Optimum weights for commercial divers

RI McCALLUM AND A PETRIE

From the Department of Occupational Health and Hygiene and the Decompression Sickness Central Registry, University of Newcastle upon Tyne, Newcastle upon Tyne, UK

ABSTRACT Obesity is one of the factors which increase the risk of decompression sickness. It has been suggested that any diver whose weight is more than 20% in excess of that derived from currently accepted tables should therefore be stopped from diving until he has lost enough weight. Published tables of average and standard weights for men, however, are unsuitable for application to men recruited for commercial diving, as the populations on which the tables were based differ in important respects from divers. Furthermore, the tables may assume that men are weighed and measured clothed and in shoes, whereas in most medical examinations the measurements are made on men without shoes and partially clad. Analysis of weight measurements of 1520 divers whose records are in the Decompression Sickness Central Registry in Newcastle upon Tyne suggests that divers as a group are substantially heavier than other populations on whom height-weight tables have been based. A table derived from American data of 1935-53 is often used as a guide. If this table is used the percentage of divers rejected as overweight may be as high as 13.6%. More recent and more appropriate data on heights and weights are required for use as reference standards for divers, or perhaps another measurement indicating obesity should be used.

The medical examination of commercial divers for work in the North Sea under the Diving Operations at Work Regulation 1981 follows the scheme devised for the underwater engineering group of the Construction Industry Research and Information Association (CIRIA).¹ Obesity is one of the factors taken into consideration in deciding whether or not a man is medically fit to dive, as susceptibility to decompression sickness is related to the amount of body fat. It is therefore suggested that a diver whose weight is more than 20% above his recommended weight given by accepted height-age tables should not be allowed to dive until he has lost sufficient weight.²

Method

A table commonly used to determine average weights of adults is that given in Documenta Geigy.³ This table is taken from the American Society of Actuaries build and blood pressure study published in 1959⁴ and relates to a North American population from 1935 to 1953. Furthermore, it is assumed

that at a medical examination a patient will be weighed and measured clothed and in shoes so that to obtain an approximate true weight and height a correction must be made for the weight of clothing and the height of shoe. The suitability of a table such as this for the assessment of present day men in the United Kingdom, still less a diving population, can therefore be questioned. One might, for example, expect pronounced differences in physique, activity, and nutrition, and particularly in type and style of clothing and height of shoe from the population on which the American Society of Actuaries table was based. A comparison has been made therefore between the recorded heights and weights of 1520 divers obtained at a medical examination under British diving regulations,⁵ records of which are held in the Decompression Sickness Central Registry at the University of Newcastle upon Tyne, and two published weight for height tables. The source of the registry data is records of about 100 approved examining doctors in the United Kingdom and abroad.

The tables used in this comparison are those of Documenta Geigy³ and Kemsley *et al.*⁶ Kemsley *et al* derived their male standards from measurements taken in 1943 of 4325 men aged 20-29, clothed, and

Received 28 February 1983
Accepted 11 April 1983

Table 1 Weights of men by height and age from diving registry data, Documenta Geigy (average) and Kemsley *et al*

Height	Weights (lb) Age 20-24			Weights (lb) Age 25-29			Weights (lb) Age 30-39		
	Divers (average)	Geigy (average)	Kemsley (standard)	Divers (average)	Geigy (average)	Kemsley (standard)	Divers (average)	Geigy (average)	Kemsley (standard)
5'6"	142.7	142	130	153.6	148	130	154.8	153	135
5'7"	152.9	145	134	156.1	151	134	159.1	157	139
5'8"	153.7	149	138	161.5	155	138	163.0	161	143
5'9"	157.6	153	141	164.0	159	141	166.0	165	146
5'10"	161.8	157	145	168.4	163	145	177.3	170	150
5'11"	164.3	161	149	170.5	167	149	175.5	174	154
6'0"	172.2	166	152	177.0	172	152	182.2	179	157
6'1"	178.1	170	156	182.3	177	156	184.8	183	161

in footwear.

