EXTENDED ACTIVITY EFFECT ON THE PERFORMANCE OF ANKLE SUPPORT DEVICES AS REFLECTED BY RANGE OF MOTION AND GROUND REACTION FORCES

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INTRODUCTION

One of the most common injuries seen in sports is that of the ankle sprain, particularly the inversion or plantarflexion type (Gamck & Requa, 1988; Lane. 1990). A variety of techniques and devices are used to offer support or aid in the rehabilitation process from those injuries. Such techniques and devices include the cloth ankle wrap, elastic and/or non-elastic tape, and more recently easy to apply alternatives, commercially available ankle braces. The support aspect of these prophylactic devices, to such a highly susceptible to injury joint, has been questioned repeatedly in the literature especially in terms of their effectiveness after lengthy athletic participation (Bunch, et al, 1985; Mack, 1982). There has also been doubt as the additive support of these devices, in terms of their effectiveness on the natural mechanisms of the ankle, and the rest of the joints of the lower extremity (McCaw and Johnson, 1992; Metcalf and Denegar, 1983). These disagreements warrant the need for more research in the area. The purpose of the present project was to study the changes on plantar-dorsiflexion and inversion-eversion ranges of motion, as well as, on selected vertical ground reaction force parameters for different supporting devices at different points of time, over a sixty minute activity period.

METHODOLOGY

Subjects (N=30) were tested under four support conditions: unsupported (UN), nonelastic adhesive tape (TAPE), Swede-0 (S-0), and SubTalar Support (STS). Measurements were taken during the following activity conditions (time): unsupported pre-activity, and post-support after 0, 15, 30, 45, and 60 minutes of selected activity on a treadmill. The chosen activity was treadmill walk simulating sports that would stress the respective ankle support. The treadmill walk time and actions were broken down into forward (2 min), left facing crossover strides (3 min), right facing crossover strides (3 min), and forward again (2 min). This sequence was performed by each subject four times over the 60 minute period, and was designed to maintain foot contact with the treadmill for as long as possible. Five trials for range of motion (ROM) measurements in each direction were done on a modified Inman Ankle machine, with the subject lying supine. The thigh and leg were immobilized with the knee and hip joints at 90°. The subject's foot was placed into the Inman footplate where it was strapped in the neutral position. The subjects were instructed to relax their leg, then a weight of 9 kg passively rotated the foot by a frictionless pulley system to the end range of motion in each direction, which was recorded using precision potentiometers.

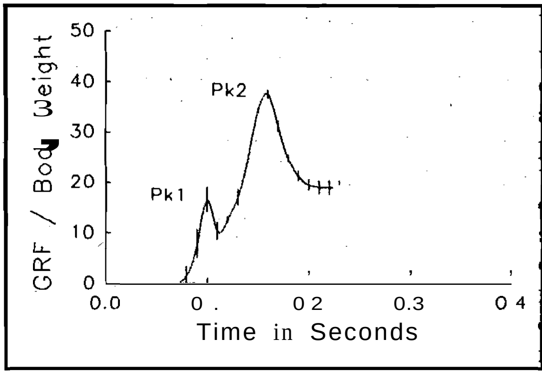

Figure 1. Criterion measures for vertical ground reaction force. For a single subject, means and standard deviations of 5 trials, are represented.

Using 24 of the subjects. a drop task was also performed at four activity conditions: unsupported pre-activity, after 0 and 60 min of activity post support, and finally after the support device was removed. Six subjects for each of the 3 support conditions and six for control. Five drop jumps per condition per subject, were performed from a suspended position, with the aid of an adjustable height apparatus, maintaining a constant 60 cm height of the lateral malleolus from the AMTI force plate (DeVita & Skelly, 1992; McCaw & Johnson, 1992;).

The vertical ground reaction forces were converted to multiples of body weight (BW) for each subject, and selected parameters were quantified with the use of an interactive computer graphics program. The data stream was displayed along with a cursor that allowed manual digitization of points on the screen. These data points were the peak forefoot (Pkl) and peak rearfoot (Pk2) ground reaction forces, and the times associated with them (tPk1 and tPk2 respectively). Figure 1 illustrates these ground reaction force parameters. Repeated measures ANOVA (on time of exercise) was used to identify any significant difference between the support devices and their behavior during the 60 min of activity.

