

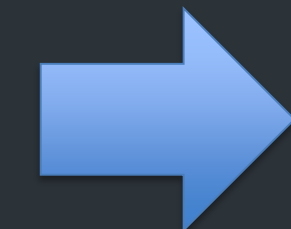
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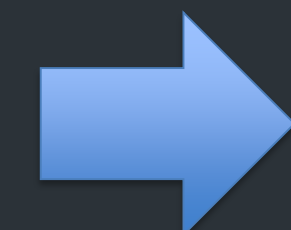


Introduction



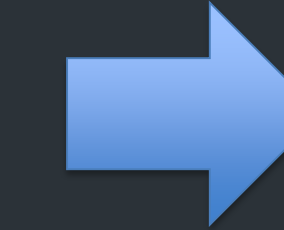
- Sudden cardiac death (SCD) accounts for 20-30% of all scuba fatalities.¹⁻³ One suspected mechanism of SCD is acute arrhythmia triggering cardiac arrest.
- This study describes the prevalence of factors that may predispose divers to SCD.

Methods

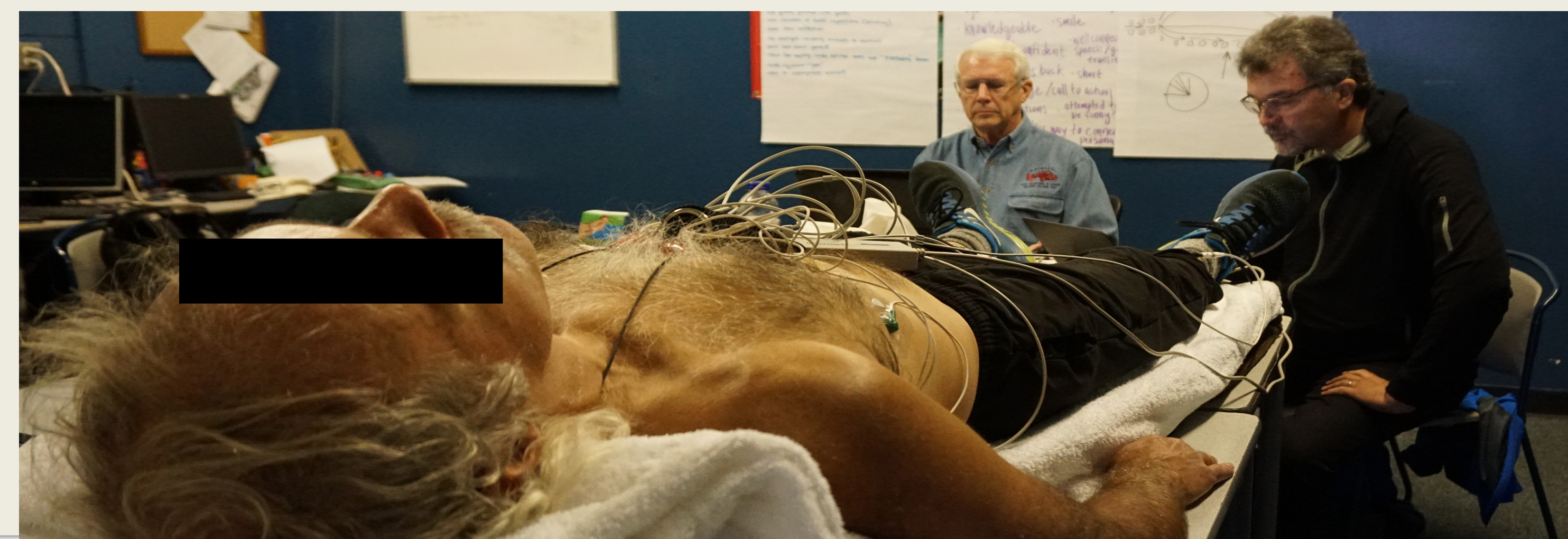


- Sixty-eight certified scuba divers made 75 dive research trips and logged ≥ 920 dives.
- Diver characteristics, medical history and diving history were reported at enrollment.
- Before and after dive trips, 12-lead ECG and 5-6 min rhythm recordings (pictured), and echocardiograms were obtained.
- Arrhythmias were identified and categorized by type.

