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Major Questions about Teres Minor: The Pattern of Reactive Changes in a Precolumbian Human Skeletal Sample From Illinois

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Abstract: The ubiquitous presence of reactive changes at the insertion of a minor muscle of the rotator cuff on the proximal humerus (teres minor) is analyzed in an adult Late Woodland (AD 800–1150) period osteological sample (N = 43) from west-central Illinois (Schroeder Mounds, 11HE177). Fifty-seven percent left (20/35) and sixty-nine percent right humeri (25/36) have reactive change to the t. minor facet. There are no statistically significant differences by sex or side asymmetry. Reactive change generally co-associates with greater humeral robusticity. Besides a minor collaborative role in shoulder joint stability, teres minor has a limit range of movement as an abductor and external rotator of the arm. Injuries to the t. minor are exrememly rare in modern clinical contexts and only in athletes who engage in actvivites that utilize overhead arm movements. That is, the reactive change may be associated with particular arm movements or body posture which, in this pre-Columbian horticulturalist sample, may be related to activities for which there are no modern clinical correlates.

Keywords: Illinois, Woodland Period, mechanical injury, teres minor, Schroeder Mounds

Introduction

The most lateral structure of the proximal humerus is the greater tubercle. Three of the four muscles that comprise the rotator cuff attach at three successive facets located on the superior to posterior margin of the tubercle (Culham and Peat 1993; Halder et al. 2000; Soslowsky et al. 1992; White et al. 2011). The muscles of the rotator cuff collaboratively act as joint stabilizers and individually perform a range of shoulder movements. The teres minor muscle attaches on the most inferior of the facets (Halder et al. 2000; Prescher 2000; Terry and Chopp 2000). Teres minor originates on the dorsal surface of the axillary border of the scapula. It primarily functions to posteriorly rotate the humerus and, when the arm is in the horizontal plane, as an arm abductor and extender (Escamila and Andrews 2009; Oveson and Nielson 1986). As part of the rotator cuff, the muscle also plays a collaborative role in shoulder joint stability. However, this role is mimimal, as it is the smallest and weakest of the cuff muscles (Keating et al. 1992), supplying only

Field Notes: A Journal of Collegiate Anthropology 8 (1): 70–85 (June 2016)

ten percent of joint muscle strength (Keating et al. 1993).

Teres minor is clinically observed to be infrequently damaged in rotator cuff injuries (Hodgson et al. 2012; Melis et al. 2011). However, reactive change at the teres minor insertion is frequently observed in the adults from the Late Woodland (circa AD 800–1100) skeletal sample from Schroeder Mounds (11He177), Illinois. Minimal attention has been given to the muscle in bioarchaeological assessment of musculo-skeletal stress in the shoulder joint (e.g., Clapper 2006; Eshed et al. 2004; Lieverse et al. 2009; Molnar 2006; Peterson 1998). Considering the limited range of motion and direction of teres minor in physical activity, the presence of reactive change in the Schroeder Mounds sample is an opportunity to quantify, assess by age and sex, and biomechanically interpret the results.

Materials and Methods

The Schroeder Mounds site (11HE177) is located in west-central Illinois in Henderson County (Figure 1). The site is a multiple overlapping mound mortuary context situated on a low bluff overlooking a floodplain of the east bank of the Mississippi River. Schroeder Mounds dates to the Late Woodland period (circa AD 800–1100) (Esarey 2000; Kolb 1982). No habitation areas are associated with the mound. The site was a salvage excavation consequential to disturbance by a domestic construction project. Schroeder Mounds yielded 119 very well preserved burials (sixty-nine adults, forty-eight subadults, two sex-indeterminate adults.). Forty-three adult (third molars in occlusion) individuals with at least one proximal humerus preserving an intact greater tubercle were examined for teres minor facets.