RESULTS AND DISCUSSION

Table 1 shows the mean ankle ROM and standard deviations on the inversion and plantarflexion for the three support conditions, and time of activity. Significant reductions were found between unsupported ankles and pre-activity (0 min), for the three support conditions, and all directions of motion ($p<.001$), with the least support offered by the STS in eversion and dorsiflexion. All three support devices significantly lost support in inversion between 0 and 15 min of exercise ($p<.001$). The S-O brace was able to maintain its residual support after the 15 min of exercise, whereas the TAPE and STS lost significant support for the duration of the 60 min of activity. Similarly, eversion ROM was also found to be better supported by the S-O brace as opposed to TAPE and STS. In plantarflexion, the S-O brace was able to maintain support without any significant reduction, for the initial 30 min of exercise. The TAPE and STS (which offered the least support originally), started to loosen after 15 min.

Table 2 shows mean and standard deviation values ($N=6$ per device) for the maximum forefoot (Pkl) and rearfoot (Pk2) impact forces, and the corresponding times associated with these events (tPk1 and tPk2, respectively). We found no significant differences in profile comparisons of the mean values across support conditions for neither the ground reaction force variables or their relative timing.

TABLE **1** Mean and standard deviation of ankle ROM for inversion and Plantarflexion in degrees, with respect to support device and time of exercise **(N=30).**

Brace	Exercise Time					
	Unsupported	**min0**	**min15**	**min30**	**min45**	**min60**
Inversion						
S-0	**44.3 ±5.8***	**32.0 ±5.2***	**34.3 ±4.9***	**34.6 ±4.8**	**35.1 ±4.3**	**35.7 ±4.1**
STS	**44.4 ±7.1***	**32.1 ±6.3***	**36.3 ±6.8***	**37.9k5.7**	**37.6 k6.5**	**38.7 5.9***
Tape	**43.5 ±8.2***	**28.7 ±6.9***	**32.5 ±6.6***	**33.5 k6.5**	**34.2 k7.2**	**35.2±8.0***
Plantarflexion						
S-O	**44.8 ±6.1***	**27.5 ±6.1***	**29.0 ±5.9**	**29.7 ±5.7***	**30.5 k5.9**	**30.8 k5.9**
STS	**44.2 ±7.2***	**32.0 ±8.8***	**34.2 ±7.7***	**35.0k8.2**	**35.5 ±7.8**	**35.7k7.6**
Tape	**45.0 ±7.0***	**25.6 ±5.9***	**28.0 ±5.8***	**29.9 ±5.9**	**31.7 ±5.2**	**32.5 ±5.6**

* **p< .001**

As expected the least effect from the support conditions was on the forefoot parameters, since they mainly depends on the height of drop, which was standardized (Dufek **&** Bates, **1991).** The **rearfoot** ground reaction parameters did **not** demonstrate any significant profile effect either. Subsequent **oneway** repeated measures analyses, for each support condition, revealed for **S-O** significant quadratic polynomial trend with activity (Figure **2)** for **Pk2** (Table 2: **37.21 - 39.14 - 39.27 - 38.23 N/kg, p<.05),** and **tPk2** (Table 2: **57.98 - 53.53 - 50.38 - 54.50** ms, **p<.05).** Also significant quadratic trends were found for the TAPE support condition with exercise **for Pk2** (Table **2: 38.53 - 39.02 - 39.08 - 37.86 N/kg, p<.05),** and **tPk2** (Table 2: **59.80 - 51.90 - 51.02 - 55.23** ms, **p<.01),** and **tPk2** for STS. These dynamic alterations at the ankle may affect the dynamics of the entire limb and thus the energy flow profiles at the knee and hip joints **(McCaw &** Johnson **1992).**

Table **2** Mean and standard deviation values for the maximum forefoot and **rearfoot** impact forces and the **corresponding** times **(N=6).**

