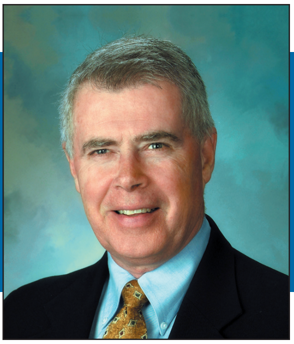
Kinetic Chain from the Toes Influences the Craniofacial Region

This study examines the relationship between plantar toe flexion and mouth opening and the resulting subjective pain relief of pain to the head, neck and mandibular regions.



Edwin Ernest, DMD

Dr. Rubenstein's article on plantar toe flexion and the kinetic chain is very interesting and offers an insight that may play a clinical role in diagnosis of TMJ and facial pain of kinetic postural and muscular origin. Similarily, Tuft's school of dental medicine published an article defining mandibular incisal opening and its influence on trapezius muscle electromyographic activity. Both articles serve to demonstrate that the TMJ and cervico/mandibular regions are both influencers of, and are influenced by, postural stresses, degenerative changes and dysfunctions that are often unrecognized by pain management clinicians.

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By David Rubenstein, PhD

This study will examine the connection of specific kinetic chain musculoskeletal and neuronal relationships from the lower extremities to those of the head, neck and mandible. The posture and functionality of the feet, toes and arches affect cervical posture and mandibular performance.[1] The toes provide a stabilizing effect to the muscles in the rest of the body by increased recruitment of leg and trunk muscles.[2,3] This study shows a direct correlation of the muscles controlling the toes and arches and their affect on the muscles of the cranio-facial musculature. We first measured the maximum incisal opening (MIO) in a standing neutral posture then compared the same measurement while the toes were in deliberate plantar flexion. A notable increase in MIO of 4–8mm was measured with an average increase of 6mm. We also noted improvements in upright stable posture during plantar toe flexion and patients reported subjective relief of pain to the head, neck and mandibular regions while plantar flexion was engaged in those subjects who reported pain in these areas.

Method

We measured the MIO of 57 subjects using a metric ruled device. We averaged the results for each of two groups as outlined below providing one number of MIO for each group. Both groups were either at or slightly below the ideal MIO according to Spahl et al [MIO 45–58].[4]

Subjects were divided into two groups. The first group reported having some cervical, head and/or mandibular pain. It consisted of 14 men (ages 22-57 with a mean age of 35) and 16 women (ages 24-60 with a mean age of 36) for a total of 30 subjects. The second group had no pain and consisted of 13 men (ages 21-63 with a mean age of 42) and 14 women (ages 23-59 with a mean age of 36) for a total of 27 subjects. Of the 57 subjects, 47% reported some type of body pain and the others reported no noticeable musculoskeletal pain.

Each subject utilized a free-will standing position allowing each subject to stand in a manner that was comfortable. The only guidance or requirement asked of the subject was to place their feet at approximately shoulder width. No other qualifiers were imposed such as knee bend, foot angles of outward or inward position, upper body posture or head posture. We allowed the subject approximately ten to fifteen seconds to become relaxed and stable in this stance during which time no other instructions were given.

At that point the subjects were asked to open their mouth to their MIO. We measured the MIO and noted the result shown below in the chart under "Neutral MIO" (see Table 1). The next measurement was taken after a rest period of ten seconds and each subject was instructed to forcefully and deliberately press their toes down, as if to grasp a small object with their toes. The resulting scores of

Table 1. Averaged Interincisal Measurements (mm) in 57 Subjects

Number of Subjects	Neutral MIO	Plantar Flexion MIO	Difference	% +,-	VAS Subjective Report of Pain Improvement/ no improvement/more pain
No Pain: 27	46	51	+5mm	+10.8	NA
Pain: 30	43	50	+7mm	+16.2	26/4/0

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MIO are under the title "Plantar Flexion MIO." An average increase in MIO of 5mm in the group without pain and 7mm in the group with pain was measured.

Discussion

Travell and Simons describe the relationship between the toes and MIO stating a dysfunction in the toes that resolution of results in an "immediate increase" in MIO.[4] They further describe articular dysfunctions in the foot "produce imbalances that may cause pain in many locations, ranging from the feet to the head and neck."[5]

Other authors, such as Bergamini et al, show through surface EMG studies how plantar flexors such as the soleus muscles affect sub-clinical dental malocclusions. They also suggest "a relationship between jaw posture and [overall] muscular strength."[6] Moreover, other authors found "a significant effect of different occlusal positions on the postural activity using a stabilometric footboard," suggesting a strong correlation of the feet and toes function to mandibular position and activity.[7]

In our study we found an average difference in MIO of 6mm between neutral and plantar toe flexion. The average baseline (neutral) MIO measurements between the pain and no pain groups varied by 3mm. In plantar toe flexion, average MIO increased by 13.5% of all subjects tested.

Subjects were also categorized as to their self-reported pain experiences using a Visual Analogue Scale (VAS) comparing the neutral toe posture to the deliberately plantar flexed toe position. 86% of the pain subjects reported a decrease in pain in the regions of the cervical spine, temporalis and masseter areas.

As the toes plantar flex, the arches increase their curvature, then the muscles of the thighs become more functionally active which increases muscular support for the upper body. This means greater stability of the lower extremity and implies relaxation or decreased tonicity of the upper extremity as it does not have to compensate for the lower body instability. In other words, the toes potentiate the arches which, in turn, potentiate the thigh muscles. If an individual has very weak feet and legs, a tendency toward more aberrant and unstable head and upper body motion would become evident resulting in compensatory muscular contractions throughout the upper extremity to help hold the person upright.

