Moving from a range of systems currently assessing practical workloads in equines to a common system

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Abstract

Horses are primarily used for leisure or competitive riding activities. Energy evaluation systems apply a varying range of methods for the practitioner to estimate energy requirements above maintenance for working horses. The energy system currently used in the USA and UK recommends an increase of 1.25, 1.5 or 2 times maintenance requirements for light (pleasure and equitation), medium (ranch work, barrel racing, jumping etc.) and intense work (race training, polo) respectively. The German and Dutch systems are based originally on a calculation from in vivo net energy research which includes weight of rider, tack and horse, duration of exercise and speed. The German system then gives average energy expenditure tables for light, medium, heavy and very heavy work. Both the Dutch and French systems offer similar tables but also give practitioners the option to choose from duration and intensity tables to calculate energy expenditure more accurately. Furthermore, the actual formula which incorporates all above mentioned factors is published in the Dutch system for educated horse owners. Current systems do not take the variety or repetition of exercise periods over an average working week into account. This paper introduces a possible method incorporating the best of current systems with a novel approach for practical application. Energy expenditure for work is derived from the following variables per type of exercise: repetition (per day and per week), duration, intensity and additional effort.

1 Introduction

Horses are primarily used for leisure or competitive riding activities. Energy evaluation systems apply a varying range of methods for the practitioner to estimate energy requirements above maintenance for working horses. This paper introduces a possible method incorporating the best of current systems with a novel approach for practical application.

2 The theory and current energy systems

All current energy systems use the same (Pagan and Hintz, 1986) or very similar equation to calculate energy requirements for working horses. These are based on a range of experimental studies using either respiratory gas analysis methods or digestibility trials. A summary of the equations produced by four of the major studies can be seen in Figure 1. Differences are due to type of horses used and feed levels.

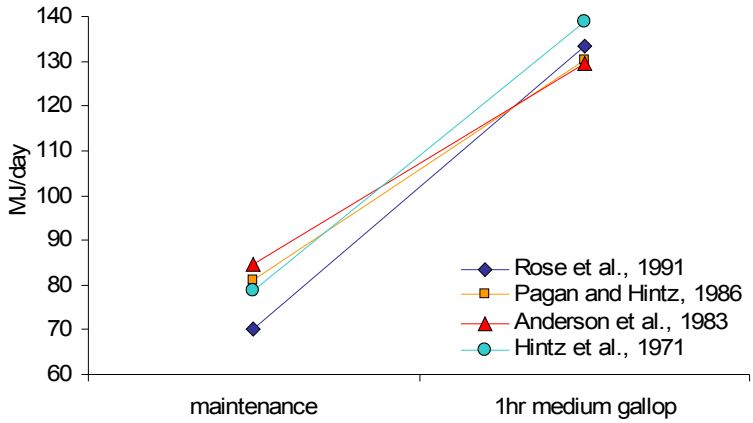

Figure 1 Requirements in MJ/day for a 600 kg horse at maintenance and for 1 hour of medium speed canter (Ellis, 2002)

Some criticisms have been made in terms of reliability due to limited in vivo data about the equation derived by Pagan and Hintz (1986) but such a discussion is not for the purpose of this paper. The following table gives an overview of the original equation and how it has been adopted by various systems:

Pagan and Hintz, 1986:

Work (kcal NE/minute/kg horse and rider) = $(e^{(3,02 +0,0065Y)} - 13,92)$

Work (kcal DE/minute/kg horse and rider) = $(e^{(3,02 +0,0065Y)} - 13,92) *(1/0.57)$

Y = speed in meters per minute

NRC 1989:

Work (kcal DE/hour/kg horse and rider) = $(e^{(3,02 +0,0065Y)} - 13,92) *(1/0.57) *0.06$

GEH 1994:

Work (kJ DE/hour/kg horse and rider) = $(e^{(3,02 +0,0065Y)} - 13,92)*(1/0.57)*0.06*4.185$

Work (kJ DE/hour/kg horse and rider) = $((e^{(3,02 +0,0065Y)} - 13,92) *0.441$

CVB 1996:

Work (MJ NE/kg/min) = $(e^{(3,02 +0,0065Y)} - 13,92) * 4,184$

INRA 1986:

Use a slightly different formula which comes to very similar results in kJ/kg/hour as the formula by Pagan and Hintz (1989) and is partially also based on this – however in this system intensity and duration factors are also accounted for to a certain extent.

On the whole it becomes very clear that the theoretical underpinning of more or less all currently used systems is the same.

