The effect of exercise at 24 or 2 hours prior to diving on the evolution of venous gas emboli.

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Background

It was thought for many years that exercise before, during or after diving was an additional risk factor for decompression illness (DCI). However, recent studies, as detailed below, have indicated that exercise prior to diving can help to reduce the number of circulating bubbles formed post-dive and thus also reduce the risk of DCI:

Rat studies (all **dry** chamber dives):

- 90 min of exercise one **day prior** to dive had the same effect as endurance training, significantly **reducing** bubble numbers
- (Wisloff and Brubakk, 2001)
- 90 min of exercise **24 and then 2 hours** prior to diving **increased** bubble numbers in comparison to exercise only at 24 hours
- (Loset et al, 2006)
- 90 min of exercise **2 hours** prior to diving had **neither increased nor decreased** effect on bubble numbers
- (Berge et al, 2005)

Human studies :

- 40 min of exercise **24 hours** prior to a **dry** dive significantly **reduced** the number of circulating bubbles (Dujic et al, 2004)
- 45 min of exercise **2 hours** prior to a **dry** dive also significantly **reduced** the number of circulating bubbles (Blatteau et al, 2005 & 2006)
- 40 min of exercise **2 hours** prior to a **wet** dive significantly **reduced** the number of circulating bubbles (Pontier and Blatteau, 2007)

Methods

- Ten apparently healthy men were compressed in a hyperbaric chamber to 18 m (0.28 MPa) for 100 minutes, then decompressed at a rate of 15 m min^{-1}, with stops at 6 m for 5 min and 15 min at 3 m, in accordance with Royal Navy Table 11 (modified).
- Each subject performed 3 dives; the first was a control dive, while the latter two took place after an ab/ba cross over design bout of exercise performed either 24 h or 2 h before diving.
- Exercise consisted of 40 minutes sub-maximal work on a cycle ergometer (3 min at 90% of max heart rate, then 2 min at approximately 50% and so on), which was very similar to the exercise protocols performed in previous studies. Exercise levels were set relative to an individuals' VO2 max, which was determined at least one week prior to the first dive using the ramp method on a cycle ergometer.
- Venous gas emboli (VGE) were evaluated using pre-cordial Doppler ultrasound rated on the Kisman Masurel scale by experienced operators, who had all recently undergone and satisfied a quality control assessment.
- Doppler measurements were made immediately on surfacing, then at 5 min intervals for 30 min, and at 15 min intervals thereafter for at least 2h, in order to gain a complete picture of bubble evolution.
- Statistical testing was made on median bubble scores, given that Doppler consist of ordinal data, using the appropriate non-parametric Friedman test.

Subject	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5
Age	30	35	45	46	36	54	51	36	25	48
BMI	27.1	27.6	34.4	28.8	22.3	23.5	29.9	25.4	32.4	25.7
Body fat %	19.3	20.7	30.5	20.8	13.1	18	25.5	17.2	23.2	19.8
Smoker	Y	N	N	N	N	N	N	N	N	N
Previous DCI	N	N	N	N	N	Y	Y	N	N	Y
VO_2 Max	52.8	35.8	31.9	41.4	62.6	33.2	40.7	46.6	45.4	55.3
Max HR	178	207	169	191	187	187	170	184	201	174

Table 1—Subject statistics

Subject	Activity (job)	Activity (leisure)	Cycling	Wet dives	Dry dives
A1	2	2	yes	1/month	1/month
A2	2	2	occasional	43 in 2007	1/month
A3	2	2	no	no	50/year
A4	2	3	no	1/month	30/year
A5	1	5	yes	no	no
B1	2	2	infrequent	no	infrequent
B2	1	3	yes	no	infrequent
B3	2	3	infrequent	yes	yes
B4	2	1	some	2-3/month	no
B5	2	5	yes	no	no

Table 2 - Subject activity levels and dive records.
Activity levels defined as: 1 Very low; 2 Low / medium; 3 Medium; 4 Medium / high; 5 Very high

