AN APPROACH TO ASSESSMENT OF THE EFFICIENCY OF DIETARY ENERGY UTILIZATION BY HORSES AND PONIES KEPT AT RIDING SCHOOLS

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SUMMARY

The ratio of calculated net energy intake (NE_i) to calculate net energy requirement (NE_r) might serve as an indicator of the efficiency of dietary energy utilization. The ratio was determined for 93 horses and ponies from 10 riding schools. For each animal with an assumed constant body weight, energy intake and energy requirements were assessed. On average, the estimated NE_i was 14 % greater than NE_r. There was a significant, negative association between crude fibre intake and the $NE_i : NE_r$ ratio. Earlier work indicated that extra fat intake may lead to over estimation of the calculated energy value of the ration due to changes in macronutrient digestibility. Dietary fat concentration was found to range from 32 to 52 g/kg dry matter (5 to 6 g/MJ net energy), but on the basis of digestibility trials this range in fat concentration is too small to significantly influence the $NE_i : NE_r$ ratio. This study shows that assessment of the efficiency of dietary energy utilization under normal conditions, on the basis of the $NE_i : NE_r$ ratio is fraught with uncertainty.

Keywords: horse, energy utilization, crude fibre, riding schools.

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INTRODUCTION

The intake of extra fat changes the apparent total tract digestibility of macronutrients in a statistically significant, dose-

Figure 1. Relation between NEi (MJ/day) and NEr (MJ/day). Results are expressed as means ± SEM for 10 commercial riding schools. The line of equality (y=x) is drawn.

