University of Alberta

# The Interpretation of Musculoskeletal Stress Marker Data from Four Different Alaskan Eskimo Populations

by

Susan L. Steen ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled The Interpretation of Musculoskeletal Stress Marker Data from Four Different Alaskan Eskimo Populations submitted by Susan L. Steen in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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This thesis is dedicated in loving memory of my Aunt

Margaret Olea Steen
November 1, 1931 to January 2, 2003

Abstract

This research is based on the analysis of the human skeleton to assess habitual or occupational activities related to subsistence strategies and focuses geographically on circumpolar populations and topically on musculoskeletal stress markers (MSMs) as indicators of physical activity. MSMs are bony changes on the human skeleton produced at muscle and ligament attachment sites by very forceful and repetitive muscular activity. Through the evaluation of MSMs in the context of specific movements of the body, it is possible to infer habitual activity patterns.

MSM data are reported on 63 bilateral muscle and ligament attachment sites. Data were collected from four different Eskimo skeletal collections–Ipiutak (N=71, 33 males and 38 females), Tigara (N=252, 118 males and 134 females), Golovin Bay (N=102, 45 males and 57 females) and Nunivak Island (N=176, 81 males and 95 females).

The samples used in this study allow for a direct comparison between Inupiaq (Ipiutak and Tigara) and Central Yup'ik Eskimo (Nunivak Island and Golovin Bay) populations, which differed not only in cultural affiliation and language, but also in environment and ecology and, hence, in subsistence strategies. There is a large temporal difference between the Inupiaq and the two Central Yup'ik populations. Ipiutak (ca. 2300-600 BP) and Tigara (ca. 400-300 BP) have been collectively labeled "Point Hope" since they are both from the Point Hope archaeological site along

the northwest coast of Alaska. Golovin Bay (ca. 300-80 BP) is located on the southeast edge of the Seward Peninsula off of Norton Sound. The Nunivak Island population is roughly contemporaneous with Golovin Bay, and is located in Bering Sea region between the Yukon-Kuskokwim Delta. Information that can be gleaned through osteological research may shed new light on our understanding of aboriginal subsistence and habitual activities as related to sex and cultural affiliation, and the ever encroaching effects of foreigners, especially Russians, Europeans, and other non-Native Americans.

The differences between these four groups may be the result of different subsistence activities coupled with increasing trade activities throughout Alaska with various local and foreign trading partners.

## Acknowledgments

Research on the Golovin Bay and Nunivak Island collections was done under a joint agreement with the Repatriation Office, National Museum of Natural History, Smithsonian Institution, and the Golovin Bay and Nunivak Island Native communities as part of the repatriation process that has now been completed with the return of the remains.

Research on the Point Hope collection was funded in part by grants from the Canadian Circumpolar Institute (C/BAR 52-03235), the University of Alberta's Department of Anthropology, and the American Museum of Natural History.

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# CHAPTER ONE

The daily life of Eskimos[1] is of great interest to researchers who endeavor to explore early human adaptations through subsistence strategies, kinship patterns, aboriginal health and healing practices, and the like. This ongoing interest is especially true for those focused on understanding aspects directly related to hunter-gatherer economies. Contemporary ethnoarchaeological studies (Binford 1978), paleo-pathological accounts (Merbs 1983), material culture reports (Murdoch 1988), and ethnographies (Lantis 1946; Nelson 1983) are useful in addressing subsistence strategies, health and healing practices, and habitual activities. Habitual activity studies based on musculoskeletal stress marker (MSM) data are useful for independently evaluating ethnographic and archaeological records of human populations.

This research specifically addresses the interpretation of the bony lesions at muscle and ligament attachment sites on bone, which are referred to in the literature under a variety of names including musculoskeletal stress markers (MSMs) (Hawkey and Merbs 1995; Steen

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[1] The name 'Eskimo' is the preferred term among the Native peoples occupying Alaska and eastern Siberia, and is not deemed pejorative. The closely related Native peoples of Canada and Greenland prefer the name 'Inuit.' (see McGhee 1996.) Dorothy Jean Ray reported (1992) that it was not until 1831 that the term 'Eskimo' came into common use with the writings of Frederick W. Beechey.

and Lane 1998), enthesopathies (Dutour 1986), markers of occupational stress (Kennedy 1989), and activity-induced stress markers (Hawkey and Street 1992).

During the summers of 1995 and 1996 I was fortunate to have had the opportunity to study the Golovin Bay and Nunivak Island skeletal material respectively. Research on the Golovin Bay and Nunivak Island collections was done under a joint agreement with the Repatriation Office, National Museum of Natural History, Smithsonian Institution, and the Golovin Bay and Nunivak Island Native communities as part of the repatriation process that has now been completed with the return of the remains. The Smithsonian Institution handled all necessary ethics and consent requirements. Research on the Point Hope collection was completed in 1998 at the American Museum of Natural History.

My study endeavors to answer a variety of questions such as are there similarities and differences in the musculoskeletal stress markers between males and females? What might account for these similarities and differences? Were the musculoskeletal stress markers from these four different Eskimo skeletal collections (Golovin Bay, Nunivak Island, Ipiutak, and Tigara) similar or different? What might account for these findings? Do musculoskeletal stress markers support or refute current cultural stereotypes about Alaskan Eskimos?

The visual reference system I employ was adapted from Hawkey's (1988) original work. It has been expanded to include more musculoskeletal attachment sites on the upper and lower extremities, and craniofacial sites, especially those associated with the muscles of mastication. The visual reference system is an important research method because it accommodates the desires of individuals or group who manage or are otherwise responsible for various skeletal collections who prohibit invasive analytical techniques (*e.g.,* bone sampling). The skeletal materials from Golovin Bay, Nunivak Island and Point Hope, Alaska are such collections.

Tigara, Golovin Bay and Nunivak Island, were roughly contemporaneous with each other. Golovin Bay and Nunivak Island, appear to have been more heavily involved in trade relationships between Russians, Europeans, Eskimos, and interior Athapaskan. Ipiutak culture disappeared prior to the onset of Russian and European trade. Ipiutak and Tigara were from the same geographical region which was different from that of either Nunivak Island or Golovin Bay. The Ipiutak and Tigara people lived north of the Arctic Circle, while both Golovin Bay and Nunivak Island are south of the Arctic Circle. Ipiutak, Tigara and Golovin Bay were located on the mainland, while the people from Nunivak were island dwellers. All four groups had different subsistence strategies ranging from heavy reliance on sea and land mammals (Ipiutak) to the readily incorporation of fish into a subsistence strategy which included seals, walrus, belugas, and birds (Nunivak Island), to an economy based on sea and land mammals, fish, birds and other smaller land mammals (Tigara) and to a highly mixed economy (Golovin Bay). The people of Golovin Bay may have been more influenced by foreign intruders who set up mining operations in their area that employed local people in a cash-based economy. All four groups traveled on a somewhat seasonal basis, but Golovin Bay and Ipiutak people most likely traveled more frequently and over longer distances than either the people of Nunivak Island or the Tigara people of Point Hope. Although all four groups exhibit both similarities and differences in social organization, all groups adhered to, to varying degrees, the sexual division of labor.

Results indicate that the musculoskeletal stress marker (MSM) data comparing Ipiutak and Tigara males shows more of differences than that expressed between the females. There also appears to be greater similarity between the males and females of Ipiutak than between the males and females of Tigara. These differences may be due to activities associated with subsistence strategies and an increasing reliance on trade. Overall, the majority of mean MSM scores of Golovin Bay were higher, though not always statistically significant, than were the scores for males from Nunivak Island, Tigara, and Ipiutak. The mean MSM scores for the Ipiutak males were, overall, the lowest of all four groups. These same patterns hold true for the females–mean MSM scores were highest, overall, for a majority of muscle and ligament attachment sites among Golovin Bay females, followed by those from Nunivak Island, Tigara, and Ipiutak. The differences between these four groups may be the result of different subsistence strategies and the result of increasing trade activities throughout Alaska with various local and foreign trading partners.

The following chapters describe my research and the results. Chapter Two is a literature review discussing the historical and biological significance of habitual activity markers. In Chapter Three, I compare and contrast findings from the Golovin Bay and Nunivak Island collections. Data from the Point Hope collection appear in Chapter Four. Finally, concluding comments are presented in Chapter Five.

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# CHAPTER TWO

Hippocrates' (ca. 470-410 B.C.) writings, known as the *Hippocratic Collection*, includes discussions of anatomy and physiology and demonstrate an extraordinary knowledge of the musculoskeletal system (Serafini1993). His study and subsequent writings on the skeletal system should come as no surprise since bone tissue survives much better than soft tissues. Using the *Hippocratic Collections*, early physicians were able to map out, quite reliably, the bones of the entire human skeleton. Hippocrates' work provided these same physicians with information on musculature, especially the larger muscle groups and those closer to the surface (Serafini1993). However, techniques that allowed for the nearly perfect preservation of the human body had not yet been perfected, and thus rapid decay, as well as the stench, presented unique problems to those working on cadavers (Serafini1993). Nevertheless, astute observers such as Hippocrates could readily distinguish both the structure and the function of the larger muscle groups of the body, especially in the case of thin, lean cadavers, since layers of decaying fat would be less likely to impede their progress.

The Renaissance witnessed a flurry of activity from scholars of all types interested in the relationship between muscles, bones, and activity, as evidenced by the work of Leonardo da Vinci (1452-1519) and Andreas

Vesalius (1514-1564). Da Vinci's contributions to the realm of the musculoskeletal system are shown in his masterful work in the sciences, especially biology. His work at Santa Maria Nuova Hospital in Florence provided him with the opportunity to develop meticulously detailed drawings that "helped others make a headway in understanding the muscular and skeletal systems, and, most significantly for biology, the relationships between them" (Serafini 1993:60).

Vesalius, from Brussels, was noted as one of the Renaissance's most distinguished biologists, producing an extraordinary and revolutionary, for the time, work of seven medical volumes entitled *De Humani Corporis Fabrica* (*The Constitution of the Human Body*) in 1543 (Serafini 1993). These volumes provided much information to physicians and other biologists, including descriptions of the entire gamut of the physical body beginning with a thorough description of the skeletal and muscular systems—he was known to be very meticulous at dissections, nearly to the point of being a bit macabre. As common as it is today to find a complete skeleton hanging in university labs and doctors' offices, such was not the case during the time of Vesalius. He collected random skeletal parts from freshly executed criminals that others had "curated" and eventually had a complete, albeit a composite, skeleton for his personal comparative collection. Although his contribution to human biology was enormous, Vesalius was not esteemed by all since his teachings went against the grain of those of Aristotle (ca. 384-322 B.C.), and Galen (ca. 131-210). His most dramatic departure from standards was his "desecration" of the human body; grave-robbing and performing vivisections (*i.e.,* dissections of living persons), of which he was accused, were seen as sacrilegious by the clergy, the laity and even other physicians—his colleagues. One must keep in mind that most of these men were investigating and researching "mysteries" of the gods in a realm of "ignorance and superstition" (Serafini 1993:78). As a result of going against the establishment of the day, one most often met with professional suicide, and sad to say such was Vesalius's case.

The *Tabulae Sceleti et Musculoreum Corporis Humani* (*Plates of the Skeleton and Muscles of the Human Body*) by Bernhard Albinus (1697-1770), a German-born anatomist, was an important contribution to biologists and anatomists concerned with the musculoskeletal system, and remains so today. Albinus's realistic portraits of skeletal elements and the many layers of musculature were the results of his accomplished artistic abilities coupled with his masterful surgical and dissection skills, and of course his "models" also contributed greatly to his work. Albinus may have been the first to use both a corpse and a comparative live model at the same time to increase the accuracy of musculoskeletal representation for use by both physicians and artists (Hale and Coyle 1979). For example, one of Albinus's fresh cadavers was a man of about

25 years old at his death, of average stature and build, yet very well proportioned, who showed signs of agility—"with all the tendons, ligaments, and cartilages attached . . . and I preserved these from decay by soaking them in vinegar" (Albinus as quoted in Hale and Coyle 1979:16). Subsequent deceased volunteers were preserved with vinegar, by freezing, or through a combination of both. For the comparison between live and deceased models to be accurate, Albinus's live models were very similar in physique to the deceased. Apparently one of Albinus's bigger problems was keeping the various corpses from thawing out while at the same time keeping his nude, living model warm—something he was compelled to do. It would be nearly another century before physicians would examine live patients, listen to their discription of muscle ailments, and hypothesize on cause and effect.

Sir William Arbuthnot Lane (1856-1938) concerned himself with the laments of his patients concerning their achy, sore, and painful muscles complaints that seemed to confound physicians and health care providers for some time. Lane, a Scot, was known to be a highly controversial surgeon and at one point had his own name removed from the prestigious Medical Register so that he could continue, without retribution from the General Medical Council, to promote the New Health Society, an organization he founded that publicized his views on healthy living and healthful eating. Among his other controversial stances, he routinely performed complete colectomies as a remedy for acute alcoholism, or as he termed it, "auto-intoxication" (Layton 1956). In the nineteenth century, Lane, after many years of examining patients and consulting with colleagues, wrote about muscle and ligament attachment sites in regard to their related habitual use. He examined various muscle and ligament attachment sites as well as other bony changes, and he suggested that certain individuals whom he had examined carried heavy loads with either flexed or extended arms, or carried heavy loads either on their heads or with the use of tumplines (Lane 1885, 1887, 1888). He is also well-known for his revolutionary work on improving the alignment of fractures by using steel screws, as well as both plates and screws (Lane 1914).

Without the scientific inquiry of the colorful individuals from the time of the early Egyptians to radical thinking physicians, surgeons, and artists, the field of physical anthropology and certainly osteology would not be where it is today. All of these early contributions have provided osteologists with a secure foundation in skeletal and musculature anatomy and a strong foundation needed for modern inquires dealing with the musculoskeletal system. In recent decades, many scholars, including clinicians, physicians, and physical anthropologists, have taken a closer and a more scientific and medical look at the musculoskeletal system, its function, actions, abilities, disabilities, and diseases.