The subjects that had self-reported pain demonstrated a greater effect on the MIO (2mm greater) with plantar toe flexion. As expected, our study correlates to this result due to lower muscular hypertonicity. Tight muscles are associated with pain and a decrease in pain allowed for the mandible to open wider. The group that had no self-reported pain also improved but to a smaller degree as fewer compensatory mechanisms were in affect in the absence of pain. The body continually attempts to attain the best possible neuromuscular position it can. It adapts or compensates to create a dynamic state of neuromuscular homeostasis that is most comfortable. According to our research, functional toes are required for neuromuscular homeostasis in a standing posture.[7]

A Lesson from a Robot

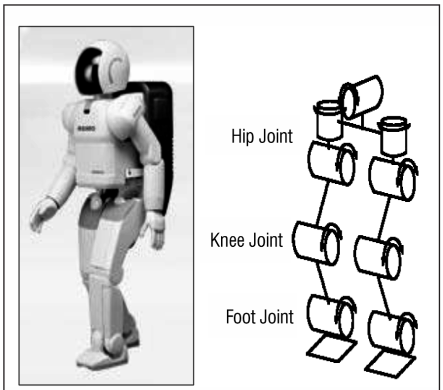
A surprising lesson about toe function and torso stability can be gleaned from a robot named ASIMO or Advanced Step in Innovative MObility, built by the Honda Corporation.[8] ASIMO was designed from the human framework in that the major joints were duplicated as shown in Figure 1. However, the multi-disciplinary group of engineers were unable to get ASIMO to be stable during motion. ASIMO would simply fall over unless it was standing still. If ASIMO moved, especially dynamically or in reaction to another force, it would tip over and fall. When, in 2005, scientists gave ASIMO toes (see Figure 2), it functioned well including in dynamic environments—something the previous version could not achieve despite eight years of testing.[8]

In the same manner that ASIMO could not stabilize the head, neck and torso without toes, so too humans are subject to this fundamental principle in biomechanics: power requires a stable platform to generate force and control momentum. The toes serve as the stabilizing platform.

During upright postures such as standing and walking, toes are designed to serve as both stabilizers of the loading phase and as stabilizers/thrusters of the push-off phase.[9] This stabilizing effect is not restricted only to the foot or lower extremity, but rather is a stabilizing body-wide effect.[5] When the toes are not providing a stabilizing effect, the brain reacts to the lack of stability and contracts other muscles to compensate for the missing stability. This compensatory reaction includes the cervical musculature which contract to stabilize head posture and lead to over-activation[10,11,12] and eventually spasm(s).[13] Poor cervical posture has been linked to pain syndromes associated with these upper regions of the body.[14,15] Neck spasms may be linked to compression of the cervical spine and various pain-related conditions. In this way, adequate or deliberate plantar toe function may prevent overactive craniofacial cervical region muscles and the pain associated with spasm.

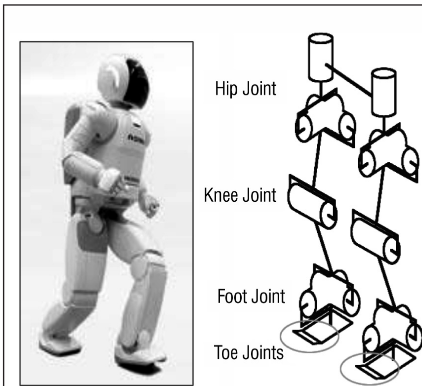
Summary

We investigated the correlation of lower extremity plantar toe flexion to upper extremity MIO. We measured the MIO of 57 subjects in a standing posture. We compared bite opening measurements from subjects in a neutral stance to subjects in a deliberate plantar toe flexion



Original Version 1997-2005

FIGURE 1. *Photo courtesy of American Honda Motor Co., Inc.*



Recent Version 2005 - Present

FIGURE 2. *Photo courtesy of American Honda Motor Co., Inc.*

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stance. We found an average difference in MIO of 6mm between neutral and plantar toe flexion. This test suggests a functional and anatomical connection between the toes and the neck and cranio-facial structures. Of the 30 subjects who reported pain in the neck, head and/or mandibular area, 86% reported immediate subjective improvement in their pain during deliberate plantar toe flexion.

When the toes do not provide a stabilizing effect via active plantar flexion, the brain reacts to the missing postural stability which may lead to downgraded upper body muscular performance—including trunk, craniofacial and cervical muscles' heightened tonicity in order to stabilize head posture. More studies are warranted on this aspect as it may suggest a treatment for craniofacial pain. ■

Acknowledgements
The author would like to acknowledge the assistance of the following individuals in this study: Viet Nghiem, DDS, AAPM, Senior Clinical Instructor, White Memorial Medical Center at the E.N.T. and T.M.J. Clinic, Q.M.E. in California, and practices at the dental practice of Craniomandibular Disorders & Maxillofacial Orthopedic Center; Scott E. Schames, Medical Researcher; Y. Dov Prero, BA, MEd, UCLA School of Dentistry, Class of 2011; David Schames, BA, Loma Linda University School of Dentistry, Class of 2012; and Gabriel L. Rosenthal, BA, USC School of Dentistry, Class of 2013.

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