Published version of this paper:

Henderson, CY. 2013. Do diseases cause entheseal changes at fibrous entheses? International Journal of Paleopathology 3: 64-69. DOI: 10.1016/j.ijpp.2013.03.007.

Brief communication: Do diseases cause entheseal changes at fibrous entheses?

C. Y. Henderson

CIAS - Research Centre for Anthropology and Health, Department of Life Sciences, University of Coimbra, Apartado 3046, 3001-401 Coimbra.

Abstract

Fibrous entheses have been widely used to study activity-related stress to infer behavioural patterns in past populations. Unlike their fibrocartilaginous counterparts, the effect of disease processes has been less widely discussed in the osteoarchaeological literature. This study uses a literature review to ascertain whether specific pathological changes should be taken into account when recording fibrous entheses. Due to the anatomical structure of fibrous entheses it was hypothesised that diseases which affect the structure of bone or the periosteum might be a factor in causing entheseal changes. A search of over one hundred terms was performed in PubMed with no year range stipulated, but no papers were found which related to entheseal changes caused by any of the expected pathological processes. The paucity of literature might be due to lack of symptoms in living individuals, it is therefore suggested that a systematic study of skeletal remains is performed using recently developed recording methods to determine if pathological conditions need to be taken into account when recording entheseal changes to study activity-related stress. The search did highlight a link between calcific tendinitis and cortical erosion at fibrous entheses, and it is recommended that this is taken into account when interpreting entheseal changes in past populations.

Keywords

osteoporosis, periostitis, Paget's disease, enthesopathy, enthesitis, tendinitis

Abbreviations.
EC – entheseal changes

1. Introduction

Fibrous entheses (for a description see Benjamin et al., 2002; Henderson et al., 2013; Jurmain et al., 2012) have been widely used to record activity-related stress (Cardoso, 2008; Chapman, 1997; Eshed et al., 2004; Hawkey, 1998; Hawkey and Merbs, 1995; Lieverse et al., 2009; Lovell and Dublenko, 1999; Molnar, 2006; Molnar, 2008; Molnar et al., 2010; Niinimäki, 2012; Pany, 2005; Papathanasiou, 2005; Peterson, 1998; Schrader, 2012; Steen and Lane, 1998; Toyne, 2008; Weiss, 2003; Weiss, 2007; Weiss et al., 2010; Wysocki and Whittle, 2000; Zaübecki, 2009). It has recently been acknowledged (Henderson et al., 2013; Jurmain et al., 2012; Villotte, 2006; Villotte and Knüsel, 2013) that the clinical literature provides insufficient data to interpret changes (previously called musculoskeletal stress markers) at fibrous entheses. Changes to fibrocartilaginous entheses are known to be associated with, among other factors, physical stress and specific diseases, e.g. the seronegative spondyloarthropathies and diffuse idiopathic skeletal hyperostosis (Henderson, 2008; Jurmain et al., 2012; Kacki and Villotte, 2006). In contrast, no diseases are regularly taken into account when recording fibrous entheses.

Many of the powerful muscles attach to the skeleton at these entheses, e.g. the deltoid insertion. It is therefore important to understand any potential factors not directly associated with movement, that cause EC at fibrous entheses. These entheses rely on large footprints to attach the tendon to the bone, sometimes via the periosteum (Benjamin et al., 2002). It is therefore hypothesised that diseases affecting the structure of the bone or involving inflammation of the periosteum will cause EC at these entheses. The aim of this brief communication is to use a literature search to determine if there is clinical or palaeopathological literature to support this hypothesis.

2. Materials and Methods

A set of search terms was predefined (Table 1) based on a previous literature search and macroscopic skeletal analysis (Henderson, 2009), alongside terms used in the biomedical literature (Villotte and Knüsel, 2013). The specific pathological changes chosen all affect the structure of the

bone and, it was hypothesised, may therefore affect the integrity of the enthesis. Clinical literature was searched using the search tool PubMed (http://www.ncbi.nlm.nih.gov/pubmed) on the 15th of February, 2013. No start date was set for the search, thus searching all of PubMed. The aim of these search terms was to be as broad as possible, while restricting the search to fibrous entheses. Web of Knowledge was used, on the following day, to search for papers in the *International Journal of Osteoarchaeology* and the *Journal of Archaeological Science*. The *International Journal of Palaeopathology* was searched using Science Direct.