3 Practical Application

All systems simplify the theoretically quite accurate calculations based on horse and rider weight, velocity and duration of exercise by using 'mean' exercise levels and giving energy expenditure per day. This is the point at which systems start to diverge. As can be seen in the figure below, even the speed of different paces is given at various rates (Figure 2):

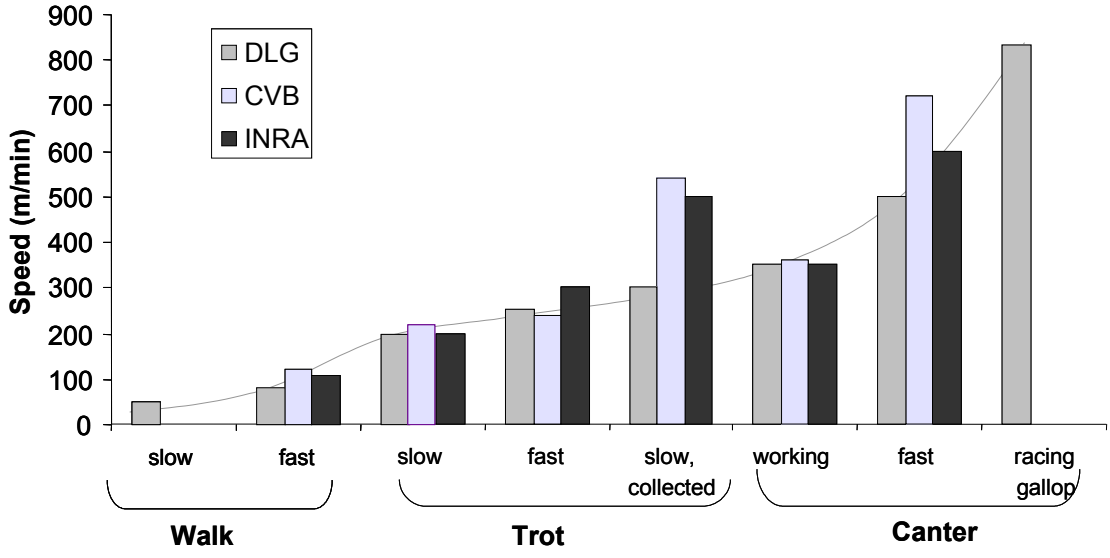

Figure 2 Definition of walk, trot and canter according to various systems

GEH For practical application systems simplify calculations further at varying levels (Table 1).

Table 1 Summary of levels used to estimate energy requirements per system

	NRC 1989	GEH 1994	INRA 1996	CVB 1996
LEVEL 1		Formula: Users can apply the formula given above and use a table of speeds as seen in Figure 2 ▪ per minute work ▪ per kg BW horse & rider & tack ▪ per speed (m/minute)	Formula is not given, but a detailed description of intensity of work time spent on walk, trot or canter and distinguishing between manege and hacking work is given as a basis to choose worklevels	Formula: Users can apply the formula given above and use a table of speeds as seen in Figure 2 ▪ per minute work ▪ per kg BW horse & rider & tack ▪ per speed (m/minute)
LEVEL 2		Users have the option to use a table which gives extra energy requirements ▪ per minute work ▪ per kg BW for: Walk Slow Fast Trot Light Medium Fast Canter Collected Medium Gallop Fast Racing	Users have the option to use a table which gives extra energy requirements ▪ per minute work ▪ per 100 kg BW for: Maintenance Waiting with rider Walking Trotting slowly Trotting normally Trotting fast Cantering Galloping Maximum Speed	Users have the option to use a table which gives extra energy requirements ▪ per hour work ▪ per kg BW ▪ using intensity table similar to INRA – level 1 table for: Walk Light Medium Heavy Very heavy
LEVEL 3	Users have the option to get energy requirements ▪ per day ▪ per range of BW for work levels of: Light[a] Medium[b] Heavy[c]	Users finally have the option to get energy requirements ▪ per day ▪ per range of BW for work levels of: Very light Light Medium Heavy Very heavy	Users finally have the option to get energy requirements ▪ per day ▪ per range of BW for work levels of: Very light Light Hack Moderate Intense	Users finally have the option to get energy requirements ▪ per day ▪ per range of BW for work levels of: Very light Light Medium Heavy Very heavy
ENERGY	Energy values are multiples of maintenance (m) Light = 1.25 *m Medium = 1.5*m Heavy = 2.0*m	Energy values in these three systems are based on calculations and assumption of average work (per day) done from detailed tables/formulas above		

[a] Western – English pleasure riding, dressage, hacking, equitation, etc.
[b] Ranchwork, roping, cutting, barrel racing, jumping, barrel racing, etc.
[c] Race training, polo, etc.