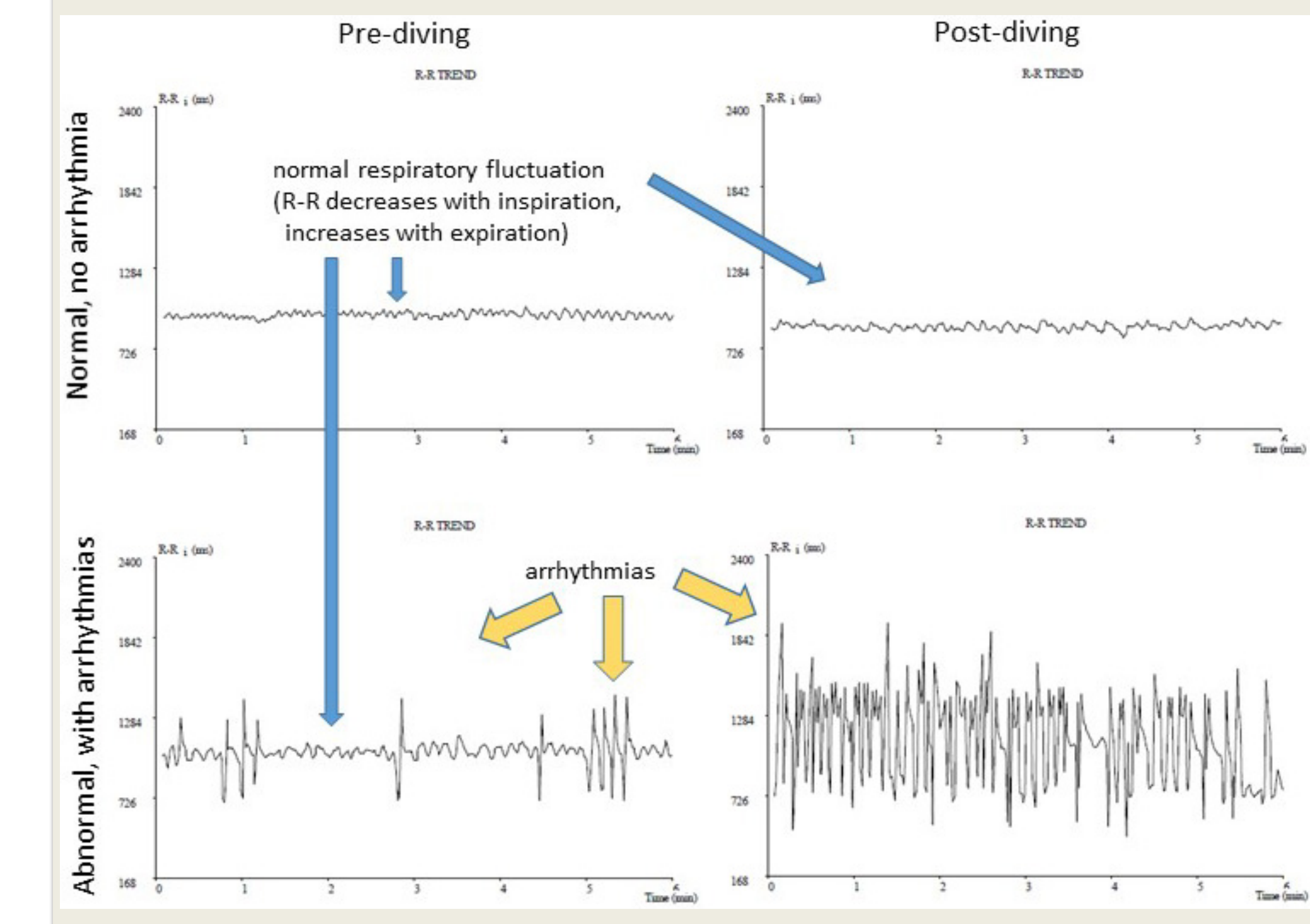
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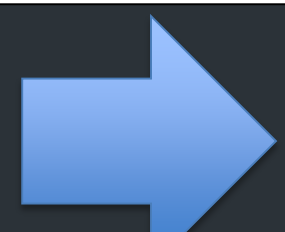
- No diver suffered SCD during this study.
- Compared with divers showing no arrhythmias (n=48), those with arrhythmias recorded either pre- or post- diving (n=20) were 17% older (59 vs. 50 years), had been diving longer (20 vs. 10 years), but had made fewer dives in the previous six months (15 vs 20).
- Their left ventricular mass was greater (176 vs. 153g) and was greater when indexed to body surface area (179 vs 161g).
- Their relative wall thickness was 11% greater (0.48 vs 0.43cm), and interventricular septum thickness was 8% greater (1.05 vs. 0.97cm).
- There were no meaningful differences between divers with arrhythmias compared to those without in the proportion who were past smokers, who were currently taking any prescription meds (other than for cholesterol), or who had left ventricular hypertrophy.
- The arrhythmia group had a higher proportion of alcohol drinkers (92% vs. 82%), higher frequency of cholesterol diagnosis (38% vs. 22%), and more were taking cholesterol medications (32% vs. 16%).
- The incidence of arrhythmias changed between pre- and post- diving in 18/20 divers.



