THE RELATIONSHIP BETWEEN BODY WEIGHT AND ENERGY REQUIREMENTS IN HORSES

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Introduction

The National Research Council (NRC 1978) defines a horse's maintenance energy requirement to be Digestible Energy (kcal/day) = 155 $W^{.75}$ where W equals weight in kilograms. This equation incorporates $W^{.75}$ or "metabolic body size" to describe the relationship between body weight and energy requirements in horses. The use of the three-fourths power of body weight is based on studies done by Brody and Procter (1932) and Kleiber (1932) in which each independently evaluated the relationship between fasting heat production and body weight in a large number of species ranging in size from a mouse to a cow. Both researchers reported that the mass exponent which best described the interspecies heat production-body weight relationship was close to .75. Their experiments, however, did not determine the relationship between energy requirements and body weight <u>within</u> a given species. Despite this, the three-fourths power of weight has been adopted as an intraspecies metabolic body size. Blaxter (1972) and Thonney et al (1976) showed that while $W^{.75}$ adequately describes the heat production-body weight relationship between a number of species, it is an inappropriate mass exponent within some species. Blaxter (1972) stated that between mature individuals within a species, metabolism varies with a higher power of weight than .75; possibly .90.

Materials and Methods

In order to investigate the relationship between energy requirements and body weight in mature equids, we conducted a series of experiments in which the resting maintenance energy requirements of equids varying greatly in body size were measured. Four male animals weighing 125 kg., 206 kg., 500 kg., and 856 kg. were used. Each animal was at least ten years old. The horses were fed three different levels of intake of a ration and the net amount of energy retained at each level was determined. The individual's resting maintenance requirement was then determined by regression analysis of energy intake against energy balance. The level of energy intake that would result in zero energy balance was considered to be the animal's maintenance energy requirement. The animals were fed a pelleted ration that consisted of 75% alfalfa meal and 25% oats. The horses were fed each level of intake for a two week adjustment period followed by a five day digestion trial in which total feces and urine were collected. After each digestion trial, the daily heat production of the animals was measured indirectly. The animals were fed at twelve hour intervals in the morning and the evening. Thirty minutes after the morning meal, oxygen consumption and carbon dioxide production were measured for a thirty minute period. Thirty minute measurements were taken each hour for the next eleven hours so that a total of twelve thirty minute measurements were taken between meals. Oxygen consumption and carbon dioxide production were measured using a face mask open circuit respiration calorimetry system. Total daily oxygen consumed and carbon dioxide produced were calculated as four times the amount consumed or produced during the six total hours of measurement. Values from the calorimetry measurements and urinary nitrogen excretions were used to calculate heat production (HP) using methods described by Brody (1945). Gross energy of feed, feces, and urine was measured by combusting samples in a bomb calorimeter. Fermentative gas losses from the gut were estimated with Wolin fermentation balances (Wolin 1960) using cecal VFA ratios measured in three cecal fistulated ponies fed the experimental ration. Fermentation substrate was assumed to be neutral detergent fiber and this fiber was further assumed to consist of hexose units. Methane losses averaged about 4.6% of digestible energy intake. Net energy retention was determined by deducting energy losses in feces, urine, methane, and total heat production from gross energy intake.

Results and Discussion

The amount of net energy retained at each level of metabolizable energy intake for the four animals is shown in figure 1. Energy retention increased linearly with increased metabolizable energy intake in each of the animals, so that the amount of metabolizable energy needed by each animal to maintain zero energy balance can be calculated with linear regression. A common method used to present energy balance data in animals of the same species is to adjust the data to a "metabolic body size" basis by dividing the energy retention and energy intake values by $W^{.75}$. The data from figure 1 are presented in this fashion in figure 2. At any level of metabolizable energy intake the smaller animals appear to retain more energy than the larger animals. There are essentially four parallel sets of data points positioned according to body weight. Linear regression of these data results in the equation Y = -41.94 + .48(X) with an R^2 value of .71. When the data are expressed on a body weight basis rather than on a metabolic body size basis (figure 3), a higher correlation between energy intake and energy retention is found. Linear regression of the data expressed on a body weight basis results in the equation Y = -10.48 + .505(X) with an R^2 value of .93. The best relationship between energy intake and energy balance in these four animals of greatly different body weights occurs when the data are divided by body weight raised to the power .88 (figure 4). Linear regression of these data gives the equation Y = -26.46 + .60(X) with an R^2 value of .97. The slope of this line indicates that the efficiency of utilization of the metabolizable energy from this diet for gain is 60%. A similar regression of energy balance on digestible energy intake shows that the efficiency of utilization of digestible energy for gain is 55%.

