A NOTE ON THE CALCULATION OF WATER EXCHANGE

By L. H. NEWBURGH, F. H. WILEY, and M. W. JOHNSTON

(*From the Department of Internal Medicine, Medical School, University of Michigan*)

(Received for publication July 13, 1933)

In a recent publication (1), Peters, Kydd, and Lavietes have "simplified" the method proposed by Newburgh and Johnston (2) for determining water exchange. Later publications from this laboratory (3), in which it was shown that the calculation of heat production directly from the insensible loss of weight is not accurate, have an important bearing on the suggestion of Peters, Kydd and Lavietes who propose to calculate heat production directly from the insensible loss of weight by means of their Equation 2:

$$1.301\ (\text{I.L.}) + 19.27 = \text{Cal. per hour},$$

where I.L. expresses insensible loss of weight per hour. This equation is derived from the data of Benedict and Root (4), who demonstrated the fact that the insensible loss of weight is roughly proportional to the heat production in the basal state.

We have found that this relationship is not quantitative for long periods of varying activity during which food is ingested; because the R.Q. does not remain uniform, as it tends to in the basal state.

The nature of the insensible loss of weight may be expressed algebraically as follows:

$$\text{I.L.} = H_2O + CO_2 - O_2.$$

It is obvious from the above equation that the only factor concerned in the dissipation of heat is the water that leaves the organism as vapor and carries with it .58 cal. per gram. We have demonstrated that the heat lost in this way is 24 per cent of the total heat when certain precautions are in effect. Hence, the relationship is one between the vaporization of water and heat rather than between the insensible loss of weight and heat. While the water vapor is a component of the insensible loss of weight, there is no strictly quantitative relationship between the two, as may be seen from the following table:

R.Q.	Water Vapor *grams/24 hrs.*	I.L. *grams/24 hrs.*
1.00	978	1193
0.82	978	1054
0.707	978	940

When the heat production calculated by the method proposed by us is compared with the "simplified" method advocated by Peters and his associates, the following values are obtained:

R.Q.	According to Newburgh et al. *Cal/24 hours*	According to Peters et al. *Cal/24 hours*
1.00	2367	2116
0.82	2367	1833
0.707	2367	1403

Therefore the Equation 2 of Peters, Kydd and Lavietes entails a serious error which limits the value of the subsequent equations that depend upon the validity of this one.

We agree with Peters, Kydd and Lavietes that preformed water should not be included in the water balance if one follows the standard practice in regard to balances. However, consideration of preformed water, as employed by Newburgh and Johnston, gives information that could not otherwise be obtained. They desired to secure a precise statement of the expected change in body weight in response to any given diet. It seemed proper to assume that, in the adult subject, there is an optimum value for the total volume of the circulating fluids. The water of the body is either part of this circulating fluid or of the protoplasm. It is generally recognized that, in the absence of disease, the per cent of water in the protoplasm is constant. Hence, any change in body weight that was not explained by change in the mass of protoplasm (i.e. solids plus their associated water), would be attributable to change in the volume of the circulating fluids. This latter phenomenon would then be a departure from the theoretical optimum. To evaluate this response, it was necessary to know how much water was to be apportioned to the gain or loss of protoplasmic solids. This increment of water was accordingly added algebraically to the sources of water, and was called "Preformed Water." Newburgh and Johnston were not concerned with the question whether such water is "free" or "bound."

REFERENCES

1. Peters, J. P., Kydd, D. M., and Lavietes, P. H., J. Clin. Invest., 1933, xii, 689. A Note on the Calculation of Water Exchange.
   Peters, J. P. and Lavietes, P. H., J. Clin. Invest., 1933, xii, 695. The Nature of Preformed Water.
2. Newburgh, L. H., Johnston, M. W. and Falcon-Lesses, M., J. Clin. Invest., 1929–30, viii, 161. Measurement of Total Water Exchange.
3. Newburgh, L. H., Wiley, F. H. and Lashmet, F. H., J. Clin. Invest., 1931, x, 703. A Method for Determining Heat Production over Long Periods of Time.
4. Benedict, F. H. and Root, H. F., Arch. Int. Med., 1926, lxxxviii, 1. Insensible Perspiration; Its Relation to Human Physiology and Pathology.