



**PASIG MONTHLY CITATION BLAST: No.68**

**January 2012**

Dear PASIG members:

We look forward to seeing you at Combined Sections Meeting in Chicago next month. We hope our members will attend both our PASIG programming and business meeting, as well as support our members presenting their research. Below is a summary of PASIG activities and performing arts-related presentations at CSM. Stop by the Orthopaedic Section table for a handout of these PA-relevant topics or print this out.

### **COMBINED SECTIONS MEETING**

**Friday, 2/10/12**

**PASIG PROGRAMMING: From Hips to Lips: A Multi-systems Approach to the Treatment of Performing Artists**

**Speakers:** Mary P. Massery, PT, DPT, Jeffrey T. Stenback, PT, OCS, Amy Humphrey, PT, DPT, OCS, MTC

**8:00 – 10:00 Part 1                      10:30 – 11:30 Part 2**

Control of spine stability and postural equilibrium has relevance across the fields of physical therapy practice, from performing arts to management of continence to neurologic balance disorders and respiratory diseases. There is accruing evidence that "core" training extends beyond the abdominal muscles to achieve dynamic trunk control. This session challenges you to acknowledge a broader definition of proximal postural control. Novel research will be presented using a model of postural control (The Soda Pop Can Model) that extends from the lips (vocal folds) at the top of the trunk to the hips (pelvic floor) at the bottom of the trunk and includes abdominal, paraspinal, intercostals, and diaphragm muscles. The speaker will describe how the interactions between breathing, talking, continence, and postural stability contribute to postural control and the consequences of inadequate postural control such as low back pain, incontinence, impaired respiratory health, and compromised balance. The speakers will compel you to evaluate and treat postural control deficits from a multisystem approach considering both physiologic and physical deficits; challenge performing arts PTs to understand the link between breathing and efficient movement; and provide performing artist case studies to enhance integration of this information.

**11:30 – 12:30 PASIG BUSINESS MEETING** This will occur in the same meeting room as our programming.

Below are performing arts-related research that may be of interest to you as well. Our PASIG student scholarship winner is Rachael Billingsley SPT, Wayne State University for her poster entitled "Rehabilitation of a 27 year old ballet dancer post periacetabular osteotomy: A case study". Please visit her at her poster on Thursday.

#### PA-related Platforms and Posters

##### Thursday 2/09

##### PLATFORM: Knee / Lower Extremity

**8:15 – 8:30am** Effect of sprung (suspended) floor on lower extremity stiffness during a force returning ballet jump. Hackney JM, Brummel S, Becker D, Chenoweth A, Koons S, Stewart M.

##### POSTERS Orthopaedic: Performing Arts

##### 1:00 – 3:00pm

**1194** Immediate effects of localized vibration on hamstring and quadriceps muscle performance. Dickerson C, Gabler G, Hopper K, Kirk D, McGregor CJ,

**1195** Rehabilitation of a 27-yr old ballet dancer post peri-acetablular osteotomy: A case study. Billingsley R, Dunleavy K.

**1196** Reliability and validity of the shoulder hypermobility flexion tests (SHFT) in healthy young gymnasts. Nilles H, Kapral K, Sleeper MD.

Our grateful thanks go to Kendra Hollman-Gage, who is our outgoing Nominating Chair. Laura Becica will become the new Nominating Committee Chair. Our newly elected Nominating Committee member is Rosie Canivares. Next year, the position of Vice President will be open. Please contact Laura Becica at CSM 2012 if you are interested in serving or wish to nominate someone.

#### PERFORMING ARTS CONTINUING EDUCATION AND CONFERENCES

##### \*\*Performing Arts Independent Study Courses\*\*

Orthopaedic Section Independent Study Course. *20.3 Physical Therapy for the Performing Artist.*

Monographs are available for:

- Figure Skating (J. Flug, J. Schneider, E. Greenberg),
- Artistic Gymnastics (A. Hunter-Giordano, Pongetti-Angeletti, S. Voelker, TJ Manal), and
- Instrumentalist Musicians (J. Dommerholt, B. Collier).

Contact: Orthopaedic Section at: [www.orthopt.org](http://www.orthopt.org)

Orthopaedic Section Independent Study Course. *Dance Medicine: Strategies for the Prevention and Care of Injuries to Dancers.*

This is a 6-monograph course and includes many PASIG members as authors.

