Steadman Sports Medicine Foundation

September 23, 1993

Charles J. Dillman, Ph.D.
Executive Director

Jim Mott
ORBITER
3333 Soquel Drive, Suite D
Santa Cruz, CA 95073

Dear Jim:

As you know, we have been using the Orbiter Treadmill for the past four months. During this time, we have had a relatively large number of athletes and patients perform either a walking or running workout on the Orbiter Shock Absorbing Treadmill. Overwhelmingly, we have received very positive comments from these individuals and many inquiries from some of our clients on how they could purchase such a system.

In addition, we have been interested in determining which muscles are active around the knee joint during uphill walking. It is Dr. Steadman's hypothesis that uphill walking can be an effective means of loading the muscles around the knee for patients undergoing rehabilitation. As our recent report illustrates, we were able to illicit controlled and moderate contractions out of the vastus medialis during uphill walking on the Orbiter Treadmill. We will continue our investigations into the muscular involvement while running on a shock absorbing treadmill such as the one that you have developed.

We really think that your system has great potential in accelerating the rehabilitation of patients who have experienced various types of knee trauma. I will keep you informed as to the further progress of our research involving the Orbiter Treadmill.

Sincerely,

Charles J. Dillman

Charles J. Dillman, Ph.D.
Executive Director

CJD/mht

Enclosure

181 West Meadow Drive Suite 420 • Vail, Colorado 81657 • 303/479-9797 • FAX: 303/479-0551

Steadman ♦ Hawkins Sports Medicine Foundation
Preliminary Report: Evaluation of the Oribiter treadmill
as a rehabilitation device during walking

Executive Summary

A. EMG activity of the quadriceps was significantly less on the Orbiter treadmill than it was on a more traditional, firm treadmill.

B. Hamstring activity was not influenced by treadmill surface.

C. The investigation suggests that the Orbiter treadmill is less traumatic to the lower extremity during gait and would be effective in early rehabilitation.

The Effect of Treadmill Surface and Grade on EMG Activity of the Quadriceps and Hamstrings

Patellofemoral pain and quadriceps insufficiency are some of the problems faced by patients that have undergone ACL reconstruction. A successful rehabilitation program for these patients requires relatively pain free exercise that activates the appropriate knee musculature and develops strength. Walking is a simple exercise that may be intensified, and perhaps better target the quadriceps muscles, by using increased grades. However, the pain tolerance of the patient must be kept in mind as intensity is modulated. This study used the parameters of peak amplitude and overall electromyographic (EMG) activity of the quadriceps and hamstring muscles to examine treadmill walking at three different grades and on two distinct treadmills.

Methods

Five males (average age = 29.6 years, weight = 76.5 kg, height = 1.78 meters) participated as subjects. None of the subjects had a prior history of patellofemoral problems. EMG activity was recorded from four muscles on the dominant side of each subject. The muscles monitored were the vastus lateralis (VL), vastus medialis oblique (VMO), medial hamstrings (MH), and biceps femoris (BF).

The two treadmills had distinctly different surfaces. One had a rubberized belt that was supported along the sides, resulting in an elastic surface (Orbiter, Baytown, TX). The other treadmill was more traditional and had a firm surface (Woodway, Inc., Waukesha, WI).

Prior to testing, all subjects participated in an orientation session to become familiar with walking on the two treadmills. During the orientation, self selected speeds were determined for each subject at three grades (0, 12, and 24%) on each treadmill. As a result of this procedure, speeds differed across treadmills and grades for each subject. Self selected speeds are commonly used to normalize the effort of each subject.

During the testing session, maximum voluntary contractions (MVC's) were recorded from each of the four muscles pre-, mid-, and post-testing. Muscle activity during walking was expressed as a percentage of the maximal contraction (%MVC). For each grade and treadmill, the subject walked at their preferred speed. EMG activity was recorded at 2, 3, and 4 minutes. The presentation order of grade and treadmill conditions was balanced across subjects.

Results and Discussion

Electromyographic activity recorded during each stride cycle was analyzed. Five complete cycles were used for each ten second collection period. The activity for each muscle was summarized in terms of absolute peak value (uV), and total area (uV*s) measured from the integrated signal.

The results of this investigation are summarized in tables 1.0 through 4.0. The tables contain the means, standard deviations (S.D.), and p-values (indicating statistical results for tests of conditions). Tables 1.0 and 2.0 illustrate the effects of grade on the average absolute peak magnitude and overall EMG activity independent of treadmill (data combined across treadmills). Tables 3.0 and 4.0 provide the effects of the different treadmills on the average absolute peak amplitude and overall EMG activity independent of grade. Each muscle was then analyzed in terms of overall activity changes and peak changes as a percentage of MVC (Figures 1 and 2). The overall area (Figures 3-6) and the absolute peak (Figures 7-10) portray the changes occurring on each treadmill relative to changes in grade.

