Influence of Equine Conformation on Rider Oscillation and Evaluation of Horses for Therapeutic Riding

Akihiro MATSUURA[1]*, Emiko OHTA[2], Koichiro UEDA[1], Hiroki NAKATSUJI[1] and Seiji KONDO[1]

[1]Graduate School of Agriculture, Hokkaido University, Kita 9 Nishi 9, Kita-ku, Sapporo 060-8589, [2]Riding for the Disabled Association Japan, Otsuka 3–5–2–301, Bunkyo-ku, Tokyo 112-0012, Japan

To obtain basic knowledge about selecting horses for therapeutic riding, the influence of equine conformation on rider oscillation and relationships between these factors and the evaluation on horses as the therapeutic riding were studied. Thirty-five riding horses were used. Equine conformation was estimated by 24 indices. Rider oscillation was measured by an accelerometer fixed at the rider's waist. The spatial position of the oscillation was estimated by a double integration of the acceleration. Horses were evaluated for therapeutic riding by a Riding for the Disabled Association instructor as a rider. Evaluations were on a scale of 1 to 5, with 5 being the highest score for 27 items. Horses were classified into 4 groups: the short and narrow (SN), short and wide (SW), tall and narrow (TN), and tall and wide (TW). The frequencies of rider oscillation both at walk and trot were higher ($P<0.01$), and the vertical ($P<0.01$) and longitudinal ($P<0.05$) amplitudes at trot were smaller, on short horses than on tall horses. The vertical amplitude at walk was smaller ($P<0.05$) and the lateral amplitude at trot was larger ($P<0.01$) on wide horses than on narrow horses. Short horses could be used for the rider who requires side walkers. Wide horses could be used for relieving muscular tension and for the rider who could not maintain good balance on the horse. Short and wide horses should be suitable for therapeutic riding.

Key words: *horses, rider oscillation, therapeutic riding, width, withers height*

J. Equine Sci.
Vol. 19, No. 1
pp. 9–18, 2008

Recently, interest in therapeutic horseback riding, such as riding for the disabled and hippotherapy, has increased. According to Bertoti, the 3-dimensional (3-D) movements that transmitted by the horse to the rider have been considered the source of the physical effects of therapeutic riding [3]. Because these 3-D movements come from the equine gait, they change periodically, and are therefore transmitted as oscillations. Accordingly, scientific analysis of the rider's oscillation is important to obtain basic knowledge of horses for therapeutic riding.

Matsuura *et al.* showed that the oscillation of the rider on Hokkaido native horses whose withers heights were 129 ± 2.3 cm characterized as higher frequency and smaller amplitude than that of Thoroughbred horses whose withers heights were 159 ± 6.1 cm [8]. Cano *et al.* compared the kinematic trot characteristics of three different breeds of horses (Andalusian, Arabian, and Anglo-Arabian) and showed that the most outstanding feature was the greater forelimb flexion recorded in Andalusian than in the other breeds, which was consistent with the elevated movements in this breed [4]. Barrey *et al.* showed that German horses (Hanoverian, Oldenburger, and Westphalian), whose withers height, back length, fore- and hind-limb length were longer, and angle of each joint was larger, than those of Andalusian, had gait characteristics more adapted for dressage competition, while Andalusian could be suited for collected gaits used for farm work and old academic dressage [2]. Johnston *et al.* pointed out that the differences in equine oscillation among breeds would originate from differences in equine

This article was accepted October 15, 2007
*Corresponding author. Present address: Department of Animal Science, School of Veterinary Medicine, Kitasato University, 35–1, Higashi 23, Towada, Aomori 034-8628, Japan
e-mail: matsuura@vmas.kitasato-u.ac.jp

conformation [7]. Little of this research, however, has studied the relationship between equine oscillation and conformation.

There are a few reports about the relationship between equine ability for dressage and conformation. Holmström *et al.* showed that elite dressage horses and showjumpers had larger hock angles and more sloping scapulas than other Swedish Warmblood horses [5]. Holmström and Philipson showed that horses with high scores for jumping had a narrow front cannon at the mid point, a short hind phalanx, and large angles of the stifle and hock joints [6].

According to the official manual of the Riding for the Disabled Association (RDA), a good, calm, kind temperament is the first essential for horses for disabled people [10]. A survey of horse temperament for therapeutic riding has been published by Anderson *et al.* [1]. If a horse's temperament is suitable, the conformation—wide or narrow, short or long stride, much or little back movement—becomes an important selection criterion [10]. RDA instructors have overall charge of the horses and the teaching of the whole group in a lesson, and are therefore responsible for allocating suitable horses to the riders. From their own experience, the instructor selects a horse by considering the rider and the objectives of the lesson. However, no scientific grounds are available to help instructors select horses.

The influence of equine conformation on the rider's oscillation needs to be understood to aid selection of horses for therapeutic riding. The relationships between equine conformation and the oscillation that the horse transmits to the rider need to be investigated to be able to evaluate a horse for this purpose. Especially, in order to select the horse in the actual situation on the ground of therapeutic riding, equine conformation should be easy to measure. Therefore, the withers height and the trunk width were used to estimate equine conformation. The aim of this study was to determine the influence of equine conformation on rider oscillation and to use the relationships between these factors to evaluate horses for therapeutic riding according to RDA standards.

