THE EFFECT OF INCLINED ERGOMETER ON ROWING PERFORMANCE

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INTRODUCTION

Rowing is a sport that demands a high technical skill level as well as strength and other physiologic requirements. Rowing ergometers have been used widely for both testing and training of the rowers. The rowing stroke consists of a cyclic sequence of events that involves the catch, the drive phase, the finish, and the recovery (Klavora, 1976; Mahoney, 1978; Mickelson & Hagerman, 1979; Nelson & Widule, 1983; Lamb, 1989). During the leg drive phase, rapid and simultaneous extension of hip, knee and ankle provides the major source of power (Hagerman, 1984). Lamb (1989) indicated that the trunk segment contributed significantly more to the drive phase portion of the rowing cycle although the legs initiated the drive phase. In order to understand the effect of the trunk, we designed an inclined platform. The rowing ergometer was stabilized on this inclined platform. We assume that the rower will increase the range of motion (ROM) of the trunk on the inclined ergometer. This concept was form when people standing on the inclined ground, then people will use ankle strategy, hip strategy or mixed ankle-hip strategy for maintain the upright. Therefore, the purpose of this study was to investigate the effect of inclined ergometer on rowing performance.

METHODS

Seven female rowers (age 21.1 ± 1.2 yr, height 1.64 ± 0.03 m, body mass 58.99 ± 4.13 kg) belonging to the national team of Taiwan volunteered for this study. The Concept II rowing ergometer (Model C) was stabilized on the inclined platform which inclined angle can be adjusted (Figure 1). One JVC digital camera (60Hz) was synchronized with a strain gauge (600Hz) that was inserted between the chain and the handle (Figure 2). The strain gauge and kinematic data were synchronized by using a simple circuit that simultaneously lit an LED and sent a voltage signal to the Biovision input box.

Each rower performed a 6-min maximal test (6MMT) under both level and inclined at 10°. Each test had to be done on two different days. Prior to each test, the rowers were asked a 15 min warm up. 6MMT was divided into four phases: 0 min (I), 2 min (II), 4 min (III), and 5.5 min (IV), and each phase consisted of 10 strokes. Five body landmarks (shoulder, hip, knee, ankle, and toe of left side) were both digitized and framed by Peak Performance for Window 98 Motus 7.0 system. A second-order Butterworth recursive digital filter was used to model the raw data (Nelson & Widule, 1983). The joint angles at the knee, hip, and the inclination of the trunk were defined according to the convention shown in Fig. 3. In this study, the discussion of the ROM was only focused on phase II. Differences between mean values were analyzed by t-test for paired samples. The significant level was set at 0.05.

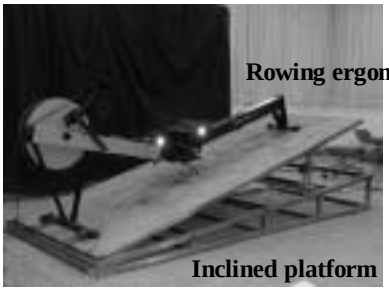

Figure 1: The experimental setup.

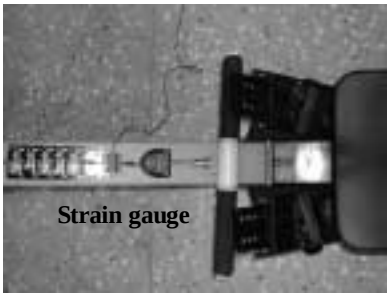

Figure 2: The strain gauge.

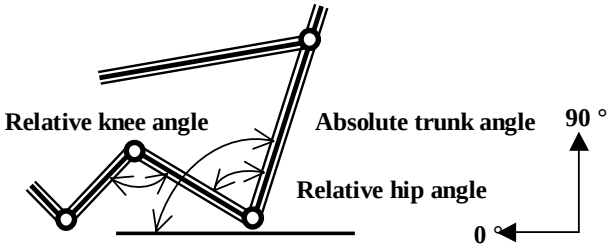

Figure 3: The joint angles at the knee, hip, and trunk.

RESULTS AND DISCUSSION

Table 1 presented a list of the two rowing distances and stroke rates. The result indicated that the rowers had significantly longer rowing distance while rowing ergometer in level. This result may be attributed to an extra part of body mass required by the lower limbs during the drive phase of rowing at the inclined platform. Due to this higher loading, the lower extremity might fatigue more easily. However, there was no significant difference in the stroke rate.

Table 1: Rowing distance and stroke rate (mean ± SD)

	Distance (m)	Stroke Rate (strokes/min)
Level	1476.29 ± 34.93*	28 ± 3
Inclined at 10°	1424.57 ± 36.80*	27 ± 3

* Significant different, p< .05

As shown in Table 2, the ROM of hip and trunk were significantly larger in inclined platform than those in level during the rowing cycle. Moreover, the minimal and maximal trunk angles were significant difference between the level and the inclined. This result was attributed to the different initiating position of the trunk in the inclined platform. While rowing at the inclined platform, the rower's minimal trunk angle was 10° less than that at level; however, the rower's maximal trunk angle was only 6° less than that at level. Therefore, the result also indicated that this increased ROM of the trunk was resulted from the backward extension of the trunk. Hence, this inclined equipment might advantage to train the trunk.

Figure 4 shows the pattern of peak force of seven rowers during 10 strokes of each phase. Both on the level and inclined platform, the peak force decreased from the first stroke to the last, and this pattern was similar to the previous study (Hartmann, Mader, Wasser, & Klauer, 1993).

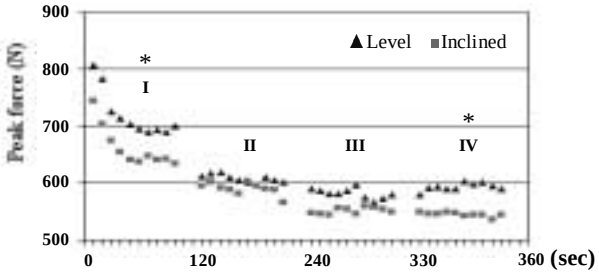

Figure 4: Peak force at each stroke during the 6 MMT.

From the result of this study, the average peak forces (10 strokes) on both phase I and IV was significantly greater in the level than those in the inclined (Table 3). This phenomenon was caused by the rowers sprinted at the beginning and before the end. Therefore, on these two phases, an extra loading for the lower extremity had greater influence on the force produced.

SUMMARY

This equipment, the inclined rowing ergometer, is helpful for rowers without enough backward trunk extension.

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Table 2: The range of motion of the limbs and the angles at hip and trunk (mean ± SD)

	Range of Motion (°)			Hip Angle (°)		Trunk Angle (°)	
	Knee	Hip	Trunk	Min.	Max.	Min.	Max.
Level	110.8 ± 4.8	104.7 ± 8.1*	73.3 ± 9.2*	26.7 ± 6.8	131.4 ± 4.7*	232.1 ± 7.5*	305.8 ± 2.5*
Inclined at 10°	106.8 ± 6.0	111.3 ± 5.5*	78.2 ± 6.6*	25.8 ± 3.7	137.2 ± 3.0*	221.8 ± 4.9*	299.6 ± 2.2*

* Significant different, $p < .05$

Table 3: The average peak force at each phase (mean ± SD)

	Phase I	Phase II	Phase III	Phase IV
Level	720.0 ± 75.8*	607.7 ± 51.5	581.4 ± 64.0	593.3 ± 64.0*
Inclined at 10°	661.9 ± 84.2*	589.8 ± 49.0	551.5 ± 49.7	544.8 ± 51.6*

* Significant different, $p < .05$