3. Results

The results (Table 1) show that of 141 searches performed in PubMed only 16 yielded results totalling 35 papers. Of these, seven related to the periodontal ligament (Albair et al., 1982; Bragger et al., 1990; Fernyhough and Page, 1983; Isidor et al., 1985; Karring et al., 1985; Luder and Zappa, 1998; Nishimura et al., 1989), and four related to experiments in non-human animals (Harris et al., 2002; Hashimoto et al., 2007; Miyakoshi et al., 2010; Suliman et al., 1997). Of the remaining papers, seven focus on one specific condition: calcific tendinitis (Cahir and Saifuddin, 2005; Chadwick, 1989; Dürr et al., 1997; El-Essawy and Vanhoenacker, 2012; Fritz et al., 1994; Hayes et al., 1987a; Ikegawa, 1996). No PubMed citations concern EC in relation to periostitis, Paget's disease or osteoporosis. The same 141 searches were performed in Web of Knowledge and yielded no results. No papers were found in The *International Journal of Paleopathology* using the terms "enthesis" or "entheses" and given the lack of papers in other journals, it was decided not to pursue this search. Instead, all titles and highlights of published papers were considered, but no papers appearing to discuss the diseases and entheses listed in Table 1 were found.

4. Discussion and conclusions

Understanding the factors which cause EC is important for the development of recording methods for EC and interpreting them. Due to the availability of clinical studies describing normal and abnormal fibrocartilaginous entheses, along with causes of EC, recent osteological research has focussed on developing methods for recording these entheses (Henderson et al., 2013). However, many of the large muscles of the body attach via fibrous entheses, e.g. the deltoid, pectoralis major and gluteus maximus insertions, as well as the tibialis anterior and posterior origins (Villotte, 2006). The anatomical structure of these entheses involves the attachment of the tendon to bone on diaphyses and meaphyses of long bones, as well as cranial muscles and the periodontal ligament

(Benjamin et al., 2002; Benjamin and Ralphs, 1997; Beresford, 1981; Hems and Tillmann, 2000). These entheses are characterised by collagen fibres (Benjamin et al., 2002; Cooper and Misol, 1970), which anchor tendon to bone or tendon to periosteum (Benjamin et al., 2002; François et al., 2001; Hems and Tillmann, 2000). During growth all these attachments occur via the periosteum, but often become direct to bone with age (Benjamin and Ralphs, 1999). The collagen fibres are anchored within bone matrix which is highly cellular and crossed with fibres (Benjamin et al., 2002; Beresford, 1981; Hems and Tillmann, 2000). Consequently, fibrous entheses which attach directly to the bone have roughened, striated and raised footprints, while those attaching via the periosteum do not leave such distinct marks (Benjamin et al., 2002; François et al., 2001).

This structure of fibrous entheses should mean that they are vulnerable to changes affecting the structural integrity of the periosteum (particularly during growth) and bone. However, no clinical observations were found to support this hypothesis. Changes at fibrous entheses in the living may be asymptomatic and their relatively large footprint may protect against rupture. It is possible that this is the reason for these results, rather than a real lack of EC in these individuals.

The lack of palaeopathological literature may support the clinical finding that fibrous EC are not associated with periostitis or other diseases. However, a non-systematic palaeopathological study has previously found EC in conjunction with periostitis and osteitis, while none were found in a skeleton with Paget's disease (Henderson, 2009a). Therefore, it is recommended that a systematic study of EC, using recently developed anatomically appropriate recording methods, should be undertaken in skeletons with diseases which affect the structure of bone or which involve the periosteum to determine if diseases should be taken into account when interpreting EC at fibrous entheses. To assist this, entheses should be more regularly recorded and EC (or the lack of EC) reported when they occur in conjunction with other pathological changes. This study would also provide valuable data on the effect of these diseases on the musculoskeletal system for both clinicians and palaeopathologists.

