INFLUENCE OF ANKLE STABILIZERS ON SHOCK ABSORPTION AND PERFORMANCE IN RUNNING AND JUMPING

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INTRODUCTION

A good ankle support is considered to reduce the risk of ankle injuries in several sports like basketball (Barrett, et. al. 1993; Robinson, et. al. 1986). For these sports, the use of **high top** sport shoes or ankle taping is broadly extended between professional and occasional players. Nevertheless, in some sports like handball, low top shoes are more extended because a high top is considered to reduce the performance of lateral braking movements (Robinson, et. al. 1986). Besides, the ankle movement is a natural shock absorption mechanism (Gross, et. al. 1988) and to limit this movement can lead to increasethe impacts transmitted to the muscle skeletal system. Because of the aforementioned reasons, performance and shock absorption on the one hand and the ankle sprain prevention on the other, seem to be opposed as design criteria of shoes for some sports. The purpose of this work was to better understand the effects of shoe ankle stabilization in shock absorption and performance in running and jumping.

METHODOLOGY

Two types of sport shoes were specially designed for this work. Both have equal sole and midsole with differences only in the design and construction of the upper vamp. The first prototype was a high top sport shoe with firm heel counters and specially designed for improved ankle support. The second prototype was a low top sport shoe without heel counters.

Three types of experiments were carried out, two for studying the performance in jumping and running with rapid lateral movements and the third one to analyze the effect of ankle stabilization in shock absorption whik landing after jumping.

The jumping performance experiments consisted of measuring the maximum counter movement jump height. Three subjects participated in the study, performing 18 jumps divided in series of three. A rest time of 3 min. between series was allowed to avoid fatigue. Each series of jumps was performed with a pair of one of the two prototypes in a randomized sequence. The jump height was determined by the flying time with a 0.001 seconds precision chronometer connected to a plate under the feet of the subjects.

The running performance experiment consisted of determining the time required to complete an obstacle course. The obstacle course was similar to Robinson's (Robinson, et. al. 1986) and included forward and backward running, changes of direction of 90 and 45 degrees to right and left and stoppings. Photo cells were set up at the start and finish of the course to register the time consumed, with 0.001 seconds of precision. Eight subjects participate in the study and were asked to complete it as quick as possible. After several trials to accommodate to the course, 8 trials were completed in series of two trials wearing the two prototypes in a randomized sequence.-Resting times of 3 min. between trials and 5 min. between series were allowed to avoid fatigue.

The shock absorbing experiment consisted of measuring the impact forces and the acceleration transmitted to the tibia and head of the participating subjects while jumping. Five subjects participated in the study. Light weight accelerometers were tightly fixed to the tibial tuberosity and to the subject's forehead. Forces were recorded by a force plate in which the subjects fell with one of their feet. To standardize the test, jump and reach height was fixed to 95% of the maximum of each subject. After few accommodating attempts, a total of 27 jumps were performed by each subject divided in series of three jumps. The trials were performed by wearing *the* two prototypes in a randomized sequence, finally, as a reference condition. the subjects performed 9 jumps barefoot. The **barefoot** jumps were performed at the end of the test to avoid accommodation that would affect the shod conditions **(Simpson,** et. **al.** 1988).

After analyzing the acceleration and force curves, a typical forefaot-heel pattern of landing was encountered in approximately the 90% of the jumps. For these landings two impact peaks were clearly detected in tibia acceleration and forces while in forehead acceleration only one impact peak was systematically **observed** (Figure 1). For the statistical analysis of the results, only the forefoot-heel landing jumps were considered and several parameters of each curve were studied. These parameters are: **AT1**: first maximum of **tibial** acceleration (corresponding to forefoot contact); **AT2:** second maximum of **tibial** acceleration (corresponding to heel contact); MAT: maximum of AT1 and AT2; **FZ1:** first maximum of forces; FZ2: second maximum of forces; MFZ: maximum of **FZ1** and FZ2; **TFZ2-TFZ1:** delay time between forefoot and heel impact force peaks; **TAT2-TAT1:** delay time between forefoot and heel acceleration peaks. To analyze better the transmission of impacts, several parameters obtained from the aforementioned ones were computed. These parameters are: **AT1/FZ1:** transmission of forefoot impact to tibia; **AT2/FZ2:** transmission of heel impact to tibia; **MAT/MFZ:** maximum transmission of impact to tibia; **AF:** maximum of forehead acceleration; **AF/MFZ:** maximum transmission of impact to forehead; **MAF/MAT:** maximum transmission from tibia to forehead.