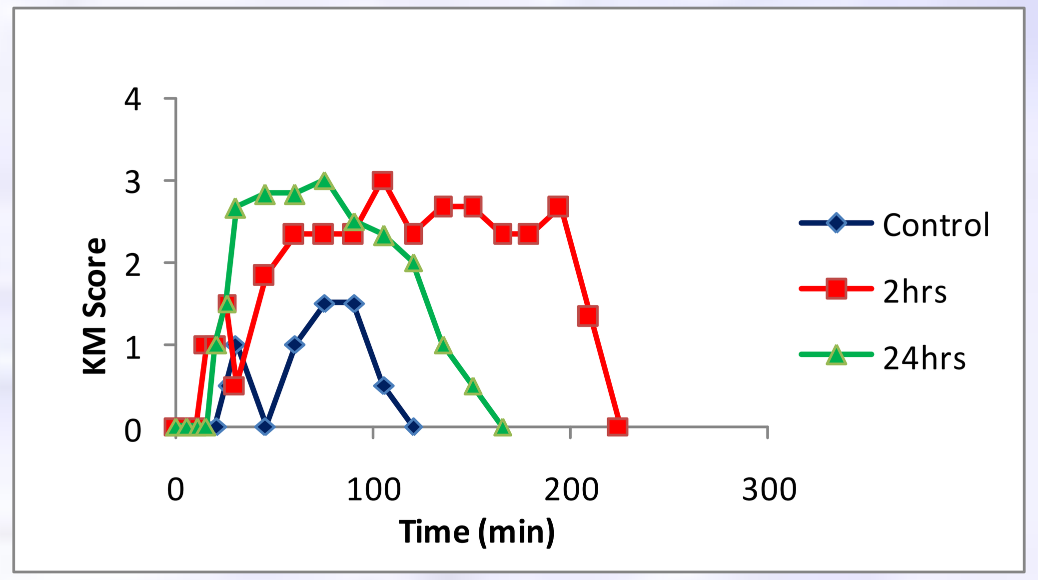


Figure 1—KM Doppler scores (median values)

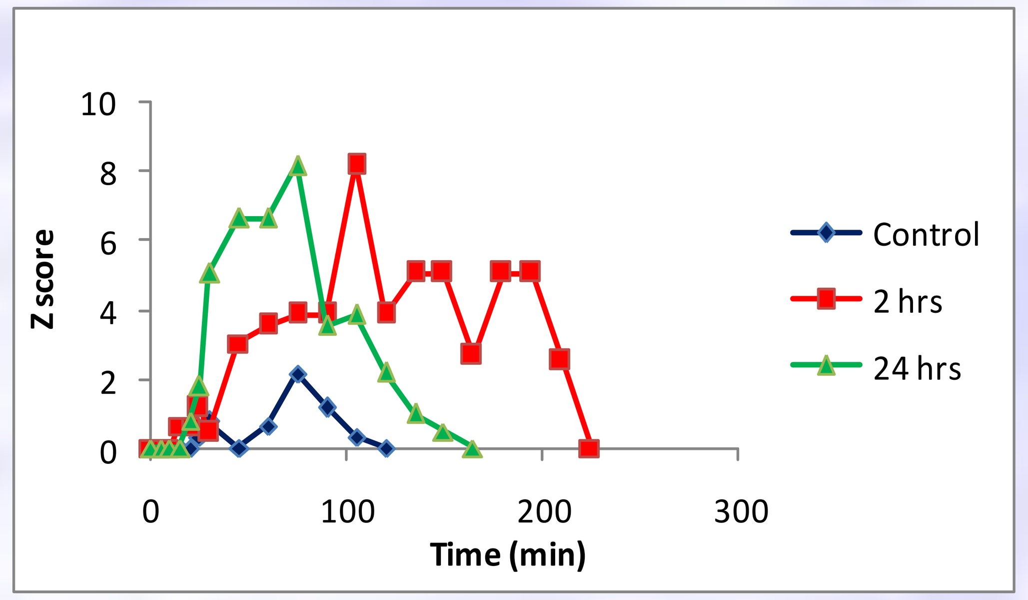


Figure 2— Z scores (median values)