The only notable condition associated with fibrous entheses was found in the seven papers which discussed calcific tendinitis in relation to cortical defects at fibrous entheses. This has only rarely been discussed in the palaeopathological literature (Henderson, 2009b; Villotte et al., 2010; Villotte, 2008). In the clinical setting, women have a higher frequency than men but the mean age of presentation is similar, at approximately 50 years old (Flemming et al., 2003; Harvie et al., 2007), although it also occurs in subadults (Flemming et al., 2003; Oliva et al., 2012). It is important to distinguish between calcific tendinitis and, what has been termed, “insertional calcific tendinitis”

(Oliva et al., 2012), which is endochondral ossification causing enthesophytes, i.e. bone spurs, at fibrocartilaginous entheses (Benjamin et al., 2000). In calcific tendinitis calcium salts are deposited at the point of communication between the blood vessels of the soft and hard tissues (Resnick, 1995), but the aetiopathogenesis is not fully understood (Oliva et al., 2012). It is likely to involve trauma, either acute or repetitive, or chemical changes associated with endocrine diseases (particularly diabetes and thyroid and oestrogen metabolism disorders), but there may also be a genetic predisposition (Harvie et al., 2007; Oliva et al., 2012). The current hypothesis is that cellular disturbance occurs during healing leading to disruption of the normal cell differentiation process, in turn leading to chondrocytes or osteoblasts replacing the tenocytes (Oliva et al., 2012). Skeletal changes are rare or are rarely identified clinically (less than 10% of a PubMed search found papers associated with bony changes), but they do occur. These changes include cortical erosions (Cahir and Saifuddin, 2005; Chadwick, 1989; Flemming et al., 2003; Fritz et al., 1994; Hayes et al., 1987b), periosteal reactions, bone marrow extensions (Dürr et al., 1997; Flemming et al., 2003) and new bone formation (Chadwick, 1989), particularly woven bone (Hayes et al., 1987). Similar changes have been identified at fibrocartilaginous entheses (Chan et al., 2004), particularly (but not exclusively) in the rotator cuff (Diehl et al., 2011; Oliva et al., 2012; Porcellini et al., 2009; Uhthoff and Loehr, 1997). Therefore, this should be considered as a possible differential diagnosis for cortical erosions, periosteal reaction or new bone formation at or adjacent to either fibrous or fibrocartilaginous entheses, especially if these changes affect only one enthesis or an endocrine disease is suspected.

In conclusion, further research involving more systematic recording of entheses is required to study if diseases cause EC at fibrous entheses. It is also important to consider calcific tendinitis as a differential diagnosis for EC at both fibrous and fibrocartilaginous entheses.

Acknowledgements

This research was funded by the Fundação para a Ciência e a Tecnologia, reference: SFRH/BPD82559/2011.

References

Anon. 1993. 3-month contraceptive injection approved. FDA Med Bull *23:*6-7.

Albair, W.B., Cobb C.M., and Killoy W.J. 1982. Connective tissue attachment to periodontally diseased roots after citric acid demineralization. J Periodontol *53:*515-26.

Benjamin, M., Kumai T., Milz S., Boszczyk B.M., Boszczyk A.A., and Ralphs J.R. 2002. The

skeletal attachment of tendons - tendon 'entheses'. Comp. Biochem. Physiol. A *133:*931-945.

Benjamin, M., and Ralphs J.R. 1997. Tendons and ligaments - an overview. Histol. Histopathol. *12:*1135-1144.

Benjamin, M., and Ralphs J.R. 1999. The attachment of tendons and ligaments to bone. In C.W. Archer, B. Caterson, M. Benjamin and J.R. Ralphs (eds.): Biology of the Synovial Joint. Amsterdam: Harwood Academic Publishers, pp. 361-371.

Benjamin, M., Rufai A., and Ralphs J.R. 2000. The mechanism of formation of bony spurs (enthesophytes) in the achilles tendon. Arthritis Rheum. *43:*576-583.

Beresford, W.A. 1981. Chondroid Bone, Secondary Cartilage and Metaplasia. Baltimore: Urban & Schwarzenberg.

Bragger, U., Nyman S., Lang N.P., Von Wyttenbach T., Salvi G., and Schurch E., Jr. 1990. The significance of alveolar bone in periodontal disease. A long-term observation in patients with cleft lip, alveolus and palate. J Clin Periodontol *17:*379-84.