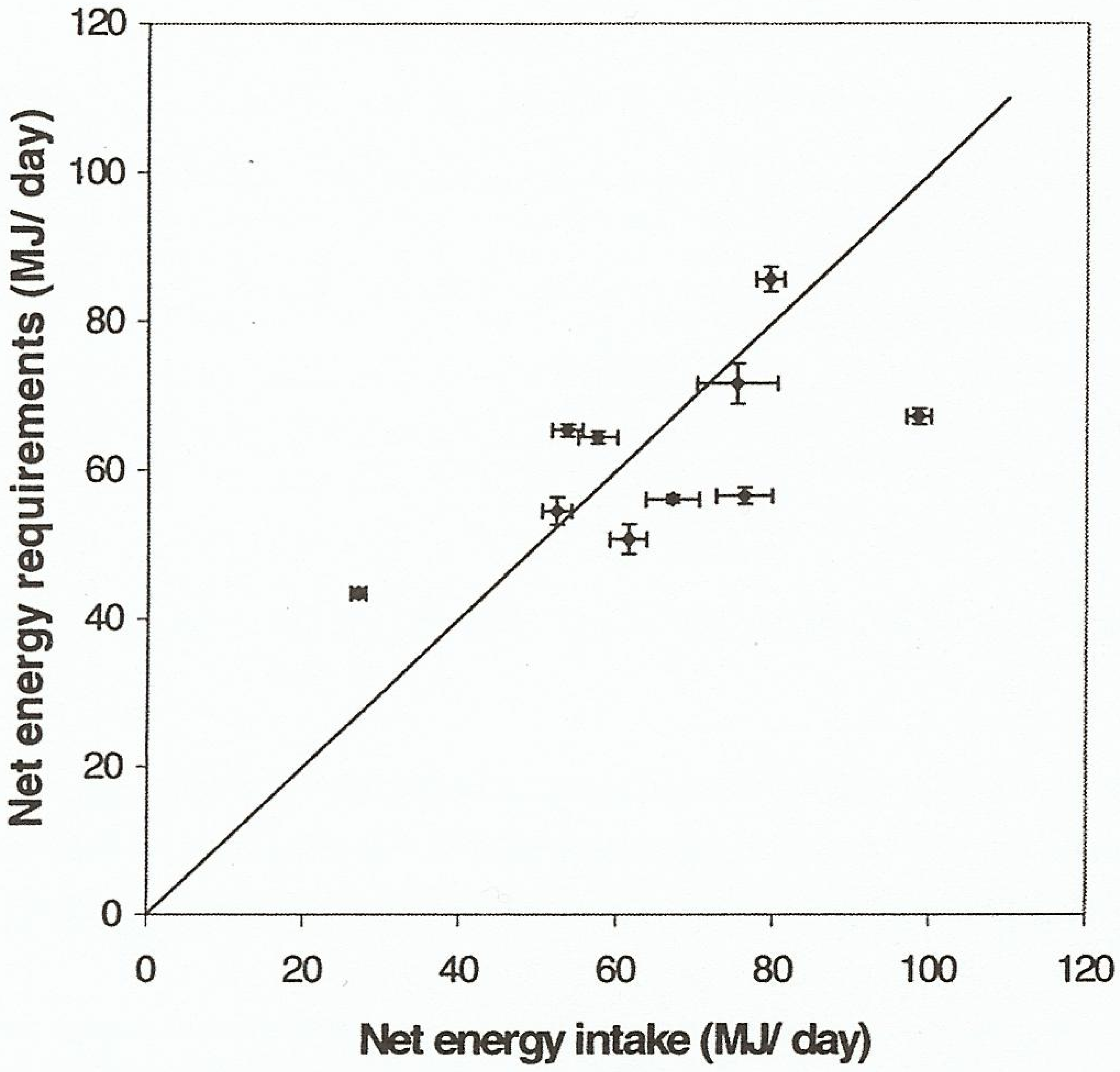
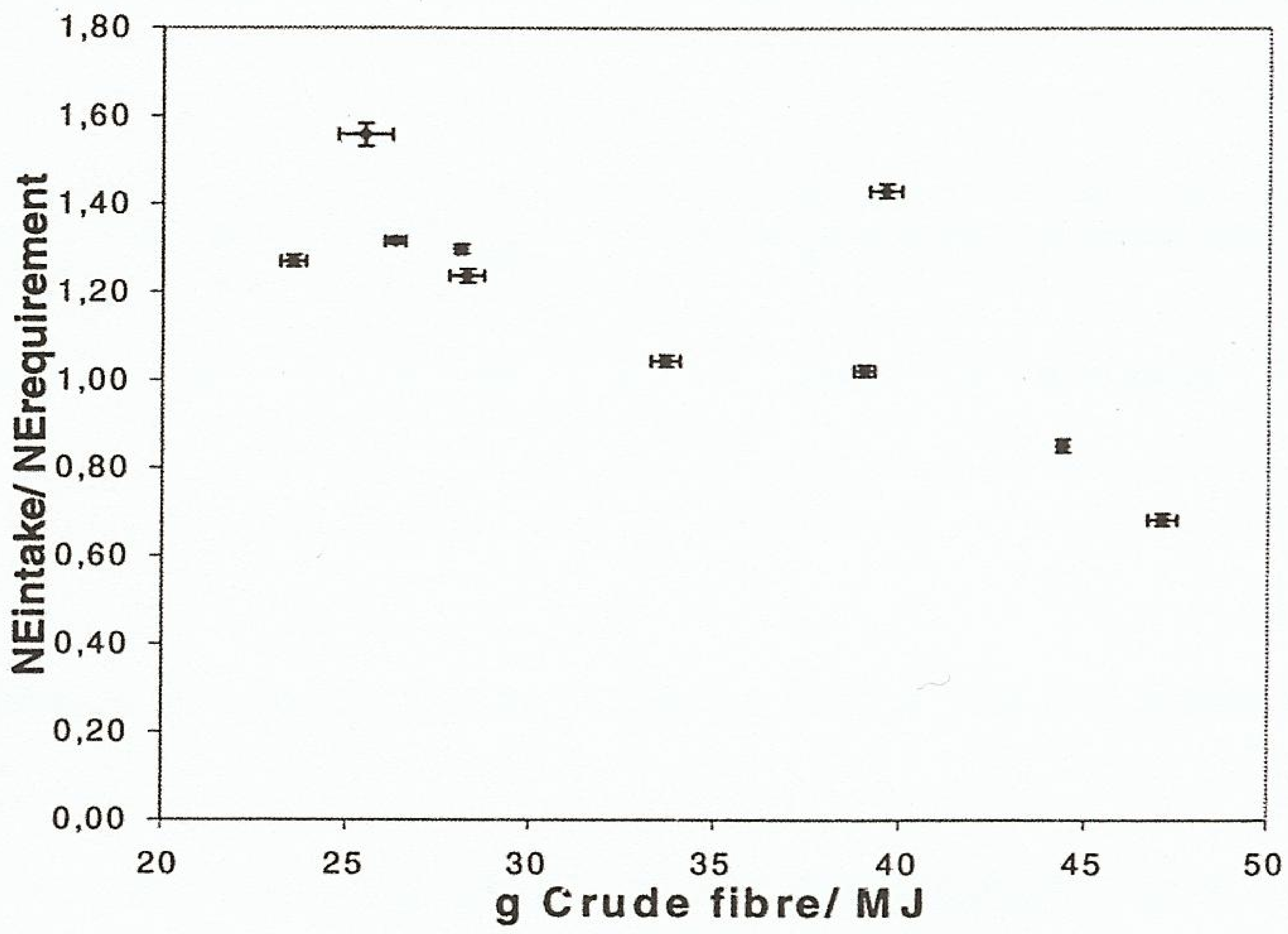