- Epidemiology of Dance Injuries: Biopsychosocial Considerations in the Management of Dancer Health (MJ Liederbach),
- Nutrition, Hydration, Metabolism, and Thinness (B Glace),
- The Dancer's Hip: Anatomic, Biomechanical, and Rehabilitation Considerations (G. Grossman),
- Common Knee Injuries in Dance (MJ Liederbach),
- Foot and Ankle Injuries in the Dancer: Examination and Treatment Strategies (M. Molnar, R. Bernstein, M. Hartog, L. Henry, M. Rodriguez, J. Smith, A. Zujko),
- Developing Expert Physical Therapy Practice in Dance Medicine – (J. Gamboa, S. Bronner, TJ Manal).

Contact: Orthopaedic Section at: [www.orthopt.org](http://www.orthopt.org)

Harkness Center for Dance Injuries, Hospital for Joint Diseases. Principles of Dance Medicine: Clinical management of the dancer patient. New York, NY, July 12 – 15, 2012. <http://hjd.med.nyu.edu/harkness/education/healthcare-professionals/upcoming-educational-courses>

Performing Arts Medical Association (PAMA). 30<sup>th</sup> Annual Symposium: Medical Problems of Performing Artists, Snowmass, CO, July 26 – 29, 2012. Contact: <http://www.artsmed.org>

Our new Research Committee Chair, Annette Karim PT, DPT, OCS, will officially begin following CSM. Please let her know of ideas you may have for research-related new projects or content for the PASIG Research Committee. While I will continue to mentor Annette, please give her your full support. She can be contacted at: [neoluvsonlyme@aol.com](mailto:neoluvsonlyme@aol.com).

For this January Citation BLAST, I have compiled references on the topic, “Exertional Compartment Syndrome.” The format is an annotated bibliography of articles generally from the last decade. The PASIG Research Committee initiated this monthly Citation BLAST on performing arts-related topics in June 2005 in the hopes of encouraging our members to stay current in the literature and, perhaps, consider conducting research themselves. Each month we send a new list of performing arts (PA) citations to members of the PASIG to further the pursuit of PA-related scholarship. (Information about EndNote referencing software can be found at <http://www.endnote.com>, including a 30-day free trial).

It has been a pleasure to serve.  
Regards,  
Shaw

Shaw Bronner PT, PhD, OCS  
Chair, PASIG Research Committee  
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#### PASIG Research Committee members

Incoming Research Chair, Annette Karim PT, DPT, OCS, [neoluvsonlyme@aol.com](mailto:neoluvsonlyme@aol.com)  
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## **Exertional Compartment Syndrome**

Based on a literature search, exertional compartment syndrome is rare in dancers. I found nothing published on it in the last 15 years. However, I did have an occasion when a dancer’s symptoms suggested a possible compartment syndrome. The company was performing choreography that a great deal of pounding jumping. Following these performances, the company immediately flew home from Europe. The dancer presented with calf numbness, tightness, and pain. He was treated with anti-inflammatories, modification of activity, and

modalities. In this case, we got lucky and his symptoms resolved never to return. It is likely that the long flight resulted in lower extremity edema in addition to the stressors due to the reparatory. Unfortunately, most leg exertional compartment syndrome cases are non-responsive to conservative management and require a fasciotomy.

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Chambers L, Hame SL, et al. (2011). Acute exertional medial compartment syndrome of the foot after playing basketball. Skeletal Radiol **40**(7): 931-935.

Compartment syndrome of the foot is an uncommon event. The most common cause of compartment syndrome of the foot is a crush injury. Exceedingly rare is acute compartment syndrome of the foot occurring in the absence of trauma. We describe the clinical scenario involving a 23-year-old healthy male who developed acute exertional compartment syndrome isolated to the medial compartment of the foot after playing basketball. The patient had no evidence of injury nor trauma, and the diagnosis was made based on physical exam, magnetic resonance imaging (MRI), and compartment pressure measurements. The patient did undergo successful fasciotomy on the day of presentation to the emergency department and has since completely recovered. We found four cases reported in the literature of acute exertional medial compartment syndrome of the foot in the absence of trauma or injury. This is the second case reported after playing basketball, while the others occurred after aerobics, a long distance run, and football. The most recent case was reported by Miozzari et al. [Am J Sports Med. 36(5):983-6, 2008] and involved a marathon runner who developed an isolated medial compartment syndrome of the foot. We would like to increase awareness of this uncommon clinical presentation in the absence of trauma and present the dramatic radiographic findings.