Braun, S., Minzlaff P., and Imhoff A.B. 2012. Subpectoral tenodesis of the long head of the biceps tendon for pathologies of the long head of the biceps tendon and the biceps pulley. Oper Orthop Traumatol *24:*479-85.

Briggs, A.M., Greig A.M., Bennell K.L., and Hodges P.W. 2007. Paraspinal muscle control in people with osteoporotic vertebral fracture. Eur Spine J *16:*1137-44.

Cahir, J., and Saifuddin A. 2005. Calcific tendonitis of pectoralis major: CT and MRI findings. Skeletal Radiol *34:*234-8.

Cardoso, F.A. 2008 A Portrait of Gender in Two 19th and 20th Century Portuguese Populations: A Palaeopathological Perspective. Doctoral thesis, Durham University, Durham.

Chadwick, C.J. 1989. Tendinitis of the pectoralis major insertion with humeral lesions. A report of two cases. J Bone Joint Surg Br *71:*816-8.

Chan, R., Kim D.H., Millett P.J., and Weissman B.N. 2004. Calcifying tendinitis of the rotator cuff with cortical bone erosion. Skeletal Radiol. *33:*596-599.

Chang, S.H., Dudley-Javoroski S., and Shields R.K. 2011. Gravitational force modulates muscle activity during mechanical oscillation of the tibia in humans. J Electromyogr Kinesiol *21:*847-53.

Chapman, N.E.M. 1997. Evidence for Spanish influence on activity induced musculoskeletal stress markers at Pecos Pueblo. Internat. J. Osteoarchaeol. *7:*497-506.

Cooper, R.R., and Misol S. 1970. Tendon and ligament insertion: a light and electron microscope study. J Bone Joint Surg A *52A:*1-20, 170.

Diehl, P., Gerdesmeyer L., Gollwitzer H., Sauer W., and Tischer T. 2011. Calcific tendinitis of the

shoulder. Orthopäde *40:*733-46.

Dufourmentel, C., and Petoin D.S. 1984. [Reconstructive surgery of the anoperineal region]. Ann Gastroenterol Hepatol (Paris) *20:*249-57.

Dupont, J.S., Jr., and Brown C.E. 2012. The concurrency of temporal tendinitis with TMD. Cranio *30:*131-5.

Dürr, H.R., Lienemann A., Silbernagl H., Nerlich A., and Refior H.J. 1997. Acute calcific tendinitis of the pectoralis major insertion associated with cortical bone erosion. Eur Radiol *7:*1215-7.

El-Essawy, M.T., and Vanhoenacker F.M. 2012. Calcific tendinopathy of the pectoralis major insertion with intracortical protrusion of calcification. Jbr-Btr *95:*374.

Eshed, V., Gopher A., Galili E., and Hershkovitz I. 2004. Musculoskeletal Stress markers in Natufian hunter-gatherers and neolithic farmers in the Levant: the upper limb. Am. J. Phys. Anthropol. *123:*303-315.

Fernyhough, W., and Page R.C. 1983. Attachment, growth and synthesis by human gingival fibroblasts on demineralized or fibronectin-treated normal and diseased tooth roots. J Periodontol *54:*133-40.

Flemming, D.J., Murphey M.D., Shekitka K.M., Temple H.T., Jelinek J.J., and Kransdorf M.J. 2003. Osseous involvement in calcific tendinitis: a retrospective review of 50 cases. Am. J. Roentgenol. *181:*965-972.

François, R.J., Braun J., and Khan M.A. 2001. Entheses and enthesitis: a histopathologic review and relevance to spondyloarthritides. Curr. Opin. Rheumatol. *13:*255-264.

Fritz, P., Bardin T., Laredo J.D., Ziza J.M., D'anglejan G., Lansaman J., Bucki B., Forest M., and Kuntz D. 1994. Paradiaphyseal calcific tendinitis with cortical bone erosion. Arthritis Rheum *37:*718-23.

Harris, N.L., Indelicato P.A., Bloomberg M.S., Meister K., and Wheeler D.L. 2002. Radiographic and histologic analysis of the tibial tunnel after allograft anterior cruciate ligament reconstruction in goats. Am J Sports Med *30:*368-73.

