THE EFFECT OF HIGH AND LOW BASKETBALL SHOES ON SUBTALAR JOINT PRONATION AND SUPINATION

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Injury is the biggest problem facing the athlete. It is difficult to ascertain the etiology of chronic overuse injuries which can develop, however, various sports appear prone to specific injuries. Basketball is an example of a sport which incorporates many different kinds of movement patterns.

This study was conducted in three phases to investigate the effects of four shoe/tape conditions on forward running, landing from a jump and lateral movement These conditions included high basketball shoe without tape (HS) and with tape (HT) and low basketball shoe without tape (LS) and with rape (LT).

Clinical as well as scientific researchers have reported that knee pain is the primary reason for runners to discontinue their running programs. Hlavac (1977) has postulated that excessive pronation of the subtalar joint is perhaps the underlying causative factor for that reported knee pain. Bates, Osternig, Mason, & James (1979). state that maximum pronation must occur simultaneously with maximum knee flexion because both are accompanied by internal tibial rotation.

These actions must reach maximum levels simultaneously or the two joints act antagonistically. While excessive pronation is associated with knee problems, excessive supination of the subtalar joint is associated with ankle problems. Excessive supination may cause a strain on the lateral ligaments of the ankle thus producing the "inversion" type sprain.

To prevent these sprains athletes have employed external support such as tape or commercial wraps. Stacoff, Steussi, & Sanderegger (1985), demonstrated that shoe height is an important variable for controlling subtalar joint supination during lateral motion. The National Athletic Injury/Illness Reporting System (1979) reported that the largest group of basketball injuries (31.2%) occurred while players were rebounding.

It appears that researchers and clinicians agree that there is potential for the cause/effect relationship between excessive pronation and knee injuries related to running. In addition. the potential f a ankle injuries during lateral movements and landing from a jump demonstrate the need to investigate the control of supination as well as pronation.

The purpose of this study was to ascertain the effects of shoe height and athletic taping on selected kinematic (Clarke, Frederick, & Hamill, 1983) and kinetic (Valiant.

1985) variables associated with lower extremity function during the activities of treadmill running, landing from a jump and lateral movement. A secondary purpose was to examine the relationship between maximum pronation and maximum knee flexion which occurs during running.

METHODOLOGY

Kinematic data were collected on 8 healthy college age women with a LOCAM 16 mm high speed camera equipped with a 100 Hz pulse generator to verify the 100 Hz camera speed. A 5' X 5' silver-fronted mirror was positioned at a 45 degree angle to the line of action of the subjects. Subjects were filmed for 10 trials from the rear thus capturing simultaneous rear and sagittal views of the lower extremity on each frame of film while running on the treadmill, running laterally and landing from a jump.

Kinetic data (10 trials) were collected simultaneously during the landing from a jump phase using an A.M.T.I. force platform interfaced to an Apple II+ microcomputer. The kinetic data were sampled at 1000 Hz. The resultant force was resolved into its three dimensional components and analyzed separately. The film data were analyzed using a Vanguard Motion Analyzer projection system.

All trials were digitized from two frames prior to foot strike to two frames after toe-off. Seven anatomical reference markers were placed on the lower extremity. Two markers estimating the longitudinal axis of the gastrocnemius and two markers estimating the longitudinal axis of the heel (placed on the shoes) were utilized to generate rearfoot angle data. In addition three anatomical markers were placed on the lateral aspect of the lower leg to estimate relative knee angle.

The markers were placed on the greater trochanter, the lateral aspect of the crease of the knee, and on the lateral malleolus. All kinematic analyses were performed on the right lower extremity. The coordinates of each of these points were obtained using a Numonics 1224 Graphics Calculator interfaced with an Apple II+ microcomputer. Subsequent to digitization, the raw X Y coordinates were filtered using a low-pass digital filter. Rearfoot angles and relative knee angles were obtained from filtered data. A cubic spline function was then employed to generate 50 data points for each curve. From this angle-time data, mean values for the 3 footfalls/trial for each dependent variable for each condition were generated for individuals and groups.

