* TTW. The proportion of compressions with incomplete hand release was significantly greater for both tunes compared with no music but not when both tunes were compared. Inadequate depth of compressions was the most common form of error. For all interventions the proportion of chest compressions given correctly was less than 25%.

Discussion

Principal findings

There was a significant increase in the proportion of participants providing an appropriate compression rate while listening to *Nellie the Elephant* compared with no music or *That's the Way (I like it)* (TTW). Listening to TTW, however, showed no significant difference in the proportion achieving correct compression rates compared with no music. Disappointingly, for all three interventions the proportion of chest compressions given correctly was less than a quarter, with no significant difference between each. When participants listened to Nellie there was a significantly greater proportion of compressions delivered at an inadequate depth compared with no music or TTW.

Strengths and weaknesses

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. Opportunistic sampling could have led to responder bias. Selection bias could have occurred as recruitment was solely from university premises.

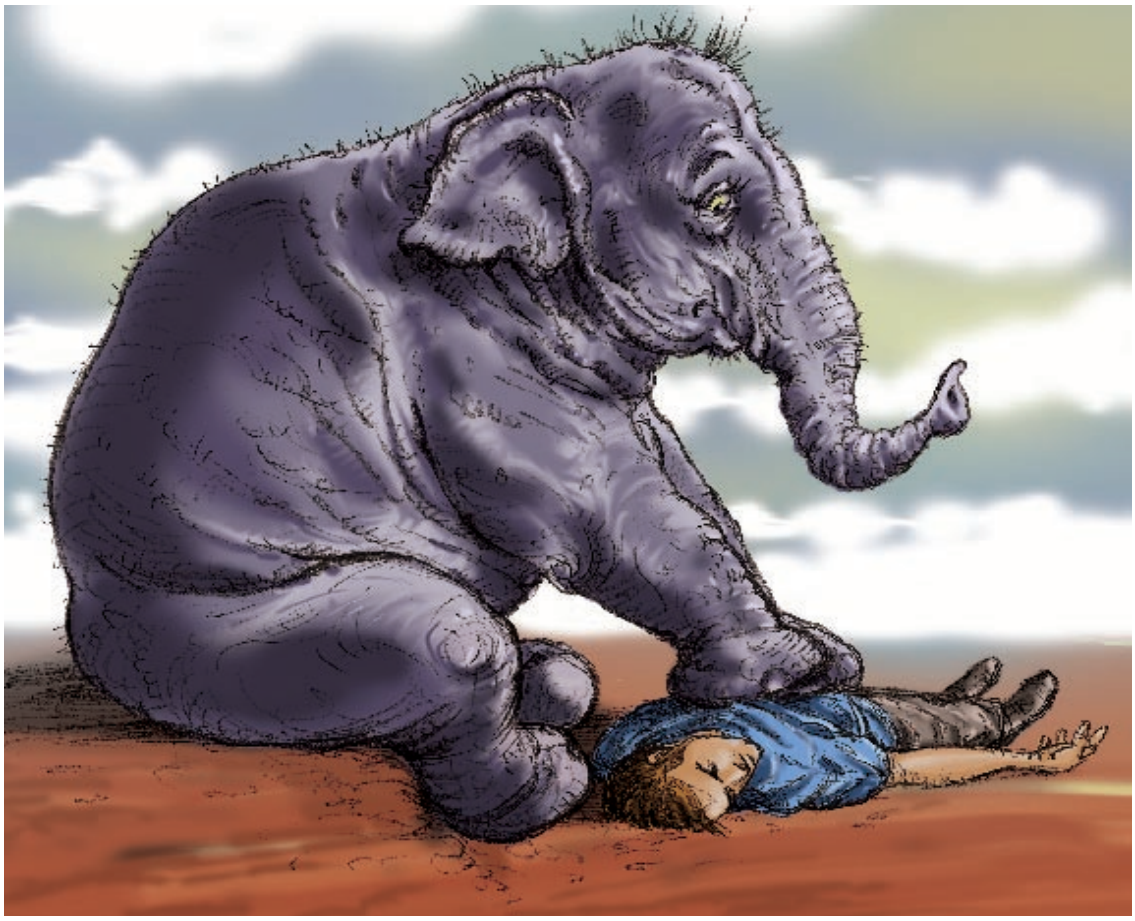
Strengths and weaknesses in relation to other studies

