*BODY WEIGHT IN HEALTH AND DISEASE.

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Water constitutes the greater part of the body weight. Bone contains nearly fifty per cent. of water and other tissues about seventy-five per cent. Of the tissues which form the bulk of the body, muscle is the most abundant. Halliburton and McDowall's "Handbook of Physiology" gives the following figures per cent.: muscles, 42; fat, 18; skeleton, 16; viscera, 9; skin, 8; brain, 2; blood, 5. Evidently, abnormalities of weight of an individual will result usually from alteration in the amount of the fat, muscle or skeleton, or from an abnormal water content.

Variations in Weight.

A natural increase in weight accompanies growth, when new tissue is being laid down, but weight and growth are not necessarily commensurate. Increasing height may be accompanied by temporary leanness. A tendency to leanness is also found in the post-adolescent period and in advanced age. The modern trend of fashion is towards thinness in the midst of plenty, a not unnatural urge of a generation which hopes for passion without pregnancy.

The weight of an individual bears some relation to his height. Build must also be taken into account. Variations in weight up to twenty per cent. of the mean are disregarded by certain insurance experts.

The weight of the individual may alter from time to time, apart from growth. The alteration may be cyclical, e.g. in relation to the menstrual cycle in association with which variation of the water balance occurs. The weight may also vary with the mental and physical activity. Of special importance are the alterations due to disease.

The Basal Metabolic Rate. The relation of the basal metabolic rate to fatness and leanness is obscure. In obesity the rate per pound is usually lessened but the rate per unit of surface is frequently normal. The fat man has a deposit of sluggish fat which lowers the B.M.R. per unit of weight. Further his increase of surface is less than his increase of weight. Since B.M.R. seems related primarily to body surface, we are not justified in arguing that the decreased basal metabolism per unit of weight is a cause of the increased weight. Rather is it a sequel. It has been said that in exogenous obesity the B.M.R. as related to surface is normal, but that in endogenous obesity or at any rate in endocrine obesity, the rate is lowered. In certain pituitary cases the rate is lessened but in others it is not. In adrenal obesity the B.M.R. is sometimes above the average, according to Adler. The accuracy of basal metabolism estimations is not great, the experimental error being ten to fifteen per cent. The method cannot therefore be expected to show fine changes, but one may imagine that in a large series of experiments the error would average out. In any case it is clear that there is no ineluctable subservience of body weight to basal metabolism. The thin hyperthyroid with a high B.M.R. and the bloated myxoedemic with a low rate are not to be held up as proving that B.M.R. and body weight are always in inverse ratio. The lean old man, for example, has a lower rate than that which obtained when he was younger and fatter.

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The Regulation of Body Weight.

The weight is to some extent affected by the water balance which is controlled primarily by the kidneys and by the sense of thirst. The pituitary controls the renal excretion of water and in turn may be controlled by the nervous system. The sweat glands are more for temperature regulation than for fluid balance. Dehydration would cause loss of weight, oedema an increase. In myxoedema part of the increased weight is believed to be due to water retained by the excess of "deposit-protein" in the tissues. The water thus retained is adsorbed, not free in the tissues, which therefore do not pit on pressure. Recent evidence indicates that normally the intercellular "fluid" is really gelatinous; but even if this view is accepted, it is clear that when oedema is present the intercellular material is liquid.

The weight of the body depends also on the metabolic balance of income and expenditure. More exercise usually means more appetite and in this we see a crude method of weight adjustment. Food, particularly protein food, stimulates metabolism and so tends to bring about its own oxidation. The specific dynamic action of protein has been depicted as fanning the catabolic fires. Various hormones help to balance the metabolic account and the nervous system also plays a part.

