THE EFFECT OF STEP-HEIGHT ON THE KNEE ANGLES AND IN-SHOE PRESSURE DISTRIBUTIONS DURING STEP-AEROBICS

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INTRODUCTION

A recent trend in indoor exercise is step-aerobics. This form of aerobic exercise involves the rhythmic stepping up to and down from a fixed platform to the beat of the accompanying "pop" music. In the past, substantial research has been done on the kinematics of the climbing of actual architectural stairs (Andriacchi et al., 1980; McFayden and Winter, 1988; Laubenthal et al., 1972) but no studies, to date, have been done to explore the kinematics of this new fitness phenomenon. Therefore, the purpose of this investigation was to study the biomechanics of step aerobics. Specifically, the effect of the step-height on the knee angles and in-shoe pressure distributions of subjects performing step aerobics was evaluated. It was hoped that the results of this study could be used to help determine any possible biomechanical health concerns of participation in step aerobics.

METHODS

Ten female college students with a mean age of 22.7 yrs ± 2.9 and a mean mass of 59.2 kg ± 6.4 were used as subjects in this investigation. Their average leg length, measured from the greater trochanter to the lateral malleolus, was 80.6 cm ± 2.7.

Retro-reflective markers were placed on each subject on the following anatomical landmarks: the greater trochanter, the lateral aspect of the tibia/femoral junction, and the lateral malleolus. An in-shoe pressure sensor (Tekscan in-shoe measurement system) was placed inside the subject's right shoe in order to measure the in-shoe pressures resulting from the stepping action. The subject then stepped at a cadence of 120 bpm at three different step heights (low - 10.4 cm, medium - 15.6 cm, and high - 21.2 cm). As the subject was stepping, a 200 Hz high speed video camera recorded the action. The in-shoe pressures were also collected at this time utilizing the Tekscan system.

RESULTS and DISCUSSION

Significant differences were found between the knee angles at step platform contact for all three heights (73.56° for the high condition, 63.98° for the medium condition, and 53.49° for the lowest condition). These differences can be explained by the increases in knee flexion necessary for the subjects to lift their feet up to the higher platform levels. Because high patella-femoral compressive forces are associated with large amounts of knee flexion during weight bearing, this increase in knee flexion angle with step height may be of concern for individuals with, or pre-disposed to, certain knee injuries. Therefore, it may be warranted to advise these individuals to limit step height to the low or medium levels. Figure 1 illustrates the knee angle for one subject during contact with step platform.

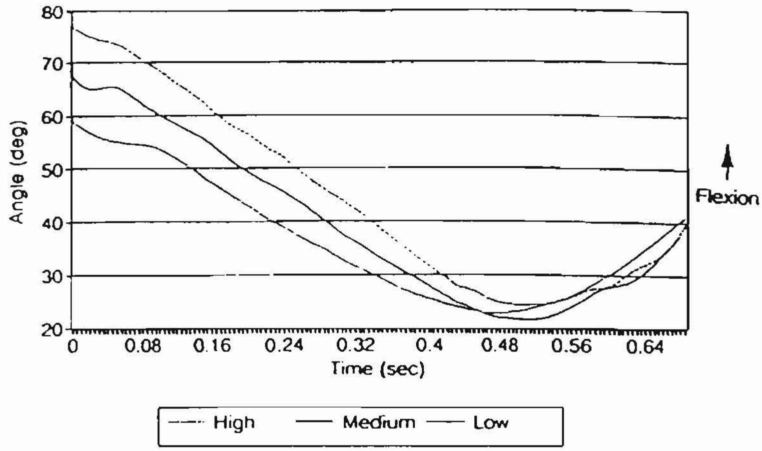

Figure 1. Knee angle while in contact with the step platform.

When the knee angles at the time of ground contact were examined, the reverse was found to be true. The largest angle at contact occurred at the lowest height (27.07°), and the smallest knee angle occurred at the highest height (22.79°). Figure 2 illustrates the knee angles for one subject during ground contact.