While weight raised to the power .88 results in the best relationship between energy intake and energy balance in these animals with greatly different body weights, the amount of energy required to maintain zero energy balance (resting energy requirement) can be directly related to body weight. Figure 5 shows the relationship between resting maintenance DE and ME intakes and body weight in the four animals. Both regressions have high R^2 values, .999 and .997 respectively. Benedict (1938) reported data from Ritzman (figure 6) which showed a similar relationship between fasting heat production and body weight in horses of greatly different body size.

The results of this study suggest that equid's maintenance energy requirements vary linearly with body weight and not with $W^{.75}$. The maintenance energy requirements found in this study, however, are somewhat theoretical in nature. Maintenance requirements under practical management conditions will almost certainly be higher because of increased activity and different environmental conditions. Further studies are needed to evaluate the effect of these factors on the maintenance energy requirement of the horse so that a practical set of requirements can be formulated. Furthermore, these feeding standards should be expressed on a body weight basis rather than as a function of metabolic body size.

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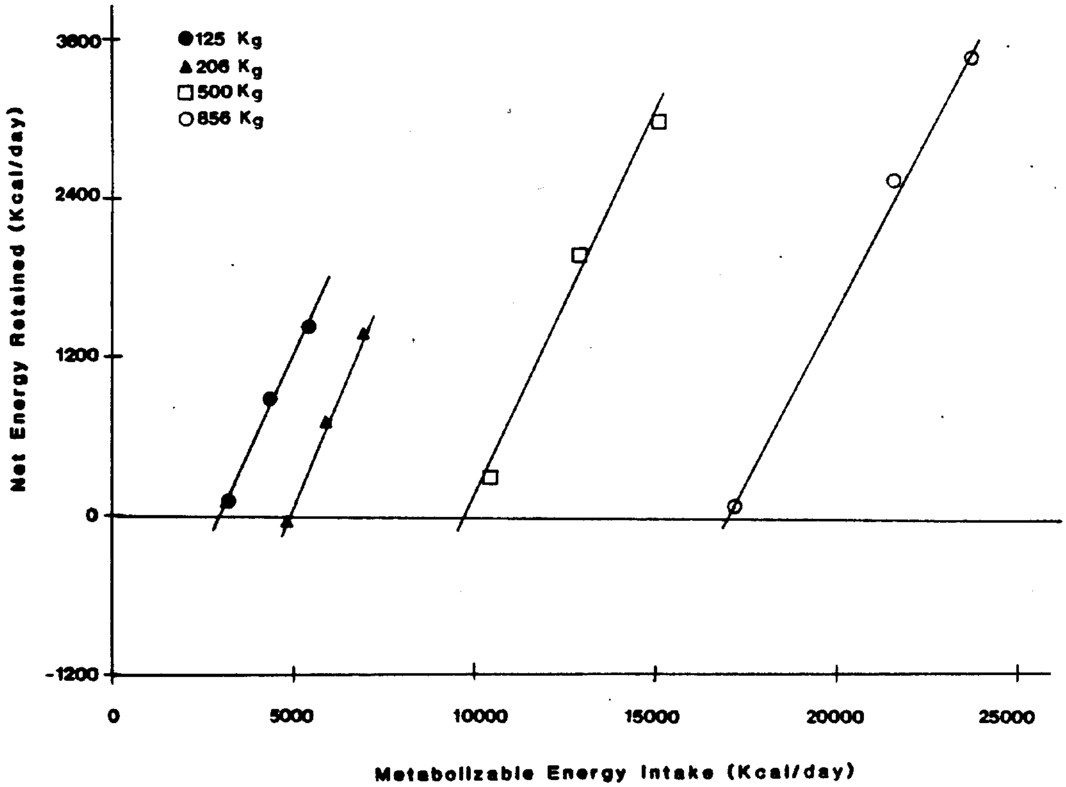

Figure 1. Relationship between net energy retention and metabolizable energy intake in four horses.