Yet there is little precise information as to the way in which the various factors concerned are integrated so as to maintain a more or less steady weight. Stored energy is mainly in the form of fat. Is there a master hormone concerned with the accumulation and perhaps with the liquidation of adipose tissue? If so, is this hormone secreted by the pituitary? The thyroid secretion, although a general stimulant of metabolism, has no specific influence on fat tissue; it increases protein catabolism as well. Other endocrine glands implicated directly or indirectly are the gonads and adrenals, while the pancreas through its influence on carbohydrate metabolism must play an indirect part. There is of course an interaction of the glands on each other as well as synergisms and antagonisms to be considered. The hypothalamus, lesions of which are believed to result in obesity, serves to link nutrition with emotion. How does this obscure, if much studied, part of the nervous system influence the storage of fat? Does it act via the pituitary or through a more direct nervous influence or both? And, to put the question in terms of anthropomorphism, how do the pituitary and hypothalamus receive the unconscious information on which they act? Do they respond to such factors as lipæmia and the blood sugar level? We can hardly imagine that they are responsible to the direct pull of gravity.

In these days, when Claude Bernard's generalization, "*la fixité du milieu intérieur est la condition de la vie libre*," holds sway over the mind of the physiologist can we include body weight as a factor of the internal environment, which must within limits be regulated?

Loss of Weight.

The two problems presented to the clinician are loss of weight and gain of weight. The mass production of weighing machines has rendered some of us weight conscious, so that occasionally obsessions occur in relation to weight. Such cases are usually recognized with ease, and a weighing machine in the surgery serves as a useful check. Weighing is also of evident value in the diagnosis of wasting diseases such as carcinoma.

Loss of weight occurs in many illnesses, particularly those of a protracted febrile or cachetic nature.

(1) **Cases where Loss of Weight is a Presenting Feature.** In such a case, disorders of the alimentary canal should be first sought. Starvation of varying degree is not unknown and such cases need food rather than medicine. Dental caries, particularly in children, may be a cause of thinness, and acts partly through rendering mastication painful. Dyspepsia should be remembered. Cancer of the oesophagus or of the stomach can usually be recognized if a correct history, supplemented by physical examination and appropriate tests, is obtained. The same applies to non-malignant pyloric stenosis. Idiopathic steatorrhoea should be remembered, although it is an infrequent condition. This disorder is often accompanied by marked asthenia and a long history of bulky frequent stools is usually but not always obtained. The look of the stools, which resemble obscene porridge, is often sufficient for diagnosis, but microscopic and chemical examinations are desirable. The prolonged use of liquid paraffin is said rarely to cause malnutrition. The paraffin coats the mucosa of the small intestine, thereby hindering absorption. For this reason, emulsions of paraffin are to be preferred to the plain substance. Intestinal worms may produce wasting.

(2) **Phthisis** should be remembered. For its diagnosis, sputum tests, records of temperature and X-rays of the chest are invaluable. In a case of bronchopneumonia marked loss of flesh may indicate an empyema; usually other signs are present.

(3) **Cancer** is a frequent cause of wasting in the middle aged and its detection may require a very careful search into obscure places.

(4) **Diabetes Mellitus** is recognized by its symptoms, and by appropriate tests on the urine and blood.

(5) **Hyperthyroidism** is a well-known cause of loss of flesh, but in its less obtrusive forms may escape diagnosis. Slight enlargement of the thyroid, von Græfe's sign, tachycardia and auricular fibrillation, tremor and glycosuria, should be sought for in doubtful cases. Oedema of the ankles, and rarely slight jaundice may occur, due apparently to cardiac failure. The appetite is often maintained. The manner is often brisk and nervous. Thyrotoxicosis in middle age is frequently of the occult type and the brunt of the disease often falls on the heart.

(6) **Pituitary cachexia** or Simmonds' syndrome is characterized by the premature appearance of the signs of senility. The skin is wrinkled, the hair and teeth are lost, the gonads and other organs atrophy. Progeria of Hastings Gilford is a similar condition which occurs before puberty.

(7) **Various psychoses and neuroses** lead to thinness. They can usually be diagnosed if borne in mind. The loss of flesh in melancholia is well known. It is obvious that refusal of food through negativism, as in dementia præcox, must lead to emaciation. The syndrome known as anorexia nervosa, while probably not an ætiological entity, is sufficiently well known to merit a special mention. The cardinal symptoms are a disgust for food, loss of weight and amenorrhoea. The loss of strength is less than the loss of weight, the emaciated patient working until the disorder is far advanced. There is often a fine growth of down on the face. Feeding and suggestion usually suffice to relieve the condition. After a few months the fine down vanishes but menstruation may not be re-established for a long time, usually two or three years.