Before/After

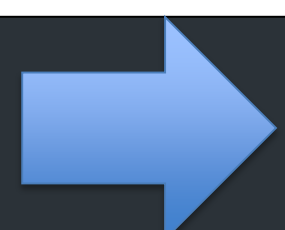


Conclusions



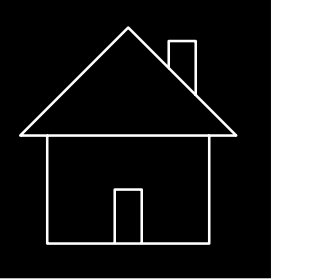
- A surprisingly high, nearly 30% of divers showed arrhythmias.
- This study, for the first time, characterizes a selected cohort of older recreational divers with cardiac arrhythmias, though this cohort may not be representative of older recreational divers generally.
- Further studies of a more controlled, less exploratory, nature are warranted.

References



Introduction

- Sudden cardiac death (SCD) is one of the most common causes of scuba fatalities, accounting for 20-30% of all cases.¹⁻³
- SCD is an unexpected natural death from a cardiac cause within one hour of the onset of acute symptoms in a person with no prior acute condition that would appear fatal.³
- The most common suspected mechanism of SCD is acute arrhythmia triggering cardiac arrest, and the incidence rate of SCD increases with age both in the general population and in scuba divers.^{1,4}
- Known risk factors for SCD in the general population include a history of coronary heart disease, male sex, cigarette smoking, hypertension, diabetes mellitus, hypercholesterolemia, obesity and left ventricular hypertrophy.⁴⁻⁷
- SCD is poorly understood, and there may be contributing factors unique to scuba diving.
- This study describes the prevalence of factors that may predispose scuba divers to SCD.



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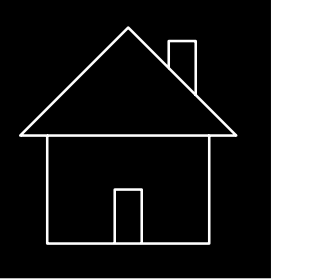
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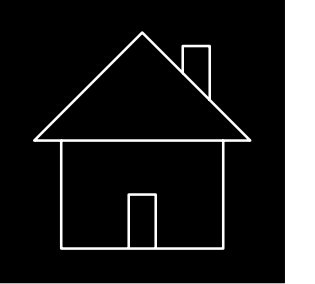
Methods

- DAN recruited volunteer diver groups via public requests. Sixty-eight certified scuba divers made 75 dive research trips and logged ≥ 920 dives.
- Diver's characteristics, medical history and diving history were reported at enrollment.
- Blood pressure was measured in both arms using an electronic blood pressure monitor (model BP761N, Omron Healthcare Co. Ltd, Muko, Kyoto, Japan).
- Echocardiographic ultrasound images of each diver's heart were recorded for the measurement of ventricular wall thickness and mass to assess possible left ventricular hypertrophy (LVH).
- Before and after dive trips, ECGs were recorded using various brands of PC-based systems (PC ECG, Welch Allyn CardioPerfect, Midmark IQecg, and IMED Cardiax).
- Divers rested in a supine position for a few minutes until heart rates stabilized. Then conventional 10 second 12-lead ECGs plus 5-6 minute rhythm recordings were conducted.
- Arrhythmias were identified by the various ECG systems' automated interpretation software and confirmed or corrected by an experienced human reader, then categorized by type and counted for frequencies.
- The study protocol was approved by the Institutional Review Board of Divers Alert Network, approval number 015-17.
- This study was entirely funded by Divers Alert Network.

