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Author's response to Letter to the Editor re Physical Therapy

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EMG Onset Timing

To the Editor:

I read the recent report by Gilleard and colleagues (January 1998) with great interest, in the hope that the study would shed more light on the issue of relative timing of vastus medialis oblique muscle (VMO) and vastus lateralis muscle (VL) electromyographic (EMG) activity during voluntary activation. I was both surprised and disappointed to find that there were no direct measures of EMG onset timing anywhere in the article. The question posed by the authors—whether patellar taping changes the relative timing of EMG onset in the VMO and VL when subjects ascend and descend stairs—is certainly worthy of investigation. But despite statements such as “changed the timing of VMO and VL activity” and “earlier activation of the VMO,” the authors never actually present any timing data, choosing instead to present, analyze, and discuss data only in terms of knee angle. In addition to the obvious question of validity (ie, whether you are measuring what you say you are measuring), there are several major problems with the approach taken by the authors of this report.

1. The procedures chosen for signal processing and data analysis cause a significant loss of temporal resolution for the data presented. The authors sampled the raw EMG data at a rate of 900 Hz, which in itself would provide the ability to resolve differences on the order of slightly more than 1 millisecond. Two other aspects of the data collection and analysis, however, degrade the temporal resolution of the results presented.

First, the rectified EMG signals were low-pass filtered with a cutoff of 3 Hz prior to using the computer algorithm to determine EMG onsets. This type of gross smoothing of the rectified EMG signals leads to
a loss of signal information that can greatly affect conclusions regarding the timing of EMG onsets. For readers unfamiliar with the effects of this smoothing procedure, the Figure (following page) graphically illustrates the temporal distortion resulting from the 3-Hz low-pass filtering technique used in this study. I believe that this visual comparison alone will convince the reader that such filtering results in significant loss of the temporal information contained in the raw EMG signal.

Second, although the time of EMG onset was determined based on computerized analysis of the filtered EMG signals, that time was not used directly in the statistical analyses, but was used only to identify a frame number from the 60-Hz video recording. Thus, the effective sampling rate for all data reported in this article is actually 60 Hz, yielding a maximum resolution of 16.66 milliseconds. To put this resolution in perspective, I refer the reader to data from our 1995 study regarding the relative onset timing of VMO and VL EMG activity (sampled at 4,000 Hz, resulting in a maximum resolution of 0.25 milliseconds) during active knee extension activities. As illustrated in Figure 4 of that report, we found that differences in the timing of EMG onset between the VMO and the VL in subjects with patellofemoral pain syndrome were typically less than 5 milliseconds and did not exceed 15 milliseconds. The 60-Hz sampling rate is clearly too low for adequate evaluation of the small VMO and VL onset timing differences observed during either reflex or voluntary activation of the quadriceps femoris muscle.

2. By quantifying "onset" in terms of knee angle, the authors have added a whole new source of potential measurement error. Although it is commendable that the authors have used a computer algorithm in an attempt to reduce errors in EMG onset determination, it is unfortunate that they have also introduced an additional source of error associated with the process of determining knee joint angles. These angle measurements were based on images from a single 60-Hz video camera at a distance of 7 m, and thus are subject to parallax error in addition to the inherent noise associated with all optical motion analysis systems. No data were provided regarding the accuracy of the marker position measurements in these experiments, but there is no doubt that the translation from onset-time data to knee angle data introduces an additional source of measurement error.

The reliability data presented suggest that the overall measurement error could be quite large in comparison with the joint angle differences that were found to be statistically significant. For example, trial-to-trial measurement error was greater than 5 degrees in more than one fourth of all measurements (Tab. 3), whereas 3 of the 4 statistically significant differences were less than 5 degrees and, in one case (control condition versus taped condition for the VMO during the step-down task), the difference was only slightly more than 1 degree.

3. The failure to publish the actual onset-timing differences makes it impossible for readers to compare these data with previously published data regarding VMO and VL onset timing differences observed.

