Electromyographic Responses of Distal Ankle Musculature of Standing Hemiplegic Patients to Continuous Anterior-Posterior Perturbations During Imposed Weight Transfer over the Affected Leg
Ruth Dickstein, Thomas Pillar, Naor Shina and Shraga Hocherman
Electromyographic Responses of Distal Ankle Musculature of Standing Hemiplegic Patients to Continuous Anterior-Posterior Perturbations During Imposed Weight Transfer over the Affected Leg

This study was undertaken to evaluate the influence of weight shift over the affected leg of standing hemiplegic patients on the electromyographic responses of the medial gastrocnemius and tibialis anterior muscles during continuous anterior-posterior movements of the base of support. Recordings were taken from 10 hemiplegic subjects and from 9 healthy subjects of comparable age. Each subject was first tested standing with both feet on a level surface and then with either leg (in healthy subjects) or the unaffected leg (in hemiplegic subjects) raised on a step. The second testing position caused unloading of the elevated leg and weight shift, that is, loading of the other leg. The measured variables were modulation of muscular activity, determined by a modulation index formulated for that purpose, and the relative amount of integrated electromyographic activity in each muscle. Changes in both variables in the uneven stance position as compared with even stance, occurred primarily in the unaffected (unloaded) leg in the hemiplegic subjects. These changes were comparable to changes in the unloaded leg of the healthy subjects. Thus, imposed loading on the affected leg of the hemiplegic subjects did not significantly improve either the reduced modulation or the relatively low IEMG activity of the investigated muscles. Further studies are required to evaluate the contribution of weight shift to recovery of postural responses in the affected leg of hemiplegic patients. [Dickstein R, Pillar T, Shina N, et al: Electromyographic responses of distal ankle musculature of standing hemiplegic patients to continuous anterior-posterior perturbations during imposed weight transfer over the affected leg. Phys Ther 69:484-491, 1989]

Key Words: Electromyography; Hemiplegia, evaluation; Lower extremity, general; Muscle performance, measurement.

R Dickstein, DSc, is Research Physical Therapist, Department of Physical Therapy, Flieman Geriatric-Rehabilitation Hospital, Ramot-Remez, PO Box 2263, Haifa 31021, Israel, and Lecturer, Department of Physical Therapy, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel. Address correspondence to Department of Physical Therapy, Flieman Geriatric-Rehabilitation Hospital, Ramot-Remez, PO Box 2263, Haifa 31021, Israel.

T Pillar, MD, is Director, Flieman Geriatric-Rehabilitation Hospital.

N Shina, BSc, is Computer Programmer, Flieman Geriatric-Rehabilitation Hospital.

S Hocherman, PhD, is Senior Lecturer, Department of Physiology and Biophysics, Technion-Israel Institute of Technology, Haifa, Israel.

This article was submitted June 29, 1988; was with the authors for revision for 17 weeks, and was accepted January 27, 1989.

A common physical therapy procedure to improve the stance and gait of hemiplegic patients is imposition of weight bearing, that is, loading of the affected lower extremity. Imposing weight shift and weight transfer through the impaired lower limb is believed to enhance sensory inflow, leading to improved postural responses. Normalization of abnormal muscle tone, especially reduction of spasticity, is also claimed to be achieved through loading exercises. A common way to impose weight.
bearing on the affected leg is to elevate the sound leg of the standing patient to a step. The validity of this technique was recently asserted by Bohannon and Larkin, who demonstrated that hemiparetic patients bore significantly more weight on the lower extremity that was not on the step during standing.4

The anterior and posterior ankle musculature play a crucial role in maintaining erect stance during anterior-posterior perturbations. Functional postural responses of the medial gastrocnemius (MG) and tibialis anterior (TA) muscles to brief and unexpected movements of the support surface, frequently classified as long-loop functional reflexes, have been investigated by various authors.5,6 In healthy standing individuals subjected to AP perturbations, voluntarily shifting body weight over one lower limb was associated with decreased response latency of functional muscular pairs in either the anterior or posterior side of the leg.7 In hemiparetic patients, it has been demonstrated that prior knowledge of such perturbations significantly shortened response latencies in the paretic limb.8

