Bioscience Research Communications
Vol. 15, No. 1, February 28, 2003
Printed in Nigeria

0795-8072/2003 $12.00 + 0.00

BRC 2001137/15109

Cardiovascular responses to breath-holding with or without face immersion in young adults

Soladoye, A.O.; Owoyele, B.V.; Olatunji, L.A. and Adelusi, S.A.

Department of Physiology and Biochemistrey, Faculty of Health Sciences, University of Ilorin, Ilorin, Nigeria.

(Received August 10, 2001)

ABSTRACT: Cardiovascular responses to breath-holding in air and breath-holding with face immersion in water were studied in 15 subjects aged 20 – 30 years. Cardiovascular responses were determined by measuring changes in heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP). Measurement were made before and shortly toward the end of 60 seconds breath-holding with or without face immersion.

The result show a significant fall in HR from the control value of 78.9 ± 2.3 beats min-1 to 62.5 ± 2.6 beats min-1 ($P<0.01$) during breath-holding with face immersion. SBP increased significantly ($P<0.05$) during breath-holding with or without face immersion, though the magnitude of the increase was higher in breath-holding alone. DBP responses was characterised by an insignificant increase during breath-holding and face immersion and a significant ($P<0.01$) increase during breath-holding in air.

We conclude therefore that bradycardia occur during breath-holding with or without face immersion, the pressure responses is characterized by an increase in blood pressure, but abated during face immersion. However, chronotropic responses are stronger than the vascular responses.

Key Words:

Introduction

Physiological adjustments to breath-holding and face immersion have continued to be a subject of research both in animals and human studies (Kawakami et al., 1967; Bartlett, 1977; Ballal and Sanford, 1994). The findings in simple breath-holding show that it follow the trend in breath-holding with face immersion. It has been reported also that both type of breath-holding lead to reflex adjustment in the cardiovascular system (Ballal and Sanford, 1994; Daly, 1991). While ordinary breath-holding is a usual manoeuvre undertaken by individuals, breath-holding with face immersion is a laboratory model of diving (Craig, 1963).

Reports has shown that alterations in cardiovascular function occur in face immersion with or without breath-holding. These alterations are smaller in magnitude during face immersion without breath-holding compared to that by face immersion with breath-holding (Anderson, 1963; Brick, 1965). Most of the available literature on humans cardiovascular responses were obtained from Caucasian. This study have been undertaken, therefore, to study the effect of breath-holding with or without face immersion in young adult Nigerian males.

Materials and Methods

The study was undertaken in 15 male subjects aged 20 – 30 years. Only subjects who satisfied the criteria being non-swimmers, free from cardiopulmonary diseases and no family history of asthma were admitted into the study. In addition, subjects who cannot hold their breath for 60 seconds were excluded from the study. All subjects were either staff or student of the University and they were certified fit for the study by the University clinic physician. The antropometric data were measured in the laboratory (Table 1). All the subjects were made accustomed to the experimental protocol before the study was carried out.

Experimental Procedure: The resting heart rate and blood pressure (Diastolic and Systolic) were measured using the standard sphygmomanometer and radial arterial pulse sound with the subjects well seated in a relaxed position. The subjects were then made to lay prone on a laboratory table with their head supported on a string above a basin filled with stirred water at temperature of 25 – 29°C. According to the method of Brick (1965).

Three seconds before the end of the initial control period, the subjects were asked to take a deep breath which they held for 1 minute. During this period of breath-holding, the heart rate and blood pressure were measured. The subjects were then allowed considerable time to recover. After recovery, the subjects were asked again to take a deep breath following which the basin containing water was raised to immerse the subjects face for a period of 60 seconds. The blood pressure and heart rate were again measured. The basin was then lowered and the face wiped clear of water following which measurement of heart rate and blood pressure were noted again after 60 seconds recovery period and the values were fairly the same with the control values.

Statistical analysis to determine the level of significance was by the student t-test for paired comparisons (Kennedy and Neville, 1976). Differences were considered significant when $P<0.05$.

Results

Response of Heart Rate

All the fifteen subjects successfully participated in the study. Though 20 subjects were initially admitted into the study, five subjects could not withstand breath-holding and face immersion in water for 60 seconds. During breath-holding and face immersion HR fell from the control value of 7.8 ± 1.6 beats min-1 to 62.5 ± 2.6 beats min-1. This represent a percentage fall of 17.2 ± 2.0% ($P<0.01$).