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Results

- No diver suffered SCD during this study.
- Compared with divers showing no arrhythmias (n=48), those with either pre- or post- diving arrhythmias (n=20):
 - were 17% older (mean 59 vs. 50 years), had been diving longer (20 vs. 10 years), but had made fewer dives in the previous six months (15 vs 20);
 - had greater left ventricular mass (176 vs. 153g) including when indexed to body surface area (179 vs 161g);
 - had relative wall thickness 11% greater (0.48 vs 0.43cm), and interventricular septum thickness 8% greater (1.05 vs. 0.97cm).
- There were no meaningful differences between divers with arrhythmias compared to those without in the proportion who were past smokers, currently taking any prescription medications other than for cholesterol (next point), or who had left ventricular hypertrophy.
- The arrhythmia group had a higher proportion of alcohol drinkers (92% vs. 82%), higher frequency of high cholesterol diagnosis (38% vs. 22%), and more were taking cholesterol medications (32% vs. 16%).
- The incidence of arrhythmias changed between pre- and post- diving in 18/20 divers.



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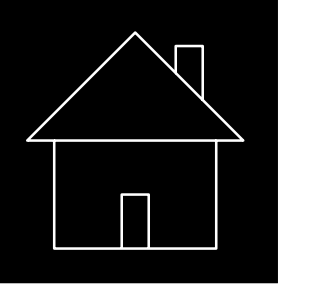
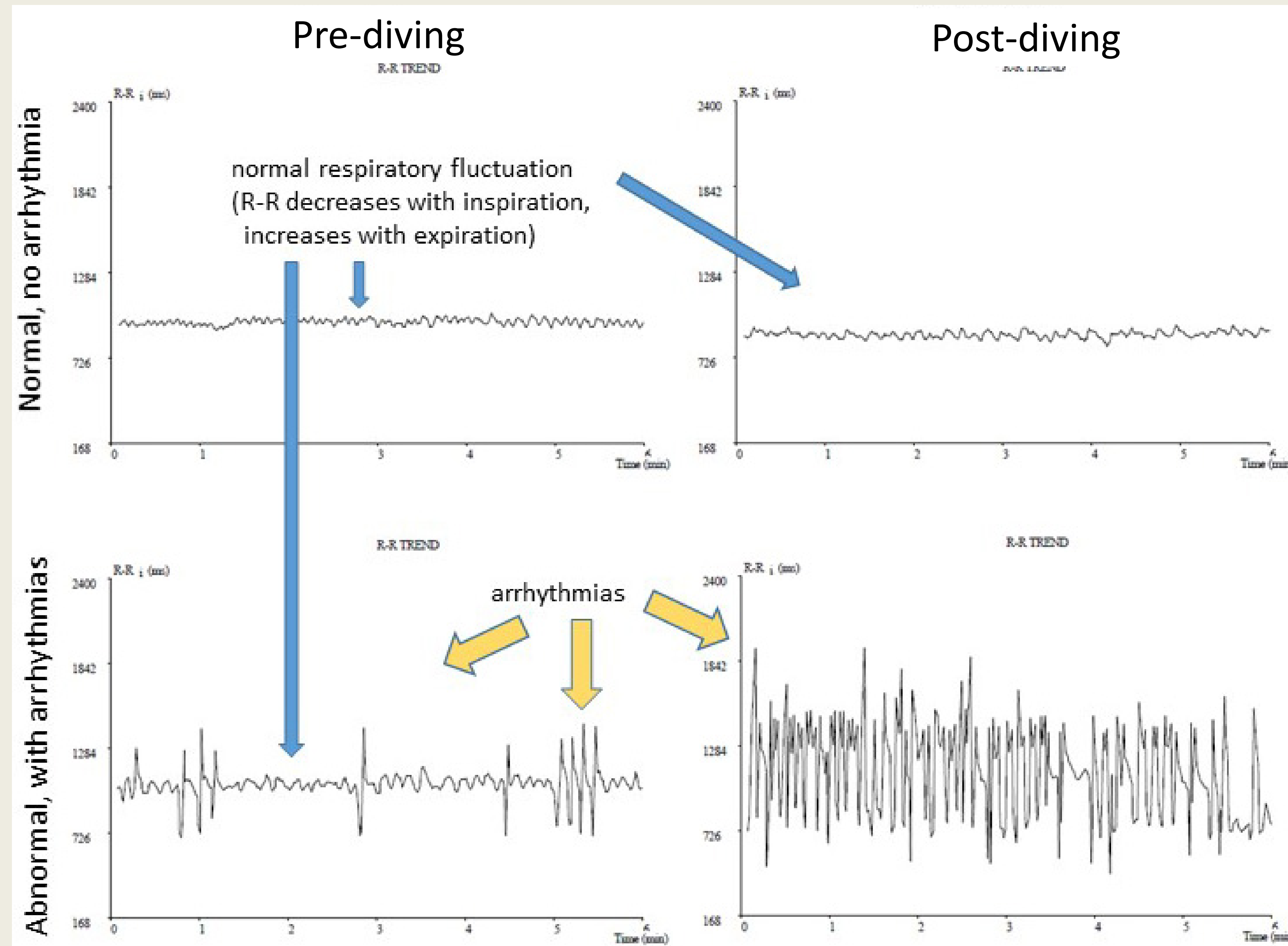
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Examples of beat-to-beat (R-R) interval (ms) trends of divers before vs after diving, 360 sec (6 min) recordings