(8) **Drug habits** may cause malnutrition. Alternation of irritability and lassitude is often observed.

(9) **Occupation**, particularly if it is of a type liable to cause dyspepsia or worry may result in thinness.

(10) Loss of weight occurs in advanced cases of muscular atrophy when the patient becomes skeletal in appearance. There must at the same time be a lack of fat. In the rare progressive muscular atrophy of childhood, the Werdnig Hoffmann disease, the subcutaneous fat persists for a time and radiography may be required to show the muscle wasting.

The various conditions which produce wasting in childhood are not considered in this article.

Excess of Weight.

Excessive weight is found in cases of œdema, myxœdema, and obesity. It is a clinical truism that several pounds of water have to be retained in the tissues before œdema is demonstrable. Hunger œdema may mask the emaciation of partial starvation. A conditioned starvation œdema is seen in rare cases of steatorrhœa. The poor absorption of amino-acids leads to lack of blood protein and there is also a lack of absorption of vitamin B.

The water balance is bound up with the salt balance. Restriction of salt is of value in the treatment of œdema. Restriction of salt intake may also cause loss of water in cases of obesity, but it is doubtful if such treatment is of lasting value.

The thyroid secretion quickens metabolism. In hypothyroidism the weight increases, partly because of the affinity of the "deposit-protein" for water. In some cases obesity is also present as the appetite and intake are not affected in the same way as the metabolism, the basal rate of which is lowered. Myxœdema is easily recognized by the symptoms and signs. Bloated appearance, mental and physical lethargy, hard dry skin, hair coming out, infrequent pulse and occasionally mental confusion and delusions are the well known results of the disorder. In doubtful cases a therapeutic test is helpful.

Obesity. Fat is derived from food fat and carbohydrate, not in great amount from protein. Fat can be used as a source of muscular energy, being apparently converted first into carbohydrate. The feelings of exhaustion experienced by dieted obese subjects are due in part to lack of readily available carbohydrate. The supposed causes of obesity have been classified as *exogenous and endogenous*, the latter being divided into constitutional and endocrine. *Exogenous obesity* is a polite description of fatness due to overfeeding. There can be little doubt that such cases exist; certain cases of phthisis pass through a stage of fatness due to therapeutic feeding, and the obesity of cooks is proverbial. Family habit, large appetites, and alcoholism may tend to fatness. In most cases, however, exogenous factors are effective only if there is a tendency to fatness, and some authors doubt if there is in fact a pure exogenous obesity. It appears as if some authors, who believe that obesity is usually exogenous and the others, who stress the endogenous factor, may both be influenced by prejudice as well as by reason. The one group tends to blame the patient, and the other to absolve him.

That a hereditary tendency to obesity may exist may be accepted. The lean cynics who deny it and say that its apparent operation is merely a disguised familial gluttony express only half a truth. It is true that over-eating promotes obesity, at least in the pre-disposed. Lack of exercise acts likewise, with the same qualifications. Certain individuals may put on great weight after an illness

which confines them to bed. Alcoholism frequently causes obesity, at least until some grave tissue damage ensues. The food-drug acts as a food-sparer, tends to increase appetite, reduces the desire for exertion and allays anxiety. Yet certain alcoholists remain lean, even in the absence of gross illness.

Temperament or at least the physiological peculiarities which, for the materialist, underlie it influences the size of the body. Great men in their more discursive moments advise us to laugh and grow fat, and in the same breath warn us that leanness and longevity go together.

Smoking seems in some individuals to affect body-weight. Patients who heroically give up smoking for a year or so, frequently put on a stone or more, perhaps because they eat or drink more, perhaps for pharmacological reasons. Disorders of the nervous system and ductless glands are sometimes undisputed causes of obesity. These cases will be referred to later.

Lastly in many cases the cause is obscure and we can only speculate on the constitutional and other factors involved.

For some, obesity is an episode, e.g. pre-pubertal adiposity tends to disappear; for others it is a permanent encumbrance.

Obesity due to Endocrine Disorders.