Materials and Methods

The research was carried out at Avalon hillside Farm, Yokohama Riding Club, Eldorado Ranch, Sawashiroko Heartland Farm, Koyodai Kisouma Ranch, and Jinnai Farm 21 in 2004. A total of 35 horses (withers height: 124.7–172.5 cm) were used: 8 American Quarter Horses, 6 Thoroughbreds, 3 Anglo-Arabians, 1 Trotter, 3 Hokkaido natives, 2 Kiso natives, 1 New Zealand Pony, and 11 crossbreds (8 Japanese native descents, 1 Appaloosa descents, 1 Arab descent, and 1 Japanese draft horse). Seven were specifically for disabled persons, 4 were for Western riding, 2 were for dressage, 10 were for trekking, and the others were for general riding. The rider was an instructor accredited by RDA.

Measurement of equine conformation

Equine conformation was measured according to the modified method of Holmström *et al.* [5]. The horses were stood without the rider in a standard position. Fourteen markers 1.5 cm in diameter were put on the reference points of the horse (Fig. 1). The horses were photographed with a digital camera (RICOH, RR30) from the left side of the horse at 20 m distance and at 1.5 m above the ground. The lengths between markers (Digital Curve Tracer 1.0, Kotaro) and joint angles (Nanamemonosashi 1.11, Daigo) were measured on a PC. The lengths of the radius or the metacarpus were used as reference lengths when comparing photographs with the live horse. The withers height, the girth circumference, the cannon circumference, the radius, and the metacarpus were measured directly on the horse. The horses with the rider were also photographed from the front. The distance between the rider's knees was also measured as an index of the width of the horse's trunk. The distance was measured in a same way on a PC using the scale of the photographed ruler which the person standing beside a rider had. Twenty-five indices (16 length measurements and 9 angle measurements) comprised the conformation indices.

Rider oscillation

Rider oscillation was estimated by a method similar to that described by Matsuura *et al.* [9]. An accelerometer (W3GT, ATF, Ebetsu, Japan) was fixed at the waist of the rider. The rider moved along a straight course (Fig. 2). To keep the speed at 1.5 m/sec for walking and 3.0 m/sec for trotting, the rider passed pylons set at even intervals following the time keeper's calls. The acceleration of the rider at a walk and a sitting trot was recorded at intervals of 1/200 sec.

For vertical, lateral, and longitudinal axes, the time series of the acceleration recorded during 10.24 sec was filtered by a high-pass filter (cut-off frequency: 0.5 Hz;

Fig. 1. Reference points for measurement of equine conformation. a: The proximal end of the spine of the scapula; b: the posterior part of the tuberculum majus of the humerus; c: the transition between the proximal and the middle thirds of the lateral collateral ligament of the elbow joint; d: the lateral tuberosity of the distal end of the radius; e: the space between the fourth carpal, the third metacarpal, and the fourth metacarpal bones; f: the proximal attachment of the lateral collateral ligament of the fetlock joint to the distal end of the third metacarpal bone; g: the proximal attachment of the lateral collateral ligament of the pasterm joint to the distal end of the first phalanx; h: the proximal end of the lateral angle of the ilium; i: the centre of the anterior part of the greater trochanter of the femur; j: the proximal attachment of the lateral collateral ligament of the stifle joint to the femur; k: the attachment of the long lateral ligament of the hock joint to the plantar border of the calcaneus bone; l: the space between the fourth tarsal, the third metatarsal, and the fourth metatarsal bones; m: the proximal attachment of the lateral collateral ligament of the fetlock joint to the distal end of the third metatarsal bone; n: the proximal attachment of the lateral collateral ligament of the pastern joint to the distal end of the first phalanx. The conformation indices are as follows.
[Length measurements]
withers height, body length, chest depth, chest circumference, cannon circumference, distance between rider' knees, length of scapula (between a and b), length of humerus (between b and c), length of radius (between c and d), length of metacarpus (between e and f), length of front phalanx (between f and g), length of pelvis (between h and i), length of femur (between i and j), length of tibia (between j and k), length of metatarsus (between l and m), length of hind phalanx (between m and n),
[Angle measurements]
1: shoulder inclination; 2: shoulder joint; 3: elbow joint; 4: front fetlock joint; 5: hip joint; 6: femur inclination; 7: stifle joint; 8: hock joint; 9: hind fetlock joint

OyoCsvFir Hattifnatt) to remove the low frequency components. The filtered series was mathematically integrated for time and filtered similarly, to give the velocity. The time series of the velocity was integrated and filtered, to give the locus of the oscillation.

The time series of the rider's oscillation was subjected to fast Fourier transformation (FFT; Kyplot 4.0 KyenceLab). The harmonic waves were extracted from the power spectrum density of FFT that displays the magnitude squared of the oscillation against the frequency. The square root of the maximal harmonic power was calculated as maximal harmonic amplitude (MHA). The amplitude root-mean-square value (Arms) was also calculated as the representative amplitude of the whole wave, according to the following formula.

