

FOOT PRESSURE STUDY DURING PULLING PHASE OF SNATCH LIFTING

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The feet act as a supporting base during the snatch lifting. Four weightlifters participated in the study in order to understand the mechanism of the applying force. The PEAK 5 video analysis system and the EMED Pedar insole system were used. Results revealed no significant differences ($P < .05$) between the force-peaks of the foot. In phase 1, COP moved backward to the center of the foot to assist lifters maintain equilibrium. In Phase 2, the "double knee bend" technique helps barbell to obtain sufficient velocity. The Forefoot Area bear the maximal force in Phase 3 and significant correlation ($P < .01$) was found between the FA force-time integral and the barbell impulse in Phase 3. Also, the ankle plantar flexed causing the COP to move forward to increase barbell velocity in phase 3.

KEY WORDS: foot pressure, snatch lifting

INTRODUCTION: Weightlifting was usually studied in terms of kinematic and kinetic parameters by various researchers (Garhammer, 1985; Baumann et al., 1988; Lee et al., 1995; Gourgoulis et al., 2000). During the lifting process, the feet become a supporting base to maintain balance and to facilitate the movement of the barbell as the forces applied on it by the weightlifter (Gourgoulis et al., 2000). Thus, an understanding of the feet react to the ground as well as the movement would be very valuable for coaches (Garhammer, 1984).

METHODS: Subjects: Four healthy weightlifters (2 males and 2 females) from the National College of Physical Education and Sports in Taiwan participated in this study. The mean (SD) age, height, and body weight of these subjects were 21.5 (1.1) years, 161.0 (14.0) cm, and 68.9 (16.4) kg respectively. The categories they joined recently were 53 kg, 77kg and 94kg and their best snatch weights were 80kg, 65kg, 135kg and 140kg.

Measurement of parameters: The analysis focused on the pulling phase from the beginning of the barbell lift-off to the second pulling phase when the right knee extending to it's maximum angle. Definitions of pulling phase, knee angle and masks that divide foot into several portions were as follows:

1.The lifting phase: the snatch lifting was divided into three phases (Fig.5) according to the change of right knee angle (Gourgoulis et al., 2000). The first pull (Phase 1) was from the barbell lift-off to the first maximum knee extension. The transition between the first and the second pull (Phase 2) was from the first maximum knee extension to the first maximum knee flexion. The second pull (Phase 3) was from the first maximum knee flexion until the second maximum extension of knee.

2.The joint angle: in Fig.1, the angular displacements of the ankle, knee and hip joints in the sagittal plane were calculated.

3.The masks to split right foot: force would centralize in different parts of foot with the moving of body (Rome et al., 1991). In snatch lifting, the trunk moved forward and backward so we split right foot into forefoot area (FA) and hind foot area (HA) liking Fig.2.

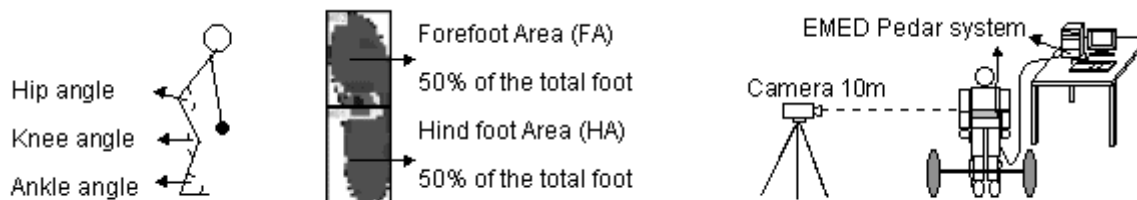


Figure 1: The joint angles. Figure 2: The split foot. Figure 3: Arrangement of instruments.

Data collection and treatment: Each subject executed four snatches with 80% of their best record. One video camera (Panasonic AG-456, 60Hz) was placed 10m from the subject and perpendicular to the sagittal plane. The EMED Pedar insoles system (Fig.3) was used to collect plantar pressure. The PEAK 5 software was used to get kinematic data with a Butterworth digital filter (cut-off frequency: 6Hz) to reduce noise (Lee et al., 1995). The Novel-win software was used to analyze foot pressure measurements. The feet's COP was used to estimate subjects' balance condition and force-peaks were compared by t-test. Kinematic data (joint displacement, joint angle and barbell displacement), COP and ground action force of foot areas were analyzed to study the acting force.