The level 3 tables are applied in most systems for the end user and are the level normally used by nutritionists or veterinarians to give advice to horse owners. Some educated horse owners will also use these tables themselves, but for the un-educated horse owner such tables and 'generalisations' can make application of the system very crude indeed – the real time spent on work (e.g. how many hours, how many times a week, the actual intensity of work and distinction between different types of work

done in a week) is not included in these energy requirement tables. Generally a level of work is chosen according to the most intensive exercise carried out on perhaps 2-3 days per week and then horses are fed according to this level 7 days per week. The NRC description of work is very crude indeed and leads to a large overestimation of requirements when comparing their values and actually calculated daily requirements applying the formula by Pagan and Hintz (1986).

With the increase in equine education and increased use of horses for leisure both feed companies and horse owners should be able to apply a more accurate, yet user-friendly system to estimate requirements for horses. A demand for this can be recognised by the fact that many feed companies and researchers have developed various systems to try and assess energy requirements of horses.

The following system (Appendix 1) has been developed on the basis of the original formula by Pagan and Hintz (1986) for intensity and duration of work, but it also incorporates average weekly schedule and additional factors. It brings together the best of current systems with a novel approach for practical application. Energy expenditure for work is derived from the following variables per type of exercise: repetition, duration, intensity and additional effort.

The system can be applied very easily by professionals with the use of a computer, but should also be user friendly enough to give horse owners a chance to assess requirements more accurately both with or without a computer programme. Figure 3 below shows the correlation between energy values calculated according to the system using the formula by Pagan and Hintz (1986) and the total points accumulated by the system for a large variety of training schedules taken from 'real live' situations (see Table 2):

Table 2: List of example calculations using the new point system

Type of Sport		Points	Work level	Energy in *maintenance
Maintenance	Grazing	2	VL (very light)	1.0
Leisure	hacking	7	VL	1.1
Leisure	combined	17	L (light)	1.2
SJ	medium	19	L	1.2
Carriage Driving	leisure	24	LM (light medium)	1.3
Dressage	medium	25	LM	1.4
SJ	prof top	27	LM	1.3
Western	leisure	29	M (medium)	1.4
Pony Trekking	medium	30	M	1.3
Eventer	medium	31	M	1.3
Dressage	top	32	M	1.5
Riding-school	horse	32	M	1.5
Endurance	beginner	38	MH (medium hard)	1.5
Racing	top	41	MH	1.6
Carriage driving	medium	42	MH	1.5
Eventer	top	47	MH	1.6
Pony Trekking	high season	49	H (hard)	1.7
Point to Pointer	mid-season	49	H	1.7
Endurance	top	50	VH (very hard	1.8

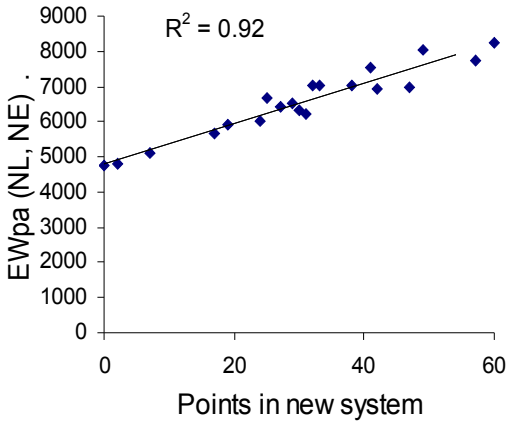

Figure 3 Correlation between points achieved in new system and net energy requirements

In conclusion, this new system is still in a late developmental stage and needs to be tested further for accuracy. General feedback from horse owners in practice have helped to simplify its application and initial calculations show a much greater degree of accuracy than using 'mean' values for work requirements given in current systems. Any suggestions and comments are welcome and the author wishes to point out that one purpose of this paper was to allow the reader to take a new fresh look at work level evaluation systems currently in use.