Figure 2. Relation between crude fibre intake (g/MJ) and NEi/NEr. Results are expressed as means ± SEM for 10 commercial riding schools.



dependent fashion (5). An increase in dietary fat concentration by 10 g/kg dry matter was associated with a decrease in crude fibre digestion by 0.9 %, a decrease in protein digestibility by 0.7 %, a decrease in digestibility of nitrogen-free extract by 0.7 % and an increase in fat digestibility by 0.9 % (5). The observed interaction between the fat content of the diet and macronutrient utilization could have practical consequences because calculating the energy content of high-fat diets on the basis of feedstuff tables will lead to over- or underestimation of the amount of energy provided by the diet. It can be calculated that, as a result of changes in macronutrient digestibility, an increase in fat intake by 25 g/kg dry matter will mean that the net energy value of the ration will be about 4 % lower than expected.

The overestimation of the calculated versus true energy value of rations with a moderately high fat content is probably too small to be detectable in a dietary survey of horses kept under normal conditions. Yet there may be conditions in which an under- or overestimation of the energy value of rations may be relevant. Thus, it was considered of interest to assess the efficiency of utilization of dietary energy under normal conditions. If the calculated energy value of a ration is higher than the true energy value, and the body condition of the horse is

Table 1. Ration composition, energy intake, and energy requirement of the horses and ponies.

	Mean	SDw	SDb	Range
Macronutrient composition, g/kg dm				
Crude protein	115	7.1	32.1	95 - 137
Crude fat	38	2.7	8.0	32 - 52
Crude fibre	240	22.8	111.6	116 - 310
Nitrogen-free extract	519	19.3	102.6	468 - 635
Ash	89	3.7	22.9	33 - 100
Macronutrient intake, g/MJ				
Crude protein	17.0	1.00	3.60	13.4 – 20.6
Crude fat	5.6	0.23	1.01	4.9 – 6.3
Crude fibre	36.5	5.93	26.73	12.4 – 56.3
Nitrogen-free extract	77.1	3.60	13.43	66.7 – 88.5
Ash	13.0	1.21	5.57	7.3 – 17.0
Dietary energy, MJ/kg dm				
NE_i	6.77	0.487	1.987	5.47 – 9.38
Energy intake, MJ/day				
NE_i *	66 **	18	55	21 - 125
NE_r *	58 **	10	37	29 - 97

Results are expressed as means and variation ($SD_{(within)}$, $SD_{(between)}$) and range among schools for 93 horses and ponies in 10 commercial riding schools. * Calculated using CVB tables (1), ** NE_i and NE_r are significantly different ($P < 0.001$).

