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Determination of total energy expenditure, resting metabolic rate and physical activity in lean and overweight people

Bestimmung des Gesamtenergieumsatzes, des Ruheenergieumsatzes und der körperlichen Aktivität bei schlanken und übergewichtigen Menschen

Summary A new $^{2}H/^{1}H$ and $^{18}O/^{16}O$ equilibration device was tested, standardized and employed for the determination of total energy expenditure. It was shown that overweight men and women have increased resting metabolic rate as well as increased total energy expenditure when compared to their lean counterparts. The physical activity level (PAL)index was slightly decreased which possibly suggests a decreased physical activity in obese people.

Zusammenfassung Für die Bestimmung des Gesamtenergieumsatzes wurde eine neuartige $^{2}H/^{1}H$- und $^{18}O/^{16}O$-Äquilibriereinheit getestet, optimiert und eingesetzt. Es konnte gezeigt werden, daß übergewichtige Frauen und Männer, verglichen mit schlanken Probanden, sowohl erhöhte Ruhe-Nüchternumsätze, als auch erhöhte Gesamtenergieumsätze aufweisen. Der physical activity level (PAL)-Index weist tendenziell eine Verminderung auf, was eine erniedrigte physische Aktivität bei Übergewichtigen vermuten läßt.

Key words $D_2{}^{18}O$method – indirect calorimetry – energy metabolism – obesity

Schlüsselwörter $D_2{}^{18}O$-Methode – indirekte Kalorimetrie – Energiemetabolismus – Übergewicht

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Introduction

The doublylabeled water (DLW) method as an isotopic technique for measuring energy is based on the calculation of CO_2 production (r_{CO2}) from the differential disappearance rates of ^{2}H and ^{18}O from body water. This requires accurate and precise techniques for measuring isotopic enrichments. An interlaboratory comparison has revealed a high variation in determining r_{CO2} (1). However, validation studies indicated that the DLWmethod can be performed with a coefficient of variation of 3% to 5% largely depending on the quality of isotopic analysis (2, 3). It is, therefore, mandatory to ensure sufficient accuracy and precision in the analytical performance.

The influence of body weight and lean body mass (LBM) on the physical activity level (PAL) as an index for total energy expenditure (TEE) is still controversial (4, 5). In the following we tested and employed an H/D/Oequilibration device for the $^{2}H/^{1}H$ and $^{18}O/^{16}O$ isotope analysis. In conjunction with indirect calorimetry we then measured TEE and resting metabolic rate (RMR) and assessed the influence of gender, body weight, and LBM on PAL in 13 female and 12 male subjects.

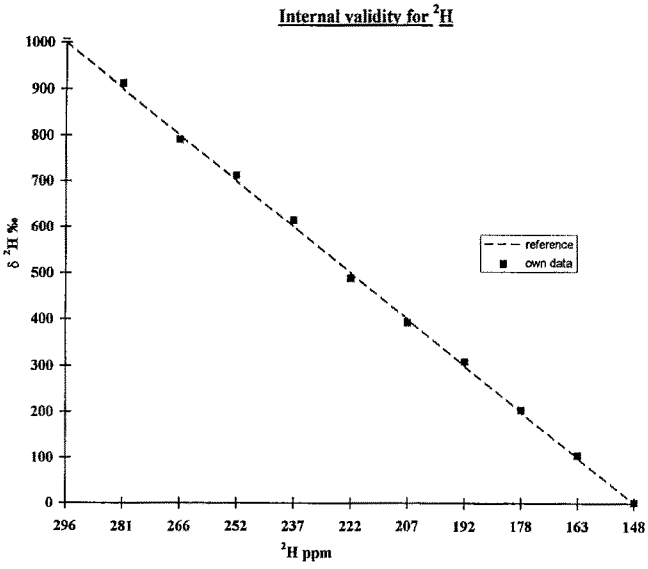

Fig. 1 Deuterium oxide dilution series. Comparison of measured ²Hvalues between the uranium reduction technique (---) and the equilibration technique (■).

Methods and materials

A dilution series was prepared and water standards were repeatedly measured in order to test the automated H/D/Oequilibration device for internal validity. The isotope abundance of the water standards ranged from +1000 % to -50 % rel. to V-SMOW in order to simulate a biologic elimination curve.

Total energy expenditure (TEE) and resting metabolic rate (RMR) were investigated in 25 subjects, aged from 37 to 66 years. People were classified according to body mass index (BMI) as lean or moderate overweight, respectively. TEE was assessed by the multipoint approach over a time period of 14 days. RMR was determined by indirect calorimetry, three times each for 20 minutes within a period of two hours from 7:00 to 9:00 a.m. Activity energy expenditure (AEE) was derived as TEE – RMR. Physical activity level (PAL) was derived as TEE / RMR.