Dahl M, Hansen P, et al. (2011). Stiffness and thickness of fascia do not explain chronic exertional compartment syndrome. Clin Orthop Relat Res **469**(12): 3495-3500.

**BACKGROUND:** Chronic exertional compartment syndrome is diagnosed based on symptoms and elevated intramuscular pressure and often is treated with fasciotomy. However, what contributes to the increased intramuscular pressure remains unknown. **QUESTIONS/PURPOSES:** We investigated whether the stiffness or thickness of the muscle fascia could help explain the raised intramuscular pressure and thus the associated chronic compartment syndrome symptoms. **PATIENTS AND METHODS:** We performed plain radiography, bone scan, and intramuscular pressure measurement to diagnose chronic compartment syndrome and to exclude other disorders. Anterior tibialis muscle fascial biopsy specimens from six healthy individuals, 11 patients with chronic compartment syndrome, and 10 patients with diabetes mellitus and chronic compartment syndrome were obtained. Weight-normalized fascial stiffness was assessed mechanically in a microtensile machine, and fascial thickness was analyzed microscopically. **RESULTS:** Mean fascial stiffness did not differ between healthy individuals (0.120 N/mg/mm; SD, 0.77 N/mg/mm), patients with chronic compartment syndrome (0.070 N/mg/mm; SD, 0.052 N/mg/mm), and patients with chronic compartment syndrome and diabetes (0.097 N/mg/mm; SD, 0.073 N/mg/mm). Similarly, no differences in fascial thickness were present. There was a negative correlation between fascial stiffness and intramuscular pressure in the patients with chronic compartment syndrome and diabetes. **CONCLUSIONS:** The lack of difference in fascial thickness and stiffness in patients with chronic compartment syndrome and patients with chronic compartment syndrome and diabetes compared with healthy individuals suggests structural and mechanical properties are unlikely to explain chronic compartment syndrome. To prevent chronic exertional compartment syndrome, it is necessary to address aspects

other than the muscle fascia. LEVEL OF EVIDENCE: Level II, prognostic study. See the guidelines online for a complete description of level of evidence.

Diebal AR, Gregory R, et al. (2011). Effects of forefoot running on chronic exertional compartment syndrome: a case series. *Int J Sports Phys Ther* 6(4): 312-321.

INTRODUCTION: Chronic exertional compartment syndrome (CECS) is a condition that occurs almost exclusively with running whereby exercise increases intramuscular pressure compromising circulation, prohibiting muscular function, and causing pain in the lower leg. Currently, a lack of evidence exists for the effective conservative management of CECS. Altering running mechanics by adopting forefoot running as opposed to heel striking may assist in the treatment of CECS, specifically with anterior compartment symptoms. CASE DESCRIPTION: The purpose of this case series is to describe the outcomes for subjects with CECS through a systematic conservative treatment model focused on forefoot running. Subject one was a 21 y/o female with a 4 year history of CECS and subject two was a 21 y/o male, 7 months status-post two-compartment right leg fasciotomy with a return of symptoms and a new onset of symptoms on the contralateral side. OUTCOME: Both subjects modified their running technique over a period of six weeks. Kinematic and kinetic analysis revealed increased step rate while step length, impulse, and peak vertical ground reaction forces decreased. In addition, leg intracompartmental pressures decreased from pre-training to post-training. Within 6 weeks of intervention subjects increased their running distance and speed absent of symptoms of CECS. Follow-up questionnaires were completed by the subjects at 7 months following intervention; subject one reported running distances up to 12.87 km pain-free and subject two reported running 6.44 km pain-free consistently 3 times a week. DISCUSSION: This case series describes a potentially beneficial conservative management approach to CECS in the form of forefoot running instruction. Further research in this area is warranted to further explore the benefits of adopting a forefoot running technique for CECS as well as other musculoskeletal overuse complaints.

Edmundsson D, Toolanen G, et al. (2010). Evidence for low muscle capillary supply as a pathogenic factor in chronic compartment syndrome. *Scand J Med Sci Sports* 20(6): 805-813.