The HR was also reduced during breath-holding in air from control value of 78.9 ± 1.6 beats min-1 to 68.6 ± 2.4 beats min-1, representing a percentage fall of 13.0 ± 2.1 beats min-1 ($P<0.01$) (Table 2). Comparison of the responses during breath-holding in air and breath-holding with face immersion show an insignificant difference ($P>0.1$).

Responses of Systolic Blood Pressure

The systolic blood pressure increase during face immersion with breath-holding from the control value of 112.8 ± 0.5 mmgH to 115.3 ± 0.5 mmgH representing a percentage increase of 2.2 + 0.2% ($P<0.05$). Likewise there was a significant ($P<0.05$) increase in SBP during breath-holding in air from the control value of 112.8 ± 0.5 mmgH to 116.7 ± 0.5 mmgH representing a percentage change of 3.5 + 0.2%. The responses are shown in Table 3. Comparison of the responses during breath-holding in air and breath-holding with face immersion show a highly significant increase during breath-holding in air ($P<0.01$).

Responses of DBP

During face immersion with breath-holding, the DBP increase slightly from 75.5 ± 0.4 mmgH to 76.1 ± 0.3 mmgH. However, this slight increase in DBP was not significant ($P>0.1$). During breath-holding in air, there was a further increase in DBP from the control value of 75.5 ± 0.4 mmgH to 76.9 ± 0.3 mmgH representing a percentage change of 1.9 ± 0.4% ($P<0.01$). The responses are shown in Table 4. Comparison of the responses during breath-holding in air and breath-holding with face immersion show an insignificant difference ($P>0.1$).

Table 1: Anthropometric data

	Age (Yrs.)	Height (m)	Weight (kg)
Mean	25.5	1.71	58.0
SEM	± 1.1	± 0.01	± 1.3

Table 2: Responses of heart rate (beats min-1) to breath-holding with or without face immersion.

	a Rest	b During immersion	c Breath-holding in air
Mean ± SEM	78.9 ± 2.3	62.5 ± 2.6	68.6 ± 1.4
% Changes		17.2 ± 2.0	13.0 ± 2.1

a Vs b P<0.01
a Vs c P<0.01
b Vs c P>0.1

Table 3: Responses of systolic blood pressure (mmHg) to breath-holding with or without face immersion.

	a Rest	b During immersion	c Breath-holding in air
Mean ± SEM	112.8 ± 0.5	115.3 ± 0.5	116.7 ± 0.50
% Changes		2.2 ± 0.2	3.5 ± 0.2

a Vs b P<0.05
a Vs c P<0.05
b Vs c P<0.05

Table 4: Responses of diastolic blood pressure to breath-holding with or without face immersion.

	Rest	During immersion	Breath-holding in air
Mean ± SEM	75.5 ± 04	76.1 ± 0.3	76.9 ± 03
% Changes		1.4 ± 0.3	1.9 ± 0.4

a Vs b P>0.1
a Vs c P<0.01
b Vs c P>0.1

Discussion

This study conducted in the laboratory is a model of diving. The ability to simulate diving in the laboratory is of great value. This is because only a small proportion of Nigerian can swim and a further smaller proportion could dive. Measurement of cardiovascular variables within the river or sear will be difficult as both the subjects and the researcher might have to be under water. In this study, we have measured the cardiovascular responses before, during face immersion and breath-holding in air. The face immersion was tedious for a number of subjects even after subjects were certified fit for the study by meeting the selection criteria.

The responses of heart rate during breath-holding in air and during 60 second of face immersion in water reported in this present study show a characteristic decrease. The pattern of changes in the responses closely agree with past studies (Brick 1965, Jones and Butler, 1982). These reports show that diving is associated with reflex bradycardia. The slight increase in HR during breath-holding in air compared to that of breath-holding with face immersion also agree with the findings in diving mammals, in which tracheal occlusion alone or immersion in water alone both caused reductions in heart rate.