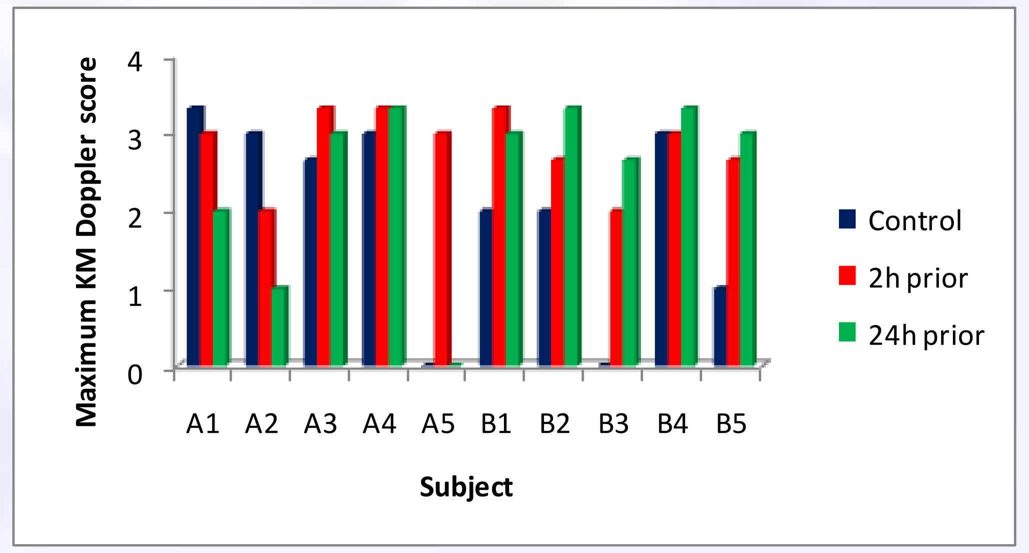
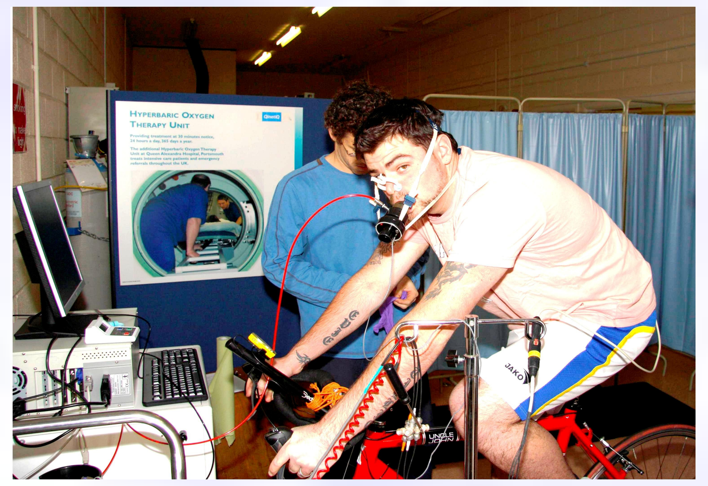
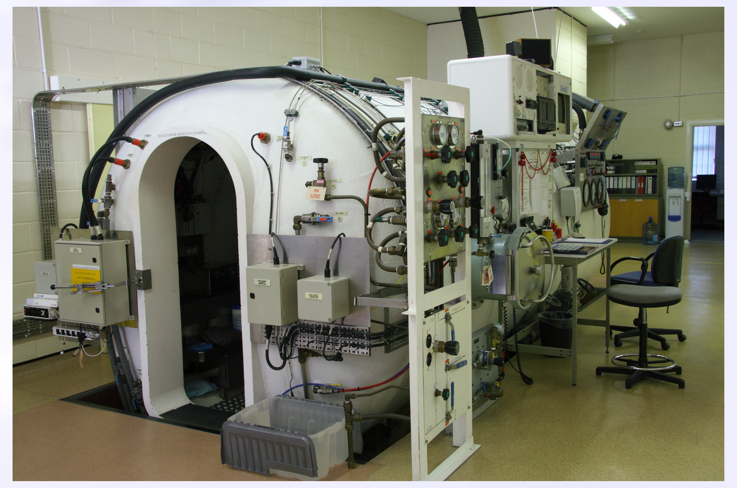


Figure 3 - Maximum KM Doppler score for each subject in each test.

Results

- A single bout of strenuous exercise taken either 24 or 2 hours prior to a dive did not reduce the median number of circulating VGE in comparison to control numbers, with a median maximum KM bubble grade in the control group of 2+ and a score of 3 for both the 2 h and 24 h exercise groups.
- At 120 min post-dive, when the median bubble score in the control dive group was zero, both pre-dive exercise groups had significantly higher median bubble scores ($p < 0.05$) indicating that bubbles disappeared from the circulation significantly faster after the control dive than the exercise dives.
- The time to median KM Doppler scores of zero was 225 min in the 2 h exercise group, and 165 min in the 24 h exercise group.
- Figure 1 displays the time course of bubble evolution using the KM scoring system, while Figure 2 shows the same data in the form of Z scores, following transformation by Kisman's bubble severity estimate system. This transformation attempts to give the values a more linear representation. Figure 3 shows the maximum KM score for each subject for each treatment.





Conclusions

Contrary to recent studies, the number of VGE was not significantly lower in either the 2h or 24h exercise groups in comparison to the non-exercise control. Unlike the previous studies, Doppler measurements were made immediately upon surfacing and continued at regular intervals until the majority of the bubbles had disappeared. This frequent monitoring allows a more complete profile of bubble evolution and dissolution to be followed. Given the disparity between our results and the earlier studies, the completeness of the Doppler data and the information regarding the subjects should be of help in determining the reasons for the different results.

Factors that might have influenced the outcome include dive profile, exercise type and intensity, all of which vary in the previous human studies. One obvious difference is that in the present study, a mixture of subjects, all with diving experience but presently of mixed diving activity were used, whereas in other studies active military divers were tested. A study comparing the effects of pre-dive exercise on active divers and non-divers will be undertaken.

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