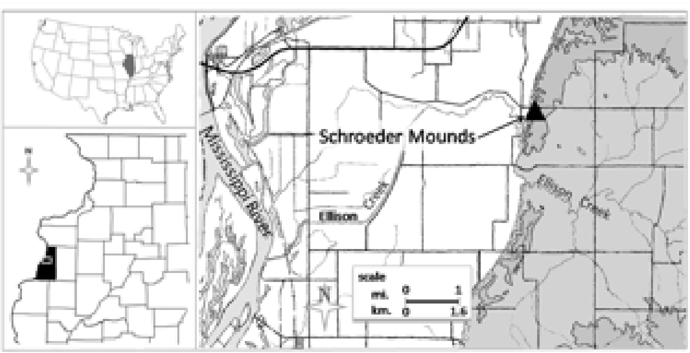

Figure 1: Map of Schroeder Mounds (11HE177), Henderson County, Illinois.

The adults were aged and sexed according to standard osteological criteria (Brooks and Suchey 1990; Buikstra and Ubelaker 1994). As the facet variant may be a progressive development, the adults were segregated into three age-at-death categories: "old" (over 40 years of age [yoa]), "middle age" (30–40 yoa), and "young" (under 30 yoa).

The glenohumeral joint is the main articulation of the shoulder joint. Besides the glenoid labrum and three glenohumeral ligaments, the joint is stabilized by a suite of seven muscles, four of which (supraspinatus, infraspinatus, teres minor, and subscapularis) define the rotator cuff and have insertions (entheses) on the greater tubercle of the humeral head (Culham and Peat 1993; Halder et al. 2000; Soslowsky et al. 1992). As noted, the teres minor enthesis is on the inferior facet (Figure 2a, b). All of the inferior facets on preserved greater tubercles of the adults in the Schroeder Mounds sample were examined for the presence of any reactive change. A score of zero identified an unremodeled (e.g., smooth, no porosity) facet surface (Figure 2b). Given the small Schroeder Mounds sample size, a simplified quantification method relative to the Coimbra protocols (see Henderson et al. 2012; Jurmain and Villotte 2010; Villotte and Knüsel 2013) was preferred. Reactive change was scored on two levels: score A (Figure 3a) reflected some evidence of cortical change (e.g., porosity, spicules) on the facet or at the margins; score B indicated more extensive and intensive reactive change resulting in facet lipping or a lytic defect or depression at the insertion site (Figure 3b). Although reactive change was macroscopicically visible, each level assignment was corroborated by photograph (Nikon S8100, 10x optical zoom). Facet size was not a scoring factor.

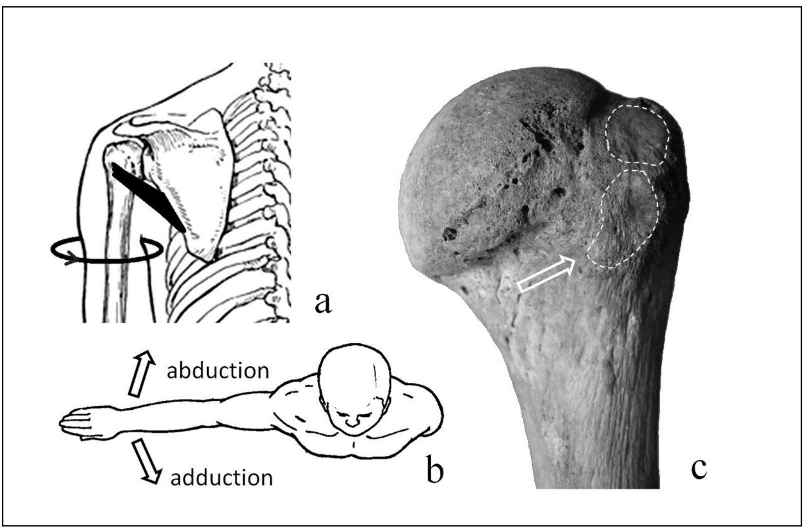

Figure 2: a) Origin and insertion of teres minor muscle and illustration of posterior rotation; b) illustration of adduction and abduction in the horizontal plane; c) location of insertion of teres minor (arrow) on the posterior-inferior facet of the greater tubercle.