The Statistical Analysis System (SAS) was used to statistically analyze all data sets. A 2 X 2 (high shoe/low shoe and tape/no tape) analysis of variance (ANOVA) with repeated measures on each factor was utilized to determine condition differences in all three phases of this study. In addition a t-test was utilized to determine whether maximum pronation occurred at the same time as maximum knee flexion during the running phase of this study.

RESULTS AND DISCUSSION

Running Phase

The ANOVA revealed a significant ($p < 0.05$) shoe by tape interaction. This interaction (see Figure 1) showed relatively the same amount of maximum pronation (MP) for the LT condition (M = -10.86 degrees) compared to the HS condition (M = -10.55 degrees). However, the interaction further revealed that the tape reduced MP for the low shoes from a mean of -12.86 degrees to a mean of -10.89 degrees. On the other hand, the tape reduced MP for the high shoes from a mean of -10.55 degrees for the HS condition compared to a mean of -9.99 degrees for the HT condition (see Table 1). No other significant differences appeared in this phase.

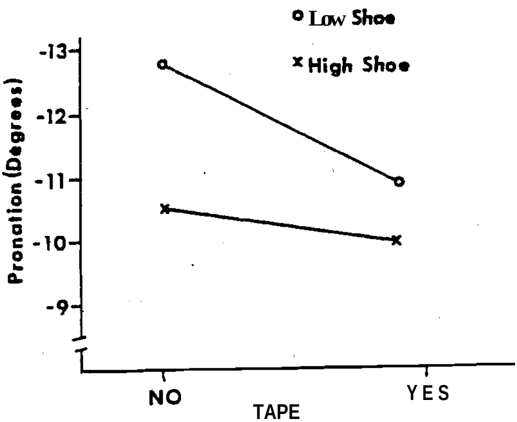

Figure 1. Shoe by tape interaction during treadmill run

Table 1 Summary of cell means for the dependent measures on the treadmill run data

DEPENDENT MEASURE	LS		LT		HS		HT	
	V1	V2	V1	V2	V1	V2	V1	V2
MAXIMUM PRONATION [A]	-13.54 (2.24)	-12.17 (2.89)	-10.96 (2.85)	-10.83 (1.67	-10.34 (3.08)	-10.76 (3.98)	-10.03 (2.22)	- 9.95 (2.48)
TIME TO MAX. PRON.[B]	123.75 (27.31)	116.75 (23.26)	110.38 (31.26)	105.13 (24.27)	112.75 (42.48)	108.75 (31.14)	121.25 (34.95)	100.63 (22.12)
MAX. KNEE FLEXION [A]	143.95 (5.48)	143.21 (6.53)	144.51 (6.73)	143.76 (6.29)	144.22 (5.95)	144.95 (5.26)	144.37 (5.86)	144.34 (6.23)
TIME TO MAX KNEE FLEX.[B]	131.63 (5.93)	121.63 (15.22)	134.38 (16.15)	122.25 (10.79)	122.75 (17.93)	121.50 (9.47)	121.00 (9.26)	122.00 (20.28)

[A] DEGREES [B] MILLISECONDS

A further result showed that the correlation generated between time to maximum knee flexion and time to maximum pronation was mediocre at best, $r = .49$. This correlation appeared low based on the work of Bates, et al., (1979). The former results are similar to those reported in Sussman & Hamill (1986).

Lateral Movement Phase

The results (see Table 2) show that the taped condition (M = 19.22 degrees) permitted significantly ($p < .05$) less maximum supination than the non-tape condition (M = 22.75 degrees). This finding was consistent with similar studies (Sussman & Hamill, 1986; Clarke et al., 1983). Further analyses revealed that the high basketball shoe permitted less time to reach maximum supination (M = 330.44 ms) compared to the low basketball shoe (M = 452.63 ms), and this lead to the high basketball shoe permitting less maximum knee flexion (M = 118.63 degrees) compared to the low basketball shoe (M = 116.34 degrees). No significant differences were discovered for the shoe height dependent variable which is inconsistent with the results reported by Stacoff, et al., (1985). But it should be noted that they used specially constructed shoes. The present study used high and low commercially accessible basketball shoes.