There is a paucity of data regarding the pathogenesis of chronic exertional compartment syndrome (CECS), its consequences for the muscles and the effects of treatment with fasciotomy. We analyzed biopsies from the tibialis anterior muscle, from nine patients, obtained during a decompressing fasciotomy and during follow-up 1 year later. Control biopsies were obtained from nine normal subjects. Muscle capillarity, fiber-type composition and fiber area were analyzed with enzyme- and immunohistochemistry and morphometry. At baseline, CECS patients had lower capillary density (273 vs 378 capillaries/mm<sup>2</sup>), P=0.008), lower number of capillaries around muscle fibers (4.5 vs 5.7, P=0.004) and lower number of capillaries in relation to the muscle fiber area (1.1 vs 1.5, P=0.01) compared with normal controls. The fiber-type composition and fiber area did not differ, but focal signs of neuromuscular damage were observed in the CECS samples. At 1-year follow-up after fasciotomy, the fiber area and the number of fibers containing developmental myosin heavy chains were increased, but no enhancement of the capillary network was detected. Thus, morphologically, patients with CECS seemed to have reduced microcirculation capacity. Fasciotomy appeared to trigger a regenerative response in the muscle, however, without any increase in the capillary bed.

Edwards PH, Wright ML, et al. (2005). A practical approach for the differential diagnosis of chronic leg pain in the athlete. *Am J Sports Med* 33(8): 1241-1249.

Chronic lower leg pain results from various conditions, most commonly, medial tibial stress syndrome, stress fracture, chronic exertional compartment syndrome, nerve entrapment, and popliteal artery entrapment syndrome. Symptoms associated with these conditions

often overlap, making a definitive diagnosis difficult. As a result, an algorithmic approach was created to aid in the evaluation of patients with complaints of lower leg pain and to assist in defining a diagnosis by providing recommended diagnostic studies for each condition. A comprehensive physical examination is imperative to confirm a diagnosis and should begin with an inquiry regarding the location and onset of the patient's pain and tenderness. Confirmation of the diagnosis requires performing the appropriate diagnostic studies, including radiographs, bone scans, magnetic resonance imaging, magnetic resonance angiography, compartmental pressure measurements, and arteriograms. Although most conditions causing lower leg pain are treated successfully with nonsurgical management, some syndromes, such as popliteal artery entrapment syndrome, may require surgical intervention. Regardless of the form of treatment, return to activity must be gradual and individualized for each patient to prevent future athletic injury.

Litwiller DV, Amrami KK, et al. (2007). Chronic exertional compartment syndrome of the lower extremities: improved screening using a novel dual birdcage coil and in-scanner exercise protocol. Skeletal Radiol **36**(11): 1067-1075.

**OBJECTIVE:** The purpose of this study was to design and evaluate an MRI screening protocol for chronic exertional compartment syndrome (CECS) of the lower legs using an in-scanner exercise protocol and novel dual birdcage coil design for improved imaging. **MATERIALS AND METHODS:** Coil and phantom studies: a custom-made dual birdcage coil designed for this protocol was evaluated for uniformity and signal-to-noise ratio (SNR) compared with a conventional phased-array receive-only torso coil and the body coil. Phantom and normal subject studies were performed to confirm coil performance. In-vivo studies: eight unaffected subjects and 42 patients with lower extremity symptoms suggestive of CECS were imaged with the dual birdcage coil and an in-scanner exercise protocol which included imaging at rest, during isometric resisted dorsi flexion, at rest (recovery), during isometric resisted plantar flexion and, again, at rest. Of 42 patients, 14 had confirmed CECS and 28 had lower extremity anomalies attributable to other causes. Ratios of relative T2-weighted signal intensities were calculated for exercise and recovery images compared to baseline after processing of images, including re-registration for motion, smoothing and segmentation to remove bone and pulsation artifacts from blood vessels. **RESULTS:** Receiver operating characteristic (ROC) analysis showed a threshold for the ratio of relative T2-weighted signal intensity of 1.54 to have a sensitivity of 96%, specificity of 90% and accuracy of 96% for CECS. Patients with CECS had their peak ratio of signal intensity compared with baseline during the first recovery period after isometric dorsi flexion, whereas unaffected subjects and patients with other causes of exercise-induced lower extremity pain reached their peak values during exercise ( $P < 0.001$ ). **CONCLUSION:** We have developed the first in-scanner MRI exercise protocol for the assessment of patients with suspected CECS. The technique shows high accuracy, sensitivity and specificity for diagnosis in this small cohort of patients with CECS. Further study may allow this non-invasive test to be used as a triage tool for invasive intracompartmental pressure measurements in patients with suspected CECS.