Figure. Top trace is raw electromyographic data collected using a preamplified bipolar surface electrode, amplified (overall gain=5,000), high-pass filtered (cutoff=20 Hz), and sampled at 900 Hz. Middle trace was derived by full-wave rectification of the top trace. Bottom trace illustrates the effect of low-pass filtering the middle trace with a cutoff of 3 Hz.
during reflex$^{2,3}$ and voluntary$^2$ activation of the quadriceps femoris muscle. The inclusion of the knee angle data in addition to the actual timing data might be justified if there is some specific point the authors want to make about the relationship between potential onset timing differences and knee kinematics, but no such point is apparent in the discussion.

In conclusion, I believe that the method used in this study has serious flaws that could affect the conclusions reached and that the use of secondarily derived joint angle measurements to characterize EMG onset timing introduces unnecessary error and confusion. Although the authors have concluded that their findings support those that we reported previously,$^2$ I can take little comfort in a conclusion based on a method that lacks the temporal resolution to detect the magnitude of onset-timing differences we observed in our study. Although I hope that this discussion leads to additional research, I would also make a plea for careful consideration of methodological issues in designing future studies. If we hope to resolve issues relating to relatively small timing differences (eg, milliseconds or tens of milliseconds), it would seem prudent to avoid low-pass filtering in order to avoid temporal distortion of the EMG signals, to sample at high frequencies to maximize temporal resolution, and to report timing differences in appropriate units (eg, milliseconds).

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References

Author Response:
In order to further investigate the mechanisms underlying the treatment of patellofemoral pain syndrome using patellofemoral taping, a functional task known to aggravate the symptoms, stair ascent and descent was chosen. Although the absolute relative difference in onset timing between the VMO and the VL is of interest and has contributed to the knowledge of this syndrome, there is currently very little knowledge of where this possible change in timing related to the taping technique occurs in tasks of normal daily activity. Hence, the decision to report muscle onset relative to the knee angle. In addition, this method also minimized the effect of limb length, which is a problem with reporting absolute onset values as discussed by Karst and Willet.$^1$

The rectified EMG signals were digitally low-pass filtered using a 2-pass fourth-order Butterworth filter. Therefore, because there is zero phase shift in this type of filter, there would be no loss of temporal resolution and our conclusions relating the EMG onsets are correct. Unfortunately, we did not report the type of filter we used within the article and are happy to have an opportunity to rectify this failure. The figure presented by Dr Karst also did not report the type of filter used, and I can only assume that it was not of a similar type to that used in our article.

A 60-Hz sampling rate is clearly not adequate for evaluating timing differ-
We would like to thank Dr. Mueller for his thoughtful commentary on our article. Supervised exercise programs undoubtedly increase exercise tolerance in adherent patients with intermittent claudication (IC). Ideally, these patients initially should be encouraged to participate in a supervised exercise program. Supervision increases motivation and reassurance, and due consideration should also be given to the underlying disease and comorbidity. The components of the exercise program should be individualized and are most efficiently determined and provided by making use of the collective skills and experience of a variety of health care professionals, including the family physician, vascular surgeon, physical therapist, dietitian, and possibly others.

Major objectives of vascular rehabilitation include not only an improved functional capacity and an improved quality of life, but also a reduction of cardiovascular complications. The facilities and equipment used as part of the exercise program should be adequate, should meet the stated standards of the program, and should comply with the guidelines for patient safety.

Unfortunately, as yet, there is no nationwide structured exercise program for patients with IC in the Netherlands. This problem was recognized years ago by the Vereniging van Vaatpatiënten (Dutch society for patients with peripheral vascular problems), which took the initiative to enlarge the availability of supervised exercise programs for this specific category of patients and to develop specific guidelines for training. The Netherlands Heart Foundation supports this initiative financially, and, as a first result, our group was invited to systematically review the literature.

Our study confirms the conclusions of the individual randomized clinical trials and the other reviews: exercise programs improve walking performance in patients with IC. We agree with Dr. Mueller that many questions remain to be answered. Future research should focus on areas such as cost-benefit analysis, the effect on quality of life, and the effect on the reduction of cardiovascular complications.

Research proposals have been submitted or are currently being written for the funding of a prospective multicenter study and a combined biomechanical-physiological study to analyze gait patterns in patients with IC and to assess training effects at the vascular and muscular levels. A postgraduate course (3 days' duration) is being developed for physical therapists in which they will be instructed in all aspects of peripheral vascular rehabilitation, including laboratories, with an emphasis on patients with IC. Information on IC and training aspects are now included in the curriculum of therapists who specialize in geriatric physical therapy.