Table 2. Summary of cell means for the dependent measures on lateral movement

Dependent Measure	LS $\bar{X}$ (SD)	LT $\bar{X}$ (SD)	HS $\bar{X}$ (SD)	HT $\bar{X}$ (SD)
TOUCHDOWN ANGLE [A]	13.34 (2.48)	13.82 (4.88)	12.39 (4.68)	12.13 (6.89)
MAXIMUM SUPINATION [A]	24.26 (3.33)	20.59 (4.94)	21.24 (4.37)	17.85 (4.98)
TIME TO MAX. SUPINATION [B]	459.38 (104.53)	445.88 (120.64)	369.25 (129.98)	291.63 (127.17)
TOTAL SUPPORT TIME [B]	570.63 (145.39)	543.75 (112.04)	597.00 (67.30)	564.63 (96.33)
TOTAL R-F MOTION [A]	9.55 (3.03)	6.84 (2.44)	8.83 (6.91)	5.72 (3.87)
MAX. KNEE FLEXION [A]	116.40 (5.91)	116.28 (7.03)	118.60 (7.52)	118.75 (7.42)
TIME TO MAX. KNEE FLEX. [B]	160.63 (55.48)	160.63 (48.31)	146.75 (27.70)	156.75 (32.81)

[A] DEGREES. [B] MILLISECONDS

Landing From A Jump Phase

Kinematic Data

The results (see Table 3) show that subjects in the taped conditions landed in a less supinated posture (M = 13.76 degrees) compared to the no tape conditions (M = 21.84 degrees). The ANOVA also revealed that subjects in the high shoe conditions were in a less supinated posture (M = 15.75 degrees) at touchdown compared to those in the low shoe conditions (M = 19.85 degrees).

Table 3. Summary of cell means for the kinematic dependent measures in the landing phase

DEPENDENT MEASURE	LS $\bar{X}$ (SD)	LT $\bar{X}$ (SD)	HS $\bar{X}$ (SD)	HT $\bar{X}$ (SD)
TD ANGLE [A]	24.21 (6.45)	15.47 (3.61)	19.46 (4.29)	12.05 (1.66)
MAX. PRONATION [A]	-3.50 (2.37)	-3.40 (2.58)	-3.33 (1.09)	-3.17 (1.57)
TIME TO MAX. PRO. [B]	173.38 (84.10)	219.63 (66.66)	185.75 (61.56)	190.88 (30.61)
TOTAL SUP. TIME [B]	382.63 (92.09)	412.75 (96.10)	401.75 (113.60)	416.88 (102.23)
TOTAL R-F MOTION [A]	27.71 (6.75)	18.87 (4.28)	22.79 (4.72)	15.28 (2.20)
MAX. KNEE FLEX. [A]	111.85 (12.04)	110.64 (13.47)	111.95 (13.77)	112.50 (11.68)
TIME TO MAX. KF [B]	148.75 (42.64)	137.63 (33.69)	147.00 (30.29)	148.75 (31.73)

[A] DEGREES [B] MILLISECONDS

Table 4. Summary of cell means for the kineteic vertical force (F_z) and mediolateral force (F_x) dependent measures on landing from a jump