Harvie, P., Pollard T.C., and Carr A.J. 2007. Calcific tendinitis: natural history and association with endocrine disorders. J Shoulder Elbow Surg *16:*169-73.

Hashimoto, Y., Yoshida G., Toyoda H., and Takaoka K. 2007. Generation of tendon-to-bone interface "enthesis" with use of recombinant BMP-2 in a rabbit model. J Orthop Res *25:*1415-24.

Hawkey, D.E. 1998. Disability, compassion and the skeletal record: using musculoskeletal stress markers (MSM) to construct an osteobiography from early New Mexico. Internat. J. Osteoarchaeol. *8:*326-340.

Hawkey, D.E., and Merbs C.F. 1995. Activity-induced musculoskeletal stress markers (MSM) and

subsistence strategy changes among ancient Hudson Bay Eskimos. Internat. J. Osteoarchaeol. *5:*324-338.

Hayes, C.W., Rosenthal D.I., Plata M.J., and Hudson T.M. 1987. Calcific tendinitis in unusual sites associated with cortical bone erosion. AJR Am J Roentgenol *149:*967-70.

Hems, T., and Tillmann B. 2000. Tendon entheses of the human masticatory muscles. Anat Embryol *202:*201-208.

Henderson, C.Y. 2008. When hard work is disease: the interpretation of enthesopathies. In M. Brickley and M. Smith (eds.): Proceedings of the Eighth Annual Conference of the British Association for Biological Anthropology and Osteoarchaeology. Oxford: British Archaeological Reports: International Series, pp. 17-25.

Henderson, C.Y. 2009. Disease-related entheseal remodelling (enthesopathies) at fibrous entheses: 11th Annual Conference of the British Association for Biological Anthropology and Osteoarchaeology. Bradford, Poster. Available from: http://www.academia.edu/2283651/Disease-related_entheseal_remodelling_enthesopathies_at_fibrous_entheses.

Henderson, C.Y., Mariotti V., Pany-Kucera D., Villotte S., and Wilczak C.A. 2013. Recording specific features of fibrocartilaginous entheses: preliminary results of the Coimbra standard method. Internat. J. Osteoarchaeol.. DOI: 10.1002/oa.2287.

Ikegawa, S. 1996. Calcific tendinitis of the pectoralis major insertion. A report of two cases. Arch Orthop Trauma Surg *115:*118-9.

Isidor, F., Karring T., Nyman S., and Lindhe J. 1985. New attachment-reattachment following reconstructive periodontal surgery. J Clin Periodontol *12:*728-35.

Jurmain, R.D., Alves Cardoso F., Henderson C.Y., and Villotte S. 2012. Bioarchaeology's Holy Grail: the reconstruction of activity. In A. Grauer (ed.): Companion to Paleopathology. Chicester, England: Wiley-Blackwell, pp. 531-552.

Kacki, S., and Villotte S. 2006. Maladie hyperostosique et mode de vie: intérêt d'une démarche bio-archéologique. Exemple du cimetière du couvent des s urs grises de beauvais (oise), xve -xviiie siècles. Bulletins et Mémoires de la Société d'Anthropologie de Paris *18:*55-64.

Karring, T., Isidor F., Nyman S., and Lindhe J. 1985. New attachment formation on teeth with a reduced but healthy periodontal ligament. J Clin Periodontol *12:*51-60.

Kau, R.L., Kim N., Hinni M.L., and Patel N.P. 2010. Repair of esophageal perforation due to anterior cervical spine instrumentation. Laryngoscope *120:*739-42.

Le Bellec, Y., Masmejean E., Cottias P., Alnot J.Y., and Huten D. 2002. Internal fixation of proximal humerus fracture by "palm tree" pinning. Rev Chir Orthop Reparatrice Appar Mot *88:*342-8.

Lee, J., Brookenthal K.R., Ramsey M.L., Kneeland J.B., and Herzog R. 2000. MR imaging

assessment of the pectoralis major myotendinous unit: an MR imaging-anatomic correlative study with surgical correlation. AJR Am J Roentgenol *174:*1371-5.

Lieverse, A.R., Bazaliiskii V.I., Goriunova O.I., and Weber A.W. 2009. Upper limb musculoskeletal stress markers among middle Holocene foragers of Siberia's Cis-Baikal region. Am. J. Phys. Anthropol. *138:*458-472.

