PROCEEDINGS OF THE Human Factors and Ergonomics Society

39TH ANNUAL MEETING

Designing for the Global Village

San Diego 1995

HUMAN FACTORS AND ERGONOMICS SOCIETY

October 9–13, 1995
Hosted by the
San Diego Chapter

Volume 1

PERCEIVED DIFFERENCES IN RUNNING AND WALKING SHOES

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Designers rely heavily on the past sales history of a particular shoe when attempting to make decisions regarding shoe characteristics of future shoes. Cushioning devices made of air, "super" gases, energy return rubber, and gel's have become popular. However, the question that needs to be asked is whether these devices are truly functional or whether they are primarily of aesthetic value. Shoe qualities such as cushioning, comfort, stability, shock absorption, and energy return play an important role during athletic activity. It is also known that the above mentioned characteristics have significant interactions with each other. Hence it is important to know the relevance of these interactions when designing shoes for a particular activity. The primary goal of this study was to investigate the interaction and relevance of shoe properties during running and walking. Four specially fabricated shoes were used in the study. The results indicate the following:

- Heel cushioning and shock absorption play an important role in the overall cushioning of a midsole.
- Runners perceive shoe-heel cushioning somewhat differently from those who use shoes for walking.
- Heel cushioning during running seems to be influenced by shock absorption, stability and possibly rebound.
- Heel cushioning during walking seems to be influenced by shock absorption and possibly rebound. Hence a good running shoe can in most cases satisfy the biomechanical needs during walking.

INTRODUCTION

Today's designers in the shoe industry suffer from a lack of data concerning the necessary qualities or characteristics of athletic footwear. Even though researchers have shown that shoe cushioning changes the impact peak loads and the loading rates (Cavanagh and Lafortune, 1980; Clarke et al, 1983; Fredrick and Hagy, 1986), there is very little research on subjective perceptions of cushioning and comfort during athletic activity. Goonetilleke and Himmelsbach (1992) investigated the relationship between objective measures of cushioning and subjective measures of shoe cushioning and concluded that dynamic characterization is a good predictor of cushioning.

Traditionally, trends in the marketplace, perceived consumer demands, and past experience have influenced decisions with regard to cushioning, stability, fit and comfort. Decisions based on such criteria tend to utilize a "seat of the pants" approach to shoe design. As a result, cushioning devices made of air, energy return rubber, gel's, phylon, etc., have become popular. Designers rely heavily on the past sales history of a particular shoe when attempting to make decisions regarding shoe characteristics of future shoes. Such an approach can make it very difficult to pinpoint optimal levels of various shoe properties because of the interactive and potentially confounding effects of shoe color, style, and associated fashion trends. For example, while a consumer might purchase a particular shoe because of its cushioning or stability properties, it is as likely (or more likely) that he or she is actually interested in non-performance issues such as colors and patterns used to create the shoe upper or in current trends in the marketplace. In fact, consumers do make purchases in spite of poor "performance" characteristics. A shoe's success in the marketplace could easily be taken as evidence by designers that its level of cushioning, or stability or any other characteristic is sufficient even when in fact just the opposite is true.

Today's system can give designers little information about optimal shoe performance parameters from the marketplace, because the general public may not generally discriminate according to performance. While performance may not be a primary factor at the initial point of purchase, repeated experiences with shoes characterized by poor performance properties can almost certainly influence a consumer's inclination away from specific brand names in the long run.

The underlying questions still exist: What are the necessary qualities of athletic footwear? How do these qualities interact? For example, it is known that increasing the cushioning level by reducing the material stiffness, may decrease the stability of a shoe for certain activities such as basketball or running (Goonetilleke and Himmelsbach, 1992). However, for other activities the same cushioning level may not have any impact on the stability. To understand this kind of relationship during walking and running, an experiment was conducted. The shoes used were fabricated with different types of midsole materials but similar midsole stiffness.

METHOD

Subjects

Twenty (20) male runners participated in the current study. The distance run by the chosen subjects ranged from 10 to 60 miles per week with a mean of 27.2 miles per week. Their running speed varied from 6.5 to 8 minutes per mile with a mean of 7.3 minutes per mile. The mean age of subjects was 33.5 years, and mean height was 5 feet 9.6 inches. Their weight ranged from 130 to 194 pounds with a mean of 158.6 pounds. Out of a total of 20 left foot shoe sizes, 5 were size 8.5, 11 were size 9, 1 was size 9.5, and 3 were size 10 on the brannock device. Out of the total of 20 right foot shoe sizes, 2 were size 8, 4 were size 8.5, 9 were size 9, 3 were size 9.5, and 2 were size 10. All subjects stated that they regularly wore size 9 running shoes. Prior to the experiment, all subjects were informed that they would be compensated with either a T-shirt or a hat for their time.