Differences in EMG parameters for the VL and VMO with respect to treadmill surface are highlighted in tables 3 and 4. The peak amplitude of the VL was significantly lower ($p < .05$) on the soft treadmill. Although not statistically significant, this trend was apparent for the VMO as well. Figures 7 and 8 depict the differences in activity observed at each grade. Since peak activity of the quadriceps is known to occur at heel strike during walking, it is safe to assume, without ground reaction force measurements, that higher forces are occurring on the firm treadmill. Someone just beginning a rehabilitation program may not be able to tolerate these higher forces.

Effective training of the quadriceps may also be represented by the overall activity (area under the curve) of the muscles during each gait cycle. This measure is a function of both the peak amplitude and the duration of muscle activity. The VMO had significantly greater activity ($p < .05$) on the hard treadmill, whereas the VL displayed a similar trend, but was not significant (Table 4). The differences in overall activity at each grade are illustrated in Figures 3 and 4. In both the VL and VMO there are similar increases in each treadmill as grade increases. The peak activity of the VL (Figure 7) mirrors the trend presented in the overall activity (Figure 3). The VMO exhibits a drop in peak activity as the grade is increased from 12 to 24 on the firm treadmill (Figure 8).

Hamstring activity was not influenced by treadmill surface (Tables 3 and 4). There was a trend for peak MH activity to be greater at grades 12 and 24, as illustrated in Figure 9, but overall it was not significant. If the goal of a conditioning or rehabilitation program was to strengthen the hamstrings, either treadmill would be equally productive. This is also apparent from Figures 1 and 2, where peak EMG activity as a percentage of MVC is similar for the hamstring muscles on both treadmills.

Table 1.0. The effect of grade on absolute peak activity (uV).

Muscle	Grade	Mean	SD	p*
VL	0	96.317	36.60	
	12	123.410	46.07	.0014
	24	169.900	56.63	
VMO	0	105.800	109.38	
	12	130.730	92.30	.4340
	24	140.670	50.53	
MH	0	98.048	35.50	
	12	126.020	57.60	.1929
	24	121.630	53.31	
BF	0	93.841	41.78	
	12	122.890	46.53	.0327
	24	130.760	53.11	

* $p < 0.05$ is significant

N = 150 with the exception of grade 0, where N = 145 due to missing data.

Table 2.0. The effect of grade on overall activity (uV*s).

Muscle	Grade	Mean	S.D.	p*
VL	0	13.432	5.97	
	12	18.354	8.64	.0006
	24	26.951	9.38	
VMO	0	14.700	11.45	
	12	17.878	11.90	.0247
	24	24.926	10.52	
MH	0	17.395	8.22	
	12	31.536	16.23	.0121
	24	37.003	18.23	
BF	0	17.289	11.23	
	12	28.073	15.82	.0091
	24	32.241	17.79	

* $p < 0.05$ is significant

N = 150 with the exception of grade 0, where N = 145 due to missing data.

Table 3.0. The effect of treadmill surface on absolute peak activity (uV).

Muscle	Treadmill	mean	S.D.	p*
VL	elastic	108.700	49.06	.0028
	firm	151.330	54.58	
VMO	elastic	93.168	42.35	.0736
	firm	157.550	108.11	
MH	elastic	107.480	41.28	.0736
	firm	123.590	58.33	
BF	elastic	115.550	48.10	.8769
	firm	116.590	51.69	

* $p < 0.05$ is significant

N = 225 for the elastic treadmill

N = 220 for the firm treadmill due to missing data.

Table 4.0. The effect of treadmill surface on overall activity (uV*s).

Muscle	Treadmill	mean	S.D.	p*
VL	elastic	16.632	9.43	.0560
	firm	22.597	9.40	
VMO	elastic	14.901	8.35	.0263
	firm	23.439	13.56	
MH	elastic	28.242	15.60	.4665
	firm	29.289	18.31	
BF	elastic	26.211	15.17	.8941
	firm	25.723	17.63	

* $p < 0.05$ is significant

N = 225 for the elastic treadmill

N = 220 for the firm treadmill due to missing data.