References

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Pagan J. D. and Hintz H. F. (1986) Equine energetics: II. Energy expenditure in horses during submaximal exercise, Journal of Animal Science, 63, 822- 830

CVB (1996) Documentatierapport nr 15, Het definitieve VEP- en VREp-systeem, centraal veevoederbureau, Lelystad (the definitive Dutch Equine Energy and Protein System)

APPENDIX

WORKING OUT THE REQUIREMENTS FOR YOUR HORSE
- A new system by Andrea D. Ellis

This system allows you to calculate the requirements of your horse according to the work you really do

Types of work (A,B,C,D):
You will need to give details about all the different types of work you do on average in one week: *For example a Leisure horse may do jumping, dressage or flat schooling and hacking in a week (so 3-4 types of work). The current table gives opportunity for 4 types of work (A,B,C,D)*

For each type of work you need to give:
a Daily *How many times do you do this work on any **one** day (mostly once a day)*
b Weekly *How many individual days per week do you do this type of work*
c Duration *For how long do you work – pick your score according to time from **'Duration Score'***
d Intensity *How hard is the work you do – pick an estimated score from **'Intensity Score'***

Adding up Scores for each Type of work
It all becomes clear from the examples given below – use the first column of the table to fill your own horse's scores in and calculate your points up to here for **each type of work (a*b*c +d)**

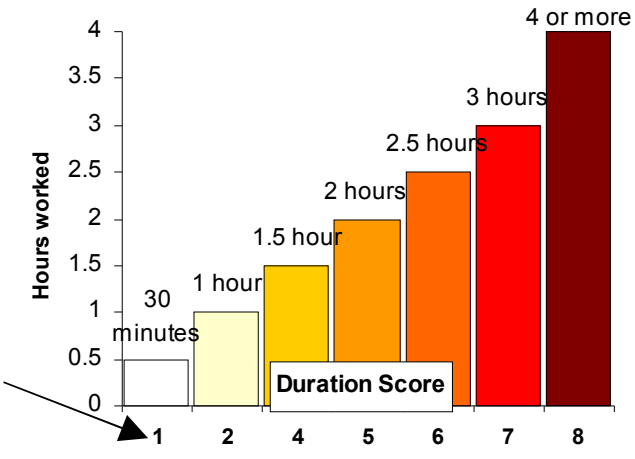
Additional Points – Extra E
The system allows for extra points in situations where your horse has to work harder
If you jump higher than 1.40 meters, work on a steep inclination for 10 minutes (up a hill or on the treadmill), work the horse at high temp (28ºC+), or your horse is pulling a carriage = you add **2 points** extra for each type of work where this occurs

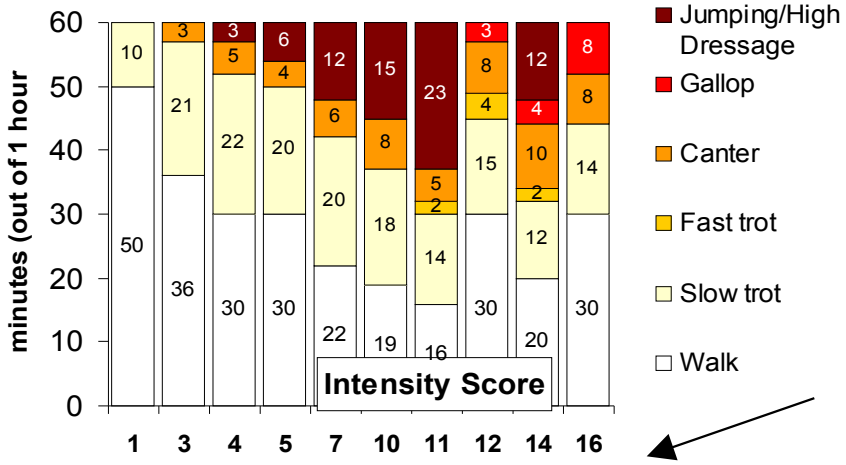
Final Adjustments – Extra F
This adjustment is necessary if your horse does more than one type of work – if you only filled in one type of work ignore this box (=0). The requirements for maintenance (no work) are included in the first type of work and they will increase slightly for the second type of work but then not increase any further. So if you have filled in **B put 1** in the F box OR if you have used **C as well put 4** in the F-box instead OR if you have used **D** as well you need to put **5 in the F box.**

Finally adding up your Work level points
Simply add all types of work scores together (A+B+C+D + E) MINUS F
Your points will then tell you the work level and the energy requirements for your horse when you look at Figure 3.