For purposes of diagnostic expediency, an obesity of rapid onset is held to be a probable indication of a focal disturbance of a ductless gland or at any rate of a pluriglandular disturbance. A rapid onset in a previously thin patient is particularly liable to occur when the lesion is a tumour.

A. Types of Adiposity attributed to Pituitary Dysfunction:

(1) *The term pre-pubertal adiposity* is applied by Langdon Brown to the state of generalized obesity and delayed puberty through which some children pass, prior to normal adolescence. The disorder is believed to indicate delay in the differentiation of the chromophobe cells of the pituitary. Its importance is that it usually gets better without treatment. Gross pituitary lesions must be excluded.

(2) *Fröhlich's syndrome* is usually held to apply to more persistent cases of hypopituitarism than the above, which arising during puberty are due either to a tumour or to maldevelopment, and characterized by obesity and genital hypoplasia, including maldescent of the testis. The obesity is greatest around the limb girdles, extending down to the elbows and knees—the fat may hang down over the knees—the “plus fours” distribution of Langdon Brown. The skeleton does not grow to its full size and in males the pelvis is broad. The pubic and axillary hair does not develop. Should a pituitary tumour be present a stereoscopic X-ray may reveal enlargement of the pituitary fossa, whereas an undersized pituitary is enclosed in a smaller fossa than normal. The sugar tolerance is increased.

The prognosis with regard to life is grave if a tumour, usually a chromophobe adenoma, is present, but in the absence of a tumour a considerably active life is possible.

An eunuchoidal type is described as arising after puberty is over. There is adiposity which is most marked in feminine sites—e.g. the hips. Impotence in the male and amenorrhoea in the female are noted. In addition an “idiopathic”

adiposo-genital syndrome, dating from the earliest years has been recorded, especially in Jewish patients. In these cases skeletal overgrowth, manifested by increased height, has been noted. The increased skeletal growth after castration is familiar.

The cause of Fröhlich's syndrome has been disputed. Some authors attribute the adiposity to the pituitary, others to the hypothalamus. The structures, however, form a functional unit and it would appear that disease of either may cause adiposity and genital hypoplasia. Increased intracranial pressure may produce dystrophia adiposo-genitalis; in these cases erosion of the posterior clinoid processes is seen in X-ray films.

(3) *The Burnier type* is an obese dwarf, and results from early hypopituitarism. The usual cause is a tumour of the pituitary ectodermal rudiment (Rathke's diverticulum). Visual disturbances, optic atrophy or optic neuritis, and sometimes polyuria accompanying the syndrome. X-rays may show enlargement of the cranial sutures and either enlargement of the pituitary fossa or shadow calcification above it.

(4) *Adiposis dolorosa* is said to be due sometimes to a pituitary lesion. The disorder is accompanied sometimes by acute attacks of arthritis. The fat deposits which may be diffuse or more or less localized are tender, and never extend beyond the wrists and ankles. The small hands and feet contrast with the general enlargement. The foregoing disorders represent lack of pituitary function and are usually accompanied by increased sugar tolerance.

(5) *In Cushing's syndrome* there is an increased pituitary function, and decreased sugar tolerance. In some cases at least, there is a basophile adenoma of the pituitary, as originally described by Cushing. There is at the same time a hypertrophy of the adrenal and some authors regard the syndrome as primarily adrenal. It is tempting to regard the adiposity as pituitary, the hirsuties as adrenal in origin.

The essential features are obesity, hirsuties, a dusky redness of the skin, hypertension and hyperglycæmia. Polycythæmia may be found. The basophile adenoma is not large enough to press on the optic chiasma. The adiposity is of proximal distribution, the tapering limbs contrasting with the broad face and obese trunk, and has been called the "buffalo type" of adiposity. An older term for the female cases which preponderate was bearded diabetic women. *Lineæ distensæ* due to the adiposity are prominent, because of the rapid onset.

Radiographs may show osteoporosis and a kyphosis may be observed clinically. Pains in the lower part of the back are frequently complained of. The prognosis is poor, although improvement after X-irradiation of the pituitary and after œstrin injection has been reported.