RESULTS AND DISCUSSION: The balance of weightlifters:

According the COP line in Figure 4 (the representative of a general behavior), the COP moved between l't and r't foot during lifting. Figure 5 (the representative of a general behavior) showed there were two force-peaks in Phase 1 and Phase 3. Although one foot's force-peak were bigger than the other, but they weren't different significantly (Table 1, P>.05). Isaka et al. (1997) compared the symmetry index (100-|(l't force-peak - r't force-peak)/r't force-peak x100|) between eight skilled weightlifters and six football players. They found weightlifters were more symmetrical than football players. Chen and Wu (1991) used LIDO system dynamometer to investigate 13 Taiwan national level weightlifters' isokinetic strength of knee extensors and flexors in 60 °/s, 180°/s and 300°/s. The results reveled all dominant legs' peak torque/body weight were higher, although not significantly (P>.05). By their explanation, it was because the athletes were demanded to symmetrize in training. It's suggested that the weightlifters should maintain balance during lifting by forcing the feet symmetrically.

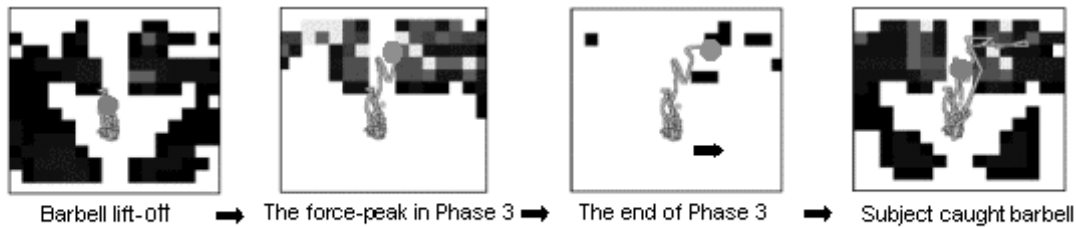


Figure 4: The COP line formed by subject's two feet during snatch lifting.

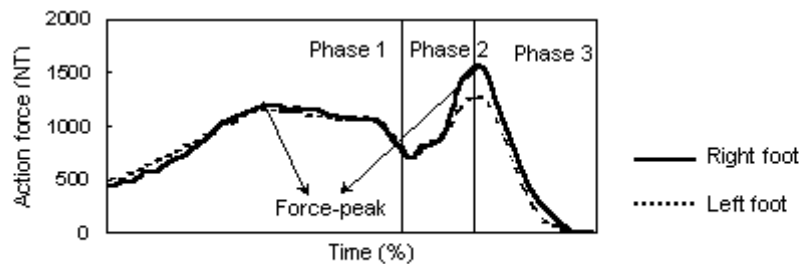


Figure 5: Force-time relationship of action force of right and left foot.

Table 1: Different analysis of force-peaks in Phase 1 and Phase 3.

Phase	Bigger force-peak of one foot		Smaller force-peak of the other		t value	P value
	Average (NT)	SD	Average (NT)	SD		
Phase 1	687.84	44.56	624.31	38.60	3.05	.239
Phase 3	896.84	67.08	840.41	44.43	1.98	.251

*P < .05

Table 2: Correlation between barbell impulse and force-time integral of foot area in Phase 2

Variable	Total foot force-time integral	HA force-time integral	FA force-time integral
Barbell impulse	0.732*	0.005	0.766*