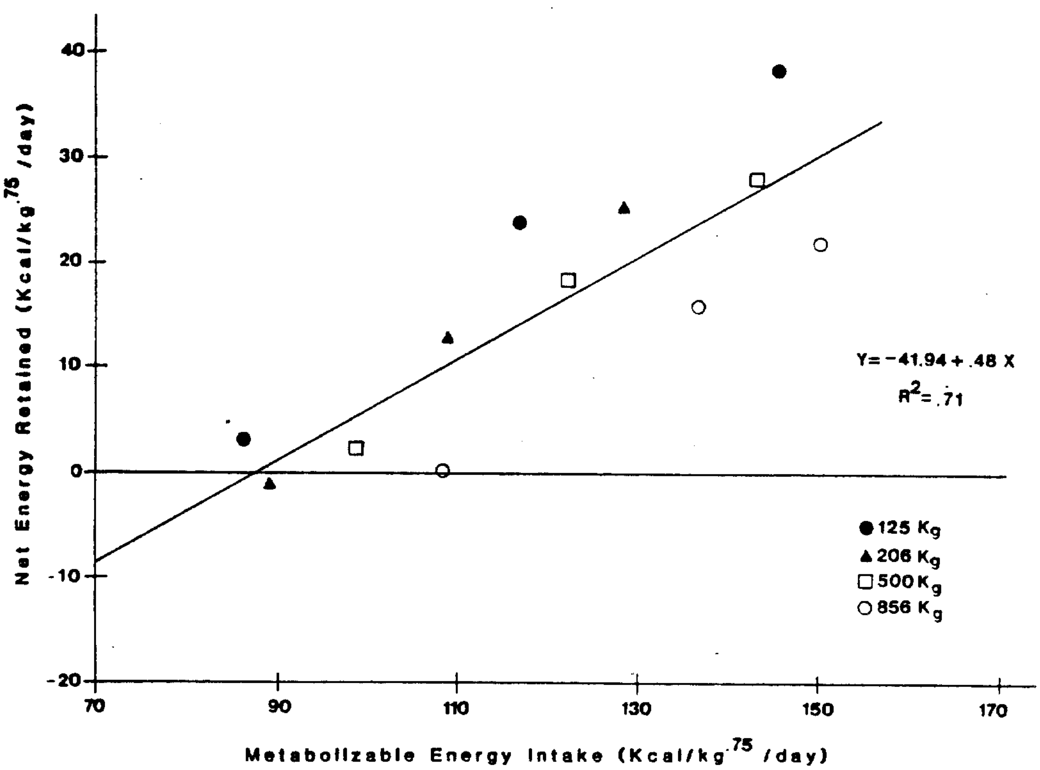

Figure 2. Energy balances expressed on a "metabolic body size" basis ($W^{.75}$).

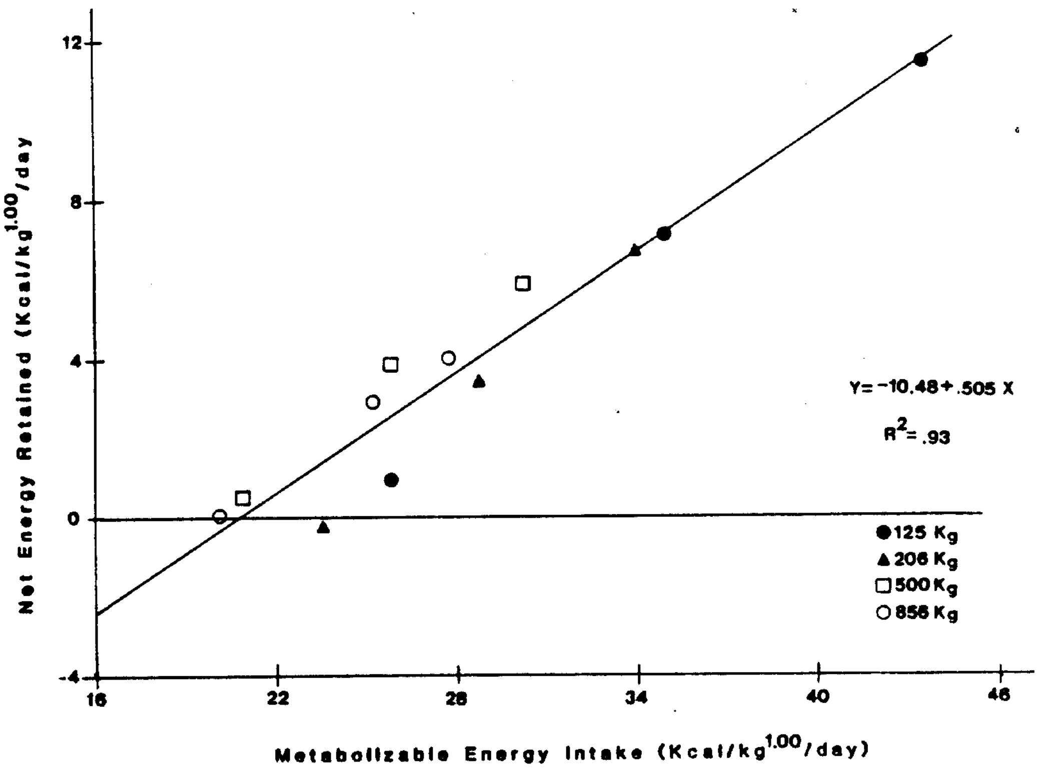

Figure 3. Energy balances expressed on a body weight basis ($W^{1.00}$).