Body size or robusticity may also be a predisposing or mediating factor in reactive changes at muscle entheses (e.g., Weiss 2005, 2006; Weiss et al. 2012; Wilczak 1998); therefore, a simple robusticity index (i.e., Pearson 2000; Stock and Shaw 2007) was employed. Three standardized measurements (Bräuer 1988) were utilized: maximum humeral length (ML), maximum diameter at midshaft (MDM), and minimum diameter at midshaft (mDM). The humeral index for each humerus was calculated:

$$(MDM \times mDM)/ML \times 100$$

Two statistical tests were utilized to determine acceptance or rejection of the null hypothesis (p-value). Mean differences were assessed using the t-test. Paired comparisions of differences by distribution (two-tailed) and direction (one-tailed) were assessed using the Fisher's exact test. Statistical significance for both tests was set at the ninety-fifth percentile ($p < .05$). The Fisher's exact test was employed because the Schroeder Mounds sample sizes were expected to be small and the p-value calculated by the Chi-square test is an approximation (D'Agostino et al. 1988). The Fisher's exact test is conservative, particularly in small samples. That is, the mathematical threshold for rejection of the null hypothesis may actually be greater than the ninety-fifth percentile. Given that biomechanical or behavioral interpretations would rest on statistically significant differences, a conservative test was preferred (Berkson 1978; D'Agostino et al. 1988).

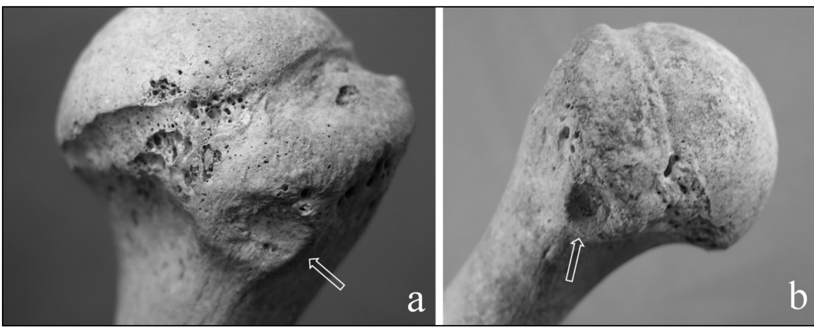

Figure 3: a) initial stage (A) reactive change at teres minor insertion; b) insertion remodeling at stage B.

Results

The Schroeder Mounds sample yielded a total of sixteen males, twenty-six females, and one sex-indeterminate individual (N = 43) who collectively generated thirty-six right and thirty-five left humeri (Table 1). Collectively, fifty-seven percent of all left humeri (20/35) and sixty-nine percent of all right humeri (25/36) had some level (i.e., A or B) of entheseal remodeling. The comparative prevalence by side was not statistically significant ($p = .3303$). When segregated by more involved reactive change (level B) (5/35 left, 7/36 right), there was also no statistically significant difference by side ($p = .7531$).

Prevalence and Pattern by Sex

Sex differences were examined within (i.e., side prevalence, expression) and between the sexes by the collective left and the collective right humeri. Within the female sample, forty-seven percent of left (10/21) and sixty-seven percent of right (14/22) teres minor entheses have reactive change (level A or B). Right-side prevalence was tested (one-tailed test) and was not statistically significant ($p = .2269$). Examining reactive change in the females (i.e., prevalence of level B) by side (1/21 versus 3/22), there was also no significant difference (p = .6069). In the male sample, over sixty-nine percent had scores of A or B on the left humerus (9/13) and over seventy-eight percent (11/14) had scores of A or B on the right. Neither right-side prevalence (p = .4539) nor left-side prevalence by reactive change (level B) (4/13 versus 4/14) (p = .6151) was significant. Prevalence differences between the sexes (Table 1) revealed a higher male frequency on the left humerus (69% versus 40%) (p = .0990) and the right humerus (78.6% versus 62%) (p = .3628) for any level of score (A+B) was not statistically significant. The B facet level comparisons (left side 4/13 versus 1/20, p = .0657, right side 4/14 versus 3/21, p= .2704) were also not statistically significant.