Responses of the MG and TA muscles to anticipated and repeated AP perturbations involve a different strategy of stabilization than that applied in response to unexpected perturbations. In expected AP perturbations, an anticipatory postural set is formed, defined as "a state of readiness to receive a stimulus that has not yet arrived or a state of readiness to perform a movement."9 10 When sinusoidal AP movement of the base of support is imposed on healthy standing subjects, the response is characterized by a stereotypic reciprocal pattern of muscular activation in which the MG muscle is predominantly active during the forward half cycle (FHC) (from midpoint to the anterior extreme and back to midpoint) and the TA muscle is predominantly active during the backward half cycle (BHC) (from midpoint to the posterior extreme and back to midpoint) of the movement trajectory.10 Peak activity of each muscle was reached in the vicinity of the respective pole that designates either the anterior or the posterior extreme of the movement trajectory. In elderly subjects, this basic pattern may be contaminated by various degrees of unintegrated tonic muscular activity.11

Several electromyographic studies of the affected leg of standing hemiparetic patients have revealed impaired postural responses of the MG and TA muscles to sudden AP movement of the base of support.12 Malfunction in responses to continuous movements has also been demonstrated recently, being reflected in lack of adaptation to the movement profile and in decreased amount of muscular activity.10

The purpose of this study was to assess the effect of weight shift over the affected leg of hemiparetic patients on two attributes of postural responses during continuous AP sinusoidal movements of the base of support: 1) adaptation of the activation pattern of the MG and TA muscles to the imposed movements and 2) the relative amount of integrated electromyographic activity of these muscles.

Method

Subjects

Ten hemiparetic patients (5 men, 5 women), with an average age of 61 years (s = 12), participated in the study. Seven Hemiparetic Group subjects had right hemiplegia and 3 had left hemiplegia. In 9 Hemiparetic Group subjects, paresis resulted from a thromboembolic cerebral infarct that occurred 3 months (s = 0.8) prior to the study. The 10th Hemiparetic Group subject had undergone excision of a meningioma 6 months before the study. All Hemiparetic Group subjects were receiving physical therapy, occupational therapy, or speech therapy, 7 as inpatients and 3 as outpatients in a rehabilitation hospital. All Hemiparetic Group subjects were capable of independent indoor ambulation, 8 with a four-point or a single-point cane and 2 unassisted. Lower extremity muscle tone of the affected leg, measured by an ordinal rating scale,13 in all Hemiparetic Group subjects was lower than that of their unaffected leg; in 7 Hemiparetic Group subjects, partial foot drop was apparent during ambulation.

A group of 9 healthy subjects (4 men, 5 women), with a mean age of 55 years (s = 25), was also tested according to the experimental protocol. All subjects gave their informed consent to the research protocol.

Instrumentation and Recording

Weight distribution between feet and amount of loading of the affected leg was measured by digital bathroom scales. Prior to measurement, the scales were calibrated with 15 kg of standard physical therapy weights.

Anterior-posterior movements of the subjects' base of support were generated by a platform designed for AP movements at a frequency of 0.5 Hz and a predetermined amplitude. Movement profile was sinusoidal; thus, peak velocity occurred at the midpoint of the platform's trajectory, and peak acceleration and deceleration occurred at the extreme backward and forward points of the movement cycle, respectively.

A four-channel EMG recorder* was interfaced with an Apple Ile computer† for data collection, storage, and analysis. Activity of the MG and TA muscles in both legs was monitored through surface disposable electrodes placed on the bellies of the muscles according to the guidelines of Basmajian and Blumenstein.14 Sig-

---

*Atlas 1572, Atlas Research, Ltd, PO Box 271, Hod Hasharon, Israel.
†Apple Computer, Inc, 10260 Brandley Dr, Cupertino, CA 95014.
Fig. 1. (a) One averaged electromyographic cycle of a healthy 74-year-old man, composed of 10 consecutive movement cycles of the platform. The two extreme vertical lines correspond to its anterior poles. The posterior pole, which is midway between the two anterior poles, is not shown. The two intermediate vertical lines designated the midpoint of the platform's trajectory, which was passed first when the platform moved backward from the anterior pole and then again when the platform moved forward from the posterior pole. The forward half cycle (FHC) corresponds to the two extreme quadrants of the cycle, and the backward half cycle (BHC) corresponds to the two middle quadrants. The modulation index is the ratio between the integrated electromyographic activity of the FHC and the total IEMG of the same cycle. (b) Example of data obtained from the same subject during three consecutive movement cycles. Each data point is a running average of five consecutive data points. Unbroken vertical lines designate the anterior pole triggers; broken lines represent the posterior pole. Midpoint of the platform's trajectory (not marked) corresponds to the halfway point between consecutive vertical lines.

