CONTRIBUTION OF THE KNEE JOINT TO MECHANICAL ENERGY IN CROUCHING START ACCORDING TO THE BACKWARD BLOCK INCLINED ANGLE INCREASE

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The purpose of this study was to analyze the contribution of the knee joint to mechanical energy in crouching start according to the backward block inclined angle increase(F, F1, F2). Using kinetic and kinematic data from 3 university sprinters participating in this study we calculated the energies absorbed and generated by the knee joints. The analysis is limited to a two-dimensional (sagittal plane) exercise. Comparing mean values of the energy absorbed and generated from lower extremity joints of each subjects according to backward block inclined angle increase (F, F1, F2). We generate a ratio of a total energy absorbed and generated from lower extremities to one from knee joints.
The generated energy of knee joints during start was the highest for all subjects and the absorbed energy of those was the lowest at 55 degree of backward block angle, or F, for subject 1, 50 degree for subject 2, and 50 degree for subject 3.

KEY WORDS: crouching start, mechanical energy, backward block

INTRODUCTION: Direct muscular action of lower extremities on block is very important in crouching start and can be a determinant on mechanical absorbed and generated energies of joints using the joint energy method (Stefanyshyn & Nigg, 1998). The joint energy method has been commonly used to analyze the training effect of sprinters, or motion analysis (Buczek & Cavangh, 1990; Czerniecki, Gitter & Munro, 1991; Devita, Stribling, 1991; Martin, Heise & Morgan, 1993). This method is expected to be useful to estimate mechanical energy of lower extremity joints that stay a still in start. To accelerate a propulsive force in start efficient muscular power generation is mandatory and each sprinter can choose a start type considering of body condition himself. So we proposed that anterior mechanical energies of knee joints, continuously propelling a body against block in concordance with block angle changes, could be different. This study was about the analysis of mechanical energy of knee joints according to an angle change of posterior block in sprinter's start, which were on a condition of the mentioned above.

METHODS: Three male sprinters (height 180-182 cm, mass 72-87 kg, age 21-24 yr, career 5-7 yr, record 10'90-11') volunteered as subjects for the study. Three trials were collected at 0.35 ± 0.05 sec. on each subject while wearing their own sprinting. Kinetic data were collected with a force platform (AMTI, BP400800, USA) sampling at 1080Hz. We put crude rubber plate 1.6 cm in thickness having a strong frictional resistance on a force platform to put a start block on a force platform and fix it firmly to minimize a motion of rubbler platform. Kinematic data were collected simultaneously with the kinetic data using a four CCD camera video system(Visol, Korea) sampling at 60 Hz. Reflective marker(1 cm in diameter) were applied over greater trochanter, lateral epicondyle, lateral malleolus, shoulder(lateral acromion process of the scapula). Additional markers were placed on the back edge of the shoe at mid-upper height and on the fifth metatarsal head. Camera shuttler exposure time was fixed as 1/500 and subjects started to run with a visual response to lightening under a control of researcher.

RESULTS AND DISCUSSION: Table 1 showed average energy absorbed and generated at the hip, knee, ankle joint. Generated energy was highest as following; Subject 1 51.69 J at an angle of F, subject 2 40.5 J at F(+1), subject 3 24.52 J at F.
These data were relatively higher than 25.3 J of knee energy generated in sprinter (Stefanyshyn & Nigg, 1997) and slightly lower than 61.9 J of running vertical jumps and 52 J of running long jumps (Stefanyshyn & Nigg, 1998). At F (+2) minor energy absorption occurred 1.15 J for subject 1, 1.15 J for subject 2, and 0.74 J for subject 3 which were attributable to anterior motion of a body while preparation without a warming-up, very high

knee energy absorption in gait motion at 30 to 36 J (Winter, 1983; Buczek & Cavangh, 1990), and in running knee energy absorbed was relatively lower at 11.4J compared with the other motions (Stefanyshyn & Nigg, 1997).

Table 1 Average energy absorbed and generated at each joint of the lower extremities.

Subject	Block angle	Hip energy		Knee energy		Ankle energy	
		Absorb[J]	Generate[J]	Absorb[J]	Generate[J]	Absorb[J]	Generate[J]
1	F	6.48	3.92	0.07	51.69	8.56	0.68
	F1	8.83	3.64	0.25	49.67	16.64	3.92
	F2	7.56	1.71	1.15	25.72	7.44	2.33
2	F	0.96	5.64	0.0	24.31	0.36	4.31
	F1	8.91	1.67	0.0	40.5	0.52	2.28
	F2	16.55	3.3	0.09	34.17	0.78	2.17
3	F	0.72	2.85	0.37	24.52	1.69	1.41
	F1	1.08	1.99	0.72	10.78	0.21	3.84
	F2	0.0	17.36	0.74	8.59	0.09	9.02

Backward Block Inclined Angle; subject 1-F(55°), F1(60°), F2(65°), subject 2-F(45°), F1(50°), F2(55°), subject 3-F(50°), F1(55°), F2(60°)

Among mechanical energies of lower extremities knee joint contribution was the same depicted in Figure 1.