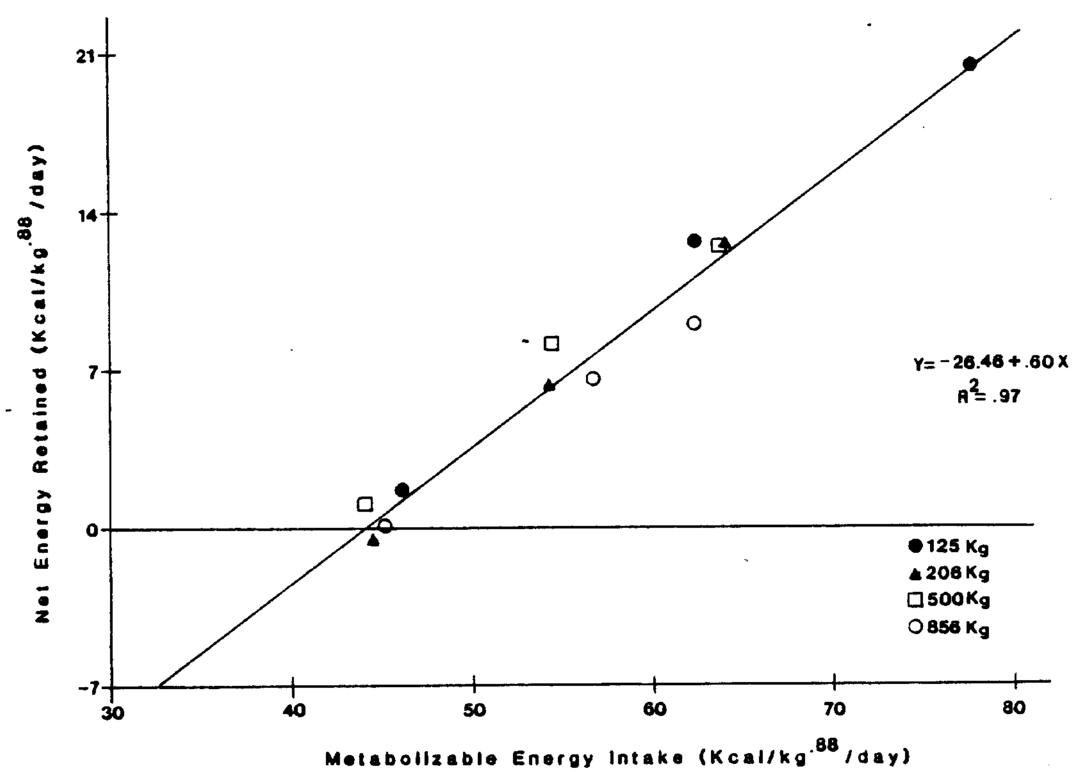

Figure 4. Energy balances expressed on a ($W^{.88}$) basis.