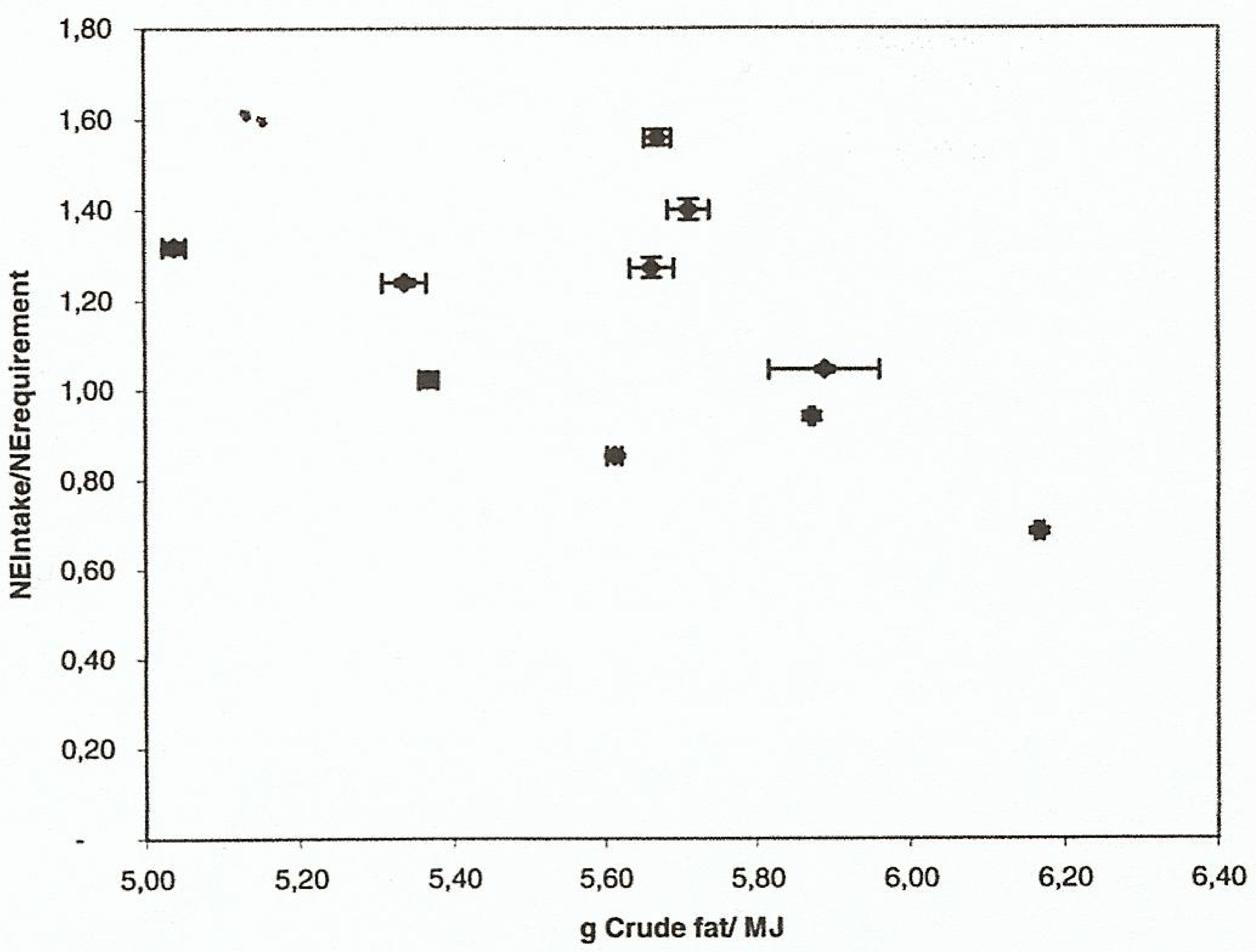


Figure 3. Relation between crude fat intake (g/MJ) and NEi/NEr.

constant, then the calculated net energy intake (NE_i) to the calculated net energy requirement (NE_r) should be increased, pointing at a diminished efficiency of dietary energy utilization. Thus, the $NE_i : NE_r$ ratio could serve as an indicator of the efficiency by which dietary energy is used. To obtain experience with the potential indicator, we carried out a dietary survey with 93 horses and ponies from 10 commercial riding schools. We determined the $NE_i : NE_r$ ratio and looked at possible relationships between the ratio and various ration characteristics.

MATERIALS AND METHODS

From a total of 232 riding schools, affiliated with the Dutch Riding School Association, a sample of 10 riding schools participated in this study. The 10 schools had a total of 593 horses and ponies, the number per school ranging from 20 to106. Each riding school owner was asked to select about 10 animals with a constant body weight, health, and activity. Body weight was monitored using a mobile weighbridge. Seventy-four horses and 19 ponies, ranging from 4 to 20 years of age, were selected. The group consisted of 49 mares and 44 geldings, their average body weight being 501 kg, range 232 – 707 kg. The animals were individually housed in stalls and were individually fed.