Signals were band-pass limited from 100 to 750 Hz, full-wave rectified, and then low-pass filtered ($T = 8$ msec). Data points were sampled in a frequency of 100 Hz, and averages of each three consecutive points were displayed and stored on magnetic disks. Trigger signals were generated when the moving platform reached either the anterior or the posterior pole, and stored together with the EMG data.

**Procedure**

Both Hemiplegic Group and Healthy Group subjects underwent the following experimental steps:

1. The proportion of body weight supported by each lower extremity was determined with subjects standing on two scales on a level surface.

2. Weight distribution was determined while the sound leg of the Hemiplegic Group subjects and either leg of the Healthy Group subjects was placed on a 5-cm high bathroom scale. The scale served as both measuring device and step. The longest constant value maintained by the subject during a 20-second period was recorded. This was the most effective method for measuring weight distribution, in view of the excessive lateral sway noted in the majority of the Hemiplegic Group subjects.

3. The subject assumed a comfortable standing position on the platform, facing its anterior pole, with both feet placed parallel at a distance of 10 to 12 cm from the midline of the platform's base. The EMG electrodes were positioned and platform movements initiated in an amplitude of 3 cm for the Healthy Group subjects and 9 cm for the Hemiplegic Group subjects. These amplitudes were nonthreatening, and all subjects could stand without hand support; however, they were sufficient for challenging stance stability and for inducing clearly visible responses in the monitored muscles.

4. Electromyographic recording was performed after subjects were familiarized with the perturbation pattern and reported standing comfortably. The EMG recording lasted 30 seconds.

5. Step 4 was repeated, with one leg elevated as described in step 2.

**Data Analysis**

All data were analyzed by software developed for this purpose. Descriptive and inferential statistical tech-
niques (t test) were applied to compare the responses of the Hemiplegic Group and Healthy Group subjects and to assess the influence of loading and unloading on the monitored muscles in each subject.

The anterior pole triggers of the platform were chosen as boundaries of one movement cycle. The EMG data were averaged over 10 consecutive cycles (i.e., 20 seconds), and the data analysis was performed on the composed averaged cycle.

A special index, called the modulation index (MI), was formulated to assess the adaptation of muscular activity pattern to the movement profile of the platform. This was a modified version of a similar index used in a previous study. The MI was defined as the ratio between the IEMG (i.e., the area underneath the EMG curve) of each muscle during the time period corresponding to the FHC and the total IEMG activity of the same muscle recorded during the whole movement cycle (i.e., the sum of the IEMG in the FHC and the BHC). Because the anterior poles were chosen as limits of a complete cycle, values between 0.5 and 1.0 were expected for the MG muscle and values less than 0.5 were anticipated for the TA muscle in the Healthy Group subjects. Within these ranges, an increase in the MI of the MG muscle and a decrease in the MI of the TA muscle were indicative of an increase in modulatory activity; the opposite trends were interpreted as a decrease in modulation. An explanatory illustration of the MI is given in Figure 1.

The effect of imposed loading and unloading on the amount of IEMG activity in the monitored muscles of each individual was evaluated by comparing the ratios of IEMG of homologous muscles in both legs while standing on a level surface with the IEMG ratio when either leg (in the Healthy Group subjects) or the sound leg (in the Hemiplegic Group subjects) was placed on the scale. The effect of loading on that ratio in the Hemiplegic Group subjects was then compared with the parallel effect in the healthy controls.

Results

Weight Distribution

While standing with feet flat on the floor, the Healthy Group subjects distributed their weight equally between both legs. When one leg was placed on the step, it was always unloaded in comparison with the leg on the floor. Mean percentage of body weight placed on the unweighted leg was 80% (s = 8.7%).