*Terminology: Enthesopathy versus Musculoskeletal Stress Markers*

The term "enthesopathy" most likely came into popular use during the mid-1960s when Niepel, Kostka, Kopecky and Manca were perhaps among the first to use it (referenced by Ball 1971). "Enthesopathy" is a term used by clinicians and soft-tissue researchers meaning "the attachment of ligaments, tendons, joint capsules and muscles to bone" (Fourie 1991:723). Another definition of "enthesopathy" refers to a "disorder of the muscular or tendonous attachment to bone," that is, "a morbid condition, or disease" (-pathy) at "the site of attachment of a muscle or ligament to bone" (enthesis; Anderson 1994: 561 and 1245 respectively). Thus, an enthesopathic condition may not necessarily be related to regular use but to a diseased condition. In this way, it therefore may not be completely appropriate to use it to describe normal activities that result in bone remodeling at muscle and ligament attachment sites. With all this said, even clinicians do not always agree on the most appropriate term to use. For example, Lemasters and co-workers state that the "term 'work related musculoskeletal disorders' is preferred," while at the same time this same term is "used in reference to conditions also called cumulative trauma disorder, repetitive strain injury, or overuse syndromes" (Lemasters *et al.* 1998:421). Needless to say, the numerous terms used as synonyms for enthesopathy can be a bit confusing. Nevertheless, all of these related terms have one thing in common: a modification at attachment sites of tendons, ligaments, or articular capsules into bone, "is most accurately termed *enthesopathy*" by clinicians and soft-tissue researchers (Resnick and Niwayama 1983:1, emphasis theirs).

Anthropologists, on the other hand, have used other terms to discuss the same phenomenon, such as markers of occupational stress, activity-induced stress markers, and habitual activity markers, as well as those used by clinicians—overuse syndrome, repetitive use syndrome, *etc.* There are several reasons why these terms may not be appropriate for physical anthropologists but useful for other researchers. First, markers of occupational stress and activity-induced stress markers are inappropriate terms for physical anthropologists because the scope of inquiry implied by such designations encompasses too broad a range (*e.g.*, degenerative joint disease, trauma, accessory facets, and muscle and ligament stress) in the interpretation of habitual activities. Furthermore, interpretation of "occupation" may involve cultural bias, depending on the latitude one affords the definition, although this may not be the case with clinicians who know first hand the circumstances surrounding their subjects. The term "enthesopathy" itself may also not be as applicable to work in physical anthropology because it does have a connotation of being able to observe the actual tendon, ligament or muscle—something most physical anthropologists, and certainly osteologists, do not have an opportunity to do on a regular basis.

On the other hand, musculoskeletal stress marker refers specifically to bony changes produced during normal, habitual use at the muscle and ligament attachment sites (Hawkey 1988). "Normal" implies any amount of daily activity over an individual's life, whether resulting from an occupation or other types of habitual activities. The type of bony response may include increased robusticity, rugosity, stress lesions, and *myositis ossificans* (Hawkey and Merbs 1995; Mann 1993). Thus, the term "musculoskeletal stress marker" more narrowly defines the type of marker under study and should not be confused with markers of degenerative joint disease, trauma, accessory facets, *etc.*, or terms used by clinicians and others in the medical profession.

In this paper, the term "musculoskeletal stress marker" will be used when referring to anthropological studies, and the term "enthesopathy" when discussing clinical studies. However, when the works of other authors are addressed (*e.g.,* Dutour 1986; Kennedy 1983) the terminology will remain consistent with those in their publications (*e.g.,* enthesopathy and occupational stress, respectively).

*Identifying Enthesopathies*

It is well-known that musculoskeletal stress marker sites "are structurally well suited for the transmission of tensile forces" (Resnick and Niwayama 1983); however, even after several millennium of evolutionary effects, these same sites are also subject to alteration from both hypertrophy and atrophy. Ball provides us with a detailed working definition of one type of enthesopathy, specifically related to ligamentous attachment sites:

> A ligamentous attachment to bone—an enthesis—presents a characteristic structural sequence. Just before reaching the bone the fibre bundles of the ligament become more compact, then cartilaginous and then calcified before being joined to the bone by a cement line. An abnormality in this area may be called an enthesopathy. (Ball 1971:214)

Ball's definition helps to pinpoint the enthesis site or the site of the musculoskeletal stress marker.

Resnick and Niwayama (1983) noted that there appears to be a pattern of development of enthesopathic lesions indicated by well-defined margins with either smooth or irregular developing enthesophytes. After studying and examining both amateur and professional baseball pitchers, Tullos and King (1972) concluded that hypertrophic bony development is evident from this type of repetitive use. In addition, van Linthoudt and colleagues examined an excised block from a radial tuberosity and reported that it "showed thickened cortical bone with small, rounded, well-defined lesions" (1991:72). They further noted that:

> Microscopic examination disclosed enlarged and thickened bone trabeculae beneath the tendon insertion. Lamellar bone structure was nevertheless normal. Muscle and tendon fibers were also normal. The bone marrow was fibrous and highly vascularized. There were no inflammatory or tumoral cells. (van Linthoudt *et al.* 1991:72)

It is clear that clinicians, physicians, athletic team doctors, and the like, have a somewhat easier time in assessing enthesopathies than physical anthropologists have in diagnosing musculoskeletal stress markers. Their advantage is the presence of soft tissue. However, these researchers have made important contributions to understanding changes in bone that can be observed by osteologists such as well defined margins, both smooth and roughened or rugose enthesis sites, hypertrophic bone, and thickened cortical bony development without changes in the lamellar bone structure.

*Relationship Between Age and Enthesopathies*

Jurmain (1999) constructively criticized the use of enthesopathies based on the relationship between musculoskeletal stress markers and age, and the lack of clinical data that considers age as a factor. Jurmain further reported that in the few clinical studies considering the age-factor, results suggest there is a relationship between age and incidence of enthesopathies. Lemasters *et al.* studied 522 carpenters and noted that older individuals ("the group with the longest (≥20 years) duration of employment in carpentry") were "significantly associated with work-related musculoskeletal disorders of the shoulders" (1998:421). Vuori noted that older individuals may display either more frequent enthesopathies or an increase in rugosity because "in older people, muscle power, strength, and functional ability in daily activities are closely related" (1995:276). In modern, clinical populations a decline in the frequency of enthesopathies, a decrease in area of effect, or both is expected, because this decline is due primarily to increased "sedentariness rather than to the aging process itself" (Vuori 1995:282). Anthropologists investigating skeletal series for clues about past peoples, especially those from hunter-gatherer, forager-collector, and early agricultural societies, recognize that most individuals, even those of advancing age, did not routinely become inactive. Thus, the relationship between age and enthesopathies as discussed by Jurmain (1999) may not be a contributing factor in assessing musculoskeletal stress markers, especially among earlier societies such hunter-gatherer, forager-collector, and early agricultural societies.

*Causes of Enthesopathic Disorder*

Physical anthropologists have operated on the hypothesis that musculoskeletal stress markers are the result of repetitive, habitual activities, that is, particular activities done on a routine basis throughout life. This hypothesis is based on clinical findings. Enthesopathy disorders have been reported as the leading cause of between one-third and one-half of sick leave among members of the work force, and as a result, clinicians are on the fast-track with research on ethesopathies (Viikari-Juntura and Riihimäki 1999). For example, Rasing and van Kampen noted a case of entheseal development as "the result of repetitive mechanical trauma during manual labor, due to full pro-and supination movements during screw-driving" (2000:602). Bongers *et al.* reported evidence supporting a relationship between enthesopathy and the demands of one's livelihood (1993). Lemasters and colleagues in their study of "work related musculoskeletal disorders in active union carpenters," noted that in addition to repetitive activities, construction laborers work in all types of environmental conditions, which may contribute to entheseal development (1998:421).

More than forty years ago, Miller (1960) reported on javelin thrower's elbow caused by repeated stress to the flexor muscles of the forearm which may lead to medial epicondylitis[1] or in extreme cases a cartilage or bone may become separated from the radial head. While undertaking research for the article, he discovered that javelin thrower's

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[1]Medial epicondylitis is an inflamation of the *ulnar collateral ligament*, the *pronator teres muscle*, and the many flexor muscles in the forearm all of which attach to the medial epicondyle.

elbow, or similar ailments, was not as uncommon as once thought. This condition appears normal during clinical examination although patients complain of soreness, stiffness, generalized pain during extension and flexion of the elbow, and rotation of the forearm. However, radiographs show irregularities of the bone of the olecranon at the insertion of the *triceps brachii* muscles. These abnormalities of the olecranon include spur formation, calcification, and "irregularities of the tip of the olecranon" (Miller 1960:790). Miller noted that this specific enthesopathy was common in javelin throwers and professional baseball pitchers, and is the result of overuse, poor technique, or a combination of both. It is noteworthy that Miller found several earlier sources published by German and Scandinavian researchers that were consistent with his findings (see Heiss 1934 and Waris 1946 as cited in Miller 1960:789).

Thirteen athletes (including both affected and control individuals) were studied by Merkel, Hess and Kunz (1982) for the occurrence of the enthesopathy of insertion tendopathy which is defined as morphological changes at the insertion site of tendons and is caused by overuse. Excised tissue (*i.e.,* removed from the individual) from those athletes with chronically-strained tendons showed various levels of pathological changes from focal necrosis and hemorrhage to considerable tissue repair, whereas the control group did not exhibit these changes. The cause of both the physical discomfort associated with the enthesopathy insertion tendopathy and the pathological changes was attributed to chronic stress through overuse by the athletes (Merkel, Hess and Kunz 1982).

Matin discusses enthesopathies in relation to sports injuries, stating that "there are specific x-ray findings [for enthesopathies], which include bone erosion, hyperostosis, fragmentation, and crystal deposition" (1988:98). He notes that patients who complained of knee pain showed abnormalities at the attachment site of the collateral ligaments, especially on the medial side. The enthesopathic process, Matin deduces, is similar to those that produce tibial stress syndrome, although confined to the knee. That is, through repetition or overuse, especially by athletes, the "increased forces from muscles or connective tissues . . . cause local changes which result in increased bone metabolism" (Matin 1988:97). Matin further notes that excised bone tissue showed "increased osteoblastic activity, vascular ingrowth, and even osteoid production" (1988:97).

Two types of factors affecting the development and continuation of enthesopathies—intrinsic and extrinsic factors—were identified by Hess and colleagues, who noted that both factors play a role in the etiology of overuse injuries which can result in the promotion of enthesopathic development (Hess *et al.* 1989). The most common intrinsic factor is one of malalignment, usually of the foot and ankle, the leg and hip, and the shoulder and arm. When skeletal elements are malaligned, the muscles must compensate for various required movements (*e.g.*, walking or running, or pitching or throwing). Enthesopathies of the Achilles tendon are among the most common enthesopathic developments among athletes who have feet with an increased height of the longitudinal arch. Differences in limb length are another important intrinsic factor, especially differences in the length of the legs, which may result in the enthesopathy known as iliotibial band syndrome. A third intrinsic factor is a muscular imbalance which is a lack of flexibility among the most active muscles without requisite strengthening of the antagonistic muscle groups. Weekend athletes most commonly suffer from the enthesopathies related to tennis elbow[2] and patellar tendinitis[3].

The most common extrinsic factors reported by Hess and his colleagues (1989) are inadequate training, improper technique, or a combination of both, thus corroborating Miller's 1960 findings. This information is very important for the clinician in the proper diagnosis and treatment of overuse enthesopathies and for the osteologist studying enthesopathies on skeletal material. Unfortunately, many skeletal

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[2]Tennis elbow is a condition which is localized to the lateral aspect of the elbow, caused by inflammation or irritation of the *radial collateral ligament*, and the tendon common to the origin of the *supinator* and some of the *extensor muscles* which attach to the lateral epicondyle.

[3]Patellar tendinitis is caused by inflammation of the *tendon of the quadriceps femoris*.

collections contain few if any complete individuals, and thus assessment of intrinsic factors may not be possible. Likewise, evaluation of extrinsic factors may not be possible for skeletal collections.

Ogata and Uhthoff examined 76 shoulders, specifically the coracoacromial arch, from cadavers (16 males, 22 females; age range 34-87, $\bar{x} = 69.3$) at a Canadian facility. From their extensive study, they noted that upon an autopsy "a bony projection that corresponded to a spur on the roentgenograms was found at the anteroinferior corner of the acromion" (1990:42). They went on to describe a classification scheme for the enthesopathic degenerative changes of the acromion in which there are four grades of severity. This clinical scoring scheme is similar to the osteological visual scoring method for musculoskeletal stress markers first developed and used by Hawkey (1988, also see Hawkey and Merbs 1995). Although the boney spur projections were not noted through a normal external exam (*i.e.,* palpation), they were observed on roentgenograms and later in autopsies. This study and the subsequent grading system have helped doctors in sports medicine to better evaluate their patients. Likewise, the information provided by Ogata and Uhthoff has aided osteologists in understanding the changes at the insertion sites of tendons and ligaments.

A study by Horn *et al.* (1991) of enthesopathies paid special attention to the clinical and morphological relationships with regard to mechanical stress and overloading. Upon examination of tissues excised from patients, the authors concluded that the "morphologically typical signs of such enthesopathies . . . are coarsening of the Sharpey fibres (*i.e.,* the anchorages of tendon structures inside and on the surface of bone)" (Horn *et al.* 1991:188). They also noted that the fibro-osseous borders were irregular and included vascularization of the entire insertion site (Horn *et al.* 1991). Although the authors did not note the occupations of the patients in this study or the possibility of any repetitive activity, they did acknowledge that each of the patients experienced pain, soreness, and stiffness of muscles in the affected regions—a common clinical diagnosis of enthesopathies.

"Tennis elbow" of the groin was reported by Ashby (1994) as chronic obscure groin pain, specifically inflammation of the *inguinal ligament* at the anterior superior iliac spine, the *rectus femoris mucles* at the anterior inferior iliac spine, and the *adductor longus muscle* at the anterior body of the pubis. Although Ashby's year-long study of 49 patients with chronic pain (two or more weeks of pain) focused on pain management, his discussion of enthesopathy is very useful. For the most part, clinical diagnoses of enthesopathy can easily be done through palpation which produces pain in the afflicted region, similar to the clinical method of diagnosis used by Horn *et al.* (1991), as noted above. The pain may be accompanied by swelling, continual soreness, and stiffness of the muscles. Ashby also notes that "acute overloading can produce macroscopic lesions" that can be viewed on excised tissue and on medical cadavers (1994:1634).

These clinical studies have aided osteologists in understanding skeletal markings on bone tissue, especially at the attachment sites of various tendons and ligaments. Using data collected from skeletal material to advance our knowledge of the activities of past people has been practiced for a long time (Merbs 1983, also see İşcan and Kennedy 1989). One of these techniques is to look closely at musculoskeletal stress markers as a means to more fully understand the daily lives of Native Alaskans (Hawkey and Street 1992, Steen and Lane 1998, Street and Hawkey 1992), as well as other populations including Hudson Bay Thule (Hawkey and Merbs 1995), Pecos Pueblo (Munson Chapman 1997), Medieval Spaniards (Galera and Garralda 1993), Gran Quivira Pueblo (Hawkey 1998), and Khoisan foragers (Churchill and Morris 1998). The use of musculoskeletal data is well grounded in clinical studies—especially those involved with athletes and occupational laborers, as discussed above—and is an applicable osteological method useful in helping to infer past activities.