Lovell, N.C., and Dublenko A.A. 1999. Further aspects of fur trade life depicted in the skeleton. Internat. J. Osteoarchaeol. *9:*248-256.

Luder, H.U., and Zappa U. 1998. Nature and attachment of cementum formed under guided conditions in human teeth. An electron microscopic study. J Periodontol *69:*889-98.

Malaviya, G.N. 2009. Fracture of calcaneum following drop foot surgery--a case report. Lepr Rev *80:*77-80.

Miyakoshi, N., Sasaki H., Kasukawa Y., Kamo K., and Shimada Y. 2010. Effects of a vitamin D analog, alfacalcidol, on bone and skeletal muscle in glucocorticoid-treated rats. Biomed Res *31:*329-36.

Molnar, P. 2006. Tracing prehistoric activities: musculoskeletal stress marker analysis of a stone-age population on the island of Gotland in the Baltic Sea. Am. J. Phys. Anthropol. *129:*12-23.

Molnar, P. 2008. Patterns of physical activity and material culture on Gotland, Sweden, during the middle neolithic. Internat. J. Osteoarchaeol. *20:*1-14.

Molnar, P., Ahlstrom T.P., and Leden I. 2010. Osteoarthritis and activity—an analysis of the relationship between eburnation, Musculoskeletal Stress Markers (MSM) and age in two neolithic hunter–gatherer populations from Gotland, Sweden. . Internat. J. Osteoarchaeol. *21:*283-291.

Murakami, K., Tanimura H., Ishimoto K., Yamaue H., Yamade N., and Shimamoto T. 1996. Reconstruction with bilateral gluteus maximus myocutaneous rotation flap after wide local excision for perianal extramammary Paget's disease. Report of two cases. Dis Colon Rectum *39:*227-31.

Nakagawa, Y., Tanaka E., Suzuki T., and Nakamura T. 2002. Tackler's bony spur in sumo wrestlers: a report of two cases. J Orthop Sci *7:*405-9.

Niinimäki, S. 2012. The relationship between musculoskeletal stress markers and biomechanical properties of the humeral diaphysis. Am. J. Phys. Anthropol. *147:*618-628.

Nishimura, K., Takada K., Noguchi Y., and Yamaoka A. 1989. Gingival fibroblasts and tissues attachment to curetted cementum surface in periodontally involved teeth. J Electron Microsc (Tokyo) *38:*16-23.

Oliva, F., Via A.G., and Maffulli N. 2012. Physiopathology of intratendinous calcific deposition. BMC Med *10:*95.

Pany, D. 2005. 'Working in a saltmine...' Erste Ergebnisse der anthropologischen Auswertung von Muskelmarken an den menschlichen Skeletten aus dem Gräberfeld Hallstatt. Interpretierte Eisenzeiten. Fallstudien, Methoden, Theorie. Tagungsbeiträge der 1. Linzer Gespräche zur interpretativen Eisenzeitarchäologie. Studien zur Kulturgeschichte von Oberösterreich *18:*101-111.

Papathanasiou, A. 2005. Health Status of the Neolithic Population of Alepotrypa Cave, Greece. Am. J. Phys. Anthropol. *126:*377-390.

Peterson, J. 1998. The Natufian hunting conundrum: spears, atlatls, or bows? musculoskeletal and armature evidence. Internat. J. Osteoarchaeol. *8:*378-389.

Porcellini, G., Paladini P., Campi F., and Pegreffi F. 2009. Osteolytic lesion of greater tuberosity in calcific tendinitis of the shoulder. J. shoulder Elbow Surg. *18:*210-215.

Revel, M., Mayoux-Benhamou M.A., Rabourdin J.P., Bagheri F., and Roux C. 1993. One-year psoas training can prevent lumbar bone loss in postmenopausal women: a randomized controlled trial. Calcif Tissue Int *53:*307-11.

Roderer, G., Erhardt J., Kuster M., Vegt P., Bahrs C., Kinzl L., and Gebhard F. 2011. Second generation locked plating of proximal humerus fractures--a prospective multicentre observational study. Int Orthop *35:*425-32.