For the Hemiplegic Group subjects, both test positions were characterized by uneven weight distribution. The mean percentage of body weight carried by the affected lower limb was 32% (s = 14%) on a level surface and 40.5% (s = 18%) with the sound leg on a step. This moderate increase in weight bearing of the affected limb was accompanied by a marked increase in lateral sway, as manifested by rapid changes in the amount of weight carried by each leg. All Hemiplegic Group subjects were able to stand without hand support during the experiment.

Activation Pattern

Healthy Group. The mean MI of the MG muscle at level surface was 0.63 (s = 0.08). Unloading of one leg by placing it on a step had no significant effect on that index (MI = 0.62, s = 0.08), and the slight increase accompanying loading (MI = 0.67, s = 0.10) also was statistically nonsignificant.

Corresponding MI values for the TA muscle were 0.49 (s = 0.08) for the level surface, 0.43 (s = 0.17) for the unloaded leg, and 0.50 (s = 0.02) for the loaded leg. None of these changes reached statistical significance.

Hemiplegic Group. On a level surface, the mean MI of the MG muscle of the affected side was 0.55 (s = 0.16), whereas that of the sound side was 0.63 (s = 0.08). Elevation of the sound leg was associated with a nonsignificant decrease in modulation (MI = 0.60, s = 0.06), whereas loading the affected leg left the MI unchanged (MI = 0.56, s = 0.10).

Corresponding MI values for the TA muscle on a level surface were 0.57 (s = 0.14) for the affected leg and 0.53 (s = 0.06) for the sound leg. Unloading of the sound side caused an increase in the TA muscle's modulation (MI = 0.47, s = 0.09), and the same trend was noted to a lesser extent in the affected (loaded) leg (MI = 0.54, s = 0.13). These changes were also statistically nonsignificant. A diagrammatic representation of the data, comparing the Hemiplegic Group and Healthy Group subjects, is provided in Figures 2 and 3.

Integrated Electromyographic Activity

Healthy Group. The ratio between the IEMG activity of one MG muscle to that of its homologous counterpart during level surface standing was compared with the same ratio while the leg of the numerator muscle was unloaded and the leg of the denominator muscle loaded. The comparison revealed a significant decrease in this ratio (t = 2.55, df = 7, p < .05) (Tab. 1, Fig. 4). To determine the relative contribution of the numerator and denominator muscles of this ratio to the noted change, we further calculated the ratios between IEMG activity of each muscle on a level surface and in either the loaded or unloaded position. These calculations revealed that unloading was associated with a reduction of 1.78 (s = 1.02) times in IEMG activity and that loading was associated with some increase in the activity of the MG muscle (Tab. 2).

A similar comparison analysis for the TA muscle indicated an increase of the level surface ratio while the muscle represented in the numerator was unloaded and the muscle represented in the denominator was loaded (t = −1.96, df = 7, p < .10) (Tab. 1, Fig. 5). Further analysis revealed that unloading was associated with an almost twofold increase (1/0.55) in TA muscle activity, whereas a similar but
more moderate increase was noted in the loaded leg (Tab. 2).

**Hemiplegic Group.** The ratio between the IEMG activity of the MG muscle on the sound side and that of the affected side decreased when the sound leg was raised; however, its comparison with the corresponding level surface yielded statistically non-significant results (Tab. 1). The IEMG activity of each MG muscle during level surface standing thereafter was compared with its activity in either the loaded or unloaded position. That comparison revealed that loading of the affected leg was not associated with a change in amount of muscular activation, whereas unloading brought about a 1.25 × decrease in the IEMG activity.
**Table 1.** Mean Ratios and Standard Deviations for Integrated Electromyographic Activity Between Homologous Muscles of Both Legs During Erect Stance on a Level Surface and with One Leg Elevated on a Step

<table>
<thead>
<tr>
<th>Group</th>
<th>MG&lt;sup&gt;b&lt;/sup&gt;</th>
<th></th>
<th></th>
<th>TA&lt;sup&gt;c&lt;/sup&gt;</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level Surface (ULS/LS)&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td>Level Surface (ULS/LS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\bar{X}$</td>
<td>$s$</td>
<td></td>
<td>$\bar{X}$</td>
<td>$s$</td>
<td></td>
</tr>
<tr>
<td>Healthy (n = 9)</td>
<td>0.78</td>
<td>0.23</td>
<td></td>
<td>1.62</td>
<td>1.11</td>
<td></td>
</tr>
<tr>
<td>Hemiplegic (n = 10)</td>
<td>4.63</td>
<td>5.78</td>
<td></td>
<td>3.41</td>
<td>3.05</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Measurements recorded during continuous anterior-posterior movements. In Hemiplegic Group subjects, values for the unaffected (unloaded) leg were represented in the numerator and values of the affected (loaded) leg were represented in the denominator.