Even with this clinical support for the relationship between musculoskeletal stress markers and repetitive activities, Jurmain objected to the use of enthesopathy studies that focus on athletes:

> Possibly, enthesopathies (or entheseal-like lesions) develop more so in athletes because the stress is either more repetitive and/or more extreme; this explanation, however, seems improbable. What is more likely is that the lesions *might* develop more so in athletic activities, because often they begin at an early age. (Jurmain 1999:161, emphasis his)

It seems quite clear from the clinical reports that repetition of specific activities does cause entheseal development be it among athletes or laborers. Jurmain's assumption that enthesopathies are more common in athletes because they start training and competing at an early age should come as no surprise and has been confirmed by Vuori (1995). This finding alone adds credence to the use of musculoskeletal stress markers in osteological research as individuals in nearly all prehistoric societies began to engage in repetitive, habitual daily activities in their pre-puberty years.

*Physical Anthropological Studies*

Prior to looking solely at the musculoskeletal system as a means for providing information on habitual activity of past people, physical anthropologists looked at a variety of pathological conditions, among the most common being arthritis although trauma and accessory facets have also been connected to habitual activities. For example, several scholars, including Merbs (1983) and Jurmain (1977), have studied arthritis to ascertain activities that are performed on a regular basis within and between various populations. In his comparison of Alaskan Eskimos, American Blacks and Whites (Terry Collection), and Pueblo Indians (Pecos Collection), Jurmain observed that:

> The most convincing etiological argument relates directly to the kind and amount of environmental stress typical of the varying life styles of the populations sampled. Ethnohistorical information leaves little doubt that the Eskimos were subjected to a great deal of functional stress often quite severe, continuous in nature, and involving most adult members of the community. Apparently, the patterns of behavior characteristic of this life style placed differentially more stress on the upper limb. The pattern of degenerative involvement is *directly associated with these behavioral observations* . . . (1977:363, emphasis added)

With regard to musculoskeletal markers or enthesopathies Dutour notes:

> Furthermore, enthesopathies caused by muscular hyperactivity are generally isolated lesions and may be readily distinguished from those caused by metabolic or inflammatory causes, *e.g.*, rheumatoid arthritis, ankylosing spondylitis, or psoriasic arthritis, where the joint surfaces are involved. Similarly, the calcifications associated with Forestier disease (or DISH) are widespread and involve the vertebrae. I am thus confident that *the enthesopathies described here may be related to prolonged and extensive use of the corresponding muscles.* (1986:224, emphasis added)

Physicians and care providers in occupational and sports medicine have long understood the relationship between habitual activities and the extensive use of muscles, which create conditions such as tennis elbow, golfer's elbow, and pitcher's arm (Clement *et al.* 1984, Dahl *et al.* 1981, Kennedy 1983, Lehman 1984, Mebane 1981). Research in these areas, unfortunately, focuses primarily on factors that may not be manifested in dried bone, such as modifications of muscles, tendons, and ligaments (Kennedy 1989).

An important research problem in a still burgeoning field of study for physical anthropologists specifically interested in human osteology is the classification and interpretation of musculoskeletal markers. Data on these particular types of stress markers contain a wealth of comparative information as they are correlated with various activities that provide insights into habitual behavioral patterns among prehistoric and historic populations worldwide (Dutour 1986; Kennedy 1983).

Much of the physical anthropological research associated with habitual activity patterns focused on pathological conditions, trauma, accessory facets, and assorted anomalies rather than specifically on stress markers at muscle and ligament attachment sites (*e.g.,* Jurmain 1977, Merbs 1983, Ortner and Putschar 1985). Some researchers have pursued a more holistic approach in assessing activity patterns, as stated aptly by Dutour, "analysis of such lesions [enthesopathies] on ancient skeletons may, in concert with other archaeological data, throw light on the activities of ancient people" (1986:224). Additionally, as Kennedy states "in short, anthropological understanding of the causes of markers and their correct identification await further investigations by skeletal biologists" (1989:154).

Kennedy (1983) looked at skeletal remains from terminal Pleistocene archaeological sites in central India, making observations on the attachment sites of several muscles: the *anconeus*, *supinator*, and *triceps brachii* of the upper extremities. The motion of these muscles is specifically involved in various overhand throwing activities, such as launching a spear, atlatl, or javelin, or hurling a rock or a ball. Kennedy's (1983) assessment of these activities coincides with archaeological evidence that suggests that these individuals used spears and atlatls for both warfare and subsistence activities, thus, firmly establishing that the archaeological finds were most likely used in the prescribed manner.

Dutour (1986) focused almost exclusively on enthesopathy data in his study of the activities of two different Neolithic Saharan populations. One group, from Mali (the Hassi el Abiod site), consists of 25 individuals (eight males, five females, and 12 of unknown sex). The second group, from Nigeria (the Chin-Tafidet site), consists of 16 adult individuals (five males, two females and nine of unknown sex). Dutour (1986) made visual observations of enthesopathy at the attachment sites for the *pronator teres, flexor carpi radialis, palmaris longus, flexor digitorum superficialis,* and *flexor carpi ulnaris* (humerus); the *triceps brachii* (scapula and ulna); the *biceps brachii* (scapula and radius); the Achilles' tendon (calcaneus); and the *adductor hallucis* (calcaneus and big toe). Based on his assessment of these attachment sites, he deduced that individuals from

Mali were involved in archery and wood-cutting activities and that those from Nigeria were involved in long-distance running and jogging or walking over hard surfaces. His findings added additional support to the evidence gleaned from archaeological data for specific reconstruction of past lifeways.

Molleson (1989, 1994) also considered a variety of morphological evidence, including musculoskeletal stress markers, in her assessment of a Neolithic skeletal collection from the Abu Hureyra site in Syria (n=162; including 27 adult males and 44 adult females). She examined the remains and observed robust muscle and ligament attachment sites, noting that they were found especially at the locations of the *deltoideus* on the humeri and the *biceps brachii* on the radii. The robusticity at these attachment sites was bilateral or symmetrical in nature, indicating that both arms were used at the same time in the same activity. The *deltoideus*, when acting in cooperation with the *scapular rotators*, abduct or raise the arm above the level of the shoulders, while the *biceps brachii* acts to flex and supinate, or rotate, the forearm and hand. Molleson (1989, 1994) suggested that these motions are consistent with the activity of grinding grain while using a saddle quern (a saddle-shaped stone mill) which is done

> When grain is ground using a saddle quern, a heavy slab of rock weighing perhaps 30 kg is positioned on the ground as close to the knees as possible and titled away. The grinding rubber, a

> cylindrical stone, is taken in both hands and pushed firmly over the grain placed on the quern and the flour collects at the far end of the saddle. (Molleson 1989:359)

One hundred four skeletons from two sites dating to the $10^{th}$ and $11^{th}$ centuries were examined visually, microscopically, and radiographically for evidence of enthesopathies by Józsa, Pap and Fóthi (1991). Their main focus was enthesopathies associated with the musculature of the leg (*i.e.,* femur and tibia) and the arm (*i.e.,* humerus and ulna), although they did consider other skeletal elements (*e.g.,* calcaneous, patella, radius, and fibula). Józsa and colleagues concluded that "20% of the adult skeletons bore overuse lesions" (1991:272). The location of these enthesopathic lesions and the related muscle groups supports their hypothesis that these individuals were engaged in activities that required "long and strenuous exertion on hard ground" (Józsa *et al.* 1991:272). They also found evidence that suggests that some of the individuals in their collection worked as wood cutters, blacksmiths, and archers. They state that there was little difference in observed enthesopathy development between the individuals from the two different archaeological sites and further suggest that those differences that do appear are most likely due to lifestyle variations between the $10^{th}$ and $11^{th}$ centuries.

By utilizing a combination of enthesopathy observations and degenerative and pathological data, Lai and Lovell (1992; also see Lovell and Lai 1994) inferred the specific habitual activities of four males from the Seafort Burial site near Rocky Mountain House, Alberta, Canada. Three of the four males were assessed as Métis (mixed European and Canadian Indian ancestry) based on burial goods.[4] The three Métis males exhibited marked robusticity at various muscle and ligament attachment sites, especially on the clavicles, humeri, ulnae, radii, femora and tibiae. Specific muscle and ligament attachment sites observed to be extremely robust included the following: (1) the *costoclavicular*, *conoid* and *trapezoid* ligaments on the clavicles; (2) the *deltoid, teres major, pectoralis major, latissimus dorsi, triceps brachii, anconeus* and *brachioradialis* on the humeri; (3) the *supinator* and *pronator quadratus* on the ulnae; (4) the *supinator, pronator teres, pronator quadratus* and *brachioradialis* on the radii; (5) the *gluteal* and hamstring groups on the femora; and (6) the *gastrocnemius* and *soleus* on the tibia. The groups of muscles and ligaments of the upper extremities that show marked robusticity at their attachment sites are typically involved in the rapid, repetitive alternating motion of the shoulder girdle, the extension and recoil of the arm at the elbow joint, and the lifting and holding of heavy

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[4]The fourth most likely of Scottish descent based on grave goods and is skeletally a European male. The three Métis individuals were the focus of Lai and Lovell's (1992) article.

objects for long periods. The group of lower extremity muscles that show marked robusticity at their respective attachment sites are involved in the stabilization of the knee and leg while walking or jogging over uneven terrain. The authors' interpretation was that these individuals were engaged in carrying heavy loads, kayaking or canoeing (or both) and portaging between waterways, activities associated with *voyageurs*[5] of the Canadian fur trade (Lai and Lovell 1992). One must keep in mind that not all people during the time of the rapidly expanding Canadian fur trade were *voyageurs*—there were missionaries, land developers, government surveyors, and other individuals. Their finding thus rules out individuals who did not habitually engage in activities typically associated with those of the *voyageurs*.

Musculoskeletal stress marker data have been analyzed in Arctic and sub-Arctic populations. Hawkey and Street (1992; see also Street and Hawkey 1992) examined an Aleut population from the eastern Aleutian Islands (n=16 adults with eight males and eight females). They considered various muscles and ligaments on the clavicle, scapula, humerus, ulna, radius and femur. The muscles and ligaments that exhibited extensive use included the *teres major, pectoralis major, deltoideus, pronator quadratus, teres minor, supinator, biceps brachii,*

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[5] *Voyageurs* is a term used to refer to canoeists in the St. Lawrence and Great Lakes fur trade industry ca. 1650-1700 (see Lai and Lovell 1992:226).

*brachialis, anconeus, latissimus dorsi* and the *costoclavicular* ligament. The motions of these muscles are consistent with those used in kayaking while in the sitting position with the legs extended and in climbing steep, high cliffs. In turn, these activities accord well with ethnohistoric data on the Aleut (Laughlin 1980). This finding was significant because kayakers in other areas (*e.g.*, Thule Eskimos and historic Koniag Eskimos) paddle while on bended knees with their feet extended and toes curled and not sitting directly on their buttocks with their legs fully or partially extended in front of them (Hawkey and Merbs 1995; Hawkey and Street 1992).

Hawkey and Merbs (1995) and Hawkey (1988) studied an ancient Hudson Bay Eskimo skeletal series (n=136). In their respective analyses, they looked at a variety of muscles and ligament attachment sites. Based on the muscles and ligaments utilized extensively and the associated actions, they concluded that these Hudson Bay Eskimos were engaged in a variety of strenuous habitual activities such as kayaking, paddling an *umiak*, throwing harpoons, scraping skins, and sewing. Again, their evidence strongly supported both archaeological findings as well as ethnohistoric accounts of daily activities among the Hudson Bay Eskimos.

Musculoskeletal stress marker data were used by Munson Chapman (1997) to support her hypothesis that the Pecos Pueblo people engaged in increasing maize production and processing as a result of Spanish influences in that region. It is interesting to note that her findings did not support her hypothesis that these same individuals had also increased their weaving activities. Munson Chapman collected musculoskeletal stress marker data from 185 adult skeletons using Hawkey's visual reference system (1997:499).

My own study (see Chapter Three) using an expanded version of Hawkey's visual reference system to include craniofacial muscles and muscles of the lower extremities produced some interesting findings, the most noteworthy of which concerned the muscles of mastication used by Alaskan Eskimo women. Balikci's ethnographic information about women's duties among the Netsilik Eskimo, of the eastern Arctic, tells us that once skins were cured they had to be "thoroughly chewed and softened" before being made into boots (1970:11). It appears that this type of information from Balikci has been oversimplified and generalized to apply to all Eskimo women. In addition to chewing skins to soften them prior to the manufacture of footwear, Haviland in an introductory text notes that one of the duties of Inuit women was "to chew her husband's boots to soften the leather for the next day so that he can resume his quest for game" (2003: 546; also see Haviland, *et al.* 2002). Haviland's statement, however, was not supported by the musculoskeletal data collected from female skeletal remains from Nunivak Island.

In summary, the case studies by a number of researchers have discussed the occupational or subsistence activities of a few individuals

(Dutour 1986; Lai and Lovell 1992; Lovell and Lai 1994) or entire populations (Józsa *et al.* 1991; Merbs 1983; Molleson 1989, 1994) based on a wide range of observations, including musculoskeletal data. In these reports, musculoskeletal stress markers were discussed primarily in qualitative terms (e.g., large, robust, smooth, barely discernible) without quantifying observations. There was no consistency in the muscle attachment sites observed and reported upon, and thus interpopulation comparison was not possible. As Peterson and Hawkey noted, "musculoskeletal stress marker data are frequently presented only in descriptive form. As a result, inductive reasoning is often used to suggest possible activity patterns and may result in the very real risk of creating a "just-so story" (1998:303). Other researchers have discussed musculoskeletal stress markers in quantitative terms, albeit using ordinal data (Hawkey 1988; Hawkey and Merbs 1995; Hawkey and Street 1992; Steen and Lane 1998; Steen *et al.*, 1996a & b; Street and Hawkey 1992). It is imperative that methods for studying musculoskeletal markers, as well as other possible activity-related markers, are standardized and applied consistently to intra- and inter-population studies. This sentiment is shared by Kennedy (1998) and Peterson and Hawkey (1998).

*The Call for Standardization*

At the close of the last century, there was an increasing concern by researchers (Churchill and Morris 1998; Hawkey 1998; Kennedy 1998; Peterson 1998; Peterson and Hawkey 1998; Robb 1998; Steen and Lane 1998; Stirland 1998; Wilczak 1998) to standardize data collection and analysis techniques. The demand for this type of standardization was evident at the Sixty-sixth Annual Meeting (1997) of the American Association of Physical Anthropologists held in St. Louis, Missouri, where Jane Patterson and Diane Hawkey organized and co-chaired a symposium titled "Activity Patterns and Musculoskeletal Stress Markers: An Integrative Approach to Bioarchaeological Questions." Although the need for standardization was clear, it was not clear how this was to be accomplished–through the use of radiographs, videotape-imagining, or a visual reference system.