Lateralization

Twenty-eight individuals (eleven males, seventeen females) preserved the greater tubercle on both a left and a right humerus (Table 1). Twenty of these individuals exhibit reactive change at the t. minor enthesis (20/28, 71.4%) on either one or both humeri, with twelve (seven females, four males, one sex-indeterminate) of these (12/20) presenting bilaterally. Where a side difference occurs (8/28), more individuals exhibit reactive change on the right side (7/8). Relative to females, males are not more likely to express a score bilaterally (p = .5646, one-tailed). Nine of the eleven males with both humeri (82%) displayed reactive change. Two of the nine males had level A reactive change on the right side. Two individuals had an asymmetrical expression: Burial 58 had a score of A on the left and B on the right, and Burial 39 displayed the opposite. The remaining five individuals with a facet on both humeri (5/11) displayed symmetrically: two individuals had level A and three had level B.

Eleven of the seventeen females with both humeri have at least one humerus with a facet score (64.7%) and all facets express at the incipient (A) level. Seven females exhibit reactive change bilaterally. Of the four females that exhibited laterality, all had reactive change on the right side.

Facet Pattern and Age at Death

The forty-three ageable Schroeder Mounds adults were segregated into three age groups (< 30, 30–40, and 40+) to assess the role of age in presence and level of reactive change (Table 2). Comparing total left and total right humeri in the young adult sample (<30 years, eight males, sixteen females, one sex-indeterminate), there is a right-side bias in reactive change (10/20 versus 16/22) and severity (2/10 level B versus 5/16), but neither (p = .2040, p = .4143 respectively) were statistically significant. The right-side bias also occurs within the male and female samples (Table 2). Among individuals who preserve both proximal humeri, over seventy-two percent (13/18) have a facet bilaterally, with six individuals (6/13) showing a right-side bias of either any level of entheseal remodeling (A or B) or advanced reactive change (level B) (Table 2). Young males have a higher prevalence of remodeling by side (5/8 versus 5/12, 6/7 versus 10/15) and a higher prevalence of a bilateral presence (6/7 versus 7/11). The observed sex differences in the young adult cohort are not statistically significant. However, the results may reflect sampling error.

The middle age cohort (circa 30–40 yoa at death) was small (five males, six females). Left and right humeri had equal prevalence of entheseal change (6/9) with four of six who preserved both humeri exhibiting bilaterally.

A noticeable pattern in this age category is the few cases with B-level reactive change (1/12, 8.3%, N humeri = 18). In contrast, out of the twenty-six total facets (26/42) in the young adult sample, seven (27%) were at the B-level. However, this age difference was not statistically significant (p = .1934, one-tailed).

Table 1: Presence and level of reactive change on the teres minor facet.

	LEFT HUMERUS			RIGHT HUMERUS			BILATERALITY						
							left side	right side			both sides		
Scores	A	B	A+B	A	B	A+B	B	A	B	A+B	A	B	A+B
Male	5/13	4/13	9/13	7/14	4/14	11/14	1/11	2/11	1/11	3/11	2/11	3/11	5/11
Female	9/21	1/21	10/21	11/22	3/22	14/22	0/17	4/17	0/17	4/17	7/17	0/17	7/17
Indeterm.	1/1	0	1/1	0	0	0	0	0	0	0	0	0	0
Total	15/35	5/35	20/35	18/36	7/36	25/36	1/28	6/28	1/28	7/28	9/28	3/28	12/28

Notes: A = low level of reactive change (e.g., spicules); B = extensive entheseal remodeling (lipping, lytic defects); A+B = all reactive changes. Samples are segregated by side (by sex and by total sample) and by individuals who preserve both a left and right humerus.

The oldest age cohort (circa 40+ years) has only two males and four females. There were five left and five right humeri with no side bias of reactive change for prevalence or severity. However, four of the six humeri with facets (two left, two right) had remodeled facets.

Table 2. Level of reactive change by age category.