Copies of the CIRIA medical examination form for divers are received in the Decompression Sickness Central Registry in the University of Newcastle upon Tyne after having been completed by an "approved doctor" under the Diving Operations at Work Regulations, 1981.⁵ Among the medical records there are only small numbers of divers in some age-height groups so that attention was confined to three age groups: 20-24, 25-29, 30-39, and to men with heights between 5'6" (1.68 m) and 6'1" (1.85 m) at intervals of one inch (0.025 m). With this restriction the smallest number of divers in any age-height group was 26.

Results

The weights of men aged 20-24, 25-29, and 30-39 for divers, Documenta Geigy average men, and

Kemsley standard men are given in table 1 for heights between 5'6" and 6'1", and these values are also shown in the figure.

Although the plots for divers are somewhat erratic, for all sources of data and all age groups there is about a 4 lb increase in weight for each additional inch of height. This is in line with the finding of Kemsley *et al*⁶ that the regression of weight on height may be regarded as fairly constant. At each age the mean weight of divers of a given height is greater than the Documenta Geigy average weight, which in turn is greater than the Kemsley standard weight. The data, however, were obtained in different ways, and any adjustment which might be made for height of shoes and weight of clothing will alter the positions of the lines. Consequently, differences in position of the lines do not necessarily reflect real differences in weight.

Weight against height at different ages according to three sources of information.

To make proper comparison between the different sets of data, allowance must be made for the way in which the measurements were made.

DIVERS, DECOMPRESSION SICKNESS REGISTRY

At the Decompression Sickness Registry heights and weights are assumed to be measured without shoes and with minimal clothing. As shown by replies to a questionnaire from 94 approved doctors, only four doctors weighed patients clothed, whereas 44 weighed them in underpants only, and 46 partially clothed. Height was measured with divers barefooted by 89 doctors, and only five doctors measured them in shoes.

KEMSLEY *et al*⁶

Subjects were measured clothed and usually wearing shoes or boots. In constructing the standard, measurements were adjusting to approximate nude heights and weights by subtracting 1 inch and 10 lbs respectively.

DOCUMENTA GEIGY⁷ (average weights)

Heights were measured in shoes and weights were measured in indoor clothing.

Comparison between the divers' registry weights and the published tables

Compared with Kemsley *et al*'s standard desirable weights the divers are roughly 17 lb, 23 lb, and 22 lb heavier at ages 20–24, 25–29, and 30–39 respectively. Nevertheless, the suitability of their data as a standard against which to compare the divers may be questioned for the following reasons.

(1) Since the measurements were made in wartime (1943) on men aged 20–29 they may not be representative of men in this age group 30 years or more later.

(2) The group would have grown up during the depression and may well not be an appropriate standard for present day men: 152 lbs seems rather light for a man 6 ft tall.

(3) Kemsley *et al* give adjustments to be added to their basic standard to allow for age.⁶ These adjustments vary from 5 lbs at age 30–39, 10 lbs at 40–49, and 5 lbs between 55 and 64.

One way of summarising the relation between the weights of the divers and those of Documenta Geigy average men would be to say that, assuming that it is reasonable to subtract 1" from height to allow for footwear, then an average 20–24 year old diver weighs the same unclothed as an average 20–24 year old Documenta Geigy man in indoor clothing.

Discussion

Crosbie *et al* have studied the physical characteristics and ventilatory function of a group of 404 commercial divers,⁷ most if not all of whom are included in the present group. They found that the divers were heavier on average than Western men of similar age and that 6% were more than 120% of predicted weight. No correction factor was applied for divers not wearing shoes which the predicted value included.

Proper comparisons between the different figures are difficult because the heights and weights were recorded in different countries at different times in different ways. The data from the registry related to a large series of fit and mainly young men, about 95% of whom have been accepted for North Sea diving. They appear to be a good deal heavier than either the British or American standard weights in Kemsley *et al* and Documenta Geigy respectively. The main reason for taking weight into account in the medical assessment of divers is to exclude obese men who might be much more prone to decompression sickness than thinner men. Weight, however, is not a good guide to obesity, which is probably better measured by skinfold thickness using skin calipers,⁸ although it is not clear yet what limits of skinfold thickness are acceptable in divers.