Shoes

Traditional shoe midsole materials have been Polyurethane or Ethylene Vinyl Acetate. To evaluate the different characteristics of shoes, independent of the shoe materials, four different types of shoe midsoles (i.e., four pairs of shoes) were used. The heel materials for the four pairs were polyurethane (PU), two mechanical spring units (S1 and S2) and the fourth being a "pillar" type (PI) material. All four shoes had a forefoot of 0.28 specific gravity polyurethane material. The polyurethane midsole shoe had a 0.34 specific gravity material in the heel. During the manufacture of the other three pairs (S1, S2, and PI) of shoes, a volume of material was removed from the heel region. This volume was then exactly filled by either a spring loaded cartridge or a pillar-type foam insert. All shoes were size 9, white, and had a standard design on the shoe upper. Shoe heel thickness ranged from 32.6 mm to 35.1 mm with an average thickness of 33.6 mm.

Procedure

The nature and protocol of the study was explained to each subject prior to data collection. It was explained that the purpose of the study was to better understand cushioning, stability, shock absorption, and energy return in 4 pairs of running shoes. Subjects were told that the left (L) and right (R) shoes worn together at any given time may or may not constitute an actual pair and that the shoes were to be rated independently of one another on a standard seven-point scale (1 = very poor, 7 = very good). During data collection, subjects ran in each of the four pairs of shoes on the treadmill for 4 minutes at a 8 minute per mile (7.5 mph) speed. Total distance run in each pair was over 0.5 mile or 4 minutes (a total of over 2 miles with all 4 pairs). After 4 minutes had elapsed, subjects were instructed to continue running while giving ratings for the shoes as the different measures were presented. Subjects were given a measure to evaluate (e.g., overall cushioning), take several strides while thinking about the rating, and then rate the characteristic for that shoe. For each measure, first the left shoe and then the right shoe was rated, (i.e., for example, left foot heel cushioning followed by right foot heel cushioning). After each shoe had been completely evaluated, subjects stepped off the treadmill and the experimenter recorded any general comments for those shoes using a hand held tape recorder. After all the comments were recorded, subjects put on the next pair of shoes, returned to the treadmill, ran for 4 more minutes, and rated that pair of shoes. This process was repeated until all four pairs of shoes were evaluated.

After the running phase was completed, the subjects repeated the process while walking. The order of presentation was the same during both running and walking. Identical measures were collected during walking as during running. However, the order in which the shoes were worn by each subject was counterbalanced to eliminate potential order effects.

Independent & Dependent Variables

The independent variable was type of midsole. The seven dependent variables used were as follows:

- Perceived overall cushioning (OC)
- Perceived heel cushioning (HC)
- Perceived forefoot cushioning (FC)
- Perceived arch cushioning (AC)
- Perceived shoe stability (SS)
- Perceived shock absorption (SA)
- Perceived liveliness or rebound or energy return (ER)

RESULTS

The mean ratings during running are shown in Table 1. Table 2 shows the correlation data for the subjective ratings across all shoe types. Tables 3 and 4 show the results for the walking ratings.

The correlation analysis performed for each shoe between subject weight and heel cushioning rating (running or walking) did not show any significant correlations at the $p < 0.05$ level. The lack of a significant correlation suggests that all subjects evaluated the shoe properties from a similar region or "window of perception" where properties contributing towards heel cushioning are regarded as relatively equal regardless of subject weight.

A one-way analysis of variance on the running subjective ratings showed significant differences ($p < 0.05$) for heel cushioning, shoe stability, shock absorption and rebound. No significant differences were found for overall cushioning, arch cushioning and forefoot cushioning. The lack of any significant difference in forefoot cushioning is primarily because there was no difference in the forefoot area of all four shoes. However, there could have been some physical difference in the arch area. But the lack of a significant difference in the arch cushioning ratings seem to indicate there were no physical differences.

The one-way analysis of variance on the walking scores showed a significant difference only for shoe stability. No other differences were evident.