	MALE					FEMALE				TOTALS				
	Left	Right	Both			Left	Right	Both		Left	Right	Both		
			bilateral	left side	right side			bilateral	right side[2]			bilateral	left side	right side
Score[1]	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)	A+B(B)
Young (<30 years) 8M 16F	5(2)/8	6(2)/7	6 (3)/7	1(1)/7	3(1)/7	5(0)/12	10(3)/15	7(0)/11	3(0)/11	10(2)/20	16(5)/22	13(3)/18	1(1)/18	6(1)/18
intermediate (30-40 years) 5M 6F	2(0)/3	3(0)/5	1(0)/2	0/2	0/2	4(1)/6	3(0)/4	3(0)/4	1(0)/4	6(1)/9	6(0)/9	4(0)/6	0/6	1(0)/6
old (40+ years) 2M 4F	2(2)/2	2(2)/2	2(2)/2	0/2	0/2	1(0)/3	1(0)/3	1(0)/2	0/2	3(2)/5	3(2)/5	3(2)/4	0/4	0/4

Notes: Presence of reactive change segregated by skeletal age-at-death. Scores are tabulated by the total sample of left and right humeri and by individuals preserving both. Individuals preserving both humeri are scored for reactive change on the left, right, or both facets. 1 A+B = any reactive change, (B) = extensive entheseal change; 2 there are no left-side cases.

Robusticity Indices and Symmetry

Body size may play a role in facet remodeling; therefore, a robusticity index was calculated for forty three individuals (sixteen males, twenty-six females, one sex-indeterminate) who had at least one measurable humerus (i.e., maximum length, minimum and maximum diameters at midshaft) as well as a preserved greater tubercle (Table 3). In general, there is no statistically significant difference in the means (t-test) in the total sample by side (p = .4865), for side asymmetry in males (p = .9931), or for side asymmetry in females (p = .5369). There is also no significantly different side asymmetry means between the sexes for either the left (p = .4035) or the right humeral index (p = .6933). However, given the probability of sampling error, the left and right humeri are evaluated separately.

Table 3: Level of reactive change by mean robusticity index.[1]

	LEFT HUMERUS *x*			RIGHT HUMERUS *x*		
	male	female	TOTAL[2]	male	female	TOTAL[2]
all[3]	11.63 (14)	11.38 (20)	11.45 (33)	11.63 (13)	11.52 (20)	11.59 (34)
no change	10.61 (4)	11.09 (12)	10.97 (16)	11.08 (3)	11.40 (7)	11.30 (10)
A facet	11.34 (4)	12.00 (7)	11.76 (11)	11.74 (7)	11.59 (10)	11.65 (17)
B facet	12.62 (4)	10.39 (1)	12.17 (5)	11.91 (3)	11.54 (2)	11.76 (5)
A+B facet	11.98 (8)	11.80 (8)	11.90 (17)	11.79 (10)	11.58 (12)	11.68 (22)

Notes: [1] Numbers in parenthesis = sample N; [2] includes unsexable individuals; [3] includes individuals without a preserved greater tubercle. The mean scores for robusticity are tabulated by presence and degrees of reactive change and are presented for the total sample and by sex.

In the subset of humeri that preserve a greater tubercle, the presence of any reactive change (A+B) versus the absence of reactive change (Table 3) is statistically significant for the left humerus (10.97 versus 11.90, p = .0009) but not on the right (11.30 versus 11.68, p = .1886). This may reflect sampling error as the total sample mean indices for left and right humeri are virtually the same (11.45 versus 11.59). The differences relate to the differences by sex. Specifically, for both the left and right humeri samples, males and females with no reactive change have the lowest mean robusticity index. The highest robusticity indices (samples of 2+ individuals) occur in the samples with B-level reactive change. Individuals with some reactive facet change (A) have mean indices between the two. Although sampling bias may influence the pattern (male N = 4), females without reactive change have a larger mean robusticity index than the males (10.61 versus 11.09 [p = .2093], 11.08 versus 11.40 [p = .5012]) and females with any score have smaller mean indices (11.98 versus 11.80 [p = .6723], 11.79 versus 11.58 [p = .5463]). Although segregating the sample by the age cohorts markedly reduces the sample size in each (Table 4), some patterns can be observed. Mirroring the total sample, the mean robusticity score across all three age categories is lowest for individuals without facet scores. With the exception of the right humerus of young males, the robusticity index of B-scored humeri are the largest. Small sample sizes result in a mixed pattern for age-controlled sex differences and asymmetry patterns; however, several trends may be apparent. The mean robusticity scores for adults with B scores are higher in the older age cohort than in the young adults.