Stirland (1992, 1998) employed the use of radiographs in her studies, while Wilczak (1998) used a videotape-imaging method that calls for applying white chalk directly to the bones at musculoskeletal attachment sites. While these methods provide adequate and accurate interpretations of activity-related use associated with musculoskeletal stress markers, they are expensive, requiring the most current technologies, and they are time consuming. Moreover, there may be limitations to the use of such techniques; for example, Hawkey (1998, as well as Hawkey and Merbs 1995, and Hawkey and Street 1992), and Steen and Lane (1998) used a visual reference system to meet the stipulations of collection holders to allow analysis. Native communities, such as Golovin Bay, Nunivak Island and Point Hope requested little if any photography (including radiography), no bone samples, no writing or otherwise marking on bones, in some cases no metal instruments or no measurements, and a prompt return of the remains. With these restrictions, it was important to use methods that would accommodate the needs of both the scientific and Native communities, as well as provide a means for accurate data collection. The visual reference system fit these criteria.

*Methodology for the Study of Musculoskeletal Stress Markers*

The use of musculoskeletal stress marker analysis has been attacked (Jurmain 1999) for its use of circular reasoning. That is, if the population under examination is known, preconceived notions as to what will be found may exist. For example, if one is examining Inuit remains, then of course one may discover that the muscles used in kayaking, for example, will be robust. This assumption of presumed circular reasoning is not without merit and is worth further discussion in that all researchers can easily fall prey inadvertently to skipping over the intervening steps between the observation and the assessment of skeletal material.

There are many steps that the osteologist uses in the assessment process. Figure 2.1 illustrates the steps used in analyzing a skeletal collection in order to provide a list of the most probable habitual activities of each group under study. In this diagram, circles represent the "material" under study and squares represent the "procedures" taken at that particular step, which are applied to the preceding material to create a new or refined material and which in turn will be subject to another set of processes or procedures, and so forth.

The first and second procedural steps are applying exclusionary criteria and data collection, respectively. These two procedures, when applied concurrently, allow for all individuals to be scored before determining sex and age, thus reducing any biases in associating certain characteristics with males-females, young-old, or both. In my research age and sex determinations were done with the use of standard criteria following procedures from the *Physical Anthropological Laboratory Manual* established by the Smithsonian Institution (Table 2.1). Data collections were completed using Hawkeys' visual reference system (Hawkey 1988, Hawkey and Merbs 1995), and my own data collection forms (Table 2.2), descriptive criteria (Table 2.3), and detailed diagrams of muscle and ligament attachment sites (Figures 2.2 to 2.11). MSMs were scored on a scale ranging from 0 to 6 with 6 being the most extreme expression. Hawkey and Merbs state that "a continuum often occurs between the robusticity and stress lesion markers" (1995:329). Therefore, they placed both the robusticity and stress lesion scores on a continuum of 0 to 6 for statistical analysis (Hawkey and Merbs 1995). This continuum exists because muscles lose their capacity to absorb stress adequately when their use surpasses their intended potential (Ciullo and Zarins 1983). Enlow (1976) Little (1973), and Weinmann and Sicher (1955) reported that repetitive and continual tension of the muscles causes small muscle fibers to tear and reattach to the periosteum which results in a blood supply disruption to the bone. Leach and Schepsis (1983) further contend that bone necrosis may occur when the disruption of blood supply to the bone is both severe and continual. Microtrauma of the muscle or ligament and underlying periosteum prevents normal healing which leads to the appearance of stress lesions in the bone cortex, especially when muscles or ligaments are used on a repetitive and continual basis. This situation may become exacerbated because bone resorption by osteoclasts occurs more rapidly than does new bone formation by osteoblasts (Tortora 1995, Tortora and Grabowski 1993).

Some researchers may argue that it is not possible to overlook sex and age when collecting data from skeletal remains, but when one is immersed in the collection of musculoskeletal data focusing on attachment sites it is fairly easy to stay concentrated on the task at hand and not to "peek" at mental eminences, mastoid processes, pubic symphyses, greater sciatic notches, and other sexing and ageing morphological characteristics. This approach (*i.e.,* blind test assessment) is used by some forensic anthropologists who prefer not to be told anything about pending cases before they make their assessments as to sex, age, time since death, manner and cause of death.

The third procedural step, statistical data analysis, is straightforward and can provide insights that simple observations cannot provide or that may substantiate or refute overall hunches a researcher has while collecting data. This procedure requires the testing of carefully conceived or formulated hypotheses and a recognition of the limits of the data. Because MSM scores are recorded in an ordinal manner, nonparametric tests are employed in this study. The Wilcoxon Matched-pairs Signed Rank test is used to ascertain whether side dominance existed while the Mann-Whitney U/Wilcoxon Rank Sum W test is used to evaluate differences between and within groups.

It is in the last four procedures (steps four through seven) that reasoning may appear to become circular, in the use of bridging arguments used to go from the most used muscle groups (*e.g.*, *pronator quadratus*) to biomechanical actions (*e.g.*, pronation of the forearm) to a list of all possible activities (*e.g.*, involving turning the hand palm up and palm down, repeatedly). In this particular type of musculoskeletal stress research steps four and five are aided by using muscle charts (Tables 2.4 to 2.7) to assist in identifying a particular action, and thus an activity which may have been used by a particular individual or a group of people. These procedural steps are limited only by our own experiences, knowledge, and scientific imagination, which, according to Platt (1964), should be kept as sharp as possible.

This linear progression stops with step five, in that if there is no evidence supporting a particular hypothesis, then the next question to ask is, how to explain the discrepancies? If there is evidence, in musculoskeletal data, that supports a particular hypothesis, is there also other supporting evidence that can be used to corroborate this finding? Some individuals in a sample may be statistical outliers, because they may have engaged in activities reserved for a few special people such as shamans, berdaches, storytellers, and so forth. Nearly all societies have a large number of work tasks and there are different roles for different people. This must be kept in mind when proceeding through steps six and seven.

The most important procedure, step seven, is that of using a four-field and interdisciplinary collaborative approach, which is often glossed over in discussions of methods employed in anthropological research.

Simply put, bones provide access to other types of information—age and sex information, nutritional data through isotopic analysis, the greater archaeological record, and forensic evidence in crime investigations. It is in step seven that assumed circularity may occur. However, this step is seen as one that eliminates or narrows the list of the most probable activities. If nothing else is known about the skeletal remains, steps six and seven cannot be undertaken. Fortunately, this has not been the case with the studies presented thus far in the anthropological literature.

Jurmain's critique is a caution for physical anthropologists. It is important to report the "elimination" step; for example, Munson Chapman (1997) clearly stated that she did not find evidence supporting the hypothesis for increased weaving activity among the people of Pecos Pueblo, New Mexico during Spanish contact. Steen and Lane (1998) reported that they did not find evidence that suggested that Eskimo women of Nunivak Island routinely chewed hides and skins. While Lai and Lovell (1992) did not explicitly provide those occupations which were eliminated in their study (*e.g.,* missionaries, land developers, shop keepers, government surveyors) the evidence they provide clearly indicates activities more in line with those performed by *voyageurs.*

In conclusion, the use of musculoskeletal stress marker data, whether collected via a visual reference system, radiography, or core or thin sections, is a viable method for use by physical anthropologists.

Figure 2.1: Flow chart for the evaluation of musculoskeletal stress markers using skeletal material

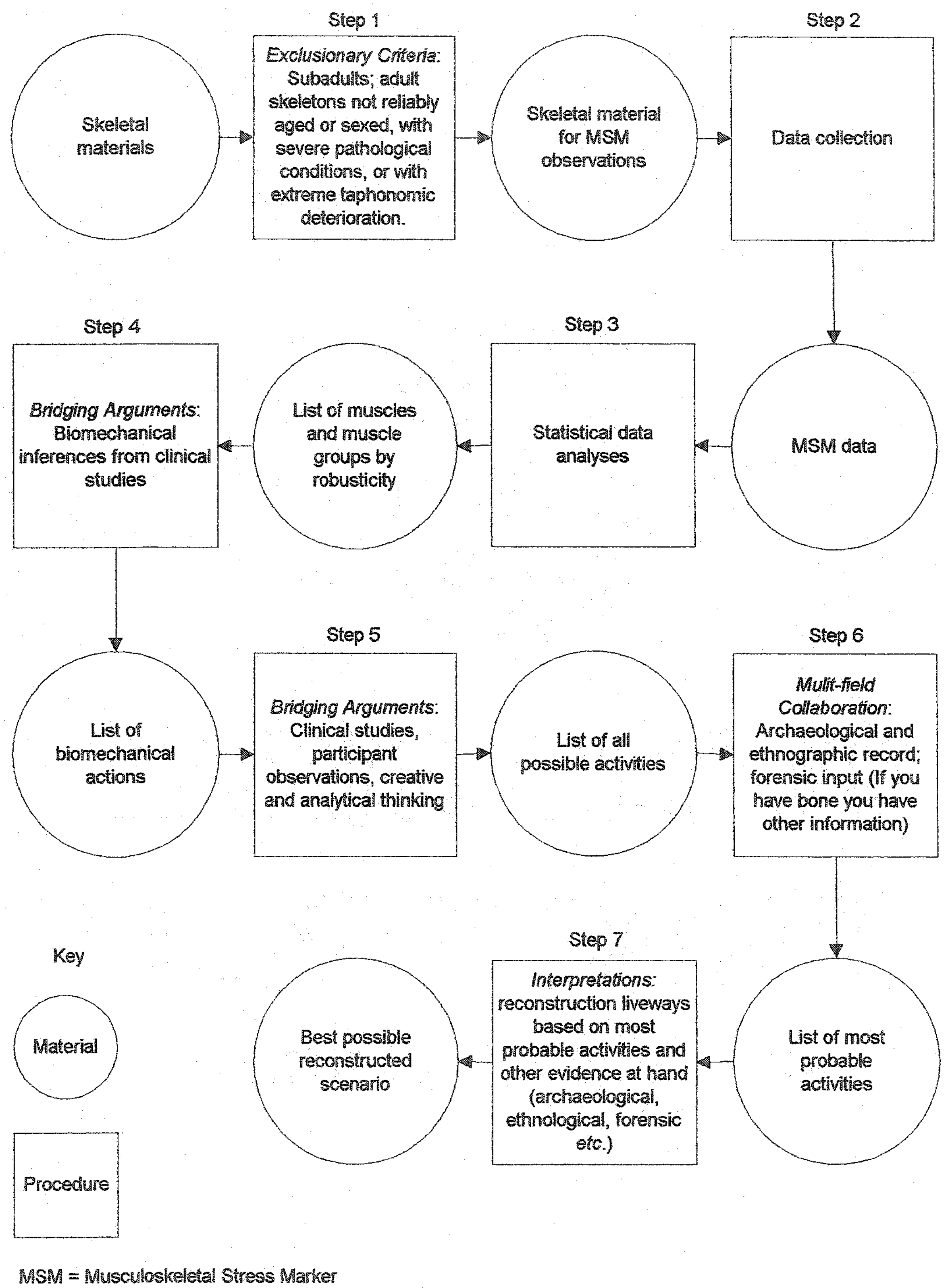


Table 2.1a: Age and Sex Determination Recording Sheet

## AGE AND SEX DETERMINATION

| | |
|---|---|
| CATKEY: | CASE ID/FIELD NUMBER: |
| PROV. 1: | PROV. 2: |
| SEX CODE: | AGE CODE: |
| RECORDER(S): | DATE: |

## SKELETAL AGING

### I. Epiphyseal union

0 = Open; 1 = Partial; 2 = Complete Union

_____ Metopic suture
_____ Mental symphysis
_____ Occipital lateral to basilar
_____ Occipital lateral to squamous
_____ Basilar suture
_____ Cervical halves
_____ Cervical arch to centrum
_____ Cervical superior rim
_____ Cervical inferior rim
_____ Thoracic halves
_____ Thoracic arch to centrum
_____ Thoracic superior rim
_____ Thoracic inferior rim
_____ Lumbar halves
_____ Lumbar arch to centrum
_____ Lumbar superior rim
_____ Lumbar inferior rim
_____ Scapula coracoid process
_____ Scapula glenoid cavity
_____ Scapula acromion
_____ Scapula inferior angle
_____ Scapula medial border
_____ Clavicle sternal end
_____ Proximal humerus
_____ Distal humerus
_____ Humerus epicondyles
_____ Proximal radius
_____ Distal radius
_____ Proximal ulna
_____ Distal ulna
_____ Ilium to pubis
_____ Ischium to pubis
_____ Ischium to ilium
_____ Ischial tuberosity
_____ Iliac crest
_____ Proximal femur
_____ Greater trochanter
_____ Lesser trochanter
_____ Distal femur
_____ Proximal tibia
_____ Distal tibia
_____ Proximal fibula
_____ Distal fibula
_____ SI to S2
_____ S2 to S3
_____ S3 to S4
_____ S4 to S5

Table 2.1b: Age and Sex Determination Recording Sheet

**II. Pubic symphysis and auricular surface**

| Left | Right | |
|---|---|---|
| _____ | _____ | Todd pubic phase |
| _____ | _____ | Suchey-Brooks pubic phase |
| _____ | _____ | Auricular group (Smithsonian Protocol) |
| _____ | _____ | Auricular group (Arkansas Standards) |

**III. Cranial suture closure**

0 = Open; 1 = Partial; 2 = Complete Union

*Ectocranial*

| Left | | Right | |
|---|---|---|---|
| _____ | | _____ | Midlambdoid |
| | _____ | | Lambda |
| | _____ | | Obelion |
| | _____ | | Anterior sagittal |
| | _____ | | Bregma |
| _____ | | _____ | Midcoronal |
| _____ | | _____ | Pterion |
| _____ | | _____ | Sphenofrontal |
| _____ | | _____ | Inferior sphenotemporal |
| _____ | | _____ | Superior sphenotemporal |

*Endocranial*

| | | | |
|---|---|---|---|
| | _____ | | Sagittal |
| _____ | | _____ | Coronal |
| _____ | | _____ | Lambdoidal |

*Palatine*

| | | | |
|---|---|---|---|
| _____ | | _____ | Incisive |
| | _____ | | Anterior medial palatine |
| | _____ | | Posterior medial palatine |
| _____ | | _____ | Transverse palatine |
| _____ | | _____ | Greater palatine foramina |

Table 2.1c: Age and Sex Determination Recording Sheet

## SKELETAL SEXING

**I. Modified Walker System**

1 = Female
3 = Ambiguous
5 = Male

______ Ventral arch ridge
______ Subpubic concavity
______ Ischiopubic ramus or ridge
______ Preauricular sulcus (Score 0-4)
______ Auricular surface elevation
______ Curvature of the sacrum
______ Femur head diameter (F<42.5|47.5>M)
______ Humerus head diameter (F<43.0|47.0>M)