Knee joint contribution to lower extremity mechanical energy was the following; For subject 1 & 2 about 0.5% & 0% at F, 0.9% & 0% at F1, and 7.1% & 0.5% at F2 in terms of energy absorbed and about 98% & 70% at F, 86.8% & 91% at F1, and 86.4 % & 86% at F2 in terms of energy generated respectively were of high knee contribution. For subject 3 contribution of energy absorbed was relatively higher than ones in the other 2 subjects 13.3% at F, 35.8% at F1, 89% at F2 and contribution of energy generated was high in knee joint 85.2% at F, 64.9% at F1, and 89.2% at F2. Energy ratio absorbed in knee joint among lower extremities was 31% in vertical jumping and 28% in long jumping and energy ratio generated was about 25% (Stefanyshyn & Nigg, 1998).

Through sprinting absorbed energy ratio in knee joint among lower extremities while lower extremity was touching to the ground was 7.5% and generated energy ratio 12.7% (Stefanyshyn & Nigg, 1997) in which higher generated energy ratio and lower absorbed energy ratio were gained comparing with the other studies. It was noteworthy that energy generated in lower extremity was mostly gained from knee joint and absorbed energy ratio was lower in knee joint. We also noticed that the higher energy absorbed of joint among a total of energy absorbed in lower extremity in start was the lower energy generation ratio. So block angle making high energy generated and low energy absorbed could be an efficient index of muscular action involving in knee joint motion in start.

CONCLUSION: In start energy generated in knee was highest and energy absorbed lowest at backward block angle of F(55°) for subject 1, F1(50°) for subject 2, and F(50°) for subject 3 and the same result was in terms of relative energy contribution, which findings were pertinent to muscular action.

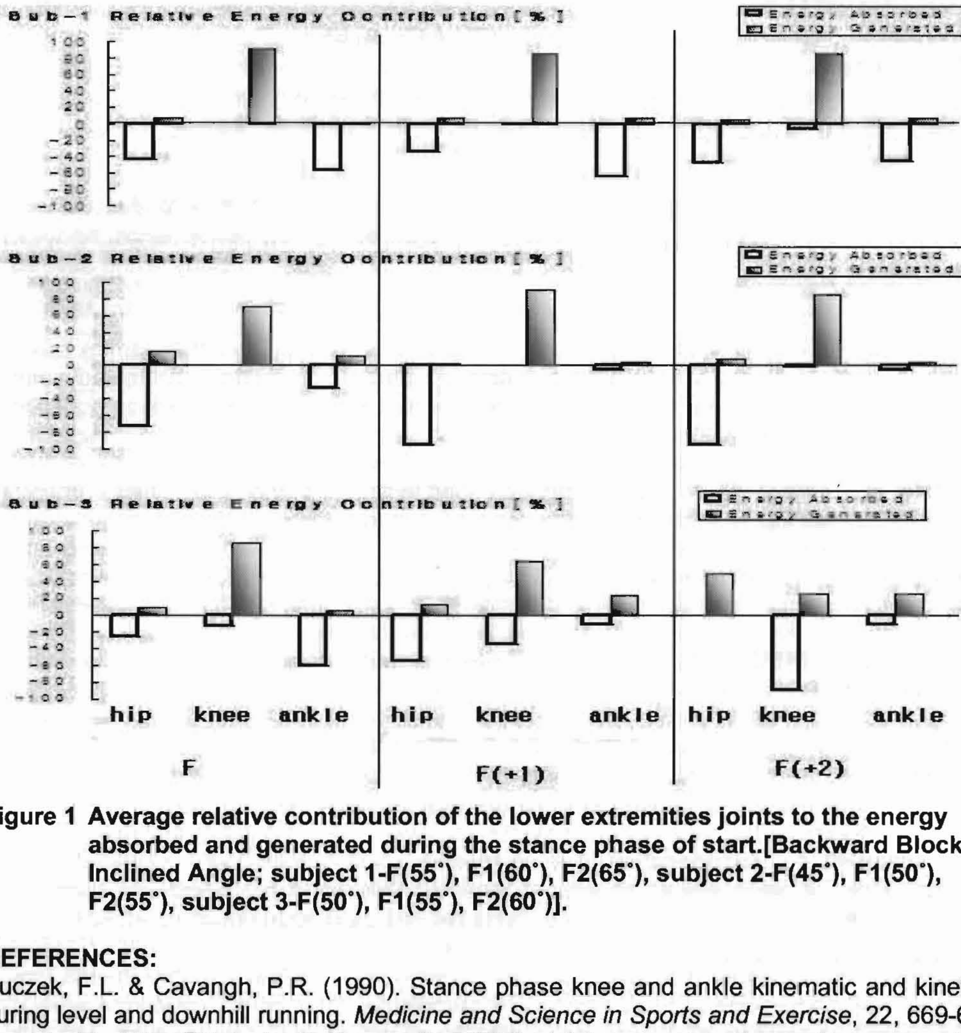

Figure 1 Average relative contribution of the lower extremities joints to the energy absorbed and generated during the stance phase of start.[Backward Block Inclined Angle; subject 1-F(55°), F1(60°), F2(65°), subject 2-F(45°), F1(50°), F2(55°), subject 3-F(50°), F1(55°), F2(60°)].

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