We expect, along with Dr. Mueller, that further research will provide additional evidence and guidelines for patients with IC that will benefit the patients and the health insurance companies.

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Corrections

Due to an electronic transmission error, the Journal received only the first paragraph of Brandsma and colleagues' response (page 288, March 1998) to Michael Mueller's invited commentary on their article titled “The Effect of Exercises on Walking Distance of Patients With Intermittent Claudication: A Study of Randomized Clinical Trials.” The full text of the authors' response is printed below:

In regard to parallax error, the camera was placed 7 in perpendicular to the plane of motion of the markers. Although some slight motion in and out of the plane due to abduction/adduction and rotation of the lower limb joints would have occurred, in the worst case, this would be approximately 0.5% of the marker position and even less of an effect on the angle calculation. The inherent noise of an Expert Vision® Motion Analysis Video System is in the order of 1 part in 5,000 and would have a minimal effect.

We agree that the use of combined muscle onsets with motion analysis data does introduce another potential

(continued on page 551)
TABLE 2: Single Dose, Placebo-Controlled Study—Common Adverse Events Reported

<table>
<thead>
<tr>
<th>Event</th>
<th>Placebo</th>
<th>Zanaflex 8 mg</th>
<th>Zanaflex 16 mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = 48</td>
<td>%</td>
<td>N = 45</td>
<td>%</td>
</tr>
<tr>
<td>N = 49</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Somnolence</td>
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<td>21</td>
<td>21</td>
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<tr>
<td>Dry mouth</td>
<td>76</td>
<td>76</td>
<td>76</td>
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<td>Asthenia</td>
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<td>67</td>
<td>75</td>
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<tr>
<td>Dizziness</td>
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<td>22</td>
<td>45</td>
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<tr>
<td>Hypersomnia</td>
<td>0</td>
<td>16</td>
<td>33</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>0</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

* unsolicited, fatigue and/or chest discomfort

OTHER ADVERSE EVENTS OBSERVED DURING THE EVALUATION OF TIZANIDINE

Tizanidine was administered to 1187 patients in additional clinical studies in which adverse event information was available. The conditions and duration of exposure varied greatly, and included (in overlapping categories) double-blind and open-label studies, uncontrolled and controlled studies, inpatient and outpatient studies, and titration studies. Untoward events associated with this exposure were recorded by clinical investigators using terminology of their own choosing. Consequently, it is not possible to provide a meaningful estimate of the proportion of individuals experiencing adverse events without first grouping similar types of untoward events into a smaller number of standardized event categories. In the tabulations that follow, reported adverse events were classified using a standard COSTART-based dictionary terminology. The frequencies presented, therefore, represent the proportion of the 1187 patients exposed to tizanidine who experienced an event of the type cited on at least one occasion while receiving tizanidine. All reported events are included except those already listed in Table 2.

Events are further categorized by body system and listed in order of decreasing frequency according to the following definitions: frequent adverse events are those occurring on one or more occasions in at least 1/100 patients (only those not already listed in the tabulated results from placebo-controlled studies appear in this listing); infrequent adverse events are those occurring in 1/100 to 1/1000 patients.

**Body as a Whole:** Frequent: fever; Infrequent: allergic reaction, malaise, abscess, neck pain, sepis, cellulitis, death, overdose; Rare: carcinoma, congenital anomaly, suicide attempt.

**Cardiovascular System:** Infrequent: vasodilatation, postural hypotension, syncope, migraine, arthralgia; Rare: angina pectoris, coronary artery disorder, heart failure, myocardial infarct, phlebitis, pulmonary embolus, ventricular extrasystoles, ventricular tachycardia.

**Digestive System:** Frequent: abdominal pain, diarrhea, dyspepsia; Infrequent: dysphagia, cholecystitis, focal impaction, flatulence, gastrointestinal hemorrhage, hepatitis, melena; Rare: gastroenteritis, hematemesis, hepatico, intestinal obstruction, liver damage.