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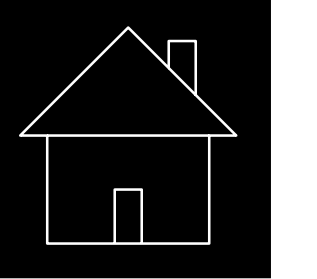
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Discussion and Conclusions

- Arrhythmias were observed in 20 of 68 divers, or nearly 30%. That means, on one hand, that about 70% showed no arrhythmias. On the other hand, however, 30% with arrhythmias represents a very high frequency, possibly higher than would be observed for the general public in this age group under comparable measurement conditions aside from diving. Lindberg et al.,⁸ found a much lower prevalence and incidence of arrhythmias in a large sample of the general elderly population (60 yr or older) in Sweden.
- The percentage of divers with arrhythmias is remarkably, though perhaps coincidentally, similar to the percentage of SCD in diver deaths. Although we observed no SCD, our results suggest that arrhythmias could be a significant risk factor for older divers, particularly those with underlying comorbid conditions.
- This study, for the first time, characterizes a selected cohort of older recreational divers with cardiac arrhythmias, though this cohort may not be representative of older recreational divers generally.
- This study was exploratory in nature using volunteer groups of divers who responded to requests from DAN.
- The exploratory nature of our data imposes several limitations on the results and conclusions:
 - The sampled population is non-random, almost entirely Caucasian from the USA, and may not represent divers in this age group in general.
 - There was wide variation among divers including age and other demographic characteristics, physical and medical conditions, and diver histories and recent diving activities.
 - There was wide variation among dive trips including depths of dives, water temperatures (and types of protective suit), lengths of trips (from 1 or 2 to 7 days), and whether live-aboard or shore-based. (Note: all trips were in salt water.)
 - There was variation, evolution, and refinement over the seven year period of this study (2013-2019) in our methodology and protocols including equipment used, technician experience, and such factors as elapsed time between the last dive of a trip and when post-diving recordings were made.
 - Some arrhythmias such as atrial fibrillation (afib, AF) were known or suspected to have occurred in divers during these trips but, by chance, were not captured during our relatively brief periods of measurement.
- Further studies of a more controlled, less exploratory, nature are warranted. We have developed and refined the protocols that could support such studies.
- We thank all of the divers who participated in this study, the live-aboard and resorts that provided space for study activities, and the various technicians and staff who helped with logistics and measurements: Brittany Rowley, Niles Clark, Chiara DiCredico, Caslyn Bennett, Jenna Walker, Charlie Edelson, Jayne Cleve, Caitlyn Ruskell and Yann Herrera Fuchs.

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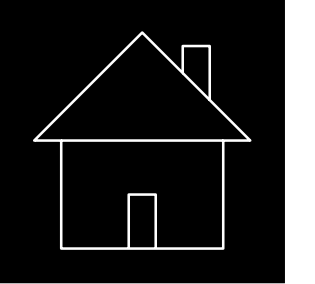
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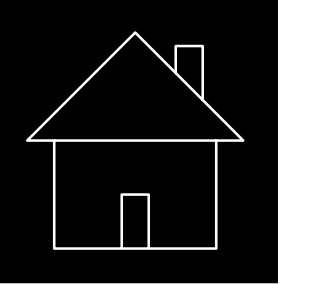
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