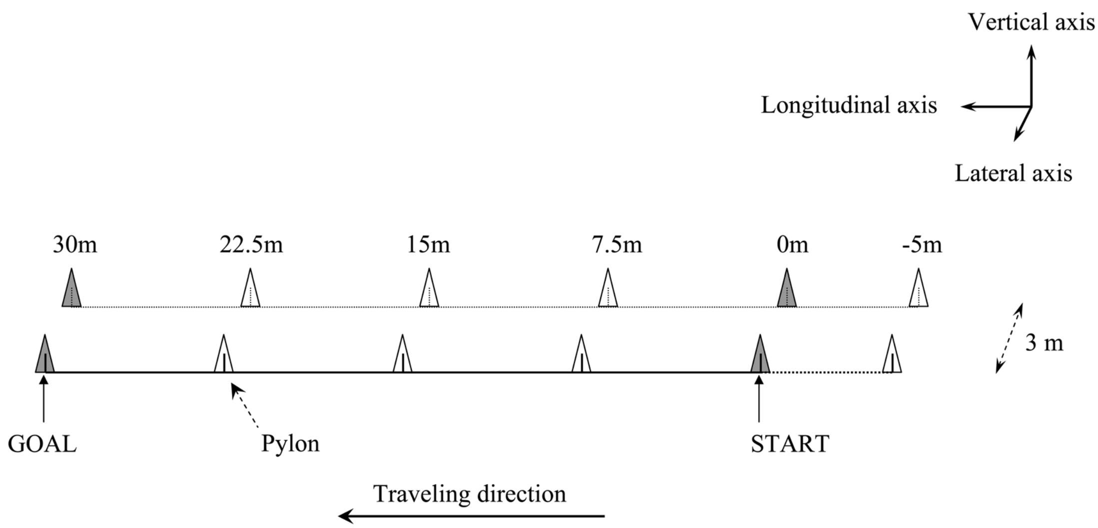

Fig. 2. Course for oscillation measurement.

$$\mathrm{Arms}=\sqrt{C_0^2+\frac{1}{2}\sum_{i=1}^{M}(C_i^2+S_i^2)}$$

C_0: Fourier coefficient of direct current component
Ci: Fourier coefficients of cosine component
Si: Fourier coefficients of sine component
M: Order at maximal harmonic component

Evaluation of the horse for therapeutic riding

Because 2 Anglo-Arabian mares out of the 35 horses originally selected were insufficiently trained as riding horses, 33 horses were evaluated for therapeutic riding. A rider, an RDA instructor, answered a questionnaire immediately after riding each horse. The instructor was asked to evaluate in accordance with the RDA official manual objectively as a RDA instructor, not from private standpoint. The instructor has a qualification, RDA Southeast Asia group instructor, that is accepted also in abroad at least in Southeast Asian range. Although some instructors in Japan had domestic qualification, few persons had one equivalent to her. Therefore, the evaluation by only one RDA instructor was adopted and used for following analyses as an important information. Evaluations were on a scale of 1 to 5, with 5 being the highest score for a given item. The scores for these 27 items were regarded as the indices of the horse.

Of the questionnaire items, 13 were about suitability for the purpose of the lesson, 11 were about the rider's handicap, and 3 were about the rider's height. Learning a sense of balance, relaxation of muscular tension, amount of exercise (fatigue), co-ordination of muscular movement, greater agility, improvement of self-confidence, learning to give depth of seat, and learning eventual control of the horse were adopted from the aims of exercises in the RDA official manual [10]. The mounted exercises, changing position, riding at prone position, trotting, and tandem riding with an instructor were adopted from lessons of RDA Yokohama. Developmental disorders were generally divided into 3 groups: cerebral palsy, autism, and mental retardation. Cerebral palsy was subdivided morphologically into monoplegia, hemiplegia, paraplegia, diplegia, and quadriplegia, and physiologically into athetoid spasticity, hypertonic spasticity, hypotonic spasticity, and ataxia. Autism and mental retardation were adopted without subdivision. The appropriate height of the rider for the horse was divided into 3 levels; under 110 cm, from 110 to 140 cm, and 140 cm or more.

Statistical analysis

Pearson's correlation coefficient analyses were used to assess the relationships between the withers height and the other conformation indices. Non-hierarchical cluster analysis was performed using the standardized value of the withers height and the distance between the rider's knees (mean=0, standard deviation=1) to classify horses into 4 groups for equine conformation. Multivariate analysis of variance (MANOVA) was used to compare equine conformation among the four groups. Two-way analyses of variance (ANOVA) were

Table 1. Correlation coefficients between the withers height and other conformation indices

	Correlation coefficients	P
Length measurements		
distance between rider's knees	–0.010	0.952
body length	0.849	<0.01
chest depth	0.883	<0.01
chest circumference	0.837	<0.01
length of scapula	0.720	<0.01
length of humerus	0.721	<0.01
length of radius	0.931	<0.01
length of metacarpus	0.808	<0.01
length of front phalanx	0.815	<0.01
length of pelvis	0.610	<0.01
length of femur	0.442	<0.01
length of tibia	0.750	<0.01
length of metatarsus	0.737	<0.01
length of hind phalanx	0.730	<0.01
cannon circumference	0.772	<0.01
Angle measurements		
shoulder inclination	–0.209	0.228
shoulder joint	0.299	0.081
elbow joint	0.007	0.968
front fetlock joint	–0.251	0.145
hip joint	–0.105	0.547
femur inclination	–0.073	0.677
stifle joint	–0.229	0.185
hock joint	0.403	<0.05
hind fetlock joint	0.348	<0.05

Pearson's correlation coefficients were shown.