The school owner recorded the food consumed for 1 week, so that nutrient and energy intake could be calculated. The quantity of roughage and concentrate for each animal was listed. By weighing the indicated quantities at the riding schools, the quantity mentioned in each list was checked and corrected if necessary. The energy content of the feeds is expressed in terms of net energy. For commercial concentrates, the information on net energy, crude protein, digestible protein, crude fibre, and crude fat content of the feed provided by the manufacturer was used. The content of nitrogen-free extract was calculated as organic matter minus crude protein, crude fibre, and crude fat. For straw, hay, and other products (such as oats, corn, brans), the net energy content, crude protein, digestible protein, crude fibre, and crude fat were derived from tables of the CVB (1); nitrogen-free extract was calculated.

Straw intake was measured in eight horses from one commercial riding school. Horses were housed in individual stalls and were individually fed. Their average body weight was 537 kg (range 452 – 610 kg). Stalls were daily covered with a weighed amount of straw. Horses were given a weighed amount of concentrate and hay. After 7 days, the bedding content of the stalls was weighed. Samples of straw, hay, concentrates and bedding were taken to measure dry matter (dm) content. Straw intake was calculated by the following equation:

$$\text{Straw intake (kg dm/day)} = \frac{\text{straw provided (kg dm)} + (1-DC_c)*Ci + (1-DC_h)*Hi - \text{stall content (kg dm)}}{DC_s}$$

where Ci is concentrate intake (kg) and Hi is hay intake (kg). The digestibility of straw (DC_s), concentrate (DC_c), and hay (DC_h) was estimated by using the tables of the CVB (1). Faecal excretion was estimated with the equation $(1-DC_c)*C_i + (1-DC_h)*H_i$. The dry matter intake of straw was found to be 2.0 ± 0.25 kg/day (mean ± SD), which is equivalent to 18 g dry matter/kg$^{0.75}$. Based on the metabolic body weight, straw intake was calculated and used to correct NE_i for each horse and pony (n= 78), which was housed in a stall covered with straw.

The energy requirement was determined for each horse and pony. The energy requirements were calculated according to the Dutch net energy system (1). The energy requirements were calculated as $NE_r = NE_m + NE_w$ (MJ/day). The net energy for maintenance (NE_m) is dependent on body weight, breed, and sex. We used only one formula for calculating the energy for maintenance: NE_m (MJ/day) = 0.369 MJ/BW^{0,75}. Body weight (BW), expressed in kg, was determined by weighing the horses and ponies.

The net energy needed for work (NE_w) is dependent on the number of working hours per day, the body weight of animal plus rider (BW_{h+m}), and the speed of activity. Animals with a body weight less than 400 kg were assumed to be used by riders of 50 kg, horses weighing between 400 and 600 kg by riders of 60 kg, and horses heavier than 600 kg by riders of 80 kg. An average speed was linked to each of the types of

Table 2. Linear correlation coefficients for relations between macronutrient intake (g/MJ), and $NE_i : NE_r$ ratio.

	NE_i:NE_r	Ash	Crude protein	Crude fibre	Crude fat	Nitrogen free extract
$NE_i : NE_r$	1.000					
Ash	-0.641	1.000				
Crude protein	-0.390	0.667	1.000			
Crude fibre	-0.670	0.899	0.419	1.000		
Crude fat	-0.414	0.397	0.366	0.483	1.000	
Nitrogen-free extract	-0.364	0.415	0.129	0.687	0.649	1.000

movements (walking, trotting, or galloping) according to the CVB (1). The following formulas were used: NE_{walk} (MJ) = $(e^{3,8} - 13.92) * 4.184 * (BW_{h+m})$ *min; $NE_{trotting}$(MJ) = $(e^{4,58} - 13.92) * 4.184 * (BW_{h+m})$ *min; $NE_{galloping}$ (MJ) = $(e^{5,36} - 13.92) * 4.184 * (BW_{h+m})$ *min. During 1 day for the entire period of exercise, the type of movement that the horses performed was recorded every 2 minutes. The energy requirements for work per working hour were calculated. The average number of hours worked per day was based on the records kept by the riding schools.