Sasaki, K., Nozaki M., Kikutchi Y., Yamaki T., and Soejima K. 1999. Reconstruction of perianal skin defect using a V-Y advancement of bilateral gluteus maximus musculocutaneous flaps: reconstruction considering anal cleft and anal function. Br J Plast Surg *52:*471-5.

Schrader, S.A. 2012. Activity patterns in New Kingdom Nubia: An examination of entheseal remodeling and osteoarthritis at Tombos. Am. J. Phys. Anthropol. *149:*60-70.

Steen, S.L., and Lane R.W. 1998. Evaluation of habitual activites among two Eskimo populations based on musculoskeletal stress markers. Internat. J. Osteoarchaeol. *8:*341-353.

Suliman, I.A., Lindgren J.U., Gillberg P.G., Diab K.M., and Adem A. 1997. Effect of immobilization on skeletal muscle nicotinic cholinergic receptors in the rat. Neuroreport *8:*2821-4.

Tjalma, W.A., Cooremans I.D., Jeuris W., Van Marck E.A., and Monaghan J.M. 2001. Recurrent Paget's disease of the vulva in a myocutaneous flap: case report and review of the literature. Eur J Gynaecol Oncol *22:*13-5.

Toyne, J.M. 2008. Offering their hearts and their heads: A bioarchaeological analysis of ancient human sacrifice on the northern coast of Peru. Doctoral thesis, Tulane University.

Uhthoff, H.K., and Loehr J.W. 1997. Calcific tendinopathy of the rotator cuff: pathogenesis, diagnosis, and management. J Am Acad Orthop Surg *5:*183-191.

Villotte, S. 2006. Connaissances médicales actuelles, cotation des enthésopathies: nouvelle

méthode. Bulletins et Mémoires de la Société d'Anthropologie de Paris *18:*65-85.

Villotte, S., and Knüsel C.J. 2013. Understanding entheseal changes: definition and life course changes. Internat. J. Osteoarchaeol. DOI:10.1002/oa.2289

Warner, J.J., and Parsons I.M.T. 2001. Latissimus dorsi tendon transfer: a comparative analysis of primary and salvage reconstruction of massive, irreparable rotator cuff tears. J Shoulder Elbow Surg *10:*514-21.

Weiss, E. 2003. Understanding muscle markers: aggregation and construct validity. Am. J. Phys. Anthropol. *121:*230-240.

Weiss, E. 2007. Muscle markers revisited: activity pattern reconstruction with controls in a central California Amerind population. Am. J. Phys. Anthropol. *133:*931-940.

Weiss, E., Corona L., and Schultz B. 2010. Sex differences in musculoskeletal stress markers: Problems with activity pattern reconstructions. Internat. J. Osteoarchaeol. *22:*70-80.

Wysocki, M., and Whittle A. 2000. Diversity, lifestyles and rites: new biological and archaeological evidence from British Earlier Neolithic mortuary assemblages. Antiquity *74:*591-601.

Zabecki, M. 2009. Late Predynastic Egyptian Workloads: Musculoskeletal Stress Markers at Hierakonpolis. Doctoral thesis, University of Arkansas.

Tables

Table 1. Set of defined searches with results. Input into PubMed took the form: “fibrous enthesis” AND rupture.