Table 4: Mean robusticity index by sex and by age category.

	LEFT HUMERUS *x*			RIGHT HUMERUS *x*		
	male	female	Total[1]	male	female	Total[1]
Young age						
all[2]	11.24 (7)	11.24 (11)	11.28 (19)	10.80 (7)	11.37 (13)	11.43 (22)
no change	10.5 (3)	11.00 (8)	10.93 (12)	11.34 (1)	11.22 (4)	11.39 (5)
A facet	11.26 (2)	11.87 (3)	11.71 (6)	11.50 (4)	11.31 (7)	11.38 (11)
B facet	12.33 (2)	---	12.33 (2)	11.06 (2)	11.54 (2)	11.30 (4)
A+B facets	11.80 (4)	11.87 (3)	11.80 (12)	11.35 (6)	11.36 (9)	11.36 (15)
Middle age						
all[2]	11.67 (5)	---	11.53 (9)	11.61 (5)	12.30 (3)	11.71 (10)
no change	10.94 (1)	---	11.20 (3)	10.96 (2)	11.93 (1)	11.28 (3)
A facet	11.43 (2)	---	11.96 (5)	12.07 (3)	12.50 (2)	12.24 (5)
B facet	---	---	---	---	---	---
A+B facets	11.43 (2)	---	11.96 (5)	12.07 (3)	12.50 (2)	12.24 (5)
Old age						
all[2]	12.95 (2)	11.29 (3)	11.94 (5)	13.62 (1)	11.43 (4)	11.50 (5)
no change	---	11.22 (2)	11.22 (2)	---	10.4 (1)	10.4 (1)
A facet	---	11.44 (1)	11.44 (1)	---	11.82 (2)	11.82 (2)
B facet	12.95 (2)	---	12.95 (2)	13.62 (1)	---	13.62 (1)
A+B facets	12.95 (2)	11.44 (1)	12.42 (3)	13.62 (1)	11.82 (2)	12.42 (3)

Notes: [1] includes unsexable individuals; [2] includes individuals without a preserved greater tubercle; numbers in parenthesis = sample N.

Although sampling error should be considered, this may potentially reflect the morbidity of young age-at-death males. Comparing side differences across all age cohorts, the side with the lower mean robusticity index has a higher mean score threshold for A-level facet change. Where sex comparisons are possible (young cohort, left and right humeri; middle age cohort, right humerus), females have a higher robusticity threshold before they exhibit facet scores.

Within-sex comparisons are largely case comparisons, but these may predict life course patterns (e.g., Elder 1998; Kuh and Shlomo 2004; Mayer 2009) in larger samples. For example, for the right humerus, the single middle age female case with no facet score has a higher robusticity index (11.93) than the two young females with B-scored facets (11.54) and a higher score than five out of the seven females with A-scored facets (range 10.3–11.8). Between the male young and middle age cohorts (right humerus), the mean robusticity index for the A facet (12.07) in the middle age sample is higher than the A (11.50) and B (11.06) facet robusticity means for the younger males.

Discussion

The presence and expression of remodeled teres minor facets in the adult Schroeder Mounds sample is certainly patterned. Reactive changes on the facet occur in both males and females. Although there is some right-side bias, most individuals with preserved left and right greater tubercles exhibit some level of reactive change bilaterally. Males are more likely to exhibit side bias and are more likely to display more involved reactive changes (i.e., score of B). The male bias predicts a co-association with body size or robusticity. The proxy for size adopted in this study is the humeral index. The mean humeral indices for the total sample and subsets (i.e., sex, age) are larger in the presence of any entheseal remodeling of the facet. However, intra-sample patterns that suggest body size is not the exclusive predictor of facet condition are apparent. These patterns include a higher mean robusticity index in females relative to males in individuals without reactive change. These higher mean values in females are apparently maintained with age (Table 4, right humeral data). This implies some sex differences in amount or manner of activity that is conducive to reactive change. It can also be interpreted that less robust male adults with reactive change may be more likely to die young. But, given the small sample size from Schroeder Mounds, particularly when subdivided by age, this can only be a speculation.