The main drop in HR occurring when the nostrils were immersed in the HR only increase when the nostrils were cleared or water with intact tracheal occlusion (Andersen, 1963; Blix et al., 1973). A probable cause for the bradycardia recorded in this study according to Angell-James and Daly (1973) might be due to nervous reflex that depend on an intact vagal component. Blair et al., (1969) had earlier suggested that man has receptors on his face similar to those around the nares of duck and stimulation of these receptors by water caused cardiovascular changes. According to Daly et al., (1972) and MUCULLOCH et al., (1977) these receptors are free nerve endings relaying via the maxillary branch of trigeminal nerve.

The magnitude of the pressor changes were smaller than the chronotropic responses. Changes in SBP during immersion and breath-holding in air were each significantly (P 0.05) increased compared to the control value. This might be due to operation of baroreceptor regulation of blood pressure. The magnitude of DBP changes were smaller than the SBP changes. This is not surprising since DBP responses to manouvres like Valsalva manouvre are usually varied and mostly insignificantly (P 0.1) during breath-holding in air compared to the control. However, comparing breath-holding with face immersion, there was an insignificant increase in DBP.

Increase in blood pressure may be due to the transient hypercapnia resulting from breath-holding, the rapid action of the vagal efferent compared with the slightly slow action of the sympathetic efferent output of the cardiac centre and also the increase intrathoracic pressure due to the breath-holding.

In conclusion, this study has shown that breath-holding leads to bradycardia, secondly the bradycardia is further enhanced during face immersion with breath-holding. Thirdly, the pressor responses is characterised by increase in blood. The magnitude of the chronotropic response was greater than the pressor responses.

ACKNOWLEDGEMENT: The authors wish to acknowledge the technical assistance of Mr. J.L. Fwangle and secretarial assistance of Mrs. V.O. Adegboyega.

References

Anderson, H.T. (1963): Factors determining the circulatory adjustments to diving/water immersion. Acta. Phs. Scand. 68, 173 – 185.

Angell-James, J.E. and Daly, M. de B. (1973). The interaction of reflexes elicited by stimulation of carotid body chemoreceptor and receptor in the nasal mucosa affecting respiratory and pulse interval in dogs. J. Physiol. 139, 133 – 140.

Ballal, M.A. and Sanford, P.A. (1994). Changes in heart rate associated with breath-holding in humans. J. Physiol. 481, 16p.

Bartlett, D. Jr. (1977). Effects ofvalsalva and Mueller manoeuvres on breath-holding time. J. Appl. Physiol. 42: 717 – 721.

Blix, A.S.; Wenneroren, G. and Folkow, B. (1988). Cardio-vascular responses to diving. Acta 33, Physiol. Scand. Suppl. 571, 61 – 68.

Bick, I. (1965). Circulatory responses to immersing the face in water. J. Appl. Physiol. 21: 33 – 36.

Bliar, D.A.; Glover, W.E. and Kidd, B.S.I. (1969). The effect of continuous positive and negative pressure breathing upon the resistance and capacitance blood vessels of the human fore-arm and hand. Clin. Sci. 18: 16 – 19.

Craig, A.B.J. (1963). Heart rate responses to apneic underwater diving and to breath-holding in man. J. Appl. Physiol. 18, 854 – 862.

Daly, M. de B.; Elsner, R. and Angell-James, J.S. (1992). Interraction of cardiovascular reflex. Sci. Basic Med. Ann. Rev. 307 – 332.

Jones, D.R. and Butler, P.J. (1982). Comparative physiology in diving in vertebrate. In advance in Physiol. and Biochem. edited by O.E. Lowenstein. New York Academic Press, vol. 8, pp. 179 – 64.

Kennedy, J.B. and Neville, A.M. (1976). Basic statistical methods for Engineers and Scientists (2^{nd} ed.), pp. 205 – 212, Harper and Row, New York.

Kawakami, Y.; Natelson, B.H. and Dubois, A.B. (1967). Cardiovascular effects of face immersion and factor affecting diving reflex in man. J. Appl. Physiol. 23: 964 – 970.

Muculloch, P.F.; Ollenberge, G.P.; Bekar, L.K. and Best, N.H. (1977). Trigeminal and Chemoreceptor.

Soladoye, A.O.; Owoyele, B.V. and Olatunji, L.A. (1999). Cardiovascular responses to baroreceptor stimulation during muscular exercise in young adults. Res. 2(2): 63 – 67.