Table 1. Mean ratings during running

	S1 shoe		S2 shoe		PU shoe		PI shoe	
	L	R	L	R	L	R	L	R
OC	3.8	4.5	4.2	4.4	4.0	4.7	4.8	4.5
HC	3.5	4.3	4.3	4.6	4.0	4.9	4.9	4.9
FC	3.8	4.5	4.2	4.5	4.2	4.4	4.7	4.0
AC	4.0	4.1	4.3	4.1	4.1	4.6	4.4	4.5
SS	3.3	4.3	4.4	4.4	4.4	4.8	4.6	4.5
SA	3.2	4.2	4.2	4.2	3.8	4.6	4.6	4.4
ER	3.2	3.9	4.1	3.9	3.9	4.5	4.0	4.5

Table 2. Pearson correlation coefficients for subject ratings during running. All correlations significant at $p < 0.05$ level

	OC	HC	FC	AC	SS	SA	ER
OC	1.0						
HC	0.80	1.0					
FC	0.62	0.30	1.0				
AC	0.38	0.27	0.30	1.0			
SS	0.60	0.64	0.30	0.29	1.0		
SA	0.81	0.76	0.49	0.46	0.64	1.0	
ER	0.62	0.59	0.42	0.47	0.50	0.69	1.0

Table 3. Mean subject ratings by shoe for walking

	S1 shoe		S2 shoe		PU shoe		PI shoe	
	L	R	L	R	L	R	L	R
OC	4.5	5.2	5.1	4.6	4.8	4.7	5.1	4.9
HC	4.1	5.0	4.9	4.8	5.0	4.9	5.0	4.9
FC	4.5	4.7	4.9	4.4	4.5	4.4	4.7	4.5
AC	4.3	4.6	4.5	4.2	4.2	4.4	4.7	4.4
SS	3.8	4.0	4.7	4.4	4.3	4.7	4.8	4.4
SA	4.7	5.2	4.7	4.4	4.8	4.5	5.0	4.8
ER	4.3	4.5	4.5	4.2	4.5	4.6	4.7	4.5

Table 4. Pearson correlation coefficients for subject ratings during walking. All correlations significant at $p < 0.05$ level

	OC	HC	FC	AC	SS	SA	ER
OC	1.0						
HC	0.79	1.0					
FC	0.54	0.43	1.0				
AC	0.38	0.26	0.26	1.0			
SS	0.20	0.35	0.18	0.22	1.0		
SA	0.77	0.65	0.39	0.52	0.17	1.0	
ER	0.60	0.57	0.36	0.47	0.36	0.68	1.0

DISCUSSION

Table 2 shows that subjective ratings for heel cushioning (HC), forefoot cushioning (FC), arch cushioning (AC), stability (SS), shock absorption (SA) and rebound/liveliness (ER) exhibit significant correlations with overall cushioning. This result implies a significant contribution to overall cushioning from each of these perceived quantities. The highest correlation with overall cushioning is shown by the subjective ratings for heel cushioning ($R^2 = 0.64$ for running and $R^2 = 0.62$ for walking; $p < 0.0001$) and shock absorption ($R^2 = 0.66$ for running and $R^2 = 0.59$ for walking; $p < 0.0001$) The strongest correlation with the subjective rating for heel cushioning is shock absorption ($R^2 = 0.58$ for running and $R^2 = 0.42$ for walking; $p < 0.0001$). Energy return ($R^2 = 0.35$) and stability ($R^2 = 0.41$) also seem to have a significant correlation ($p < 0.0001$) with heel cushioning during running. The wide separation of the physical energy loss coefficients between the spring shoes (energy loss nearly zero) and the non-spring shoes (non-zero energy loss due to good energy dissipation ability) could possibly have resulted in the significant correlation between the heel cushioning rating and the energy return rating assuming the energy stored is a measure of rebound. It appears that the perception of heel cushioning during running is influenced by perceived levels of shock absorption (SA), stability (SS) and possibly rebound/liveliness/energy return (ER).

The significant shoe effects seen for heel cushioning, stability, shock absorption and rebound during running were such that the spring shoe S1(Left) was rated the worst. The similarity between the results for the different ratings reflect a high degree of interconnectedness or interaction between the different ratings as shown by the correlations discussed above.

Similar findings were observed for the walking condition. Heel cushioning during walking is also influenced by the perceived levels of shock absorption and rebound/liveliness. However, stability did not seem to influence the subject's perception of heel cushioning ($R^2 = 0.12$) unlike running. Subject comments support the above findings.

In concluding, the following are the significant findings:

- Runners perceive shoe-heel cushioning somewhat differently from those who use shoes for walking.
- Heel cushioning and shock absorption play an important role in the overall cushioning of a midsole.
- Heel cushioning during running seems to be influenced by shock absorption, stability and possibly rebound.

- Heel cushioning during walking seems to be influenced by shock absorption and possibly rebound only.
- Since heel cushioning during running seems to be influenced by shock absorption, stability and possibly rebound, whereas heel cushioning during walking is influenced by shock absorption and possible rebound, it may be concluded that a running shoe needs are greater than a walking shoe. In addition, it means that in most cases, a good running shoe can potentially satisfy the biomechanical needs during walking.

ACKNOWLEDGMENTS

The authors wish to thank NIKE, Inc., for their support.

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