**Endocrine System:** Rare: adrenal insufficiency.

**Gastrointestinal System:** Infrequent: colitis, hemorhoid, weight loss; Rare: pancreatic endocrine insufficiency.

**Genitourinary System:** Frequent: dysuria, back pain; Infrequent: radiologic fracture, arrhythmia, arthritis, bursitis.

**Hematologic System:** Frequent: myasthenia, back pain; Infrequent: pathological fracture, arthralgia, arthritis, bursitis.

**Hepatic System:** Frequent: depression, anxiety, paresthesia; Infrequent: tremor, emotional lability, convulsion, paralysis.

**Mental and Nervous System:** Infrequent: edema, hypoamylasemia, weight loss; Rare: adrenal cortex insufficiency, hypoglycemia, hypokalemia, hyporexia, hypoproteinemia, respiratory acidosis.

**Musculoskeletal System:** Frequent: myopathy, back pain; Infrequent: radiculopathy, fracture, arthritis, bursitis.

**Muscular System:** Infrequent: myalgia, edema.

**Nervous System:** Frequent: depression, anxiety, paresthesia; Infrequent: tremor, emotional lability, convulsion, paralysis, thinking abnormal, vertigo, abnormal dreams, agitation, depression, delirium, euphoria, migraine, stupor, dysautonomia, neurolgia; Rare: dementia, hemiplegia, neuropathy.

**Respiratory System:** Infrequent: sinusitis, pneumonia, bronchitis; Rare: asthma.

**Skin and Appendages:** Infrequent: rash, sweating, skin ulcer; Infrequent: acne, alopecia, urticaria; Rare: exfoliative dermatitis, herpes simplex, herpes zoster, skin carcinoma.

**Special Senses:** Infrequent: ear pain, tinnitus, deafness, glaucoma, conjunctivitis, eye pain, dry eyes, weight loss; Rare: retinal hemorrhage, visual field defect; Rare: iritis, keratitis, optic atrophy.

**Urinary System:** Infrequent: urinary urgency, cystitis, menopausal, ptyalosis, urinary retention, kidney calculi, uterine fibroids enlarged, vaginal moniliasis, vaginitis; Rare: albuminuria, glycosuria, hematuria, metrorrhagia.

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source of measurement error. Of equal importance is that the use of motion analysis data also introduces another component of subject reliability in reproducing the knee joint motion during daily tasks. As discussed in the article, it is only one of the literature what level of variation is normally present; however, it has been reported that some variation is present.3 To assume that the results of the reliability tests were due to measurement error alone is incorrect. It is also interesting that despite the trial-to-trial variation, significant differences in knee angle at muscle onset were found using a repeated-measures statistical design. Again, although some of these differences in group means were small (5.8 to 2.3 degrees), it is unknown what difference in knee angle at muscle onset will affect the biomechanics of the knee joint.

The inclusion of actual onset-timing differences in this article may have allowed comparison to previously published data. However, as onset time differences appear to be task specific, a direct comparison of differences would be erroneous.

In conclusion, we believe that the methodology used in our study, although not without its limitations, is sound and that the results contribute further to the understanding of the effects of patellofemoral taping as a treatment for patellofemoral pain syndrome.

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References


Letters to the Editor

Letters to the Editor provide a forum for discussion of all matters that are important to the physical therapy profession. Letters responding to articles should be received on a timely basis to ensure meaningful dialogue. Due to space constraints, we ask that letters be less than 600 words. All letters should be signed.

Receipt of Letters to the Editor is not acknowledged; however, correspondents will be notified if the letter has been accepted for publication. The Journal reserves the right to copyedit letters. Unless excessive copyediting is required, correspondents will not be sent a copy of the edited version to review. Letters regarding a specific article will be printed with an author response whenever possible.

Submission by mail or fax: Letters should be typed, double-spaced. Send two copies to the Editor. Physical Therapy. American Physical Therapy Association, 1111 North Fairfax Street, Alexandria, VA 22314-1488; fax, 703/706-3169. Submission via e-mail: Letters should include the correspondent's mailing address. Send to ptjournal@apta.org.

APTA Judicial Committee Disciplinary Action

The Judicial Committee of the American Physical Therapy Association (APTA) has suspended Gregory B. Snowden for a period of 1 year for violating Principles 2 and 5 of APTA's Code of Ethics, effective June 21, 1997.

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