DEPENDENT MEASURES	LS $\bar{X}$ (SD)	LT $\bar{X}$ (SD)	HS $\bar{X}$ (SD)	HT $\bar{X}$ (SD)
VERTICAL FORCE MEASURES				
FIRST PEAK FORCE[A]	12.00 (4.59)	10.00 (2.92)	10.86 (4.55)	10.17 (3.47)
TIME TO FIRST PEAK[B]	15.69 (3.59)	13.41 (2.28)	14.44 (3.26)	12.96 (1.83)
SECOND PEAK FORCE[A]	28.76 (8.58)	18.02 (6.72)	30.64 (8.52)	30.49 (1.04)
TIME TO SECOND PEAK[B]	57.28 (12.89)	50.84 (6.31)	55.05 (7.00)	46.78 (4.18)
MEDIOLATERAL FORCE MEASURES				
TOTAL NEG. IMPULSE[C]	-0.43 (0.07)	-0.95 (0.06)	-0.96 (0.06)	-0.98 (0.08)
PEAK NEGATIVE FORCE[A]	-2.33 (0.46)	-2.18 (0.22)	-2.37 (0.09)	-2.39 (0.41)
TIME TO PEAK NEG. FORCE[a]	8.65 (1.92)	10.26 (2.75)	7.55 (1.82)	8.90 (4.16)

[A] NEWTONS [B] MILLISECONDS [C] NEWTON-SECONDS

Kinetic Data

These results (see Table 4) showed that while in the taped conditions, subjects reached the first peak force (M = 12.91 ms) significantly ($p < .05$) before the no tape conditions (M = 15.06 ms). It was also shown that while in the taped conditions subjects reached the second peak force (M = 48.67 ms) before the no tape conditions (M = 56.16 ms). These data were similar to the work of Valiant & Cavanagh (1985).

CONCLUSIONS

High basketball shoes controlled the amount of subtalar joint pronation during running 14.2% more than the low basketball shoes. Prophylactic taping added 15.3% more rearfoot control to the low shoe compared to a comparable 5% increase in pronation for the high sboe during running. Athletic taping in conjunction with both high and low basketball shoes decreased the amount of maximum supination by 15.1% and I696 respectively, during the lateral movement phase of this study. The high basketball sboe controlled the amount of subtalar joint supination at touchdown during the landing by 20.7% more than the low basketball sboe, Athletic taping controlled the amount of subtalar joint supination at touchdown during the landing by 37% more than the no tape conditions without subsequent changes in the first or second peak forces. However, the timing of the first and second peak forces occurred approximately 13-14% sooner with ankle taping than without tape.

It appeared that for activities requiring different types of movement patterns, such as those found in ball sports, a combination of high basketball shoes and taping may help decrease the incidence of injury due to their combined and singular effect on both subtalar joint pronation and supination. The trade-off seems to be that while restrictions in ankle mobility may be desirable under certain conditions, this restriction may produce negative effects in that the forces of the foot/ground interface may not be effectively dissipated. This author recommends that future studies investigate other types of movement patterns such as stopping, starting, pivots and running backward.

REFERENCES

Bates, B.T., Osternig, L.R. Mason, B., and James, S.L. (1979). Functional variability of the lower extremity during the support phase of running. *Medicine and Science in Sports, 11*, 328-331.

Clarke, T.E., Frederick, E.C., and Hamill, E. (1983). The effects of shoe design parameters on rearfoot control in running. *Medicine and Science in Sport and Exercise, 15*, 376-381.

Hlavac, H.F.(1977). *The Foot Book.* World Pub., Mountain View, CA.

Stacoff, A., Steussi, E., and Sonderegger, D. (1985). Later stability of sport shoes. In: D.A. Winter, R.W. Norman, R.P. Wells, K.C. Hayes, snd A.E. Patla (eds.), *Biomechanics IX-B:* 139-143. Human Kinetics Publishers, Champaign, IL.

Sussman, D.H. and Hamill, J. (1986). The effects of a high versus low basketball sboe on subtalar joint pronation. (From *Abstracts:* Research Papers AAHPERD Convention, 1986).

Valiant, G.A. snd Cavanagh, P.R. (1985). A study of landing from a jump: implications for the design of a basketball shoe. In: D.A. Winter, R.W. Norman, R.P. Wells, K.C. Hayes, and A.E. Patla (eds.), *Biomechanics IX-B*:117-122. Human Kinetics Publishers, Champaign, IL.