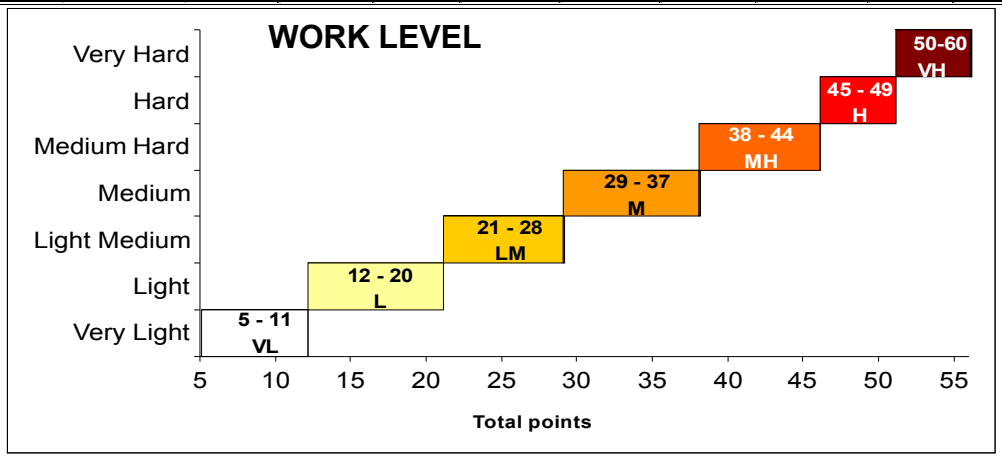
On the following pages some general advise is given about what the diet of your horse may look like – of course you need to adjust it according to **temperament and body condition** of your horse. The ideal body condition means that when looking form behind the spine should be the highest point and you should still just be able to see the outline from the ribs. If you are not sure it is always useful to get some advise from professionals or look at a book with more detailed descriptions.

So have a look at the table on the following page – it may take a little practice but by looking at the examples you soon get the hang of how to fill in the scores:





			YOUR HORSE	Leisure hacking	Leisure combined	SJ prof top	Dressage medium	Dressage top	Western leisure	Endurance beginner	Racing top	Eventer top	Carriage Driving leisure
	A	Type of exercise		hacking	schoolin g		schooling	schooling	training	tracking	on the track	Dressage	training
a	Daily	on any one day		1	1	1	1	1	1	2	1	1	1
b	Weekly	days per week		3	3	4	5	4	3	2	1	2	3
c	Duration	score		2	2	2	2	4	4	6	1	2	4
d	Intensity	score		1	3	10	7	10	7	3	16	7	4
	Subtotal	a*b*c+d =											
	B	Type of exercise			hacking	lunging	long rein/lunge		hacking	schooling	training	interval training	lunge
a	Daily	on any one day			1	1	1	1	1	1	1	1	1
b	Weekly	days per week			2	2	2	2	2	2	4	2	2
c	Duration	score			2	1	2	1	4	4	2	2	2
d	Intensity	score			5	4	3	3	3	4	12	11	3
	B	B											
	C	Type of exercise				hacking	hacking	hacking			walker	x-country	
a	Daily	on any one day				1	1	1			1	1	
b	Weekly	days per week				1	1	1			3	1	
c	Duration	score				2	2	2			1	2	
d	Intensity	score				3	3	3			3	14	
	C	C											
	D	Type of exercise										SJ	
a	Daily	on any one day										1	
b	Weekly	days per week										1	
c	Duration	score										1	
d	Intensity	score										7	
	C	D											
Extra E	jump>1.4m, steep inclination, high temp (28ºC+), carriage pulling = 2 points extra/type					2					2	2	2
Extra F	if B>0 add 1;if B+C>0 add 4;if B,C,D>0 add 5)		0	0	1	4	4	4	1	1	4	5	1
TOTAL	A+B+C+D+E minus F			7	17	27	25	32	29	38	41	47	24
				VL	L	LM	LM	M	M	MH	MH	H	LM



Reference Table (first three tables – energy units per country)

NL, EWpa	100	150	200	250	300	350	400	450	500	550	600	650	700	750
Maintenance	1233	1672	2074	2452	2811	3156	3488	3810	4124	4429	4728	5021	5307	5589
VL	1275	1733	2154	2549	2926	3289	3639	3978	4309	4631	4947	5256	5560	5859
L	1420	1945	2432	2894	3337	3764	4179	4583	4978	5365	5745	6118	6486	6848
LM	1527	2103	2642	3155	3648	4126	4591	5045	5490	5927	6357	6780	7197	7609
M	1589	2193	2758	3298	3818	4322	4813	5293	5764	6226	6681	7130	7572	8009
MH	1705	2366	2988	3584	4159	4719	5265	5801	6327	6845	7355	7859	8356	8848
H	1863	2599	3295	3965	4614	5247	5866	6475	7073	7664	8246	8822	9392	9956
VH	1968	2750	3490	4203	4895	5570	6231	6881	7521	8151	8774	9390	10000	10604