Ash, crude protein, crude fat, crude fibre, and nitrogen-free extract in the rations are expressed as g/MJ NE_i to avoid interaction with the ratio $NE_i : NE_r$. The ration concentrations of macronutrients (g/MJ NE_i) as well as the ratio of roughage to concentrate (NE_i roughage : NE_r concentrate ratio) were correlated with the ratio $NE_i : NE_r$ by linear regression analysis. The standard deviations between and within schools were derived from the mean squares, as computed by analysis of variance with school as factor. All statistical analyses were done using the Genstat computer program (Lawes Agricultural Trust, Harpenden, England). A P value <0.05 was preset as level of statistical significance.

RESULTS

The composition of the ration and calculated NE_i and NE_r are presented in table 1. The variation between schools was consistently greater than that within schools. NE_i was significantly higher than NE_r. For individual schools the correlation of NE_i and NE_r (Figure 1) was not strong ($r^2 = 0.367$, n=10, P = 0.063). The NE_r depends on the type and duration of activity. The average exercise per animal was 48 minutes of walking, 50 minutes of trotting, and 9 minutes of galloping per day. The animals were used for on average 107 min per day. A value for speed was linked to each type of movement (1), the average speed being 192 ± 17.4 m/min (mean ± SD).

Table 2 shows the linear correlation coefficients for the relationships between the $NE_i : NE_r$ ratio and various ration characteristics. The correlation coefficients were calculated for individual animals. The intake of crude fibre and ash was negatively associated with the $NE_i : NE_r$ ratio, the relations explaining at least 40% of the variance in $NE_i : NE_r$ ratio. Figure 2 illustrates the relation between crude fibre intake and the $NE_i : NE_r$ ratio for the means of riding schools. There was a strong association between the intake of crude fibre and ash. Figure 3 shows that, based on school mean values, crude fat intake and the $NE_i : NE_r$ ratio had a weak, negative association.

DISCUSSION

The correlation between NE_r and NE_i was weak. Moreover, NE_i on average was 14% greater than NE_r, the difference being statistically significant. This difference could point to inefficient energy utilization and/or methodological errors. In a similar, recent survey in event horses in training, but with assumed constant body weight, the calculated energy intake was 30% higher than the estimated energy requirement (3) Clearly, energy intake was overestimated and/or the energy requirement underestimated. Possible explanations related to methodological errors have been put forward (3), but they remain uncertain.

Crude fibre intake (g/MJ) explained part of the variation in the $NE_i : NE_r$ ratio. This study does not allow to a conclusion to be drawn on whether the relationship is a causal one or that crude fibre intake acts as a surrogate variable for another, more powerful determinant. As would be expected, the roughage : concentrate ratio also was negatively correlated with the $NE_i : NE_r$ ratio (r= - 0.599, n=93, P < 0,001). Unexpectedly, ash intake was negatively associated with the $NE_i : NE_r$ ratio, but ash and crude fibre intake were strongly interrelated. It could be sugges-ted that the intake of extra crude fibre increases the efficiency of utilzation of dietary energy. However, it would be expected that extra crude fibre would increase the passage rate of digested materials, so that macronutrient digestibility would be depressed and thus energy utilization would be diminished.

Feeding regimens within riding schools are dependent. Crude fibre intake (g/MJ) was averaged per riding school and correlated with the ratio $NE_i : NE_r$ by linear regression analysis, the regression being $NE_i : NE_r = 2.036 - 0.02453$ * Crude fibre intake ($r^2 = 0.651$, P= 0.005). An important problem with this regression equation is the within school variation in the variables. The effect of within-school variability in nutrient intake on the correlation coefficient between diet characteristics and the $NE_i : NE_r$ ratio can be calculated (2,6), using the quotient of the variation coefficients within and between schools (Table 1). Because of the relatively small within school variation coefficients the effect of this correction was negligible and the r^2 would become 0.656.

The intake of extra fat changes the apparent total tract digestibility of macronutrients (4,5). Average crude fat intake in this study was 38 g/kg dry matter, with a minimum intake of 32 and a maximum intake of 52 g/kg dry matter. As mentioned above, this range in fat intake is too small to influence the $NE_i : NE_r$ ratio. Thus, it is expected that, under normal feeding conditions, the effect of fat intake on the efficiency of energy intake is negligible. Indeed, in this survey only a weak correlation between crude fat intake and the $NE_i : NE_r$ ratio was found, but more importantly the correlation was negative. If any, a positive correlation between fat intake and the $NE_i : NE_r$ ratio would be expected on the basis of controlled digestibility trials (4).

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