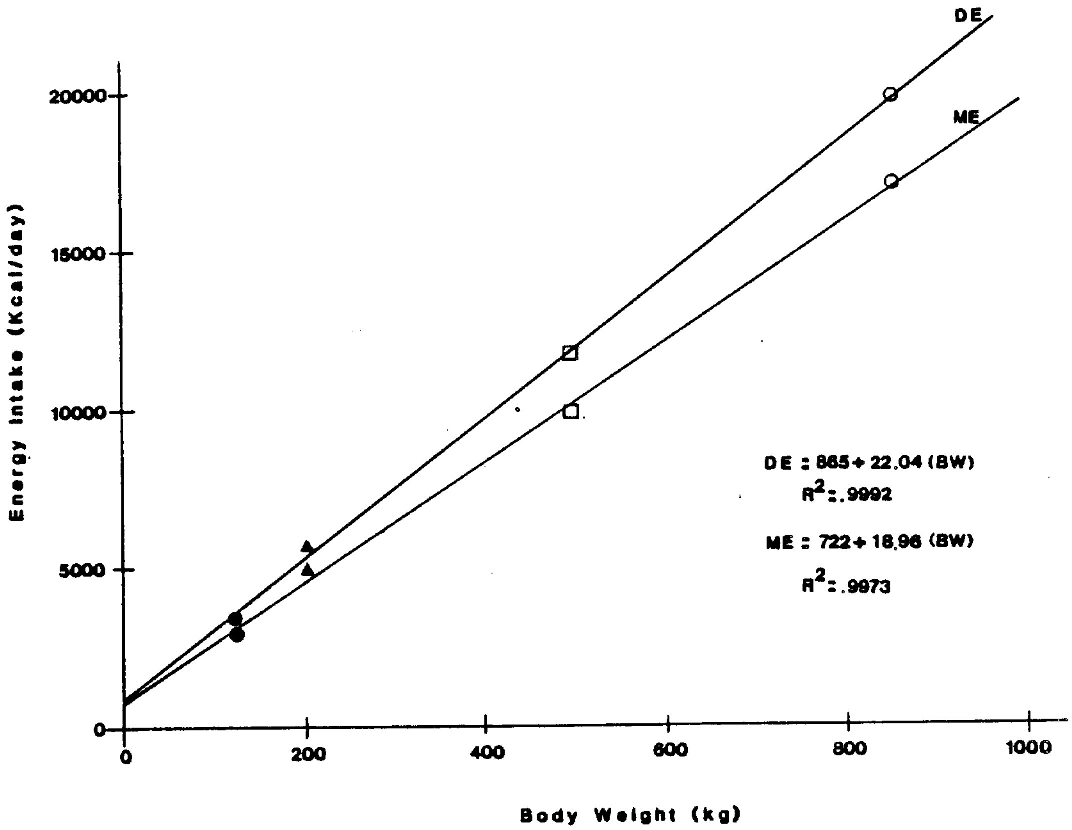

Figure 5. Linear regressions of maintenance digestible energy (DE) and metabolizable energy (ME) on body weight (BW) in four horses.

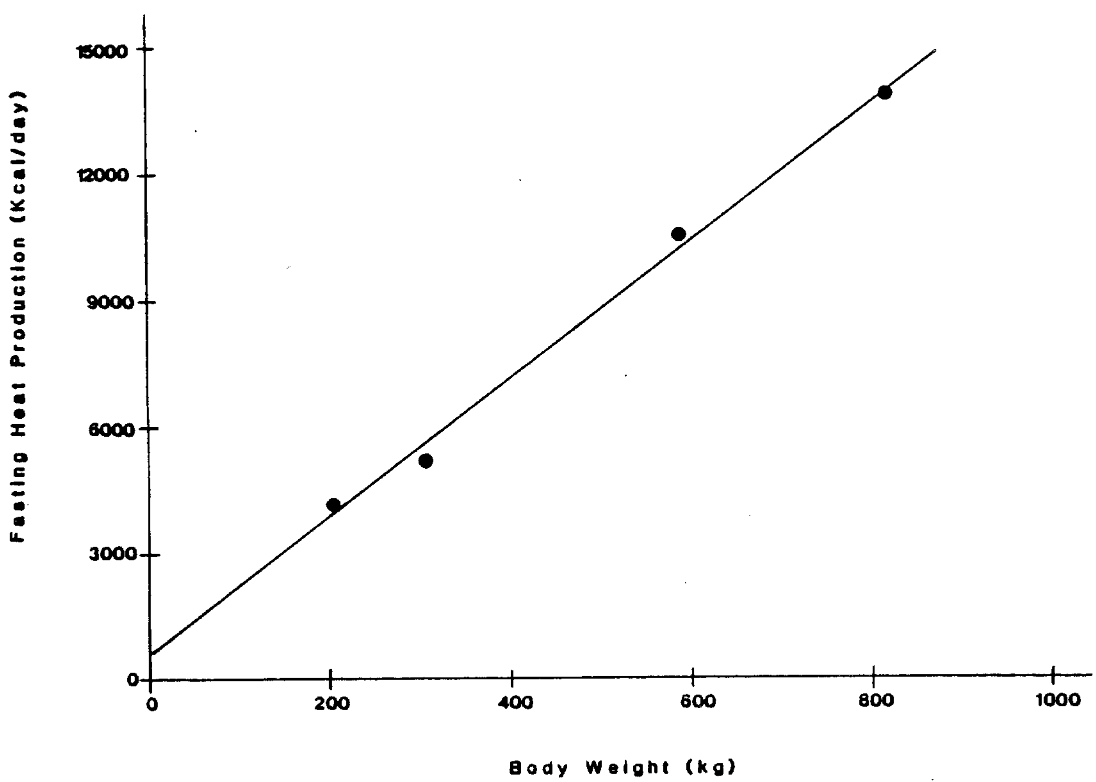

Figure 6. Linear regression of fasting heat production on body weight in four horses (Adapted from Benedict, 1938)