**II. Walker System**

1 = Female
2 = Probable female
3 = Ambiguous
4 = Probable male
5 = Male

______ Greater sciatic notch width
______ Nuchal crest
______ Mastoid process
______ Supraorbital sharpness
______ Supraorbital ridge size
______ Prominence of Glabella
______ Mental eminence size/shape

## AGE AND SEX SUMMARY

Age Codes

1 = Fetal
2 = New born to < 1 yr.
3 = 1 - 4 yrs.
4 = 5 - 9 yrs.
5 = 10 - 14 yrs.
6 = 15 - 19 yrs.
7 = 20 - 34 yrs. (Young adult)
8 = 35 - 49 yrs. (Middle adult)
9 = > 50 yrs. (Old adult)
10 = Subadult, age indeterminate
11 = Adult, age indeterminate
12 = Unknown age

Sex Codes

1 = Male
2 = Female
3 = Indeterminate (subadults)
4 = Probably male
5 = Probably female
6 = Ambiguous sex

Comments:

Table 2.2a: MSM Recording Form

**MSM SCORING SHEETS**

| | |
|---|---|
| CATKEY: | CASE ID/FIELD NUMBER: |
| PROV. 1: | PROV. 2: |
| SEX CODE: | AGE CODE: |
| RECORDER(S): | DATE: |

| **CRANIUM** | **L** | **R** |
|---|---|---|
| Rectus capitis (Inferior nuchal line) | | |
| Sternocleidomastoideus (Lateral ½ of superior nuchal line) | | |
| ***Comments:*** | | |
| | | |
| | | |

| **MANDIBLE** | **L** | **R** |
|---|---|---|
| Pterygoid lateralis (Pterygoid fovea) | | |
| Pterygoid medials (Medial surface of angle and ramus) | | |
| Masseter (Lateral surface of angle and ramus) | | |
| Temporalis (Coronoid process) | | |
| ***Comments:*** | | |
| | | |
| | | |

| **CLAVICLE** ***(Insertion)*** | **L** | **R** |
|---|---|---|
| Subclavius (Subclavian groove) | | |
| Costoclavicular ligament (Costal tuberosity) | | |
| ***Comments:*** | | |
| | | |

Table 2.2b: MSM Recording Form

| **SCAPULA** ***(Insertions)*** | **L** | **R** |
|---|---|---|
| Trapezius (Medial margin of acromion and length of spine) | | |
| Pectoralis minor (Coracoid process) | | |
| ***Comments:*** | | |

| **HUMERUS** ***(Insertions)*** | **L** | **R** |
|---|---|---|
| Infraspinatus (Superior-posterior portion of the greater tubercle) | | |
| Supraspinatus (Superior-anterior portion of the greater tubercle) | | |
| Latissimus dorsi (Floor of bicipital groove) | | |
| Teres major (Intertubercular sulcus) | | |
| Pectoralis major (Lateral lip of intertubercular groove) | | |
| Deltoideus (Deltoid tuberosity) | | |
| Teres minor (Inferior-posterior portion of the greater tubercle) | | |
| ***Comments:*** | | |

| **ULNA** ***(Insertions)*** | **L** | **R** |
|---|---|---|
| Brachialis (Coronoid process) | | |
| Triceps brachii (Posterior portion of the olecranon process) | | |
| Anconeus (Olecranon and superior portion of shaft) | | |
| ***Comments:*** | | |

Table 2.2c: MSM Recording Form

| **RADIUS** ***(Insertions)*** | **L** | **R** |
|---|---|---|
| Biceps brachii (Bicipital/Radial tuberosity) | | |
| Supinator (Posterior-lateral upper ⅓ surface) | | |
| Pronator quadratus (Distal portion of radial shaft) | | |
| Pronator teres (Pronator teres insertion site) | | |
| ***Comments:*** | | |

| **FEMUR** ***(Insertions)*** | **L** | **R** |
|---|---|---|
| Gluteus medius (Greater trochanter) | | |
| Quadratus femoris (Quadrate tubercle) | | |
| Iliacus (Tendon of psoas major at lesser trochanter) | | |
| Pectineus (Pectineal line) | | |
| Gluteus maximus (Gluteal tuberosity) | | |
| Adductor magnus (Linea aspera) | | |
| Piriformis (Superior border of greater trochanter) | | |
| Obturator externus (Trochanteric fossa) | | |
| Gluteus minimus (Greater trochanter) | | |
| ***Comments:*** | | |

| **TIBIA** ***(Insertions)*** | **L** | **R** |
|---|---|---|
| Semimembranosus (Medial condyle) | | |
| Popliteus (Proximal ⅓ of anterior surface) | | |
| ***Comments:*** | | |

Table 2.2d: MSM Recording Form

Additional comments:

Table 2.3: Descriptive Criteria for Scoring Musculoskeletal Stress Markers*

---

0 = **No Expression: Barely visible, palpable, discernable**
Attachment site is not well defined, or may appear to be underdeveloped from the normal range of expression for that particular muscle, muscle group or ligament.

1 = **Faint Expression: Slightly visible and palpable; slightly enlarged**
Attachment site appears faintly robust/rugose. Tuberosities, tubercles, etc. appear slightly enlarged or more robust/rugose.

2 = **Moderate Expression: Definitely visible and palpable; somewhat enlarged**
Attachment site appears moderately robust/rugose, being both visible and palpable at first glance or touch. Tuberosities, tubercles, etc. appear moderately enlarged, for example, nearly "breaking" the margin of shaft

3 = **Strong Expression: Definitely enlarged, rough/rugose**
Attachment site appears very robust/rugose. Tuberosities, tubercles, etc. definitely appear enlarged, for example, protruding beyond the shaft margin, or appearing raised.

4 = **Faint Stress Lesion: First stages of lesion**
Lesion begins to develop at the attachment site, but does not perforate the outer table.

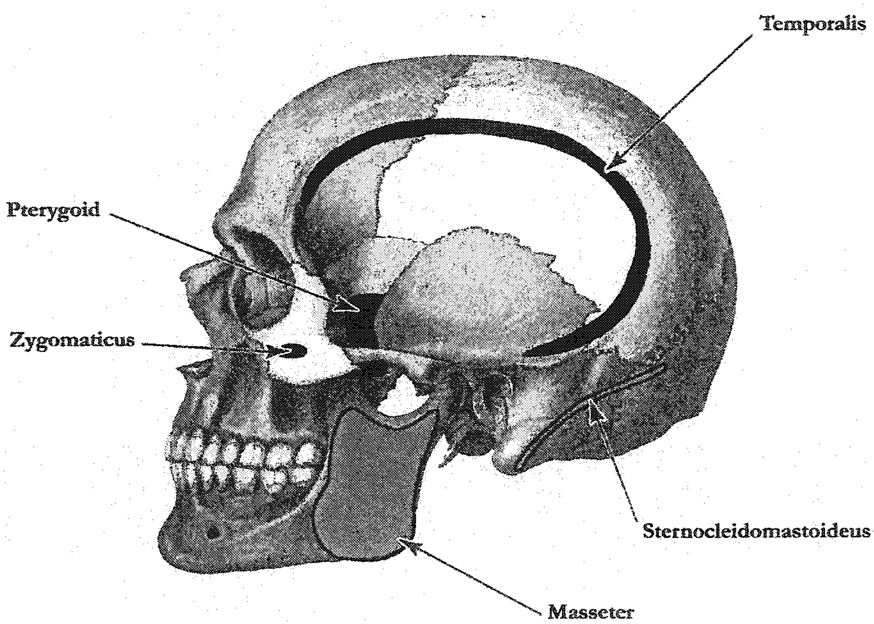
5 = **Moderate Stress Lesion: Penetrates outer table**
Lesion at the attachment site goes through the outer table, perforating the inner table, but does not penetrate the medullary cavity.

6 = **Strong Lesion: Penetrates the medullary cavity**
Stress lesion perforates the medullary cavity.

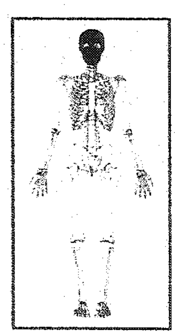
9 = **Cannot be observed: Unobservable**

* Adapted from Hawkey 1988 and Hawkey and Merbs 1995.

