VISCOELASTIC CHARACTERISTICS OF THE NEW VAULTING TABLE OF GYMNASTICS AND ITS EFFECT ON VAULTING PERFORMANCE

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INTRODUCTION

A new type of vaulting horse called "vaulting table" has been officially adapted in gymnastics since 2001. However, its mechanical property and effect on the vaulting performance have not been examined. The purpose of this study was 1) to estimate how viscoelasticity has been changed between the former vaulting horse and the vaulting table, and 2) to investigate how viscoelasticity of the new vaulting table affected the vaulting performance.

METHODS

The surface of both the vaulting horse (VH) and vaulting table (VT) were assumed as a viscoelastic model. The equation of damped oscillation was

$$x = Ae^{-D_1 t}\sin\left(\sqrt{\omega_0^2 - D_1^2}\,t + \alpha\right),\ \omega_0^2 = k/m,\ 2D_1 = D \qquad (1)$$

where m = mass, k = coefficient of elasticity, D = coefficient of viscosity.
Using the values derived from the regulation of the vaulting horse and table, their elasticity and viscosity were calculated.

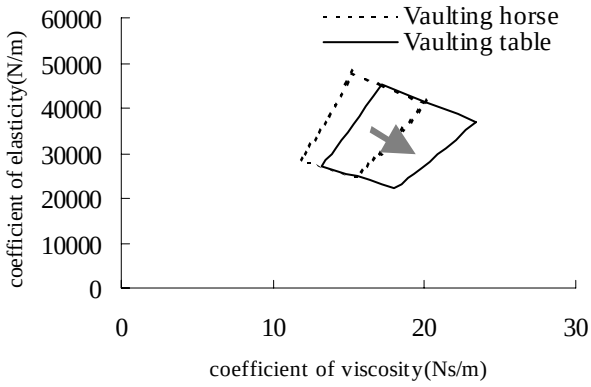
Table 1: Parameters for vaulting horse and vaulting table.

	Deflection (mm)	Height of rebound (mm)	F_{max} (N)
Vaulting horse	34≦ h≦ 44	150≦ h≦ 200	≦ 2200
Vaulting table	34≦ h≦ 44	120≦ h≦ 180	≦ 2500

Vaulting motions were recorded by two high-speed video cameras, during Men's vaulting horse event at international gymnastic competition (Chunichi cup) before (2000) and after (2001) alteration of the vaulting horse regulation. As one gymnast performed a handspring double somersault vault using both types of the vaulting horses (VH and VT), these two trials were chosen to compare the effect of viscoelasticity on his vaulting performance.

RESULTS AND DISCUSSION

Elasticity of the VT was smaller than that of the VH (Figure 1). This suggests that gymnasts would suffer a smaller shock



force from the VT than that of the VH.
Figure 1: Coefficient of elasticity and viscosity of vaulting horse and vaulting table

In contrast, the impulse from the VT to the gymnast was larger than that of the VH (Table2) during hand-horse contacting. Consequently, gymnasts may launch from the vaulting horse with a greater vertical velocity, which resulted in a higher post-flight trajectory. In addition to smaller elasticity, a peculiar shape of the VT; wide and tilt surface, also may account for this.

Table2： Kinematic and kinetic data of vaulting horse and vaulting table

			Vaulting horse	Vaulting table
Pre-flight	Velocity at horse contact(m/s)	Horizontal	4.53	4.75
		Vertical	3.25	3.19
		resultant	5.59	5.73
	Angular momentum on pre-flight(kgm^2/s)		83.41	92.28
Hand placement	impulse(N･s/WT)	Horizontal	-0.96	-1.66
		Vertical	1.69	1.91
		resultant	1.94	2.53
	Angle of impulse(deg)		60.32	49.04
Post-flight	Velocity at horse take-off(m/s)	Horizontal	3.57	3.09
		Vertical	3.37	3.54
		resultant	4.92	4.70
	Angular momentum on post-flight(kgm^2/s)		56.90	59.43
	Maximum height of CG in post-fright(m)		3.00	3.12