<sup>b</sup>MG = medial gastrocnemius muscle.

<sup>c</sup>TA = tibialis anterior muscle.

<sup>d</sup>ULS = values measured during level surface standing from the leg that was later unloaded.

<sup>e</sup>UL = unloaded leg.

<sup>f</sup>L = loaded leg.

<sup>h</sup>Significantly different ($p < .05$) from level surface standing ratio of the same muscle.

The IEMG activity of the MG muscle of the sound leg (Tab. 2).

With regard to the TA muscle, elevation of the sound leg was not associated with a significant change in the ratio for IEMG activity between the two homologous muscles (Tab. 1). The IEMG activity of the TA muscle increased both in the affected (loaded) side and in the unaffected (unloaded) side. This increase, however, was more pronounced in the sound leg than in the affected leg (Tab. 2).

**Discussion**

Clinical judgment of postural responses is usually based on observation of performance of several postural tasks. Although valuable information is gained by this method, covert strategies of performance are often missed. Lack of awareness of this shortcoming can account for the assumption that correcting or over-correcting weight distribution imbalances between the feet of hemiplegic patients is automatically associated with improved postural responses of the impaired leg. The limited results of this study have not supported that assumption.

The MI expressed the degree to which the activity of the MG and TA muscles was modulated by the forward and backward movement of the platform. The MI could be interpreted as a crude measure of adaptability, which is a crucial determinant of motor control. A comparison of the MIs of the MG muscle between the Hemiplegic Group and Healthy Group subjects indicated a normal MI in the sound leg and an impaired MI in the affected leg. Loading slightly increased the MI of the MG muscle in the Healthy Group subjects, but no such effect was noted in the affected (loaded) leg of the Hemiplegic Group subjects. An additional slight decrease in the MI of the sound (unloaded) leg of the Hemiplegic Group subjects caused a further deviation from normal values. The MI of the affected TA muscle also was not improved by loading, whereas the sound TA muscle in the Hemiplegic Group subjects increased its modulation in response to unloading, similar to the trend noted in the Healthy Group subjects.

The IEMG activity of the MG muscle of the Healthy Group subjects decreased in the unloaded side and somewhat increased in the loaded side. The same trend was found in the sound (unloaded) leg in the Hemiplegic Group subjects, but without a concomitant increase in the IEMG of the MG muscle in the affected (loaded) leg. It is conceivable, therefore, that the imposed uneven posture reduced the overall activity of the MG muscles, probably adversely affecting the subject's ability to counteract forward body sway. With regard to the TA muscles, Hemiplegic Group as well as Healthy Group subjects showed the greatest increase in IEMG activity in the uneven standing posture in the unloaded side (ie, in the sound side of the Hemiplegic Group patients).

Thus, for Healthy Group subjects, the findings indicated that most of the changes in the measured variables during step standing took place in the unloaded leg. The same was true for the Hemiplegic Group subjects whose unloaded leg was the unaffected leg. That is, adaptation to AP movements during imposed uneven standing affected mainly the modulatory activity and the amount of IEMG of the muscles of the sound side. Loading by the technique used in this study apparently made no positive contribution to the postural response of the muscles of the affected leg. These findings are supported by a recent report that improvement in gait and balance of...
hemiplegic patients undergoing intensive rehabilitation seemed to stem more from increased reliance on the sound leg than from incorporation of the affected leg into function.\textsuperscript{17}

Limitations in the scope of this study should be mentioned. In addition to an inherently heterogeneous sample and a limited number of participants, only two postural variables were tested and only two muscles were monitored. The role of proximal muscles that might have been activated was not examined. Follow-up studies to determine possible changes of these responses with repeated training have not been performed. The method applied gave no objective way to assert that weight distribution as measured during static, uneven standing was actually maintained throughout the perturbations. We might also argue that the sound leg of the Hemiplegic Group subjects was insufficiently raised, precluding a more substantial weight shift over the affected side. A step of 17 cm, such as that used by Bohannon and Larkin,\textsuperscript{4} might have been more effective. We chose a relatively low step because it allowed the subjects to maintain their balance during perturbations. The optimal height that the sound leg should be raised in this exercise remains to be determined.