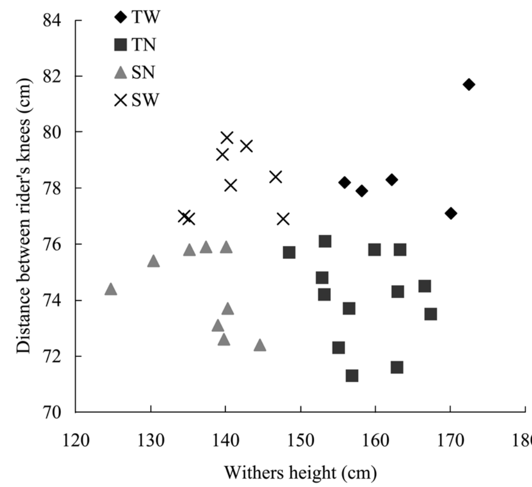

Fig. 3. Classification of horses. Nonhierarchical cluster analysis was performed using the standardized value of the withers height and distance between the rider's knees (mean=0, standard deviation=1). Horses were classified into 4 groups: the short and narrow (SN, 9 horses), the short and wide (SW, 8 horses), the tall and narrow (TN, 13 horses), and the tall and wide (TW, 5 horses).

used to compare rider's oscillation among the four groups. Two-way ANOVA was also used to compare horse evaluation since the score could be considered as interval scale. Generally, if the score were put down with scale on the questionnaire, ordinal scale could be considered as interval scale. When differences were significant, Scheffe's multiple comparison tests were used.

Results

Classification of horses

Correlation coefficients between the withers height and other conformation indices are shown in Table 1. Significant correlations were observed between all length measurement indices other than the distance between rider's knees and the withers height (P<0.01). For angle measurements, significant correlations were observed between the angles of the hock joint and the hind fetlock joint, and the withers height (P<0.05).

Classification by cluster analysis is shown in Fig. 3. Horses were classified into 4 groups: short and narrow (SN, 9 horses), short and wide (SW, 8 horses), tall and narrow (TN, 13 horses), and tall and wide (TW, 5 horses).

Equine conformation

Pillai's Trace, Wilk's Lambda, Hotelling-Lawley Trace, and Roy's Greatest Root were significant (P<0.01). Significance was also observed in all indices of equine conformation. Thus, one-way ANOVA was used to compare each conformation index between the four groups. The differences in equine conformation between the four groups are shown in Table 2. For length measurements, all indices other than the ilium and the femur lengths were significantly different between the four groups (P<0.01 or P<0.05). The indices for length and depth of the equine trunk such as the body length and the chest depth, and the indices for length of the forelegs such as length of the radius, the front phalanx, and the hind phalanx, were larger in TN and TW than in SN and SW (P<0.01). The width of the equine trunk was larger in SW and TW than in SN and TN (P<0.01). For angle measurements, the hock

Table 2. Differences in equine conformation between the four groups

	SN		SW		TN		TW		P
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	
Length measurements (cm)									
withers height	136.8 [b]	(6.00)	140.9 [b]	(4.79)	158.4 [a]	(5.87)	163.8 [a]	(7.28)	<0.001
distance between rider's knees	74.4 [b]	(1.45)	78.2 [a]	(1.20)	74.1 [b]	(1.60)	78.6 [a]	(1.77)	<0.001
body length	140.1 [b]	(5.58)	143.3 [b]	(9.42)	160.8 [a]	(7.91)	171.7 [a]	(13.02)	<0.001
chest depth	66.7 [b]	(4.18)	67.1 [b]	(3.87)	75.5 [a]	(3.15)	78.3 [a]	(4.18)	<0.001
chest circumference	165.3 [c]	(9.68)	168.2 [bc]	(11.00)	183.0 [b]	(5.74)	199.3 [a]	(19.60)	<0.001
length of scapula	46.1 [b]	(3.49)	46.4 [b]	(3.50)	49.3 [ab]	(3.01)	53.8 [a]	(5.02)	0.002
length of humerus	25.5 [c]	(1.90)	27.0 [bc]	(3.44)	30.0 [ab]	(1.24)	31.2 [a]	(3.88)	<0.001
length of radius	32.2 [b]	(1.73)	33.4 [b]	(1.23)	38.3 [a]	(2.15)	40.3 [a]	(1.94)	<0.001
length of metacarpus	20.1 [c]	(1.87)	20.9 [bc]	(1.58)	23.2 [ab]	(1.20)	23.8 [a]	(1.72)	<0.001
length of front phalanx	7.3 [b]	(1.31)	7.6 [b]	(0.95)	9.6 [a]	(1.13)	10.0 [a]	(1.05)	<0.001
length of pelvis	30.0	(3.03)	31.8	(4.10)	35.8	(6.05)	36.9	(8.83)	0.056
length of femur	33.8	(2.54)	35.8	(2.92)	35.0	(2.61)	35.6	(3.00)	0.444
length of tibia	44.8 [bc]	(4.37)	42.0 [c]	(5.82)	50.1 [ab]	(2.83)	55.2 [a]	(3.74)	< 0.001
length of metatarsus	24.8 [b]	(2.28)	26.2 [b]	(2.73)	28.8 [ab]	(2.99)	31.9 [a]	(2.88)	<0.001
length of hind phalanx	7.6 [b]	(0.61)	7.7 [b]	(0.87)	9.3 [a]	(0.97)	9.5 [a]	(2.06)	0.001
cannon circumference	17.4 [b]	(1.07)	17.3 [b]	(1.08)	19.1 [b]	(0.80)	21.6 [a]	(2.99)	<0.001
Angle measurements									
shoulder inclination	61.1	(2.39)	59.7	(4.02)	60.8	(3.65)	58.0	(5.23)	0.454
shoulder joint	99.8	(3.92)	102.1	(3.42)	104.7	(4.69)	101.9	(3.79)	0.071
elbow joint	133.2	(7.21)	137.1	(4.14)	136.8	(5.10)	133.7	(2.92)	0.306
front fetlock joint	65.6	(3.69)	66.2	(2.34)	64.2	(5.89)	62.3	(4.18)	0.423
hip joint	86.7	(6.88)	89.4	(11.81)	88.6	(8.48)	87.0	(6.75)	0.913
femur inclination	59.1	(7.82)	63.9	(11.52)	60.4	(6.61)	60.5	(5.25)	0.659
stifle joint	116.6	(7.74)	126.4	(13.58)	118.7	(11.87)	117.2	(7.03)	0.264
hock joint	140.8 [b]	(3.66)	147.3 [a]	(5.68)	146.0 [ab]	(2.82)	147.2 [a]	(3.08)	0.005
hind fetlock joint	65.7	(7.38)	64.9	(8.66)	68.7	(6.36)	68.8	(6.17)	0.581