Associating reactive changes (e.g., osteoarthritis and enthesopathies) observed on osteoarchaeological material to specific activities has proven to be problematic (Doying 2010; Jurmain 1999; Jurmain et al. 2012; Kennedy 1989; Knüsel 2000; Niinimäki 2011; Stirland 1988; Villotte and Knüsel 2012; Weiss 2005, 2006; Weiss et al. 2012). The reactive changes are multifactorial, probably synergistic, and often associated with body size (Jurmain 1999; Weiss 2005). However, clinically, injuries to the rotator cuff are primarily due to advancing age or consequential to shoulder activities where the arm is elevated (e.g., tennis, golf, baseball, swimming [Melis et al. 2011; Miranda et al. 2005; Ouellette et al. 2008; Prescher 2000; Rizio and Uribe 2001], and equivalent arm use in industrial labor [e.g., Buckle and Devereaux 2002; Ohlsson et al. 1995]). The fact that in clinical contexts the teres minor muscle is rarely involved in rotator cuff injuries could suggest elevated arm movement activities in the Schroeder Mounds sample that are uncommon or absent in Western culture (e.g., Clapper 2006; Molleson 2007; Molnar 2006).

The prevalence in both males and females and the bilaterality of the reactive change does not support the performance of lateralized activities such as use of the bow and arrow or the atlatl (e.g., Bridges 1990; Capasso et al. 1999; Peterson 1998; Ubelaker and Zarenko 2012). It could include body postures where both arms are elevated, such as arboreal seed crop harvesting where a long pole is used to knock the nuts from high branches (e.g., Pinyon nut harvesting by the Paiute, Washo, Shoshone, and Navajo [Fenenga 1975; Giambastiani 2007; Hildebrandt and Ruby 2005; Rode 1988]) or the use (by both sexes) of a canoe paddle (Claassen 1997, 71). It may also reflect arm elevation in scraping or grinding activites where the body is in a prone postion. These activities are traditionally associated with women and would be consistent with the results from the small Schroeder Mounds sample. The right-side bias may reflect handedness (but see Ubelaker and Zarenko 2012) or lateralized behavior obscured by other elevated arm tasks that employ both arms. The female pattern is of interest, as independent assessment of degenerative vertebral disk disease in the Schroeder Mounds sample suggests burden-bearing behavior (Andrews 2012; Boncal and Smith 2013; Caldwell and Smith 2013). A case of Porter's Neck and a seven percent frequency of *os acromiale* (i.e., a failure of epiphyseal fusion of the acromial process) were observed. As the name implies, Porter's Neck is the fracturing of the upper cervical vertebrae associated with axial load bearing (Joosab et al. 1994; Kennedy 1989; Levy 1968). In sum, os acromiale is frequently associated with rotator cuff pathology (e.g., Biglioni et al 1991; Boehm et al. 2005; Mudge et al. 1984). Recent meta-analyses of the same site samples on vertebral disk disease (Boncal 2014) and reactive changes at the rotator cuff, including the teres minor insertion (Neidich 2013, 2014), support this interpretation.

Conclusion

Over fifty percent of both the left and right humeri of the Schroeder Mounds adult sample exhibited reactive change at the insertion of the teres minor muscle. The percent and levels of reactive change suggest activities that are bilateral, engaged in by both males and females, and partly related to body size/robusticity. Injuries to the rotator cuff in clinical contexts are primarily age-related or consequential to activities where the arm is elevated. In these clinical contexts, injuries at the teres minor insertion are infrequent. It is very likely that reactive change at the site of the teres minor insertion in the Schroeder Mounds adults is a collateral of multiple types of overuse activity that have no corollary in Western society. More comprehensive analysis of the entheses on the greater tubercle is underway. Auxiliary assessment of osteoarthritis of the humeral head and glenoid fossa is certainly needed. Of course, ultimately, more subsistence-settlement controlled studies are needed to determine the ubiquity and pattern of entheseal change at the teres minor insertion and the insertions of the other rotator cuff muscles.

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Neidich and Ostendorf Smith: Major Questions about Teres Minor

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