First part of search phrase	Conjunction	Second part of search phrase	PubMed	IJO and J. Arch Sci
		pathology		0
		periostitis		0
		spur		0
fibrous enthesis		lytic	The phrase "fibrous enthesis" w as not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		rupture		0
		enthesopathy		0
		hypertrophic osteoarthropathy	0	0
		Paget's disease	0	0
		enthesiopathy	0	0
		enthesitis	0	0
		enthesopathy	0	0
		insertiopathy	The term "insertiopathy" w as not found in PubMed	0
		insertitis	The term "insertitis" w as not found in PubMed	0
		lytic	0	0
fibrous attachment		osteoporosis	0	0
		pathology	Albair et al., 1982; Bragger et al., 1990; Fernyhough and Page, 1983; Harris et al., 2002; Hashimoto et al., 2007; Isidor et al., 1985; Karring et al., 1985; Luder and Zappa, 1998; Nishimura et al., 1989	0
		periostitis	0	0
		rupture	Hashimoto et al., 2007	0
		spur	0	0
		tendinitis	0	0
		tendinopathy	0	0
		tendonitis	0	0
		hypertrophic osteoarthropathy	0	0
		Paget's disease	0	0
		enthesiopathy	0	0
		enthesitis	0	0
		enthesopathy	0	0
		insertiopathy	The term "insertiopathy" w as not found in PubMed	0
		insertitis	The term "insertitis" w as not found in PubMed	0
fibrous insertion		lytic	0	0
		osteoporosis	0	0
		pathology	Dupont and Brow n, 2012	0
		periostitis	0	0
		rupture	0	0
		spur	0	0
		tendinitis	Dupont and Brow n, 2012	0
		tendinopathy	Dupont and Brow n, 2012	0
		tendonitis	Dupont and Brow n, 2012	0
		rupture	Warner and Parsons, 2001	0
		periostitis	0	0
		spur	Nakagaw a et al., 2002	0
deltoid insertion		lytic	0	0
		enthesitis	0	0
		tendinopathy	Fritz et al., 1994	0
		enthesopathy	0	0
		rupture	0	0
		periostitis	0	0
		spur	0	0
deltoid attachment		lytic	0	0
		enthesitis	0	0
		tendinopathy	0	0
		enthesopathy	0	0
		rupture	Lee et al., 2000	0
		periostitis	0	0
		spur	0	0
deltoid tuberosity		lytic	0	0
		enthesitis	0	0
		tendinopathy	0	0
		enthesopathy	0	0
		rupture	0	0
		periostitis	0	0
		spur	0	0
pectoralis major insertion		lytic	0	0
		enthesitis	0	0
		tendinopathy	Cahir and Saifuddin, 2005; Chadw ick, 1989; Durr et al., 1997; El-Essaw y and Vanhoenacker, 2012; Hayes et al., 1987; Ikegaw a, 1996	0
		enthesopathy	0	0
		rupture		0
		periostitis		0
	AND	spur		0
pectoralis major attachment		lytic	The phrase "pectoralis major attachment" w as not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		enthesopathy		0
		rupture		0
		periostitis		0
		spur		0
teres major insertion		lytic	The phrase "teres major insertion" not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		enthesopathy		0
		rupture		0
		periostitis		0
		spur		0
teres major attachment		lytic	The phrase "teres major attachment" not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		enthesopathy		0
		rupture		0
		periostitis		0
		spur		0
gluteus maximus insertion		lytic	The phrase "gluteus maximus insertion" w as not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		enthesopathy		0
		rupture		0
		periostitis		0
		spur		0
gluteus maximus attachment		lytic	The phrase "gluteus maximus attachment" w as not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		enthesopathy		0
		rupture		0
		periostitis		0
		spur		0
tibialis anterior insertion		lytic	The phrase "tibialis anterior insertion" w as not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		enthesopathy		0
		rupture		0
		periostitis		0
		spur		0
tibialis anterior attachment		lytic	The phrase "tibialis anterior attachment" w as not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		enthesopathy		0
		rupture		0
		periostitis		0
		spur		0
tibialis posterior insertion		lytic	The phrase "tibialis posterior insertion" w as not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		enthesopathy		0
		rupture		0
		periostitis		0
		spur		0
tibialis posterior attachment		lytic	The phrase "tibialis posterior attachment" w as not found in PubMed	0
		enthesitis		0
		tendinopathy		0
		enthesopathy		0
deltoid		Paget's disease	0	0
		osteoporosis	Anon., 1993; Briggs et al., 2007; Le Bellec et al., 2002; Revel et al., 1993; Roderer et al., 2011	0
pectoralis major		Paget's disease	0	0
		osteoporosis	Braun et al., 2012; Kau et al., 2010	0
gluteus maximus		Paget's disease	Dufourmentel and Petoin, 1984; Murakami et al., 1996; Sasaki et al., 1999; Tjalma et al., 2001	0
		osteoporosis	0	0
tibialis anterior		Paget's disease	0	0
		osteoporosis	Chang et al., 2011; Malaviya, 2009; Miyakoshi et al., 2010; Suliman et al., 1997	0
tibialis posterior		Paget's disease	0	0
		osteoporosis	Malaviya, 2009	0