Within the row, different letters represent significant difference ([abc] P<0.05 by Scheffe test).
SN=Short and Narrow; SW=Short and Wide; TN=Tall and Narrow; TW=Tall and Wide.

joint angle was larger in SW and TW than in SN (P<0.01).

Rider oscillation

The maximal harmonic waves in vertical and longitudinal axes correspond to the half-stride periodic motion at walk and trot. These facts were previously showed in which used both VTR- and accelerometer-based method [9], though stride frequency were not measured in this study. In the lateral axis, the maximal harmonic wave at which the frequency was half as high as the frequencies in the vertical and longitudinal axes corresponded to the one-stride periodic motion at walk and trot. Therefore, the frequency in the vertical or longitudinal axis is shown in this study.

The differences in rider oscillation between the four groups are shown in Table 3. When walking, the frequencies were higher in short horses than in tall horses (P<0.01). The amplitudes, both MHA and Arms, of the vertical axis were larger in narrow horses than in wide horses (P<0.05).

When trotting, the frequency was also higher in short horses than in tall horses (P<0.01). The amplitudes, both MHA and Arms, of the vertical axis were larger in tall horses than in short horses (P<0.01). The amplitudes, both MHA and Arms, of the lateral axis were larger in wide horses than in narrow horses (P<0.01). The Arms of the longitudinal axis was larger in tall horses than in short horses (P<0.05).

Evaluation of horses for therapeutic riding

The differences in evaluation of horses for therapeutic riding between the four groups were shown in Table 4. For 'greater agility', 'improvement of self-confidence', 'diplegia', 'quadriplegia', 'riders under 110 cm', and 'those from 110 to 140 cm', short horses had higher score than tall horses (P<0.01 or P<0.05). In contrast, for 'mounted exercise' and 'tandem riding with an instructor', tall horses had higher score than short horses (P<0.05 and P<0.01, respectively). For

Table 3. Differences in the rider's oscillation between the four groups

		SN	SW	TN	TW	P		
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Tall	Wide	Tall × Wide
Walk								
Frequency of longitudinal axis	(Hz)	1.91 (0.121)	1.86 (0.117)	1.68 (0.081)	1.68 (0.145)	<0.01	NS	NS
MHA of vertical axis	(mm)	14.6 (4.63)	9.1 (2.61)	13.3 (4.64)	10.7 (3.49)	NS	<0.05	NS
Arms of vertical axis	(mm)	18.8 (4.48)	14.4 (2.20)	18.5 (4.24)	15.8 (3.17)	NS	<0.05	NS
MHA of lateral axis	(mm)	9.9 (2.68)	8.4 (2.34)	10.0 (4.21)	11.8 (5.51)	NS	NS	NS
Arms of lateral axis	(mm)	14.6 (3.23)	13.1 (2.88)	14.3 (3.65)	16.5 (4.35)	NS	NS	NS
MHA of longitudinal axis	(mm)	18.4 (6.50)	17.2 (4.34)	17.7 (5.28)	19.1 (3.26)	NS	NS	NS
Arms of longitudinal axis	(mm)	23.0 (6.19)	22.7 (3.70)	23.2 (6.27)	24.6 (2.23)	NS	NS	NS
Trot								
Frequency of vertical axis	(Hz)	3.02 (0.186)	2.97 (0.173)	2.65 (0.148)	2.66 (0.160)	<0.01	NS	NS
MHA of vertical axis	(mm)	31.5 (8.80)	35.4 (5.40)	43.4 (4.76)	39.6 (2.25)	<0.01	NS	NS
Arms of vertical axis	(mm)	39.9 (7.83)	43.3 (3.87)	51.0 (5.53)	49.7 (3.83)	<0.01	NS	NS
MHA of lateral axis	(mm)	16.8 (3.74)	21.6 (4.14)	14.8 (3.93)	21.8 (4.79)	NS	<0.01	NS
Arms of lateral axis	(mm)	23.5 (4.50)	29.4 (4.13)	23.3 (4.29)	29.6 (4.79)	NS	<0.01	NS
MHA of longitudinal axis	(mm)	8.1 (2.69)	12.0 (3.50)	12.0 (3.28)	11.9 (2.74)	NS	NS	NS
Arms of longitudinal axis	(mm)	16.4 (4.21)	21.1 (4.72)	22.5 (4.99)	22.5 (3.41)	<0.05	NS	NS

