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Time-varying Relationship between Chest Compression Force and Depth during manual CPR

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INTRODUCTION

- Chest wall stiffness decreases with increasing number of chest compressions (CCs) during cardiopulmonary resuscitation (CPR). Tomlinson et al. Resuscitation. 2007;72(3):364-70.
- Since then, CPR guidelines have changed, analysis of updated CPR data is warranted.

Aim: To quantify the evolution over time of the compression force needed to achieve a certain depth during manual CPR.

MATERIALS

- Adult out-of-hospital cardiac arrest (OHCA)** episodes from Tualatin Valley Fire & Rescue (Tigard, OR, USA) from 2010 to 2016.
- Manual CPR monitored with defibrillators equipped with **CPR feedback technology** (Heartstart MRx, Philips).
- Depth** calculated using recorded **force** and **acceleration** signals.

METHODS

- Annotation of **individual CC** using custom programs.
- CCs with complete chest recoil were included:
  - release force ≤ 2.5 kg
- Measurements for each individual CC (see Figure).
- Values averaged every 30 seconds and clustered as:
  - Depth (mm):** 40-45 >45-50 >50-55
  - CPR duration (min):** <10 10-20 >20-30

$$CAI_f (\%) = 100 \cdot \frac{A_c}{T_c \cdot F_c}$$

$$RAI_f (\%) = 100 \cdot \frac{A_r}{T_r \cdot F_c}$$

d_c maximum compression depth

F_c maximum compression force

CAI_f compression area index

RAI_f release area index

RESULTS

- Episodes ($n = 102$), median (IQR) duration: **25 (19-33) min**; **254,103 CCs annotated**, 2327 (1714-2954) per episode.

- F_c decreased with CPR duration ($p < 0.0001$)
- Conversely, d_c did not change [1].

[1] González-Otero et al. Evolution of chest compression waveform metrics over time... Resuscitation, 2019.

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- CAI_f and RAI_f increased with time ($p < 0.001$).

CONCLUSIONS

- The **force** required to achieve a certain depth **decreased with CPR time, confirming the decrease of chest resistance**.
- Slight increases in force area indices suggest small **alterations in rescuers force pattern**, possibly caused by chest moulding and/or fatigue, especially in longer resuscitations (>20 min).