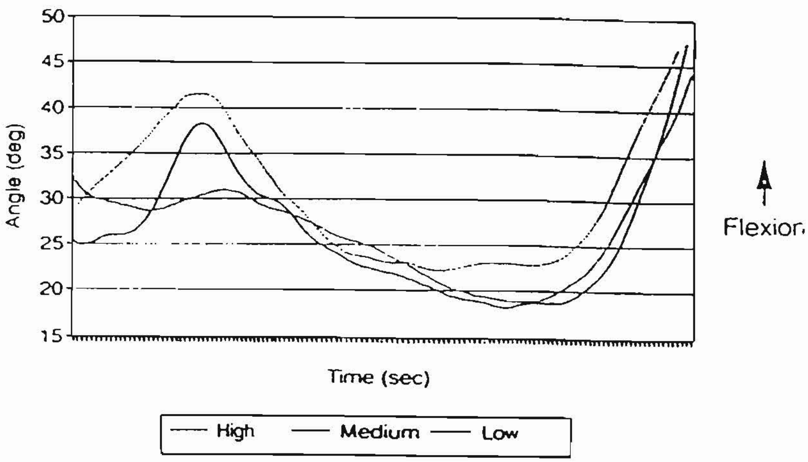

Figure 2. Knee angle while in contact with the ground.

The subjects exhibited significantly less knee extension at the high condition (23.13°) while on the step platform as compared to the low (16.86°) and medium (18.84°) height conditions. This may have been due to the cadence that the subjects had to follow in order to successfully complete each stepping cycle. Since they started at a higher initial knee angle of flexion at the higher platform height and had a longer vertical distance to travel, they perhaps did not have enough time to achieve the maximum extension value attained at the two lower heights and still remain on pace with the required cadence.

There were no significant differences found in the knee angles at toe-off for the subjects on either the step platform or on the ground nor at any of the three height conditions. Additionally, no significant differences were found for the maximum knee flexion values which occurred while the subjects were on the ground.

Table 1. Mean values (± sd) and statistical analyses for knee angle parameters.

	Step Height						
	High		Medium		Low		P-value
On the step platform							
Angle @ contact	73.6	(3.3)	64.0	(4.4)	53.5	(5.8)	0.000 a
Max. extension	23.1	(9.9)	18.8	(9.0)	16.9	(6.9)	0.001 b
Angle @ toe-off	38.8	(9.1)	37.4	(8.0)	36.6	(7.3)	0.181
On the ground							
Angle @ contact	22.8	(6.9)	23.6	(5.0)	27.1	(5.3)	0.018 c
Max flexion	26.1	(7.4)	26.5	(6.6)	22.6	(6.5)	0.121
Max. extension	16.0	(8.4)	12.5	(7.2)	10.8	(6.6)	0.019 d
Angle @ toe-off	49.6	(8.9)	48.4	(7.4)	47.3	(8.1)	0.343

$p<0.05$ a- High>Medium>Low; b- High>Medium and Low; c- High<Low; d- High>Low

Mean values (± sd) and statistical analyses for the in-shoe pressure data are presented in Table 2.

Table 2. Mean values (± sd) and statistical analyses for peak in-shoe pressures.

	Step Height						
	High		Medium		Low		P-value
On the platform							
Rearfoot	166.7	(41.5)	170.8	(48.3)	170.4	(45.8)	0.843
Forefoot	172.7	(44.0)	177.9	(47.7)	184.8	(51.2)	0.246
On the ground							
Rearfoot	224.4	(56.4)	218.1	(59.6)	216.0	(54.0)	0.486
Forefoot	177.2	(46.8)	173.0	(48.2)	188.4	(53.3)	0.182

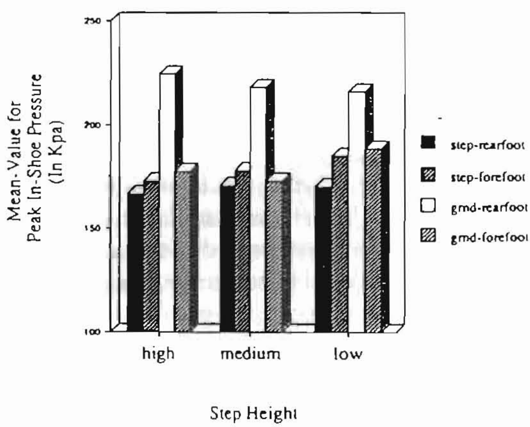

Figure 3. Peak in-shoe pressures while stepping.

The analysis of the in-shoe pressure data also revealed an interesting trend. The peak in-shoe pressures, while in contact with the ground, were found to be greater in the rearfoot region than in the forefoot region of the subjects' feet for all three step-height conditions. During ground contact, the subjects landed with forefoot-heel contact patterns. The higher pressure in the rearfoot region probably resulted from rapidly lowering the body onto the rearfoot. This pattern may have important implications for the design characteristics of specialized step-aerobic fitness shoes. In view of these pressure gradients, step-fitness shoes should be constructed with sufficient cushioning in the rearfoot region in order to absorb these potentially harmful higher pressures. Figure 3 illustrates the mean peak in-shoe pressures for all subjects during step platform and ground contact.

REFERENCES

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