Two-way ANOVA was used.
SN=Short and Narrow; SW=Short and Wide; TN=Tall and Narrow; TW=Tall and Wide.
MHA=maximal harmonic amplitude; Arms=amplitude root-mean-square value.

'learning the sense of balance', 'relaxation of muscular tension', 'mounted exercise', 'changing position', 'riding at prone position', 'hemiplegia', and 'hypertonic spasticity', wide horses had a higher score than narrow horses (P<0.01 or P<0.05). There was a significant interaction between tall and wide for 'learning to give depth of seat' (P<0.05).

Discussion

Generally, the withers height is the most popular index of equine conformation. This study showed significant correlations between the withers height and all indices other than distance between rider's knees (P<0.01), confirming the withers height as a basic index of equine conformation. The distance between rider's knees reflects not only body width but also width of back: It was large in the horse whose shape at back section was flat, while it was small in the horse whose shape at back was close to triangle. Therefore, the withers height and distance between rider's knees were the most suitable indices to roughly classify horses by their conformation. Furthermore, these two indices were easy to measure. Therefore, in this study, equine conformation was classified by the withers height and the trunk width.

The sidewalkers were often used to help the rider in the lesson of the riding for the disabled person. The leader has to lead the horse in consideration of the easiness to help for the sidewalkers. Therefore, the moving speed was not always decided by the priority to easiness of walk for a horse. As well as the literature (Matsuura *et al.*, 2003), the moving speed suitable for the lesson of the riding for the disabled person was set at 1.5 m/sec for walking and 3.0 m/sec for trotting in this study, although the equine oscillation were changed according to the moving speed.

Little work has been published on the effect of equine conformation on rider oscillation. The frequencies of rider oscillation both at walk and trot were higher on short horses than on tall horses in this study (P<0.01). These results were similar to that of Matsuura *et al.*, who studied Thoroughbred horses (withers height: 159 ± 6.1 cm) and Hokkaido native horses (withers height: 129 ± 2.3 cm) [8]. The MHA and Arms of vertical axis at walk were smaller on wide horses than on narrow horses in our study (P<0.05), and the MHA and Arms of vertical axis at trot were smaller on short horses than on tall horses (P<0.01). Barrey *et al.* showed that Andalusia horses whose withers height, back length, and forelimbs were smaller than German horses (Hanoverian, Oldenburger, and Westphalian) had smaller vertical amplitude than the German horses [2]. Although Barrey *et al.* investigated the amplitude of the horses but not the riders [2],

Table 4. Differences in evaluation of horses for therapeutic riding between the four groups