A non-randomised observational pilot study previously investigated the effect of listening to *Stayin' Alive* by the Bee Gees on compression rates performed by healthcare professionals but had only 15 participants.[5] Our trial was on a larger scale, with 130 participants and a more robust randomised crossover

Table 2 | Comparison between interventions in proportion of compressions given correctly or incorrectly. Figures are median percentages (interquartile range, range)

Compressions	No music (n=130)	*Nellie the Elephant* (n=129*)	*That's the Way (I like it)* (n=130)	P value for difference		
				No music *v* Nellie	No music *v* TTW	Nellie *v* TTW
Correct	22 (0-61, 0-99)	14 (0-56, 0-97)	9 (0-53, 0-98)	0.07	0.07	0.41
Too shallow	47 (3-88, 0-100)	56 (6-97, 0-100)	57 (10-94, 0-100)	0.02	0.05	0.90
Too deep	0 (0-4, 0-98)	0 (0-3, 0-96)	0 (0-4, 0-98)	0.52	0.41	0.19
Incomplete hand release	0 (0-0, 0-60)	0 (0-0, 0-95)	0 (0-0, 0-87)	0.03	0.02	0.95
Incorrect hand position	0 (0-0, 0-76)	0 (0-1, 0-64)	0 (0-1, 0-89)	0.86	0.48	0.63

*Data missing for one participant.



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design. Both studies reported a positive impact on the delivery of compressions at the correct rate when listening to music.

Previous research has reported poor performance of chest compressions. Before a basic life support course healthcare professionals delivered a median compression rate of 127 (interquartile range 93-133). After training, the median compression rate rose to 147 (135-161, P<0.001).[6] This suggests that, in this population, traditional instructor led training decreased the likelihood of participants compressing at the correct rate, whereas in the current trial listening to Nellie had some positive effect.

An observational study evaluating CPR performance after training in lay volunteers found that the proportion of participants giving compressions at a rate in the range 90-110 increased from a baseline of 10/118 (9%) before training to 24/112 (21%) after training (difference 13%, 3% to 23%, P=0.006).[7] The proportion of participants in our study who listened to Nellie and compressed at the "correct" rate in the narrower range of 95-105 per minute was higher at 32%.

Meaning of study

The significant increase in the proportion of participants achieving compression rates of 95-105 per minute when listening to Nellie might be because of the simplicity and familiarity of the song. Even though TTW has a similar tempo to Nellie, it resulted in no significant difference in the achievement of correct compression rates compared with no music. This might be because this song has a different style with more complex lyrics and percussion. The significantly greater proportion of compressions delivered at an inadequate depth when people listened to Nellie could be because of distraction from the task by the music, as several participants seemed amused by the song.

Implications for clinicians and policymakers

As current resuscitation guidelines give equal emphasis to the importance of performing chest compressions at both the correct rate and depth, we regretfully recommend that playing or imagining hearing *Nellie the Elephant* during CPR training should be discontinued.

Unanswered questions and future research

Research is urgently required to identify other tunes that could be played during CPR training to improve the proportion of participants giving compressions at the correct rate and to determine if songs with a greater musical emphasis on each beat could provide motivation to deliver more compressions at a greater depth. Potential tunes include *Another One Bites the Dust* (Queen), *Quit Playing Games (With my Heart)* (Backstreet Boys), and *Achy Breaky Heart* (Billy Ray Cyrus).

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Data sharing: See bmj.com.

References are in the version on bmj.com

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