F, UFC	100	150	200	250	300	350	400	450	500	550	600	650	700	750
Maintenance	1.2	1.7	2.1	2.5	2.8	3.2	3.5	3.8	4.1	4.4	4.7	5.0	5.3	5.6
VL	1.3	1.7	2.2	2.5	2.9	3.3	3.6	4.0	4.3	4.6	4.9	5.3	5.6	5.9
L	1.4	1.9	2.4	2.9	3.3	3.8	4.2	4.6	5.0	5.4	5.7	6.1	6.5	6.8
LM	1.5	2.1	2.6	3.2	3.6	4.1	4.6	5.0	5.5	5.9	6.4	6.8	7.2	7.6
M	1.6	2.2	2.8	3.3	3.8	4.3	4.8	5.3	5.8	6.2	6.7	7.1	7.6	8.0
MH	1.7	2.4	3.0	3.6	4.2	4.7	5.3	5.8	6.3	6.8	7.4	7.9	8.4	8.8
H	1.9	2.6	3.3	4.0	4.6	5.2	5.9	6.5	7.1	7.7	8.2	8.8	9.4	10.0
VH	2.0	2.7	3.5	4.2	4.9	5.6	6.2	6.9	7.5	8.2	8.8	9.4	10.0	10.6

USA, D, UK, MJ DE	100	150	200	250	300	350	400	450	500	550	600	650	700	750
Maintenance	20	28	34	40	46	52	58	63	68	73	78	83	88	92
VL	21	29	36	42	48	54	60	66	71	76	82	87	92	97
L	23	32	40	48	55	62	69	76	82	89	95	101	107	113
LM	25	35	44	52	60	68	76	83	91	98	105	112	119	126
M	26	36	46	54	63	71	79	87	95	103	110	118	125	132
MH	28	39	49	59	69	78	87	96	104	113	121	130	138	146
H	31	43	54	65	76	87	97	107	117	127	136	146	155	164
VH	33	45	58	69	81	92	103	114	124	135	145	155	165	175

Recommended Structural Fibre intake: Hay, Haylage (high dry matter), Straw, Lucerne hay, chopped and dried forages minimum in kg

	100	150	200	250	300	350	400	450	500	550	600	650	700	750
Maintenance	2	3	4	6	7	8	9	10	11	12	13	14	15	17
VL	2	3	4	6	7	8	9	10	11	12	13	14	15	17
L	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LM	2	3	4	5	6	7	8	9	10	10	11	12	13	14
M	2	3	4	5	5	6	7	8	9	10	11	12	13	14
MH	2	2	3	4	5	5	6	7	8	8	9	10	11	11
H	1	2	2	3	4	4	5	5	6	7	7	8	8	9
VH	1	2	3	3	4	5	5	6	7	7	8	8	9	10

Concentrate feed - compound mixes, mueslis, straight barley, oats, micronised maize etc. maximum in kg

	100	150	200	250	300	350	400	450	500	550	600	650	700	750
Maintenance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
LM	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	2.1	2.3
M	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
MH	0.7	1.1	1.4	1.8	2.1	2.5	2.8	3.2	3.5	3.9	4.2	4.6	4.9	5.3
H	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
VH	0.9	1.4	1.8	2.3	2.7	3.2	3.6	4.1	4.5	5.0	5.4	5.9	6.3	6.8

				YOUR HORSE		YOUR HORSE	
		A	Type of exercise			schoolin g	school g
a		Daily	on any one day				
b		Weekly	days per week				
c		Duration	score				
d		Intensity	score				
		Subtotal	a*b*c+d =				
		B	Type of exercise				lor
a		Daily	on any one day				
b		Weekly	days per week				
c		Duration	score				
d		Intensity	score				
		B	B				
		C	Type of exercise				
a		Daily	on any one day				
b		Weekly	days per week				
c		Duration	score				
d		Intensity	score				
		C	C				
		D	Type of exercise				
a		Daily	on any one day				
b		Weekly	days per week				
c		Duration	score				
d		Intensity	score				
		C	D				
Extra E		jump>1.4m, steep inclination, high temp (28ºC+), carriage pulling = 2 points extra/type					
Extra F		if B>0 add 1;if B+C>0 add 4;if B,C,D>0 add 5)		0		0	
TOTAL		A+B+C+D+E minus F					