	SN Mean (SD)	SW Mean (SD)	TN Mean (SD)	TW Mean (SD)	P Tall	P Wide	P Tall × Wide
Learning the sense of balance	3.8 (0.7)	4.5 (0.8)	4.1 (0.5)	4.4 (0.5)	NS	<0.05	NS
Relaxation of muscular tensions	3.7 (0.7)	4.4 (0.7)	3.5 (0.8)	4.6 (0.5)	NS	<0.01	NS
Quantity of exercise (fatigue)	3.9 (0.9)	4.0 (0.5)	3.9 (0.5)	4.0 (0.7)	NS	NS	NS
Co-ordination of muscular movement	3.8 (0.7)	4.1 (0.6)	4.1 (0.7)	3.8 (0.8)	NS	NS	NS
Greater agility	4.1 (0.8)	4.1 (0.6)	3.9 (0.8)	3.2 (0.4)	<0.05	NS	NS
Improvement of self-confidence	4.8 (0.4)	4.8 (0.5)	4.2 (0.6)	4.2 (0.8)	<0.01	NS	NS
Learning to give depth of seat	3.2 (0.8)	4.1 (0.6)	3.7 (0.6)	3.6 (0.5)	NS	NS	<0.05
Learning eventual control of the horse	4.6 (0.5)	4.4 (0.5)	4.1 (0.8)	4.0 (0.0)	NS	NS	NS
Mounted exercises	3.9 (0.9)	4.3 (0.5)	4.2 (0.8)	5.0 (0.0)	<0.05	<0.05	NS
Changing position	3.2 (1.0)	3.9 (1.1)	3.2 (1.1)	5.0 (0.0)	NS	<0.01	NS
Riding at prone position	3.1 (1.1)	4.0 (0.9)	3.1 (1.0)	4.4 (1.3)	NS	<0.01	NS
Trotting	4.3 (0.5)	4.3 (0.5)	3.8 (1.0)	4.0 (0.7)	NS	NS	NS
Tandem riding with an instructor	2.0 (0.7)	2.1 (1.5)	3.0 (1.3)	4.4 (0.9)	<0.01	NS	NS
Monoplegia	4.3 (0.5)	4.4 (0.5)	4.2 (0.6)	4.4 (0.5)	NS	NS	NS
Hemiplegia	3.6 (0.9)	4.4 (0.5)	3.7 (0.6)	4.0 (0.7)	NS	<0.05	NS
Paraplegia	4.2 (0.7)	4.4 (0.5)	3.9 (0.7)	4.0 (1.0)	NS	NS	NS
Diplegia	4.3 (0.7)	4.0 (0.0)	3.6 (0.9)	3.2 (0.8)	<0.01	NS	NS
Quadriplegia	4.3 (0.7)	4.3 (0.5)	2.5 (0.9)	2.4 (1.1)	<0.01	NS	NS
Athetoid spasticity	3.7 (0.7)	4.0 (0.0)	3.5 (0.8)	3.8 (0.4)	NS	NS	NS
Hypertonic spasticity	3.7 (0.7)	4.0 (0.5)	3.5 (0.5)	4.2 (0.4)	NS	<0.05	NS
Hypotonic spasticity	3.8 (1.2)	4.0 (0.8)	3.3 (0.6)	3.2 (0.8)	NS	NS	NS
Ataxia	3.7 (0.5)	3.9 (0.4)	3.5 (0.8)	3.8 (0.8)	NS	NS	NS
Autism	4.2 (1.0)	4.1 (0.8)	3.9 (0.8)	3.8 (0.8)	NS	NS	NS
Mental retardation	4.2 (0.7)	4.1 (0.8)	3.9 (0.8)	4.6 (0.5)	NS	NS	NS
Under 110 cm	3.8 (1.1)	3.5 (1.2)	1.5 (0.5)	1.2 (0.4)	<0.01	NS	NS
From 110 to 140 cm	4.7 (0.5)	4.5 (0.5)	2.3 (0.9)	2.4 (1.1)	<0.01	NS	NS
140 cm or more	4.0 (1.2)	4.0 (1.3)	4.5 (0.5)	4.4 (0.5)	NS	NS	NS

Two-way ANOVA was used.
SN=Short and Narrow; SW=Short and Wide; TN=Tall and Narrow; TW=Tall and Wide.

similar results to them were obtained also in our study.

For the severely disabled rider, such as 'quadriplegia' and 'diplegia', short horses also had a higher score than tall horses (P<0.01). Using tall horses for such a severely disabled rider involves a high degree of risk, as the MHA and Arms of vertical axis at trot was large. Kendall's correlation coefficient between the score for 'quadriplegia' and the MHA, and between the score and Arms of vertical axis at trot was –0.54 (P<0.01), and –0.71 (P<0.01) respectively. Similarly, Kendall's correlation coefficient between the score for 'diplegia' and the MHA, and between the score and Arms of vertical axis at trot was –0.45 (P<0.01), and –0.55 (P<0.01) respectively. Therefore, short horses seemed to be suitable for severely disabled riders because they impart small MHA and Arms of vertical axis to the rider at trot. Short horses also had higher score than tall horses for 'the rider under 110 cm tall' and 'from 110 to 140 cm'. Side walkers are important in the lesson for the 'Quadriplegia', 'diplegia', and or 'under 140 cm tall' riders. Therefore, short horses were shown to be suitable for the rider who requires side walkers. Short horses had higher score than tall horses for 'greater agility' and 'Improvement of self-confidence'. To explain this reason, the influence of equine conformation and the rider oscillation on the rider's psychological development will have to be studied further.

Tall horses, however, had a higher score than short horses for 'tandem riding with an instructor' (P<0.01). Kendall's correlation coefficient between the score for 'tandem riding' and the body length was 0.52 (P<0.01). Tall horses obtained a high evaluation for 'tandem riding with an instructor' because they had a long body length.

Wide horses impart smaller MHA and Arms of vertical axis at walk (P<0.05) and larger MHA and Arms of lateral axis at trot (P<0.01) than narrow horses. Wide horses also had a higher score than narrow horses for many items. They obtained a higher evaluation for 'relaxation of muscular tensions' ($P<0.01$) and 'hypertonic spasticity' ($P<0.05$). Kendall's correlation coefficient between the score for 'relaxation of muscular tensions' and the MHA of lateral axis at trot was 0.39 ($P<0.01$). Kendall's correlation coefficient between the score for 'hypertonic spasticity' and the MHA of vertical axis at walk, and between the score and the MHA of lateral axis at trot were –0.28 ($P<0.05$), and 0.33 ($P<0.05$) respectively. These results showed that the small vertical oscillation at walk and large lateral oscillation at trot in wide horses possibly relieved muscular tension. Medical effects are not discussed in this study. However, the instructor evaluated horses by recognizing relationships between the oscillation transmitted to the rider and the rider's muscular tension.