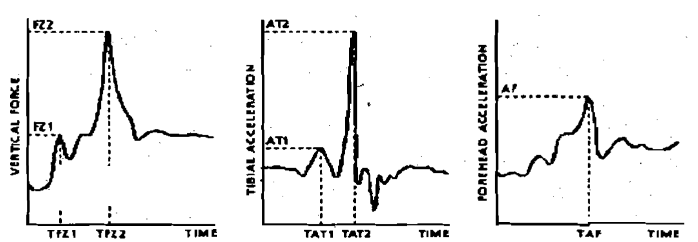

Figure 1: Typical results of forces** and **tibial** and **forehead acceleration. Parameters for the statistical analysis are shown in the figure.

With these parameters and those of the efficiency test, a multifactor analysis of variance **(ANOVA)** was performed considering subject and condition (shoes or barefoot) as factors. Alfa level was fixed at 0.05. Post **hoc** analysis were done with LSD method.

RESULTS

TEST	HIGH TOP SHO	LOW TOP SHOE
Jump test (cm)	28.9	30.2
Run test	8.717	8.683

Table 1. Results of the performance tests.

Differences of 1% of the time consumed to complete the obstacle course were encountered between shoes (p=0.048). As it was expected, lower times were found with low top shoes. Differences of 4% between shoes (p=0.0013) in the jump test were found between shoes with ankle support (lower jump heights) and without ankle support (higher jump heights). Results of these tests are showed in table 1.

Variable	p	Barefoot	High Top (1)	Low Top (2)
AT1	0.1359	6.434 ± 0.821	6.013 ± 0.878	5.939 ± 0.792
AT2	0.2034	14.840 ± 1.235	14.859 ± 1.394	16.064 ± 1.190
MAT	0.3275	16.404 ± 1.107	16.720 ± 1.188	16.968 ± 1.086
AF	0.0068 *	3.238 ± 0.398	3.837 ± 0.421	3.501 ± 0.442
FZ1	0.0001 *	0.888 ± 0.046	0.830 ± 0.054	0.734 ± 0.036
FZ2	0.4709	2.775 ± 0.205	2.548 ± 0.168	2.519 ± 0.148
MFZ	0.4426	2.784 ± 0.204	2.566 ± 0.165	2.519 ± 0.148
AF/MFZ	0.0009 *	1.149 ± 0.132	1.412 ± 0.132	1.275 ± 0.144
AF/MAT	0.0033 *	0.181 ± 0.017	0.219 ± 0.018	0.192 ± 0.020
AT1/FZ1	0.7159	8.273 ± 1.391	8.274 ± 1.319	8.386 ± 1.153
AT2/FZ2	0.0106 *	5.290 ± 0.256	5.523 ± 0.415	6.264 ± 0.336
MAT/MFZ	0.0154 *	6.095 ± 0.294	6.525 ± 0.386	6.776 ± 0.325
TFZ2-TFZ1	0.0118 *	0.0604 ± 0.0027	0.0553 ± 0.0039	0.0524 ± 0.0025
TAT2-TAT1	0.3802	0.0362 ± 0.0022	0.0349 ± 0.0043	0.0320 ± 0.0025

Table 2. Results of the impact test (for p<0.05).*

For the impact test, forehead acceleration (af) was found to be significative lower jumping barefoot than jumping with high top shoe (prototype 1). No significative differences were found for this parameter between low top (prototype 2) and, barefoot or high top prototype conditions. Prototype 2 showed significative lower forefoot impact forces (fz1) than barefoot and high top conditions. A significative increase in delay time between forefoot and heel impacts forces was found for the barefoot compared to prototype 2 condition but no significative differences were found between prototype 1 and prototype 2 or barefoot for this parameter. Relating to transmission of forces to forehead (af/mfz), significative lower values were found jumping barefoot with respect to prototype 1. No significative differences were found between prototype 2 and barefoot or prototype 1. The transmission of heel impact to tibia (at2/fz2) was found to be higher for prototype 2 than for the barefoot condition, while the maximum transmission of forces to tibia (mat/mfz) showed significative differences just between the barefoot and the 2 condition. The parameter of acceleration transmission (af/mat) was found to be lower for the barefoot and prototype 2 conditions with respect to prototype 1 condition. In table 2, results for mean and standard error of all the variables studied for the impact test are presented (* for $p<0.05$).

CONCLUSIONS AND DISCUSSION

High top shoe was found to lower performance in jumps and obstacle course. These reductions in performance were of 4% and **1%** respectively. Differences founded in the obstacle course test are similar to those founded by **Robinson** et. al. **(1986).** In some sports like basketball, these reductions in performance could be assumed considering the benefits of reducing the risk of injuries. Ankle stabilization has shown to increase forefoot impact and both, **the** accelerations and the transmission of heel impacts to forehead. This supports the idea that the limitation of the physiological range of movements reduces the natural **ability** to reduce the impact that reach the upper body. For this reason, the design of the **midsole** of high top shoes has to consider specially the shock absorption as an important item. An increase of heel impact transmission to **tibia** was found for the low top shoes compared with the barefoot condition. Jumping barefoot has also shown to increase the time between heel and forefoot impacts.

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