The results of this research confirm findings of other studies that pointed to the dependency of postural responses on various intrinsic and extrinsic variables.\textsuperscript{5-8,10,11} They challenge the generalization that imposed loading of the affected leg is associated with improvement of its postural responses. Rather, the findings highlight the need for further study on the effects of this technique in specific clinical contexts and with additional experimental paradigms. Because postural responses encompass a large repertoire of motor behaviors, numerous experiments are required before a conclusive statement can be made.

\begin{table}[h]
\centering
\begin{tabular}{llllll}
\hline
 & & & & & \\
 & MG\textsuperscript{b} & & & & \\
 & S/L\textsuperscript{d} & S/UL\textsuperscript{f} & & & \\
Group & & & & & \\
Healthy (n = 9) & 0.72 & 0.23 & 1.78 & 1.02 & \\
Hemiplegic (n = 10) & 0.99 & 0.47 & 1.25 & 0.44 & \\
\hline
 & & & & & \\
 & TA\textsuperscript{c} & & & & \\
 & S/L\textsuperscript{d} & S/UL\textsuperscript{f} & & & \\
 & & & & & \\
Healthy (n = 9) & 0.72 & 0.12 & 0.55 & 0.27 & \\
Hemiplegic (n = 10) & 0.77 & 0.24 & 0.63 & 0.28 & \\
\hline
\end{tabular}
\caption{Mean Ratios and Standard Deviations for Integrated Electromyographic Activity of the Same Muscle During Erect Stance on a Level Surface and with One Leg Elevated on a Step\textsuperscript{a}}
\end{table}

\textsuperscript{a}Measurements recorded during continuous anterior-posterior movements. In Hemiplegic Group subjects, the unaffected leg was the unloaded leg and the affected leg was the loaded leg.

\textsuperscript{b}MG = medial gastrocnemius muscle.

\textsuperscript{c}TA = tibialis anterior muscle.

\textsuperscript{d}S = level surface.

\textsuperscript{e}L = loaded leg during step standing.

\textsuperscript{f}UL = unloaded leg during step standing.
Fig. 5. Ratios of integrated electromyographic activity between homologous tibialis anterior muscles 1) during level surface standing (SL) and 2) when one leg (the unaffected leg in the Hemiplegic Group subjects) was unloaded (UL) and the other leg was loaded (L).

Conclusions

Erect standing with the sound leg on a step and imposing moderate weight shift over the affected lower limb of hemiplegic patients during rhythmic, sinusoidal AP movements was not associated with improvement in modulation and in the amount of IEMG activity of the MG and TA muscles of the affected leg. Changes in these variables were noted in the muscles of the sound leg raised on the step. These findings do not rule out the possibility that postural adaptation to uneven standing affected proximal muscles of the affected leg. Further studies are needed to elucidate the role of imposed loading of the affected leg on postural responses of hemiplegic patients.

References

11 Pillar T, Dickstein R, Hocherman S: Responses of the Ankle Musculature of Healthy Aged and Hemiplegic Patients to AP Perturbations During Stance. Read at the Seventh Conference of the Israel Gerontological Society, Ramat Gan, Israel, March 1986
Electromyographic Responses of Distal Ankle Musculature of Standing Hemiplegic Patients to Continuous Anterior-Posterior Perturbations During Imposed Weight Transfer over the Affected Leg
Ruth Dickstein, Thomas Pillar, Naor Shina and Shraga Hocherman

Cited by
This article has been cited by 2 HighWire-hosted articles:
http://ptjournal.apta.org/content/69/6/484#otherarticles

Subscription Information
http://ptjournal.apta.org/subscriptions/

Permissions and Reprints
http://ptjournal.apta.org/site/misc/terms.xhtml

Information for Authors
http://ptjournal.apta.org/site/misc/ifora.xhtml