Wide horses had higher score for 'learning the sense of balance' ($P<0.05$), 'mounted exercise' ($P<0.05$), 'changing position' ($P<0.01$), 'riding at prone position' ($P<0.01$), and 'hemiplegia' than narrow horses ($P<0.05$). 'Mounted exercise' means the lesson in which the rider exercises his or her upper limbs and the body on the horse's back. 'Changing position' means the lesson in which the rider consecutively changes their direction on the horse's back, such as facing the front, side, or tail. 'Riding at prone position' means the lesson in which the rider is over the horse's back perpendicular to the direction of travel. 'Hemiplegia' means palsy on one side of the upper and the lower limbs. 'Mounted exercise', 'changing position' ($P<0.01$), and 'riding at prone position' were often used in the lesson for the riders whose sense of balance is not good, such as 'hemiplegia'. Therefore, wide horses seemed to obtain a higher score for the rider who cannot keep a good balance on the horse. Accordingly, wide horses obtained a higher score for the rider whose sense of balance was not good.

According to the RDA, the instructor must select the horse with a conformation that suits the individual rider—wide or narrow, short or long stride, much or little back movement. The instructor must also match the height of horse to the helper [10]. The Garran version of the Highland pony, and the Fell pony, Connemara pony, Dale pony, and Welsh Cobs are all deemed suitable horses for instruction by the RDA. These are all breeds of British native horses. In our study, the differences between horses were taken to be the result of differences in equine conformation and not as the result of differences of breed, because the effects of differences of breed on rider oscillation would converge with differences in equine conformation. The British native horses mentioned above are similar to the short and wide horses in our study. The short and wide horses were evaluated more highly as horses for therapeutic riding than the other groups. Hokkaido native horses and Kiso horses are also short and wide horses. Therefore, these Japanese native horses have the potential to become good horses for therapeutic riding.

The characteristics of the rider's oscillation could be explained by the differences of the withers height and the trunk width of the horse. The RDA instructor evaluated the suitable horse for each rider with recognizing the riders' oscillation characterized by the conformation of the horse. Therefore, this study showed fundamental knowledge about the selection of the horse for the therapeutic riding and supported RDA instruction which had based on experience.

In conclusion, equine conformation was shown to influence rider oscillation. On short horses, the frequencies of rider oscillation both at walk and trot were higher, and the MHA and Arms of vertical axis and Arms of longitudinal axis at trot were smaller, than on tall horses. Short horses could be used for the rider who requires side walkers. On wide horses, the MHA and Arms of vertical axis at walk was smaller and the MHA and Arms of lateral axis at trot was larger than on narrow horses. Wide horses could be used for relieving muscular tension and for the rider who cannot maintain good balance on the horse. Thus short and wide horses should be suitable for therapeutic riding.

Acknowledgments

This works was supported by a grant from the Alumni Association, Faculty of Agriculture, Hokkaido University. The authors are grateful to Ms. Keiko Kikuchi, Ms. Masako Nakata, Mr. Akira Noguchi, and many volunteers in RDA Yokohama for assistance with field work. The authors thank the staff of Avalon Hillside Farm, Yokohama Riding Club, Eldorado Ranch, Sawashiroko Heartland Farm, Koyodai Kisouma Ranch, and Jinnai Farm 21.

References

1. Anderson, M. K., Friend, T. H., Evans, J. W., and Bushong, D. M. 1999. Behavioral assessment of

horses in therapeutic riding programs. *Appl. Anim. Behav. Sci.* **63**: 11–24.

2. Barrey, E., Desliens, F., Poirel, D., Biau, S., Lemaire, S., Rivero, J. -L. L., and Langlois, B. 2002. Early evaluation of dressage ability in different breeds. *Equine Vet. J. Suppl.* **34**: 319–324.
3. Bertoti, D. B. 1988. Effect of therapeutic horseback riding on posture in children with cerebral palsy. *Phys. Ther.* **68**: 1505–1512.
4. Cano, M. R., Vivo, J., Miró, F., Morales, J. L., and Galisteo, A. M. 2001. Kinematic characteristics of Andalusian, Arabian and Anglo-Arabian horses: a comparative study. *Res. Vet. Sci.* **71**: 147–153.
5. Holmström, M., Magnusson, L. -E., and Philipsson, J. 1990. Variation in conformation of Swedish Warmblood horses and conformational characteristics of élite sport horses. *Equine Vet. J.* **22**: 186–193.
6. Holmström, M., and Philipsson, J. 1993. Relationships between conformation, performance and health in 4-year-old Swedish Warmblood riding horses. *Livest. Prod. Sci.* **33**: 293–312.
7. Johnston, C., Holm, K., Faber, M., Erichsen, C., Eksell, P., and Drevemo, S. 2002. Effect of conformational aspects on the movement of the equine back. *Equine Vet. J. Suppl.* **34**: 314–318.
8. Matsuura, A., Takita, N., Shingu, Y., Kondo, S., Matsui, A., Hiraga, A., Asai, Y., Hata, H., and Okubo. M. 2003. Rhythm Analysis for Movements of Horse and Rider on a Treadmill by Sequential Still VTR Pictures. *J. Equine Sci.* **14**: 125–131.
9. Matsuura, A., Masumura, K., Chiba, Y., Nakatsuji, H., and Kondo, S. 2005. Analysis of rhythmical movements of both horse and the rider using accelerometer. *Animal Behaviour and Management* **41**: 5–11.
10. The Riding for the Disabled Association. 1990. Horses, Ponies and Donkeys. pp. 43–50. *In*: The RDA official manual, The Kenilworth Press, London.