STS	Pkl **(N/kg)**	**Pk2 (N/kg)**	**tPk1** (ms)	**tPk2 (ms)**
Unsupported Re-Act	16.25 ($1.65)	32.99 ($3.62)	11.60 ($4.8)	63.43 **(±4.6)***
Supported - 0 **min**	14.76 ($1.87)	33.69 **(±2.11)**	12.03 **(±5.6)**	56.20 **(±5.8)***
Supported - 60 min	**14.92 (±2.01** j	**35.32 (±4.02)**	14.37 **(±4.4)**	**56.46 (±4.2)***
Unsupported Post-Act.	15.83 ($1.32)	34.66 ($3.54)	15.03 ($3.6)	62.73 **(±6.3)***
Swede-O				
Unsupported Re-Act	15.87 ($2.35)	37.21 **(±1.79)***	14.08 ($3.5)	57.98 **(±8.4)***
Supported - 0 **min**	15.98 ($2.05)	39.14 **(±4.31)***	12.25 ($2.8)	53.53 **(±9.0)***
Supported - 60 **min**	15.55 ($1.94)	39.27 **(±3.50)***	12.18 ($2.9)	50.38 **(±8.8)***
Unsupported Post-Act	14.94 (±1.47)	38.23 **(±2.62)***	12.95 ($2.9)	54.50 **(±8.0)***
TAPE				
Unsupported Pre-Act.	18.20 ($3.12)	38.53 **(±4.46)***	14.18 ($4.2)	59.80 **(±7.3)***
Supported - 0 **min**	17.35 **(±2.81)**	39.02 **(±3.92)***	11.21 ($2.7)	51.90 **(±8.3)***
Supported - 60 **min**	17.47 ($2.62)	39.08 **(±3.88)***	12.20 ($3.1)	51.02 **(±7.6)***
Unsupported Post-Act	16.94 ($2.51)	37.86 **(±4.54)***	12.91 ($3.7)	55.23 **(±6.8)***

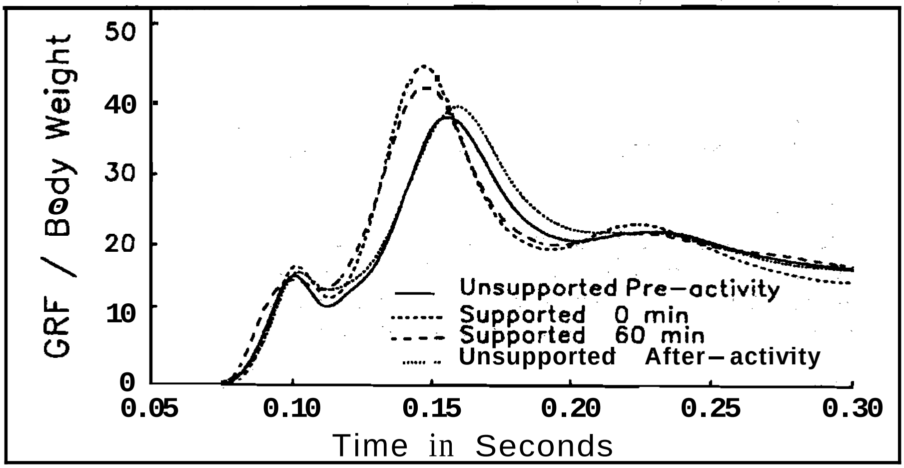

Figure 2. Representative ground reaction force profiles in N/kg over the weight absorption period for one subject with Swede-O brace support.

CONCLUSIONS

The three support devices offered different amount of support at the preactivity condition. Their ability to maintain support during activity was also different showing that the S-O brace and the TAPE performed better than STS. The ground reaction force findings indicate that the S-O and TAPE devices increased the peak rearfoot ground reaction force (Pk2) and that this peak appeared earlier in time (tPk2). The quadratic trend observed for the GRF data with activity as a result of S-O and TAPE support in magnitude and timing, suggests changes in the dynamic characteristics of the ankle joint in terms of its ability to absorb energy during landing.

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