P.O. Box 144345 Austin, TX 78714-4345 ▪ 512.926.4900 ▪ Fax: 512.926.2345 ▪ www.herbalgram.org

HerbClip™

File: ■ Chocolate (*Theobroma cacao*)
■ Endothelial Dysfunction
■ Breath-hold Divers

HC 111331-485

Date: November 27, 2013

RE: Dark Chocolate Reduces Endothelial Dysfunction in Breath-hold Divers

Theunissen S, Schumacker J, Guerrero F, et al. Dark chocolate reduces endothelial dysfunction after successive breath-hold dives in cool water. *Eur J Appl Physiol*. 2013; [epub ahead of print]. doi: 10.1007/s00421-013-2732-6.

Breath-hold divers include spear fishermen, pearl collectors, and competitive divers, all who dive deep for long periods of time. They sometimes spend several hours in an ocean's cold water without thermal protection. In earlier studies of breath-hold diving in thermoneutral conditions, endothelial dysfunction was accompanied by an increase in circulating nitric oxide (NO), which has been associated with the cardiovascular effort required by breath-hold diving. Dark chocolate (*Theobroma cacao*) has been reported to have beneficial effects on endothelial function.[1,2] These authors conducted a study to verify whether the underlying mechanisms of endothelial dysfunction are maintained in cold water conditions and to observe whether eating dark chocolate before a series of breath-hold dives can limit the endothelial dysfunction generally observed post-apnea.

Enrolled in the study were 20 nonsmoking, experienced breath-hold divers. They were instructed to refrain from strenuous exercise and nitrate-rich foods for 48 hours before the testing and not to dive for 72 hours before testing. They were divided into a chocolate group (9 men and 1 woman) and a control group (8 men and 2 women). Both groups were similar in age, height, and weight. Each diver performed successive 20-meter dives in the diving pool of Conflans-Ste-Honorine in Paris, France, for a cumulative breath-hold time of 20 minutes. Each diver spent about 1 hour in the water. Air temperature was 30°C (86°F); water temperature was 27°C (80.6°F).

One hour before diving, the divers in the chocolate group ingested 30 g of a commercially available Belgian dark chocolate with 86% cocoa. Polyphenols in the chocolate totaled 135.8 ± 2.9 µmol of catechin equivalents per gram.

Arterial endothelial function was assessed before and after the breath-hold dives by measuring the flow-mediated dilation (FMD) of each diver's brachial artery. Arterial stiffness was assessed using photoplethysmography. Blood samples were collected before diving and 15 minutes after the series of dives to measure levels of nitrite and nitrate, NO metabolites, and the oxidant peroxynitrite.

The authors report that the mean number of breath-hold repetitions was 10 ± 2 dives in the control group with an immersion time of 19.57 ± 2.41 minutes and 9 ± 2 dives with a mean immersion time of 18.53 ± 3.5 minutes in the chocolate group. For both groups, the mean recovery period between dives was 4.55 ± 1.19 minutes.

All divers completed the study, and none of the divers suffered decompression sickness.

No increase in pre-occlusion brachial artery diameter was observed for either group. An FMD decrease was, however, observed in the control group before and after the dives (95.3 ± 2.9% of pre-dive values, $P<0.001$); whereas the FMD was increased in the chocolate group (104.1 ± 2.9% of pre-dive values; $P<0.01$). The difference between the 2 groups was statistically significant ($P<0.001$). Regarding microcirculation, no variations were found in the 2 groups between the values before and after the dives of the peak-to-peak time, described as "the time taken for pressure to propagate along the aorta and large arteries to the major site of reflection in the lower body and back to the root of the subclavian artery." Further, no variations were observed in the arterial rigidity values. A reduction in circulating NO was observed after the dives in the control group ($P<0.05$) but no NO variation was seen in the chocolate group ($P>0.05$). No variations in oxidative stress markers were observed for either group.

The authors explain that physical exercise is known to increase NO production and that, under normal conditions, physical training enhances endothelial function. "This phenomenon was not found in this study: we have instead found a decrease in NO in the control group." They explain several factors that may have counterbalanced the NO production normally induced by exercise: "We could therefore consider that here the decrease in circulating NO in the control group is due to the additional effect of cold. The increase in NO production linked to the cardiovascular effort would here not be enough to compensate the combined effect of oxidative stress, hyperoxia at the start of the dive, hypoxia of the end of the dive and the cold."

The increase in FMD in the chocolate group could be explained by the antioxidative characteristics of the chocolate. "The antioxidant characteristics of chocolate are then maybe responsible for the FMD increase without circulating NO increase after the dive, but the underlying mechanisms remain to be determined."

The authors conclude that the antioxidants in dark chocolate scavenge the free radicals produced during breath-hold diving and suggest that ingesting 30 g of dark chocolate 1 hour before a dive could help prevent the endothelial dysfunction observed after a series of breath-hold dives.

—Shari Henson

References

[1]Grassi D, Desideri G, Necozione S, et al. Protective effects of flavanol-rich dark chocolate on endothelial function and wave reflection during acute hyperglycemia. *Hypertension*. 2012;60(3):827-832.

[2]Monahan KD. Effect of cocoa/chocolate ingestion on brachial artery flow-mediated dilation and its relevance to cardiovascular health and disease in humans. *Arch Biochem Biophys*. 2012;527(2):90-94.

The American Botanical Council has chosen not to include the original article.