# Figure 2.2: Cranium



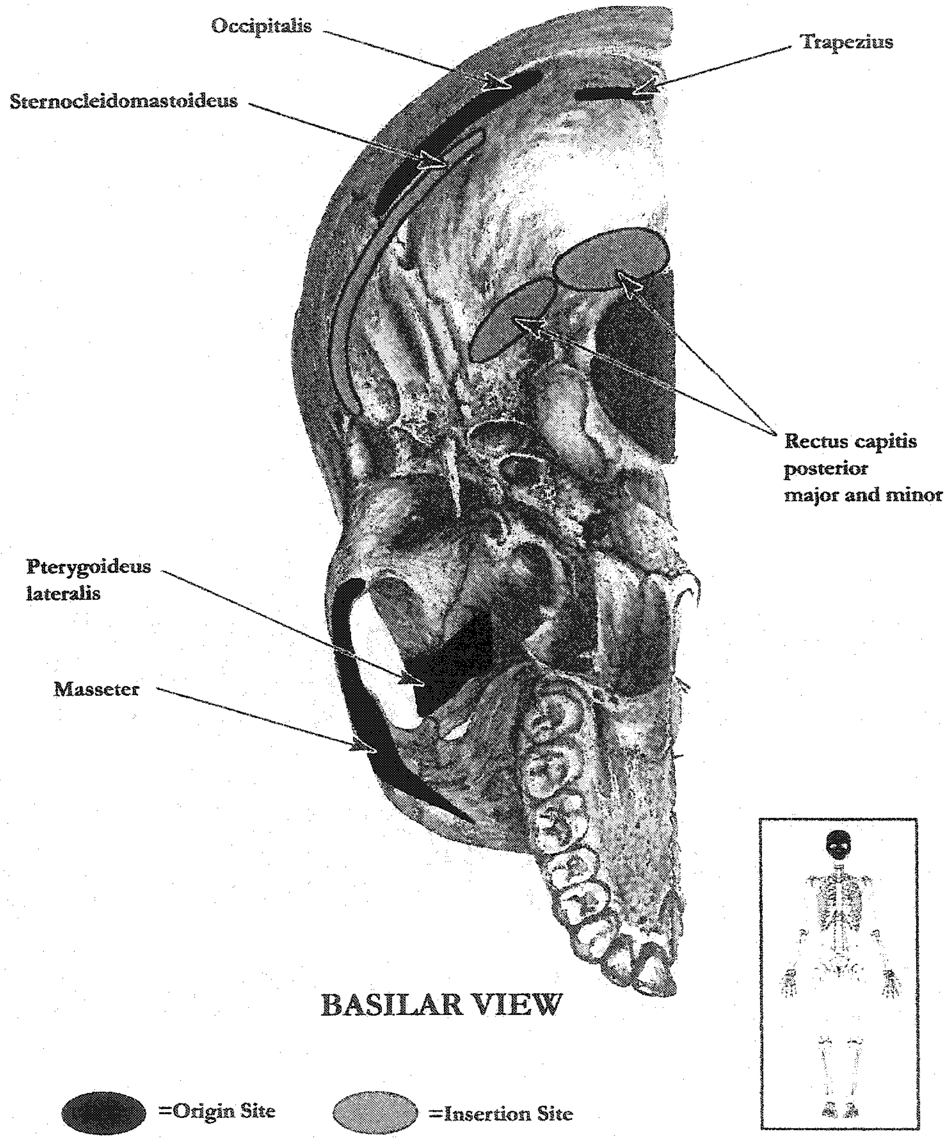

LEFT LATERAL VIEW



=Origin Site = Insertion Site

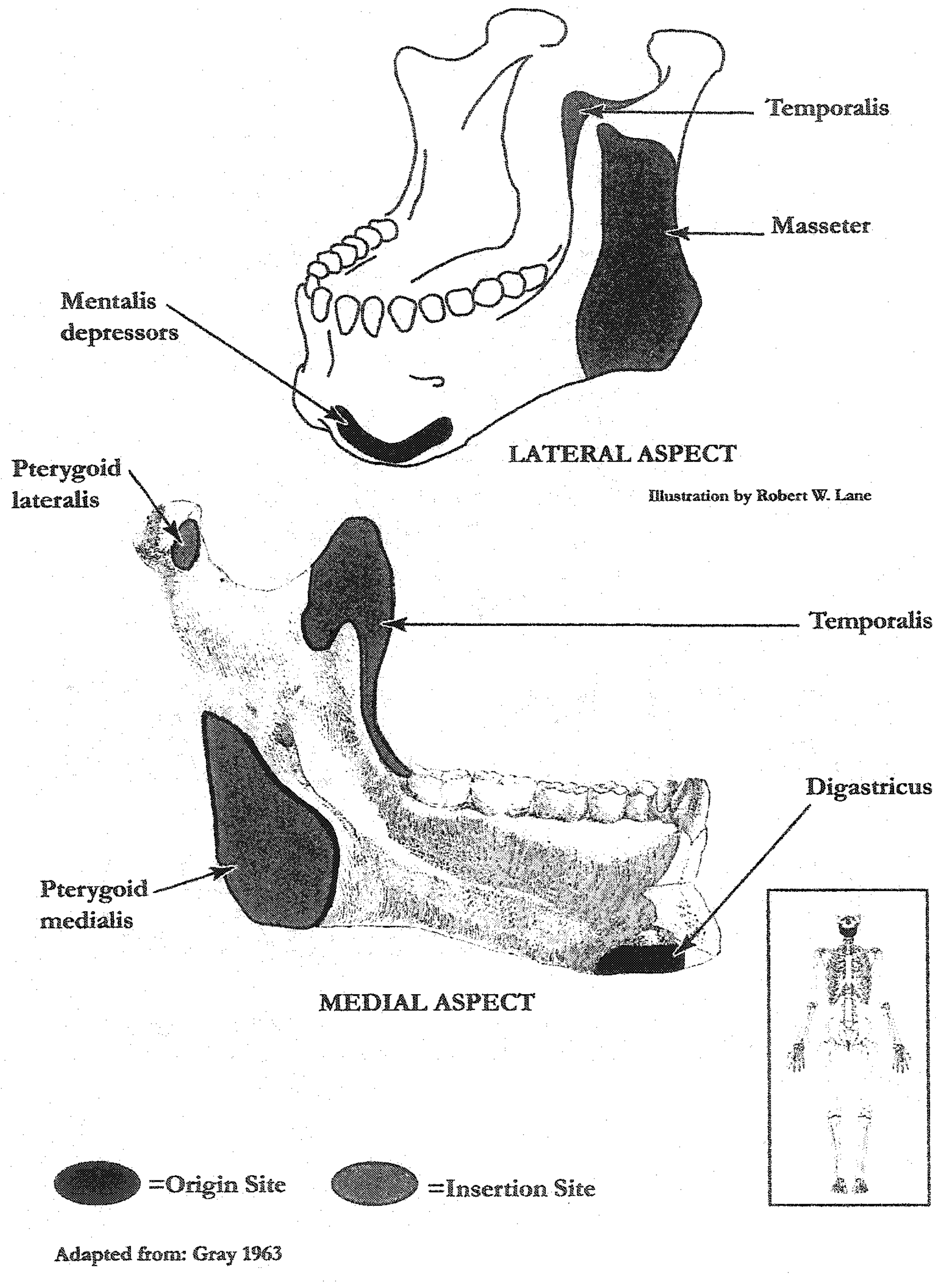
Adapted from : Gray 1963

# Figure 2.3: Cranium



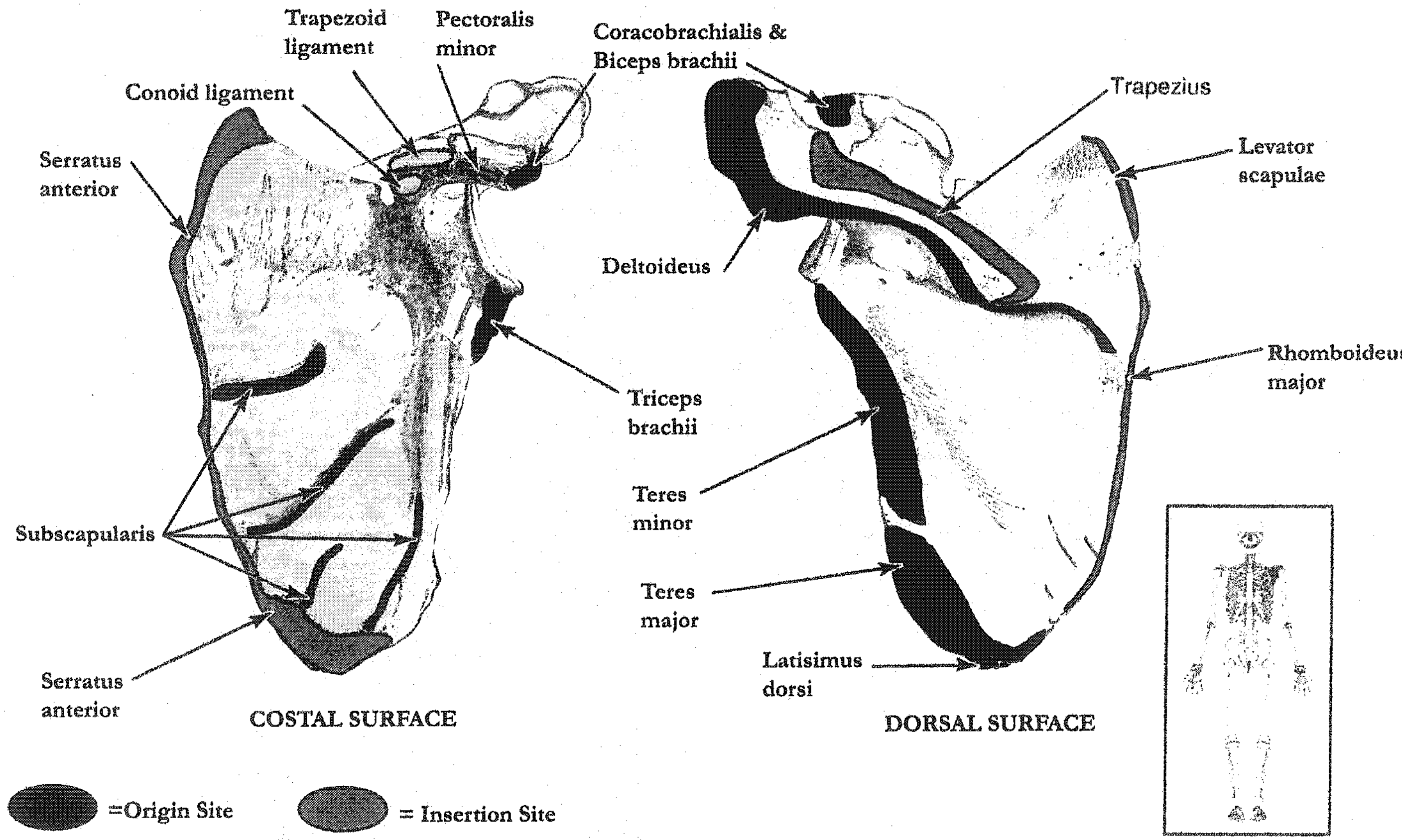

Adapted from: Gray 1963

# Figure 2.4: Mandible



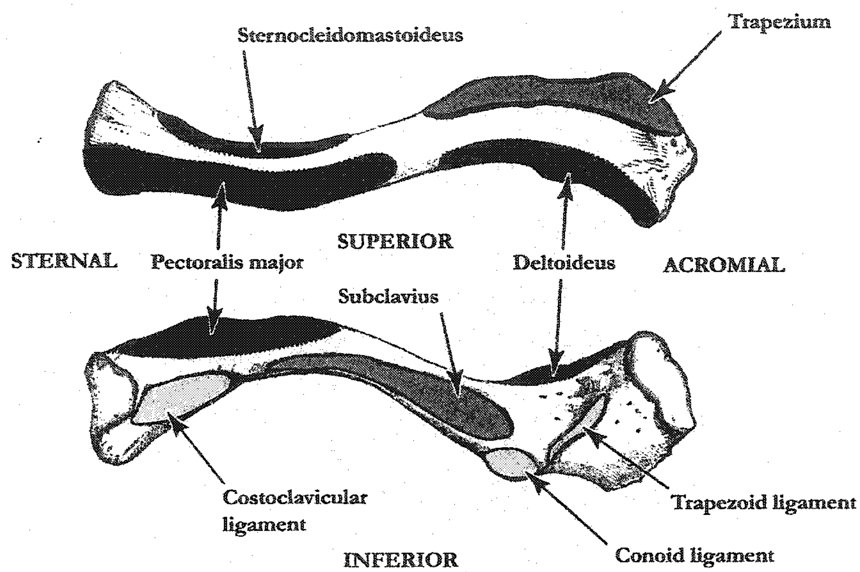

Adapted from: Gray 1963

## Figure 2.5: Left Scapula




Adapted from: Gray 1963

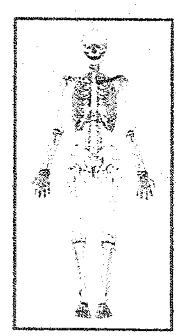
# Figure 2.6: Left Clavicle



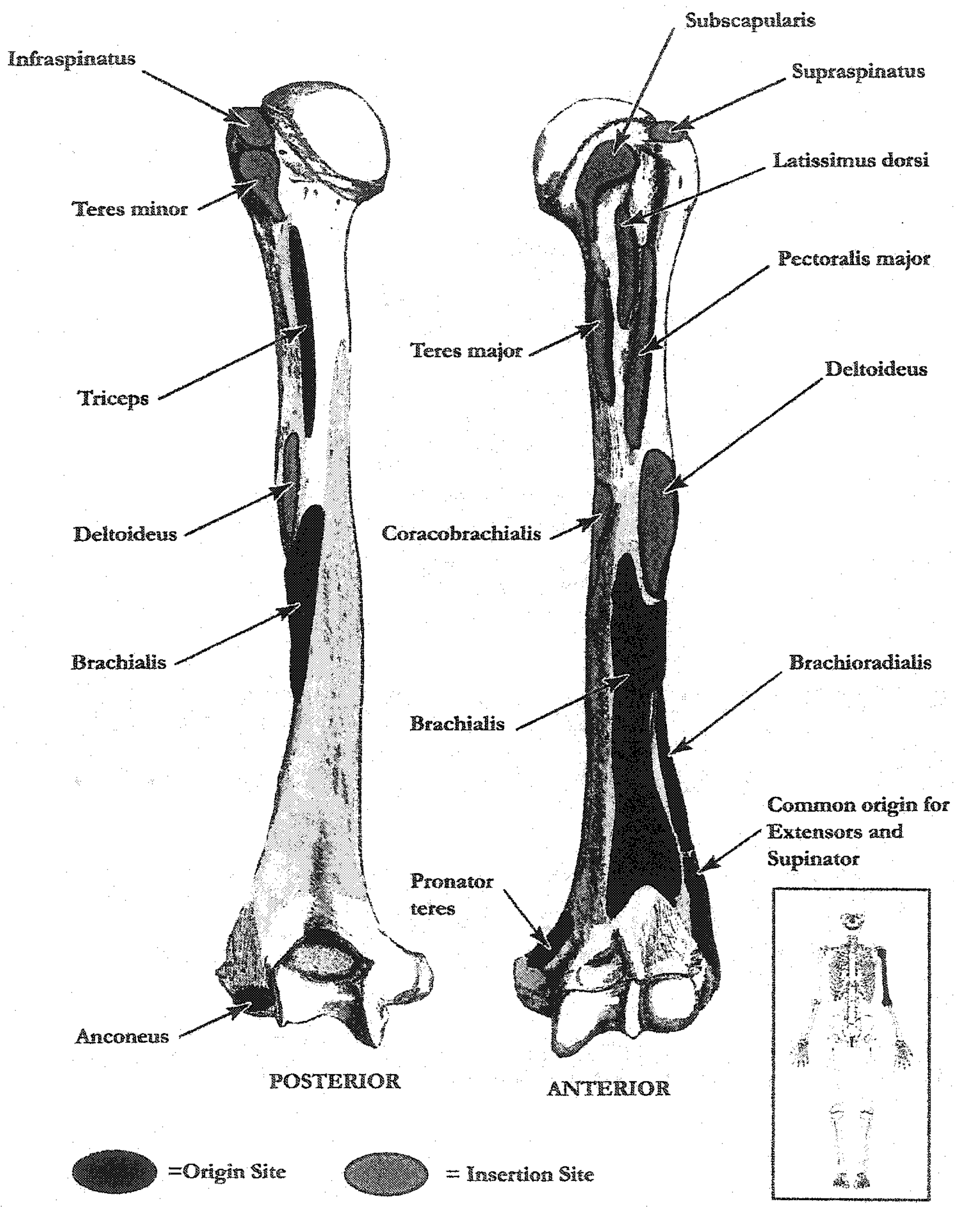

= Origin Site

= Insertion Site

Adapted from Gray 1963

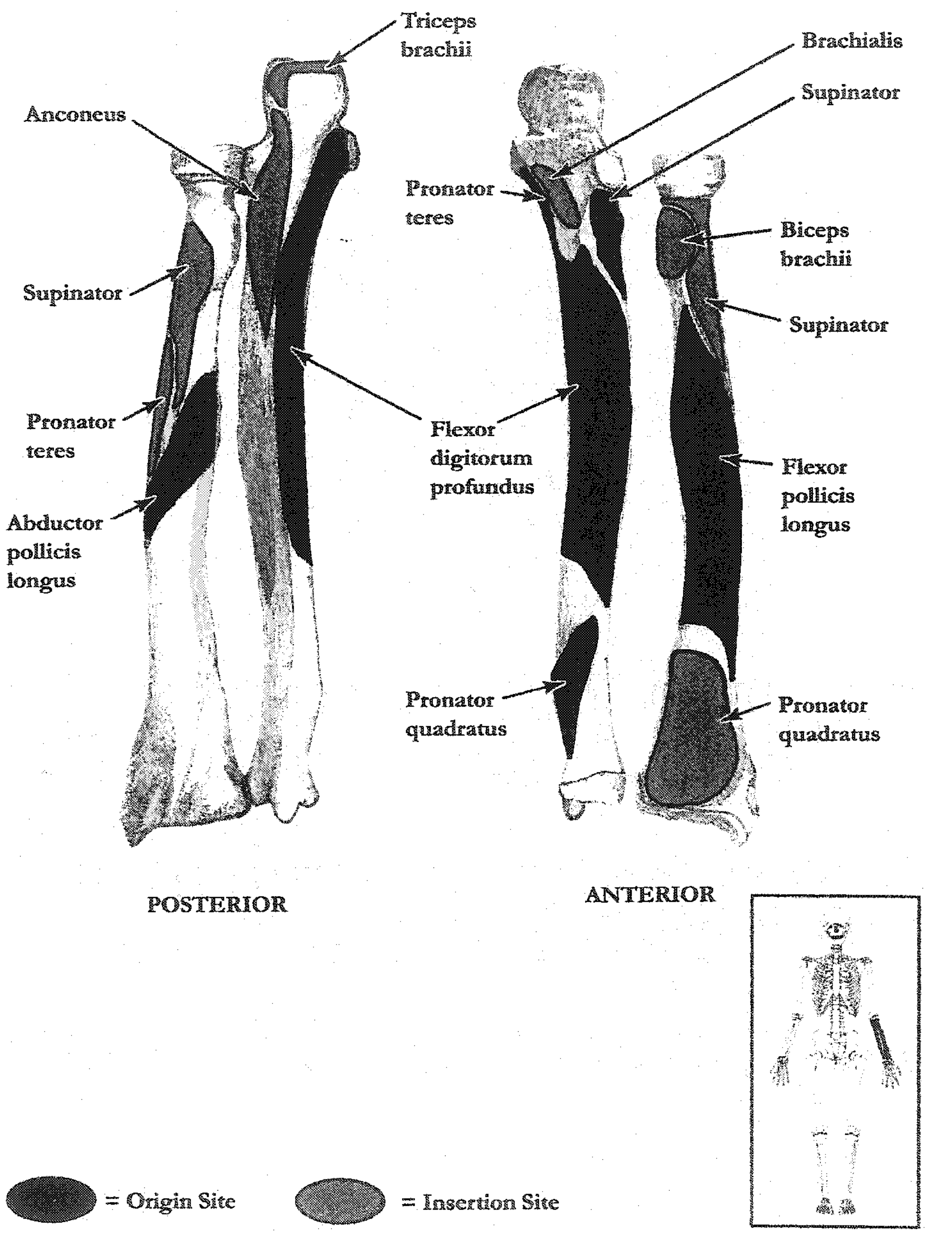


# Figure 2.7: Left Humerus



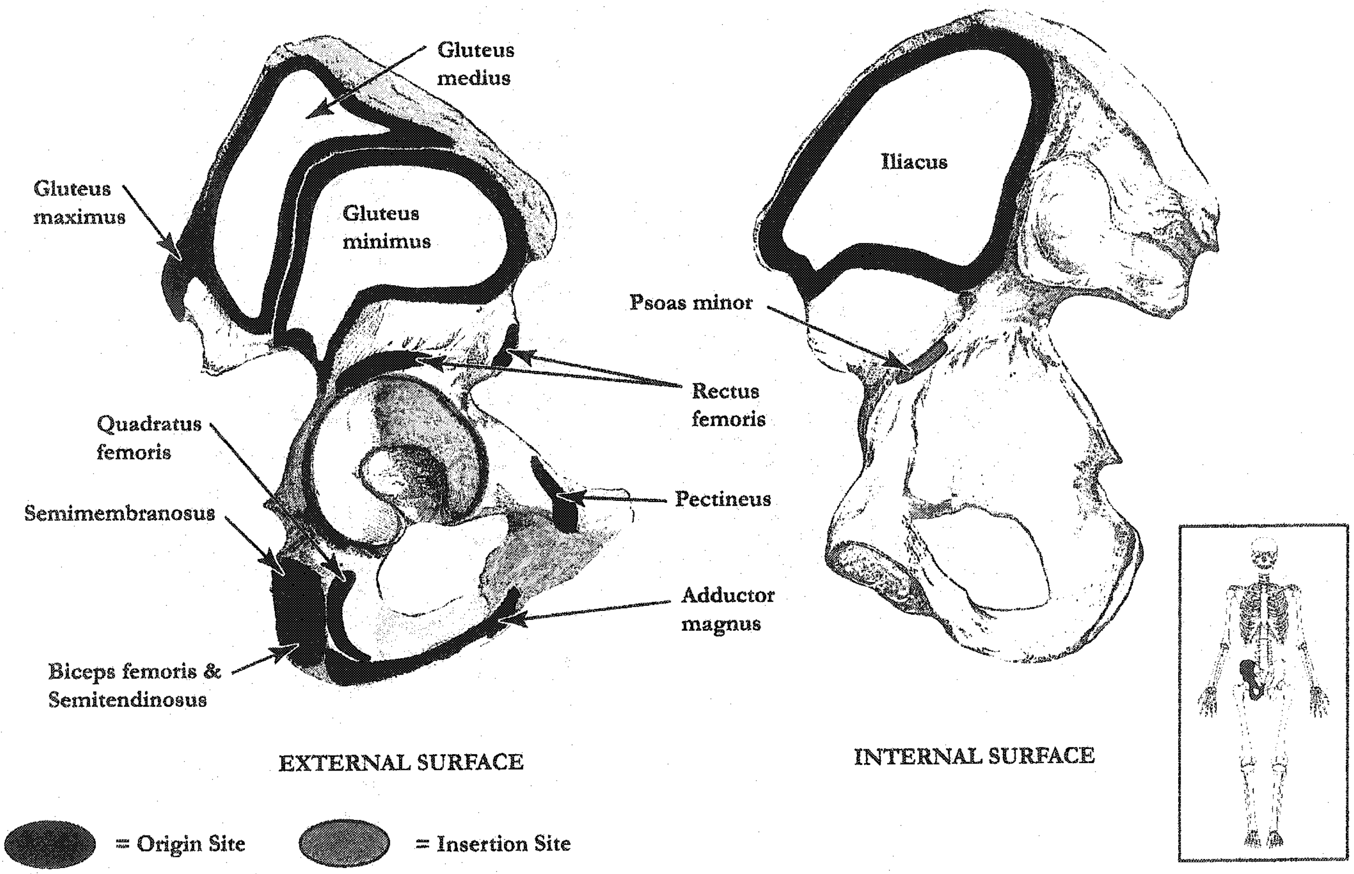

Adapted from: Gray 1963

# Figure 2.8: Left Ulna & Radius




Adapted from: Gray 1963

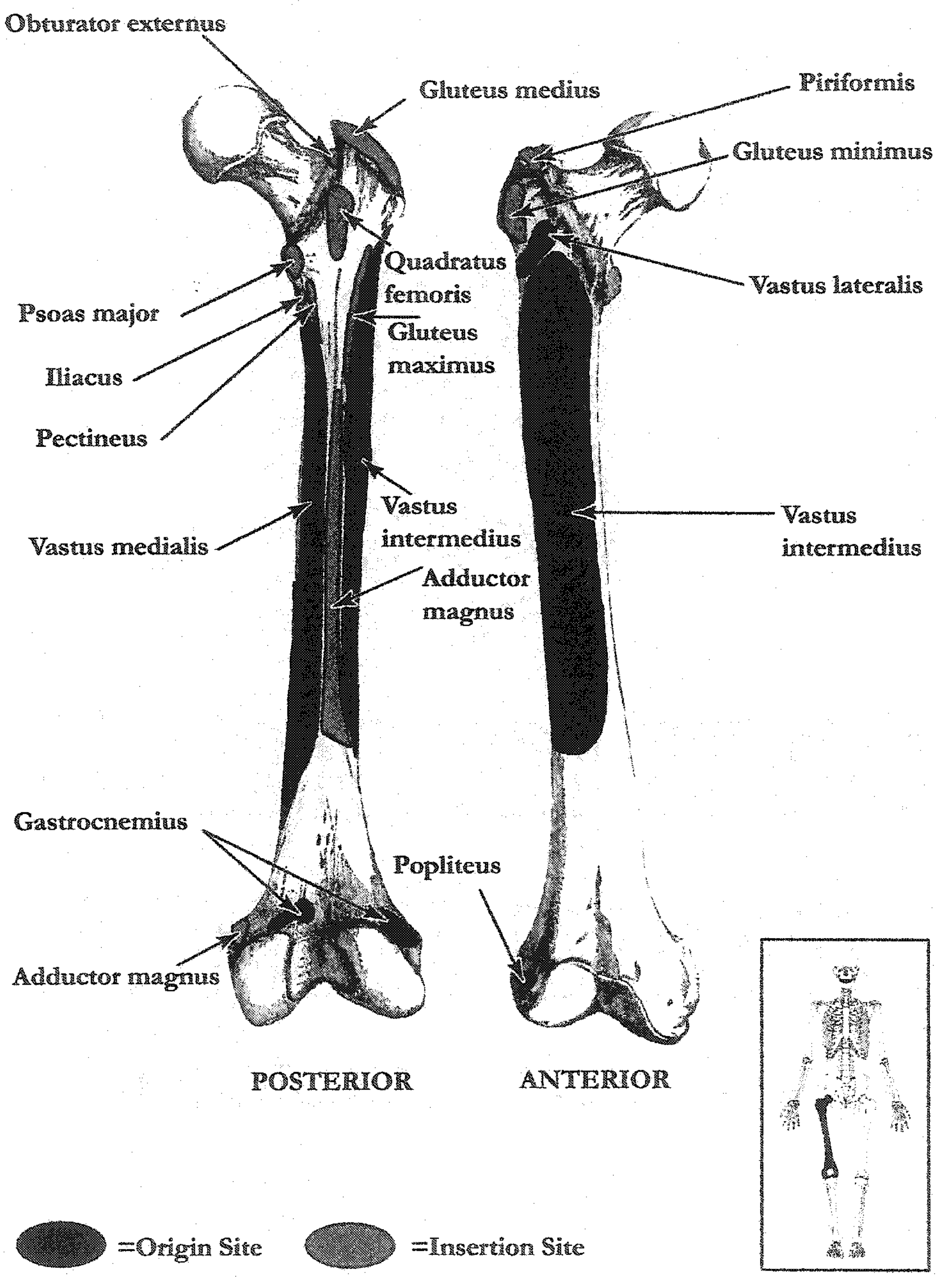
# Figure 2.9: Right Innominate




= Origin Site = Insertion Site

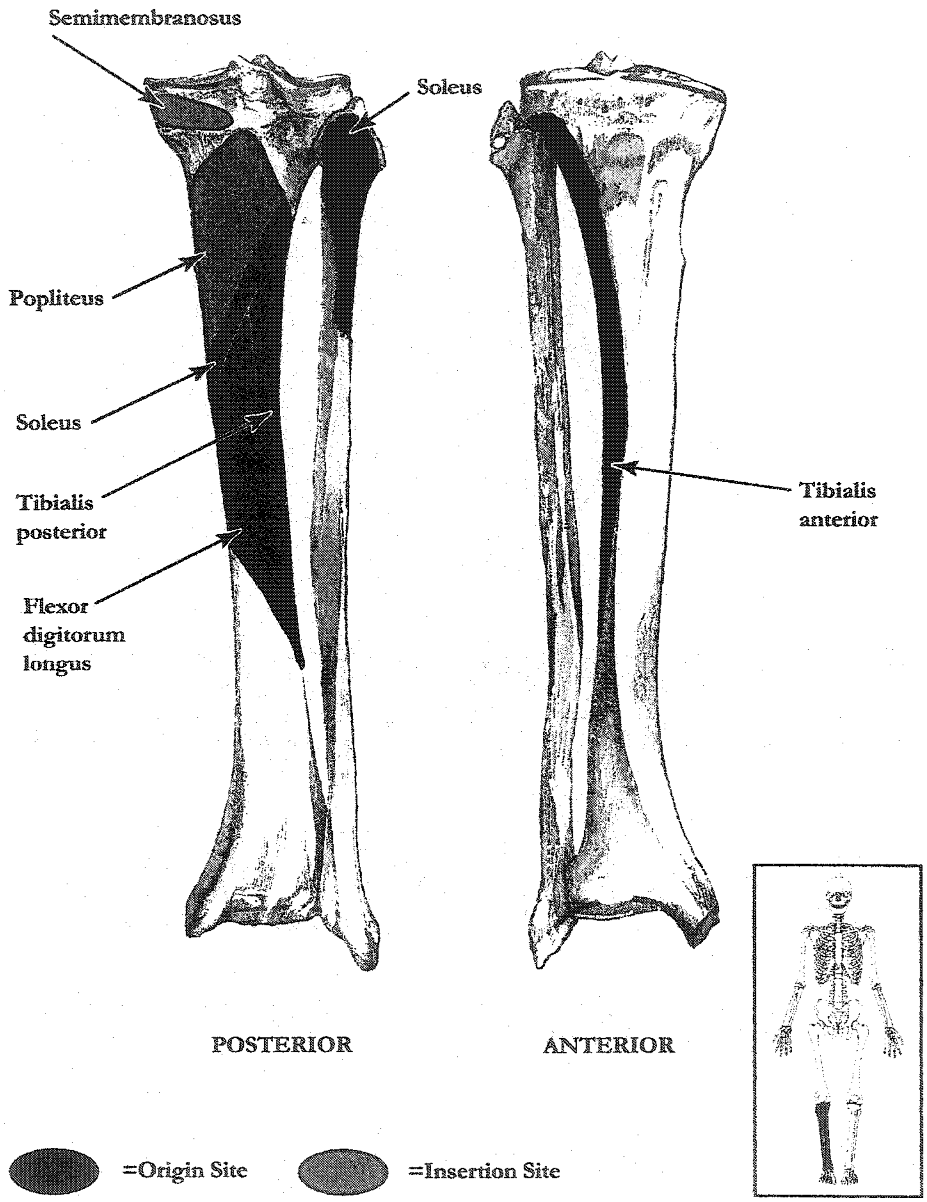
Adapted from: Gray 1963

# Figure 2.10: Right Femur




Adapted from: Gray 1963

# Figure 2.11: Right Tibia/Fibula




Adapted from: Gray 1963

Table 2.4a: Craniofacial Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the lower jaw/mandible | | | | |
| Digastricus | Posterior belly-mastoid notch of temporal bone; Anterior belly-inner side of inferior border of mandible near symphysis | Intermediate tendon attached to hyoid bone | Raises hyoid bone, assists in opening jaws, moves hyoid forward or backward | Opens jaws |
| Masseter | Zygomatic process of maxilla, medial and inferior surfaces of zygomatic arch | Angle and ramus of mandible, lateral surface of coronoid process of mandible | Elevates mandible, assists in side to side movement of mandible, and protracts (protrudes) mandible | Closes mouth |
| Pterygoid | Medial surface of lateral pterygoid plate of sphenoid bone, palatine bone and tuberosity of maxilla; Superior head-lateral surface of greater with of sphenoid; Inferior head-lateral surface of lateral pterygoid plate | Medial surface of ramus and angle of mandible; condyle of mandible, and temporomandibular joint | Elevates and protracts mandible and moves mandible from side to side, protrudes mandible | Closes lower jaw, opens jaws, clenches teeth |
| Temporalis | Temporal fossa including frontal, parietal, and temporal bones | Coronoid process and anterior border of ramus of mandible | Elevates and retracts mandible and assists in side to side movement of mandible | Clenches teeth, closes mouth |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.4b: Craniofacial Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles of Facial Expression | | | | |
| Mentalis depressors | Incisive fossa of mandible | Skin of chin | Raises and protrudes lower lip | Wrinkles skin of chin |
| Occipitalis | Lateral two-thirds of superior nuchal line of occipital bone, mastoid process of temporal bone | Galea aponeurotica (an intermediate tendon leading to frontal belly) | Draws scalp backward | Wrinkles forehead, raises eyebrows |
| Zygomaticus | Zygomatic bone | Angle of mouth and upper lip | Draws angle of mouth upward and backward, forms nasolabial furrow | Laughing, smiling |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.4c: Craniofacial Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the head | | | | |
| Rectus capitis posterior major and minor | Major-spinous process of axis<br><br>Minor-posterior arch of atlas | Lateral and medial portion of inferior nuchal line of occipital bone | Extends and rotates head | Extends and rotates head |
| Sternocleido-mastoideus | Sternal head - manubrium of sternum; Clavicular head - medial part of clavicle | Mastoid process of temporal bone, lateral half of superior nuchal line of occipital bone | One side - bends neck laterally, rotates head<br><br>Both sides together - flexes neck, draws head ventrally and elevates chin, draws sternum superiorly in deep inspiration | Rotates head, elevates chin, draws head forward |
| Trapezius | Medial third of superior nuchal line, external occipital protuberance, ligamentum nuchae, spinous processes and supraspinous ligaments of seventh cervical and all thoracic vertebrae | Lateral third of clavicle, medial margin of acromion, entire length of spine of scapula | Elevates lateral point of scapula (rotates scapula during abduction and elevation of arm), adducts scapula, lower portion depresses scapula | Extends head |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.5a: Upper Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the shoulder/pectoral girdle | | | | |
| Pectoralis minor | External surfaces of the third, fourth, and fifth ribs | Coracoid process of scapula | Depresses and moves scapula anteriorly, elevates third through fifth ribs during forced inspiration when scapula is fixed | Draws scapula forward and downward, raises ribs in forced inspiration |
| Subclavius | Junction of the first rib with its costal cartilage | Groove on the inferior surface of the clavicle | Depresses clavicle | Draws shoulder forward and downward, steadies clavicle during movements of shoulder girdle |
| Trapezius | Superior nuchal line of occipital bone, ligamentum nuchae, and spines of seventh cervical and all thoracic vertebrae | Clavicle and acromion and spine of scapula | Elevates clavicle, adducts scapula, rotates scapula upward | Elevates or depresses scapula, and extends head |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.5b: Upper Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the arm/humerus | | | | |
| Deltoideus | Anterior portion - anterior border and superior surface of the lateral third of the clavicle; Middle portion - lateral border of the acromion process; Posterior portion - lower border of the crest of the spine of the scapula | Deltoid tuberosity, on the middle of the lateral surface of the shaft of the humerus | Abducts, flexes, extends, and medially and laterally rotates arm | Flexes, extends, and rotates arm |
| Infraspinatus | Infraspinous fossa of scapula | Greater tubercle of humerus | Rotates arm laterally; adducts arm | Rotates arm laterally, adducts arm |
| Latissimus dorsi | Spines of lower six thoracic vertebrae, lumbar vertebrae, crests of sacrum and ilium, lower four ribs | Floor (bottom) of the bicipital groove of humerus | Extends, adducts, and medially rotates the arm, keeps inferior angle of scapula against the chest wall, accessory muscle of respiration | Draws arm downward and backward |
| Pectoralis major | Clavicle, sternum, cartilages of second to sixth ribs | Lateral lip of intertubercular groove of humerus, crest below greater tubercle of humerus | Flexes and adducts arm, rotates the arm medially | Rotates arm, depresses arm and shoulder |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.5c: Upper Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the arm/humerus (Continued) | | | | |
| Supraspinatus | Supraspinous fossa of scapula | Greater tubercle of humerus | Assists deltoid muscle in abducting arm | Strengthens shoulder joint, weak lateral rotator and flexor |
| Teres major | Inferior angle of scapula | Intertubercular sulcus of humerus | Medially rotates arm, adducts arm, extends arm | Extends, rotates, and adducts arm |