*P < .01

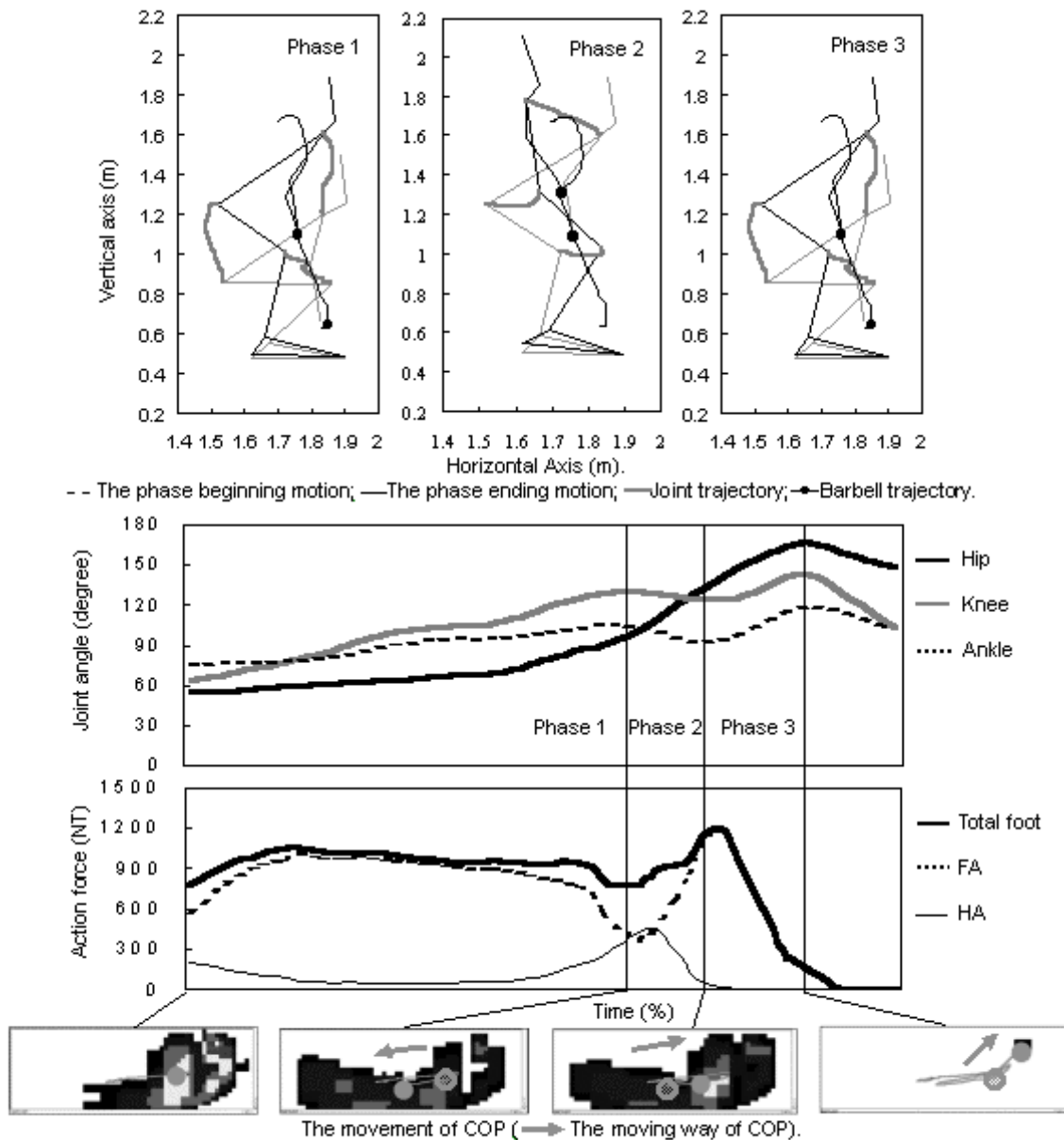


Figure 6: Parameters of kinematics and foot pressure.

The means of foot forcing to the ground: In snatch lifting, joint angle displacement, barbell and joint trajectories were important to observe and the whole pulling of could be divided into several phases to assess weightlifters. In phase 1 of Figure 6, ankle, knee and hip joint were extending, Barbell and knee moving backward, Hip and shoulder moving upward and COP was moving backward. So action force of foot centralized on FA in the beginning and distributed equally on FA and HA at the end. The barbell and knee moving backward would cause COP moving backward to the center of foot (Garhammer, 1984). Therefore, if the weightlifter could control the motion of COP around the center of the feet, it would help to maintain equilibrium.

After Phase 1, hip joint kept extending. Knee and ankle flexed slightly. Knee trajectory moving forward and resulted in action force of foot centralizing on FA and COP moving forward. This technique was called “double knee bend” (Gourgoulis et al, 2000) and it could store elastic energy to facilitate the stretch reflex of the knee extensors to develop the explosive muscle power in Phase 3 (Enoka, 1979). This technique was helpful for muscle power and it also made action force of foot centralizing on FA. Table 2 revealed Total foot and FA force-time integral in Phase 2 correlated significantly ($P < .01$) with barbell impulse in Phase 3. So we could

understand the phenomenon of action force of foot centralizing on FA resulted from the “double knee bend” technique was helpful for barbell to obtain enough velocity.

As mentioned by Gourgoulis et al. (2000), during the second pull, the hip was explosively extended, followed by extension of the knee. Then, the lifter used a powerful ankle plantar flexion to raise the heel. Hip, knee and ankle extended to maximum angles at the end of Phase 3. According to Weide (1989), the powerful ankle plantar flexion had been used by many elite weightlifters and was essential for the vertical acceleration of the barbell, contributing about 10% of the maximum barbell velocity. Consequently, the foot action force centralizing on FA and COP moving forward continuously were achieving the ankle plantar flexion and increasing the vertical acceleration of the barbell.

CONCLUSION: The parameters of foot pressure and kinematics of snatch lifting were analyzed to study how weightlifters acquire equilibrium and how they put force to the ground. The results revealed that COP moved around the center of feet during pulling phase of snatch lifting and the force-peaks between the foot weren't different significantly ($P < .05$).

In phase 1, barbell and knee moved backward resulted in COP moving backward to the center of feet. In Phase 2, Knee and ankle were flexed slightly to achieve the “double knee bend” technique that making barbell to get enough velocity in Phase 3 and would result in action force of foot centralizing on FA. Statistical data proved FA force-time integral in Phase 2 was correlated significantly ($P < .01$) with barbell impulse in Phase 3. So action force of foot centralizing on FA is helpful for observing if weightlifters achieve the “double knee bend” technique that was also helpful for barbell in getting enough velocity in Phase 3. In phase 3, the ankle plantar flexed to increase barbell velocity. So COP moving forward accordingly.

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