Characteristics of pituitary adiposity. These are (a) a proximal distribution of the excess fat; (b) lethargy and somnolence; (c) altered sugar tolerance; and (d) sometimes an abnormal X-ray appearance of the skull; (e) diabetes insipidus may occur.

B. Types of Adiposity accompanying the Adrenogenital Syndrome. While tumours of the adrenal may produce an appearance like that of Cushing's syndrome, the body is usually more feminine in appearance in the latter than in the former, in spite of the hirsuties. In fact a patient with Cushing's syndrome seen recently thought she was pregnant, on account of the swelling of the

abdomen and amenorrhoea. Broster, who believes that Cushing's syndrome is primarily adrenal and secondarily pituitary, is nevertheless of the opinion that it differs from adrenal virilism in that the fat is softer to the touch than in the latter condition. It is a tumour rather than a hypertrophy of the adrenal which is likely rapidly to produce obesity and hirsuties. With a hypertrophy time is given for virile muscular development and should adiposity then appear, the fat, supported by firm muscle, has a hard feel.

We are thus reminded that increased weight is not always due entirely to an accumulation of fat. Leonard Findlay has pointed out that certain cases of obesity in childhood show also an exaggerated muscular and skeletal development. Findlay quotes Kahn's observations on creatinine excretion, which suggests an abnormal muscle bulk in some obese children.

C. Adiposity occurs from Gonadal Lesions. Thus it may develop after gonadectomy in either sex and at the menopause. It is now known that the pituitary not only influences the gonads, but is also influenced by them. Perhaps the gonads control the sexual distribution of fat, the pituitary the general fat deposit but the two systems interact with each other and with the adrenal.

Obesity associated with Nervous Disease.

Various neural disorders may result in obesity. Such disorders include (1) trauma, (2) increased intracranial pressure from brain tumour, (3) hydrocephalus, and (4) infective conditions e.g. encephalitis lethargica and, in children, at least, neuro-syphilis. The hypothalamus or the posterior pituitary may be damaged, but why some cases of intracranial disease and not the majority produce an adiposo-genital syndrome is not known. The Laurence-Moon-Biedl syndrome consists of obesity, genital hypoplasia, mental deficiency and retinitis pigmentosa. The disease is familial, and while the pituitary or hypothalamus is blamed for the adiposity the pathogenesis of the disease apart from the hereditary factor, is unknown.

Localized Adiposity and Wasting.

Localized adiposity is seen in certain types of adiposis dolorosa and other lipomatoses. In lipodystrophia progressiva the lack of fat in the upper part of the body contrasts with the obese lower part. In certain obese individuals the abdomen is fattest, their corporation being exaggerated by a compensatory lumbar lordosis. In these cases there is probably an excess of omental fat.

The effects of Obesity.

Gross fatness produces dyspnoea and sweating on exertion, because a greatly increased load has to be transported. The dyspnoea has also been attributed to fatty infiltration of the heart but on this point there has been hot discussion. The somnolence in obesity is marked chiefly in pituitary cases. Indeed Conrad depicts fat men who are nimble and active. Gross obesity usually shortens life, although I have observed a few remarkable exceptions. Obesity is sometimes accompanied by cholelithiasis or by diabetes mellitus or by hypertension.

Among the effects of obesity must be included the effects of treatment. Prolonged use of large doses of thyroid may produce cardiac poisoning. I have seen one death due to this cause. This is not to say that short courses of thyroid are impermissible for the obese, but they should be carefully regulated. The prolonged use of thyroid may produce a condition like diabetes, which clears

up when the treatment is stopped. Dinitrophenol and similar drugs were hailed as a boon to the obese. These drugs accelerate catabolism by a direct action on the tissues; thus the metabolism of a perfused foot of the dog is increased by dinitrophenol. In myxœdema, the basal metabolic rate is increased but the mentality is not restored by the drugs. These act more rapidly than thyroid and their action is less sustained. They may, however, set up grave visceral damage. Cataract, rash, and peripheral neuritis are admitted sequelæ and grave liver and kidney lesions are thought to occur.

It seems as if there is no panacea for obesity and that the treatment must be selected according to the cause in so far as this is known. Failing a known cause, dietetic restriction and increased exercise are to be advocated in moderation.

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