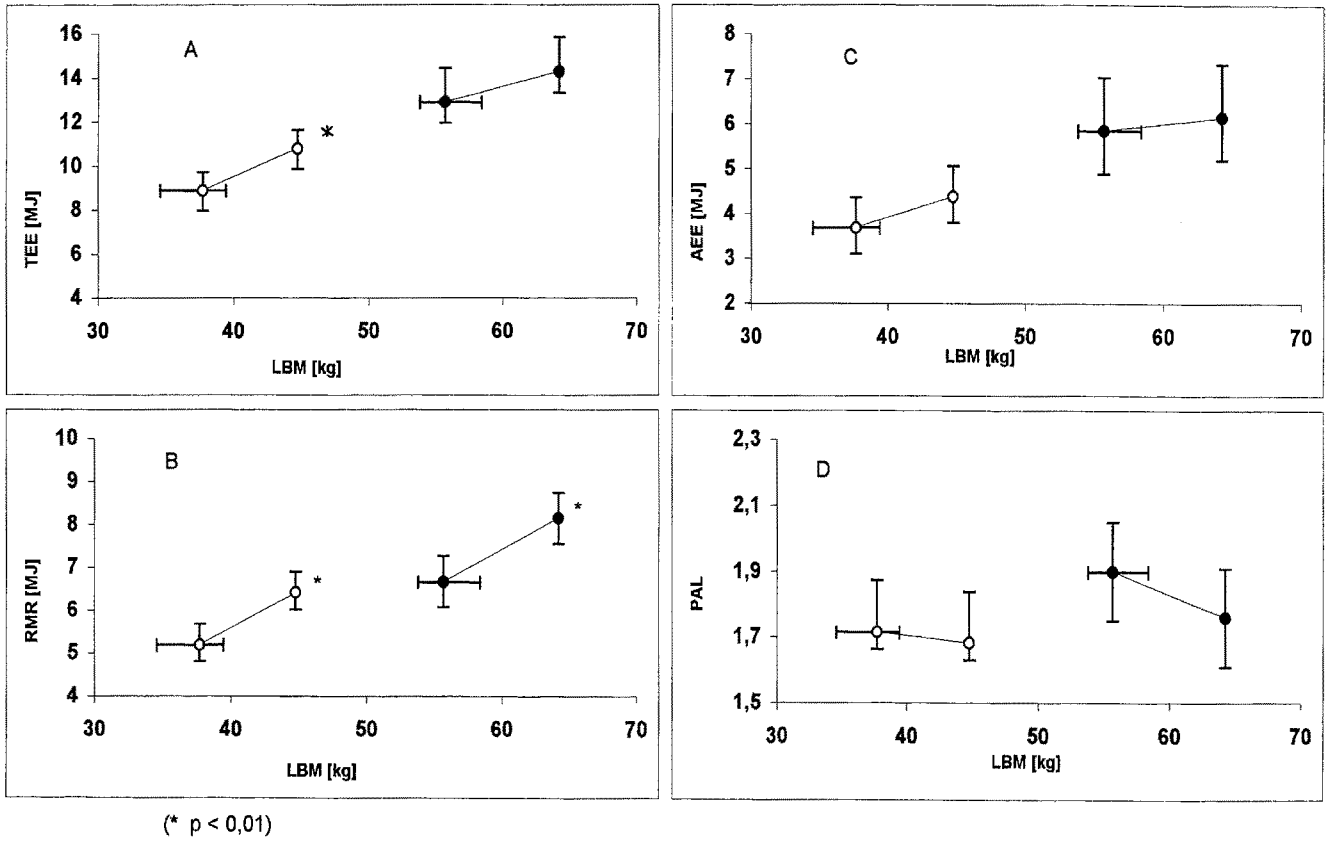

Fig. 2 A-D Relation of LBM on Total Energy Expenditure (TEE), Resting Metabolic Rate (RMR), Activity Energy Expenditure (AEE: TEE-RMR) and Physical Activity Level (PAL: TEE/RMR). Open circles (◯), women: closed circles (●), men. (mean ± S.D.).

Results

Fig. 1. demonstrates that the H/D/Oequilibration is highly linear over the whole range of the D_2O dilution series (closed squares) when compared to the reference values obtained by uranium reduction method (dotted line). The results of the uranium reduction method were kindly provided by W.A. Coward (Cambridge, U.K.). The average difference to the reference values is 1.04% indicating good accuracy. The precision is 0.7 % and 0.04 % for ^2H and ^{18}O, respectively. This fulfills the analytical requirements for DLWstudies in order to obtain a CV% of 5 or better (6). This assumes that no variation is introduced during sample preparation.

The increases of all components of energy expenditure with increasing LBM is shown in Fig. 2A-D. There is a significant gender difference at the given LBM classifications. This can partly be explained by the greater lean : fat tissue ratio in men which raises with RMR per kg body weight. When expressed as PAL values which is designed to eliminate body size effects, there is no significant difference for the LBM categories although a trend of decreased PAL was observed, in both men and women.

Conclusion

The results confirm that the H/D/Oequilibration is a valuable technique for DLWstudies because it shows good analytical performance and reduces the time and the labor of sample preparation.

This study indicates that even in a narrow range of overweight, energy expenditure is raised with increased body weight. The slightly decreased PAL value in moderate overweight subjects would suggest a decreased physical activity when compared to lean counterparts. When findings are analysed by BMI (data not shown) all components of energy expenditure increase with increasing BMI, whereas the PAL index remains rather constant.

References

1. Roberts SB, Dietz W, Sharp T, Hill GE (1995) Obes Res 3 (suppl. 1):3
2. Schoeller DA, Ravussin E, Schutz Y, Acheson KJ, Baertschi P, Jequier E (1986) Am J Physiol 240:R823-R830
3. Ravussin E, Harper IT, Rising R, Bogardus C (1991) Am J Physiol 261:E402-E409
4. Prentice AM, Black AE, Coward WA, Cole TJ (1996) Eur J Clin Nutr 50:93-97
5. Rising R, Harper IT, Fontvielle AM, Ferraro RT, Spraul M, Ravussin E (1994) Am J Clin Nutr 59:800-804
6. Schoeller DA, Taylor PB, Shay K (1995) Obes Res 3 (suppl. 1):15-20