| Teres minor | Inferior lateral border of scapula | Greater tubercle of humerus | Rotates arm laterally; extends and adducts arm | Extends, rotates, and adducts arm; stabilizes the shoulder joint |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.5d: Upper Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles move the forearm/ulna and radius | | | | |
| Anconeus | Lateral epicondyle of humerus | Olecranon and superior portion of shaft of ulna | Extends arm (assists triceps) | Extends forearm |
| Biceps brachii | Long head originates from tubercle above glenoid cavity; short head originates from coracoid process of scapula | Tuberosity of radius, bicipital aponeurosis into deep fascia on medial part of forearm | Supinates hand, flexes forearm, weak flexor of arm at shoulder joint | Flexes and supinates forearm; flexes arm |
| Brachialis | Anterior of lower half of humerus | Coronoid process of ulna, tuberosity of ulna | Flexes forearm | Flexes forearm |
| Pronator quadratus | Distal portion of shaft of ulna | Distal portion of shaft of radius | Pronates forearm and hand | Pronates forearm and hand |
| Pronator teres | Medial epicondyle of humerus and coronoid process of ulna | Midlateral surface of radius (pronator tuberosity) | Pronates forearm and hand | Flexes forearm and hand |
| Triceps brachii | Long head - infraglenoid tubercle of the scapula | Posterior part of olecranon process of the ulna | Extends forearm, long head aids in adduction if arm is abducted | Extends arm, extends forearm |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.5e: Upper Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the wrist, hand, and fingers | | | | |
| Extensors and Supinators | Extensor-supracondylar ridge of humerus<br><br>Supinator-lateral epicondyle of humerus | Extensor-Posterior surface of the base of the second metacarpal bone<br><br>Supinator-dorsal and lateral surfaces of upper third of radius | Extensor-extends and abducts hand at wrist joint<br><br>Supinator-supinates forearm and hand | Extensor-extends and abducts hand at wrist joint<br><br>Supinator-turns the palm upward or anteriorly |
| Flexor digitorum profundus | Anterior medial surface of body of ulna | Bases of distal phalanges | Flexes distal phalanges of each finger | Flexes each finger |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.6a: Lower Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the thigh/femur | | | | |
| Adductor magnus | Inferior ramus of pubis and ischium to ischial tuberosity | Linea aspera of femur | Adducts thigh at hip joint, assists in lateral rotation and extension | Adducts, flexes, medially rotates, and extends thigh |
| Gluteus maximus | Iliac crest, sacrum, coccyx, and aponeurosis of sacrospinalis | Iliotibial tract of fascia lata, gluteal tuberosity of femur | Extends and laterally rotates hip joint | Extends trunk, extends and rotates thigh |
| Gluteus medius | Ilium | Greater trochanter of femur | Abducts femur and rotates thigh medially | Rotates thigh |
| Gluteus minimus | Ilium | Greater trochanter of femur | Abducts and rotates thigh medially | Rotates thigh |
| Iliacus | Iliac fossa | Tendon of psoas major | Flexes and rotates thigh laterally and flexes vertebral column | Flexes thigh at hip joint |
| Obturator externus | Outer surface of obturator membrane | Trochanteric fossa of femur | Rotates thigh laterally | Rotates thigh laterally |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.6b: Lower Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the thigh/femur (Continued) | | | | |
| Pectineus | Superior ramus of pubis | From lesser trochanter to linea aspera of femur | Flexes and adducts thigh at hip joint, medially rotates thigh | Flexes and adducts thigh |
| Piriformis | Anterior sacrum | Superior border of greater trochanter of femur | Rotates thigh laterally and abducts it | Rotates thigh laterally and abducts it |
| Quadratus femoris | Ischial tuberosity | Below intertrochanteric crest (quadrate line) | Laterally rotates and adducts thigh | Rotates and adducts thigh |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.6c: Lower Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the thigh/femur and the leg/tibia and fibula | | | | |
| Biceps femoris | Long head-ischial tuberosity; short head-linea aspera of femur | Head of fibula and lateral condyle of tibia | Flexes leg at knee joint, long head also extends thigh at hip joint | Flexes leg, extends thigh |
| Rectus femoris | Anterior inferior iliac spine | Upper border of patella | Extends leg at knee joint; flexes thigh at hip joint | Extends leg, flexes thigh |
| Semi-membranosus | Ischial tuberosity | Medial condyle of tibia | Flexes and slightly medially rotates leg at knee joint after flexion, extends thigh at hip joint | Flexes leg, extends thigh |
| Semitendinosus | Ischial tuberosity | Medial surface of shaft of tibia | Flexes and slightly medially rotates leg at knee joint after flexion, extends thigh at hip joint | Flexes leg and extends thigh |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.6d: Lower Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles move the leg/tibia and fibula | | | | |
| Popliteus | Lateral condyle of femur | Proximal tibia | Flexes and medially rotates leg | Flexes and medially rotates leg |
| Vastus intermedius | Anterior and lateral surfaces of body of femur | Deep aspect of quadriceps tendon then through patella to tibial tuberosity | Extends leg at knee joint | Extends leg at knee joint |
| Vastus lateralis | Greater trochanter and linea aspera of femur | Lateral margin of patella then by patellar ligament to tuberosity of tibia | Extends leg at knee joint | Extends leg at knee joint |
| Vastus medialis | Linea aspera of femur | Medial border of the patella then by patellar ligament into tibial tuberosity, medial condyle of tibia | Extends leg at knee joint | Extends leg at knee joint |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.6e: Lower Extremity Muscle Origin/Insertion and Action/Activity[1]

| Muscle | Origin | Insertion | Action | Activity |
|---|---|---|---|---|
| Muscles that move the leg/tibia and fibula, and the foot and toes | | | | |
| Gastrocnemius | Lateral and medial condyles of femur and capsule of knee | Posterior surface of the calcaneus | Plantar flexes foot and flexes leg | Plantar flexes foot and flexes leg |
| Muscles that move the foot and toes | | | | |
| Flexor digitorum longus | Posterior surface of tibia | Distal phalanges of four outer toes | Flexes distal phalanges of lateral four toes, assists in plantar flexing foot, inverts foot | Plantar flexes and inverts foot and flexes toes |
| Soleus | Head of fibula and medial border of tibia | Posterior surface of the calcaneus | Plantar flexes foot | Plantar flexes foot |
| Tibialis anterior | Lateral condyle and body of tibia and interosseous membrane | First metatarsal and first (medial) cuneiform | Dorsiflexes and inverts foot | Dorsiflexes foot at ankle joint, supinates foot |
| Tibialis posterior | Tibia, fibula, and interosseous membrane | Second, third, and fourth metatarsals; navicular; all three cuneiforms; and cuboid | Plantar flexes, inverts foot | Plantar flexes, inverts foot |

[1]Taken from Gray 1963, Stone and Stone 1990, Tortora and Grabowski 1993, and White 1991.

Table 2.7: Ligament Attachment and Function[1]

| Ligament | Description | Notes |
|---|---|---|