Figure 1. Peak activity (%MVC)
Elastic Treadmill

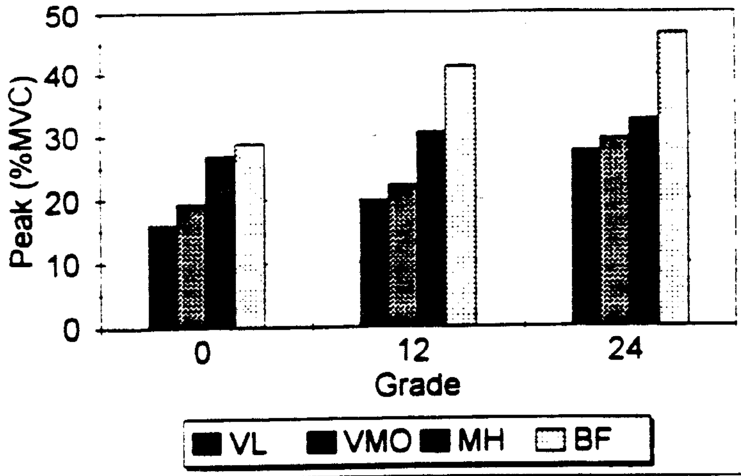


Figure 2. Peak activity (% MVC)
Firm Treadmill

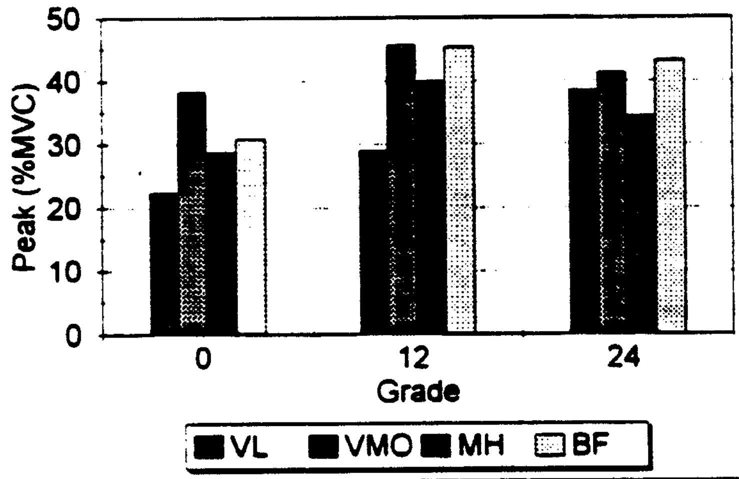


Figure 3. Overall Activity of the VL

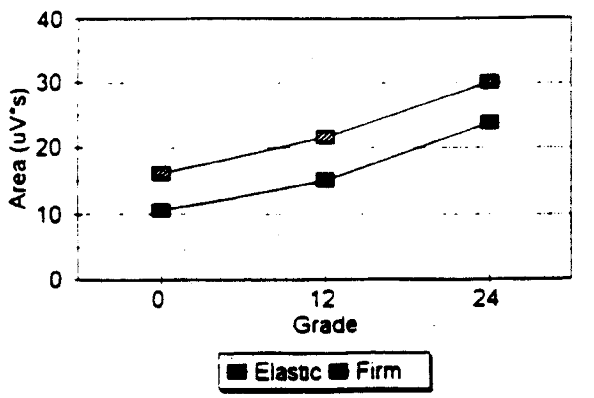


Figure 4. Overall Activity of the VMO

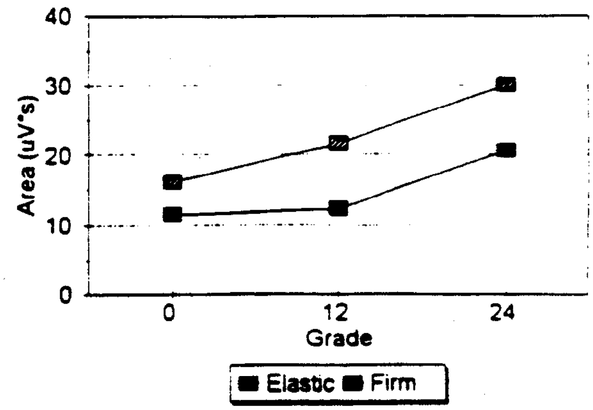


Figure 5. Overall Activity of the MH

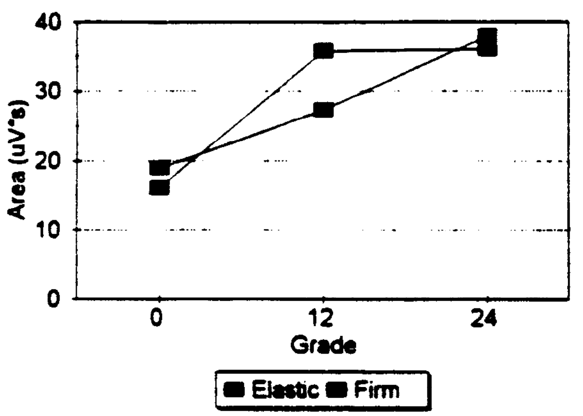
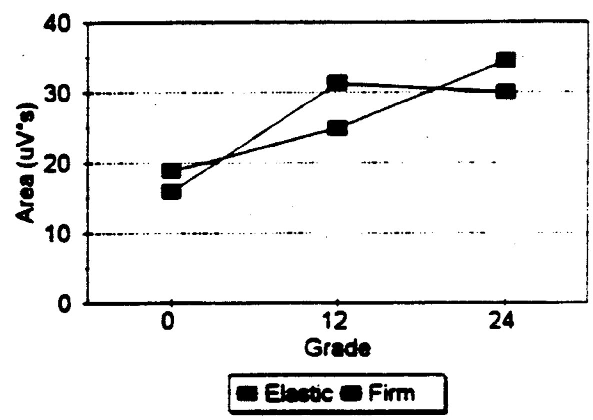