Popovic N, Bottoni C, et al. (2011). Unrecognized acute exertional compartment syndrome of the leg and treatment. Acta Orthop Belg **77**(2): 265-269.

Acute-on-chronic exertional compartment syndrome is rare and may be easily missed without a high degree of awareness and clinical suspicion. We report a case of unrecognized acute-on-chronic exertional compartment syndrome in a recreational soccer player. The late sequela of this condition, foot drop, was successfully treated with transfer of the peroneus longus tendon.

Roberts A, Franklyn-Miller A (2011). The validity of the diagnostic criteria used in chronic exertional compartment syndrome: A systematic review. Scand J Med Sci Sports.

Chronic exertional compartment syndrome (CECS) of the lower limb is part of a group of overuse lower limb injuries with common presenting features. It is commonly diagnosed by the measurement of raised intramuscular pressures in the lower limb. The pathophysiology of the condition is poorly understood, and the criteria used to make the diagnosis are based on small sample sizes of symptomatic patients. We carried out a systematic review to compare intramuscular pressures in the anterior compartment of healthy subjects with commonly used criteria for CECS. Thirty-eight studies were included. With the exception of relaxation pressure, the current criteria for diagnosing CECS, considered to be the gold standard, overlap the range found in normal healthy subjects. Several studies reported mean pressures that would prompt a positive diagnosis for CECS, despite none of the subjects reporting any symptoms. The intramuscular pressure at all time points has also shown to vary in relation to a number of other factors other than the presence of CECS. Taken together, these data have major implications on the ability to use these published criteria for diagnosis and question the underlying pathophysiology. Clinicians are recommended to use protocol-specific upper confidence limits to guide the diagnosis following a failed conservative management.

Tubb CC, Vermillion D (2001). Chronic exertional compartment syndrome after minor injury to the lower extremity. Mil Med **166**(4): 366-368.

Since the 1950s, chronic exertional compartment syndrome of the lower leg has been thoroughly reported in the literature. The predisposing factors and pathophysiology of this condition, however, still are not fully understood. We present a case of a well-conditioned individual who developed a chronic exertional compartment syndrome of the left lower leg anterior compartment after a direct blow injury during a softball game. Trauma is not routinely implicated as a risk factor for chronic compartment syndrome, and the literature on this topic is scarce. We suggest that trauma, even low-velocity trauma, may precipitate a chronic exertional compartment syndrome. We review the literature regarding chronic exertional compartment syndromes preceded by trauma and offer explanations regarding the mechanisms by which a traumatic event may induce a chronic compartment syndrome.

Tucker AK (2010). Chronic exertional compartment syndrome of the leg. Curr Rev Musculoskelet Med **3**(1-4): 32-37.

Chronic exertional compartment syndrome (CECS) is an underdiagnosed cause of chronic exertional leg pain. The syndrome most commonly occurs in young adult recreational runners, elite athletes, and military recruits. CECS is caused by increased intracompartmental pressure within a fascial space; however, the mechanism of why pain occurs is unknown. Symptoms are classically pain in the affected compartment at the same time, distance, or intensity of exercise. CECS is a clinical diagnosis; however, it is confirmed by intracompartmental pressure testing. Fasciotomy is the treatment of choice for athletes who would like to maintain the same level of activity. Athletes who have a release of the anterior and lateral compartments have a high success rate.

Wilder RP, Magrum E (2010). Exertional compartment syndrome. Clin Sports Med **29**(3): 429-435.

Chronic exertional compartment syndrome should be considered in any runner experiencing exertional leg pain. Runners typically describe a tight, cramping ache over the involved compartment that commences at a reproducible point in the run and resolves with rest. Diagnosis should include a careful history and physical examination as well as documentation with intramuscular compartment pressure monitoring. Milder cases will resolve with activity modification and conservative care. More severe cases or those failing conservative care are referred for fasciotomy.