Table 2 shows mean weights of divers and estimated standard deviations compared with the Documenta Geigy average weights for heights from

Table 2 Average weight in pounds at different heights for 1520 divers aged 20–24 and estimated percentage of divers overweight at Documenta Geigy average values plus 20% and 15%

Height (ft, inches)	Divers' average weight (estimated standard deviation)	Divers' average weight plus 2 estimated standard deviations	Documenta Geigy average weights			Estimated percentage of divers rejected if upper limit is	
			as given	plus 20%	plus 15%	Documenta Geigy average plus 20%	Documenta Geigy average plus 15%
5'6"	142.7 (19.7)	162.1	142	170.4	163.3	0.2	1.7
5'7"	152.9 (19.2)	191.3	145	174.0	166.8	13.6	23.6
5'8"	153.7 (13.9)	181.5	149	178.8	171.1	3.5	10.6
5'9"	157.6 (16.4)	190.4	153	183.6	176.0	5.6	13.1
5'10"	161.8 (15.0)	191.8	157	188.4	180.6	3.8	10.6
5'11"	164.3 (16.7)	197.7	161	193.2	185.2	4.2	10.6
6'0"	172.2 (17.9)	208.0	166	199.2	190.9	6.6	14.9
6'1"	178.1 (17.9)	213.9	170	204.0	195.5	7.4	16.6

5'6" and 6'1" at age 20–24. Applying a 20% excess limit to the Documenta Geigy average table, a varying proportion of divers would be rejected on grounds of overweight, ranging from 0.2% at height 5'6" to 13.6% at 5'7". With a 15% limit the range would be from 1.7% at 5'6" to 23.6% at 5'7". This assumes that the divers' weights have a normal (Gaussian) distribution, which has yet to be confirmed.

At present there is for divers no agreed figure for a desirable weight for a given height and age and none of the available data is without defect. Apart from variables introduced by standard allowances for weight of clothing and height of shoe there is a pronounced variation between the weights for a given height and age in the published tables. The data from the registry give an indication of the range of weights for height in a population of men most of whom are considered fit for diving. It should be possible to use the registry data which are already available as a guide but further data on heights and weights of divers are being added so that the range of weights for height with age should increase with time. It might be useful, for example, to be able to say whether or not a man is within two standard deviations of an appropriate figure derived from these records.

Thanks are due to members of the Decompression Sickness Central Registry for the data relating to diving and in particular to Mr Patrick Trowbridge. Acknowledgements also to the many approved doctors who have supplied completed medical examination forms to the registry and who replied to the questionnaire on measurements of height and

weight.

The work of the Decompression Sickness Central Registry has been supported by the Medical Research Council through a grant to Professor DN Walder, Department of Surgery, University of Newcastle upon Tyne, and now by the Health and Safety Executive through a grant to Professor RI McCallum.

Mrs A Petrie was senior research associate from 1976 to 1979 in the Department of Occupational Health and Hygiene, University of Newcastle upon Tyne, and was supported by a grant from Messrs Anzon Limited.

References

- ¹ *Principles of Safe Diving Practice*. Rev ed. Report UR2, CIRIA Underwater Engineering Group. London: Construction Industry Research and Information Association, 1975.
- ² Employment Medical Advisory Service. *Medical examination of divers*. MA1. London: Health and Safety Executive, 1981. (K41/81.)
- ³ Documenta Geigy. *Scientific tables: average weights of adults*. Diem K, Lentner C eds. 7th ed. Macclesfield: Geigy Pharmaceuticals, 1970:711.
- ⁴ Society of Actuaries. *Build and blood pressure study*. Vol 1. Chicago: Society of Actuaries, 1959;16–29.
- ⁵ *Diving Operations at Work Regulations*, 1981. London: HMSO, 1981.
- ⁶ Kemsley WFF, Billewicz WZ, Thomson AM. A new weight-for-height standard based on British anthropometric data. *Br J Prev Soc Med* 1962;16:186–95.
- ⁷ Crosbie WA, Clarke MB, Cox RAF, et al. Physical characteristics and ventilations function of 404 commercial divers working in the North Sea. *Br J Ind Med* 1977;34:19–25.
- ⁸ Durnin JVGA, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *Br J Nutr* 1974;32:77–97.