Figure 6. Overall activity of the BF



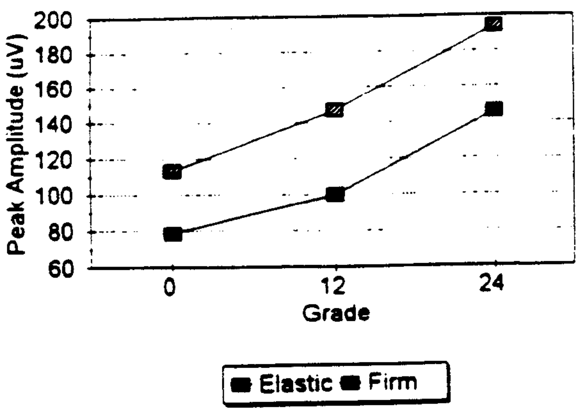


Figure 7. Peak Activity of the VL

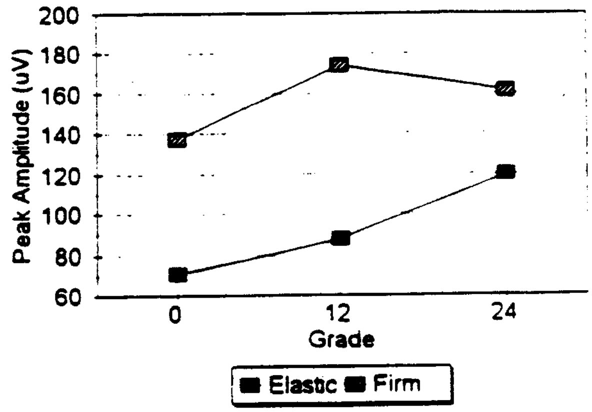


Figure 8. Peak Activity of the VMO

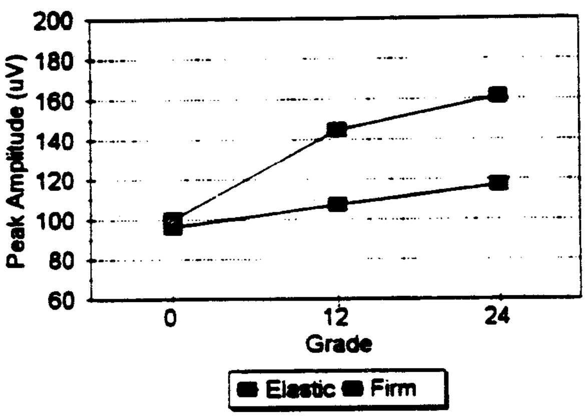


Figure 9. Peak Activity of the MH

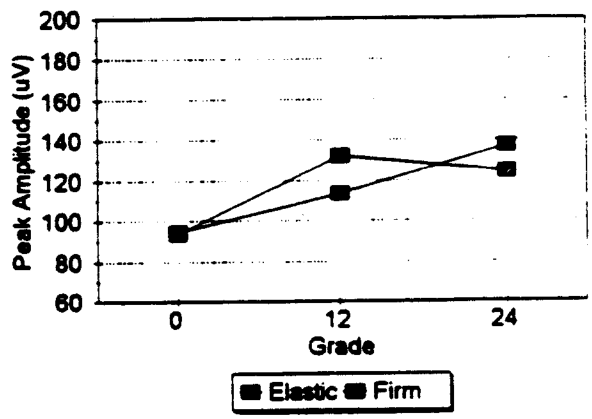


Figure 10. Peak Activity of the BF

Conclusions and Recommendations

The major finding of this investigation was the significantly reduced peak EMG amplitudes observed in the quadriceps during walking on the Orbiter Treadmill. Use of an elastic surfaced treadmill of this nature would be applicable to any physician, therapist, or patient seeking a lower impact alternative to conventional treadmill walking. This may not only benefit patients with lower extremity problems, but also those patients with hip and back problems as well.

The ability to use the Orbiter Treadmill much sooner in rehabilitation than a firm treadmill can help quicken a patients return to full function.