| Costoclavicular ligament | Extends from the superior margin of the first costal cartilage to the inferior surface at the sternal end of the clavicle | Resists superior displacement of the proximal end of the clavicle; the combined effect of this ligament, the sternoclavicular ligament and the interclavicular ligament is to produce a very strong sternoclavicular joint that seldom dislocates |

[1]Taken from Newman 2000, Tank 1999, and White 1991.

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# CHAPTER THREE[1]

## Introduction

The daily life of Eskimos is of great interest to researchers, especially those concerned with hunter-gatherer economies. Contemporary ethnoarchaeological studies (Binford 1978), paleopathological analysis (Merbs 1983), reports on Eskimo material culture (Murdoch 1988), and ethnographies (Lantis 1946; Nelson 1983) are useful in addressing subsistence and other habitual activities. The use of musculoskeletal stress marker (MSM) data provides additional information for independently evaluating ethnographic and archaeological observations of human populations. Habitual or occupational activities have been assessed using a wide variety of osteological observations, such as the presence of arthritis, accessory facets, trauma, and musculoskeletal stress markers (Kennedy 1989). This chapter specifically addresses the interpretation of the habitual activity markers that deal with muscle and ligament attachment sites on bone, which are referred to in the literature under a variety of names including enthesopathies (Dutour 1986), markers of occupational stress (Kennedy

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[1] A version of this chapter has been published previously: Steen SL, Lane RW. 1998. Habitual activities among Alaskan Eskimo based on musculoskeletal stress markers. *International Journal of Osteoarchaeology* 8(5):341-354.

1989), activity-induced stress markers (Hawkey and Street 1992), and MSMs (Hawkey and Merbs 1995).

Enthesopathy refers to a "disorder of the muscular or tendonous attachment to bone," that is, "a morbid condition, or disease" (-pathy) at "the site of attachment of a muscle or ligament to bone" (enthesis) (Anderson 1994:561 and 1245, respectively). Thus, an enthesopathic condition may not necessarily be related to regular use but to a diseased condition. Therefore, the term "enthesopathy" is not appropriate in describing normal activities that result in bone remodeling at muscle and ligament attachment sites. "Markers of occupational stress" and "activity-induced stress markers" are likewise inappropriate terms because the scope of inquiry implied by such designations encompasses too broad a range (e.g., degenerative joint disease, trauma, accessory facets, and muscle/ligament stress) in the interpretation of habitual activities. Furthermore, interpretation of "occupation" may involve cultural bias, depending on the latitude one affords the definition.

Musculoskeletal stress markers (MSMs) refer specifically to bony changes produced during normal, habitual use at the muscle and ligament attachment sites. "Normal" implies any amount of daily activity over an individual's life, whether resulting from an individual's occupation or habitual activities. The type of bony response may include increased robusticity, rugosity, stress lesions, and myositis ossificans (Hawkey and

Merbs 1995; Mann 1993). The term "MSM" narrowly defines the type of marker under study so it is not confused with markers of degenerative joint disease, trauma, accessory facets, etc. MSMs are the result of muscular hypertrophy, an enlargement in the diameter of muscle fibers from an increased production of myofibrils, mitochondria, and sarcoplasmic reticulum. Muscular hypertrophy occurs as a result of very forceful and repetitive muscular activity, such as through strength or weight training or any habitual activity at excessive levels. The increase in muscle size requires an increased region for the muscles and ligaments to attach to the periosteum and the underlying bony cortex. Hypertrophied muscles are capable of more forceful contractions, whereas weak muscular activity does not produce significant hypertrophy. Additionally, osteon remodeling, stimulated by an increased blood flow in the well-vascularized periosteum, occurs where repetitive muscular activity takes place. The development of robust, rugose muscle attachment sites is the direct result of increased and continual muscle usage in habitual activities (Dutour 1986; Kennedy 1989). Therefore, the human skeleton contains a well-preserved record of an individual's habitual activity pattern and, collectively, an entire community's activity patterns.

The process of classifying, standardizing and interpreting these various forms of habitual activities to facilitate inter- and intra-population comparisons continues to be an important and ongoing research problem in osteology. This was clearly demonstrated by the variety and number of papers presented at the 1997 American Association of Physical Anthropologists symposium "Activity-patterns and Musculoskeletal Stress Markers" (St. Louis, Missouri), culminating in the publication of those papers, and selected other contributions in the *International Journal of Osteoarchaeology* (volume 8, number 5, 1998)

In other case studies, a number of researchers have discussed the occupational and/or subsistence activities of a few individuals (Dutour 1986; Lai and Lovell 1992) or entire populations (Merbs 1983; Molleson 1989, 1994) based on a wide range of observations, including MSM data. In these reports, MSMs are discussed in subjective, qualitative terms (e.g., large, robust, smooth, barely discernible) that are not always clearly defined. This approach does not readily allow for intra- or inter-population comparison by other researchers because, for example the terms “large” and “robust” may not mean the same thing to others. However, other researchers have discussed MSMs in quantitative, albeit ordinal terms (Hawkey and Street 1992; Hawkey and Merbs 1995; Hawkey 1988; Lovell and Dublenko 1999; Steen *et al.* 1996; Street and Hawkey 1992), and have attempted to standardize methods for studying MSMs, as well as other possible activity-related markers so that they may be consistent.

**Materials and methods**

Human remains from the Norton Sound region (Figure 3.1), primarily from Golovin Bay, were collected between 1912 and 1930 by Riley Moore in 1912, Aleš Hrdlička in 1926, Henry B. Collins between 1928 and 1930, and James A. Ford in 1930 (Collins 1929-30; Ford 1930; Hrdlička 1913, 1930; Mudar *et al.* 1996). The remains date from between approximately 300 and 80 years ago (United States Bureau of Indian Affairs Alaska Native Settle Claims Act Office 1992).

The skeletal remains from Nunivak Island (Figure 3.1), which were accessioned into the Smithsonian Institution collections between 1898 and 1931, come from at least nine prehistoric sites. Most of the remains were collected in 1927 by Henry B. Collins and T. Dale Stewart under the auspices of the Smithsonian Institution (Speaker *et al.* 1996). There was little overall evidence of abrasion from the burial matrix or from postmortem damage. The overall condition of the remains from both skeletal series ranged from good to excellent (Scott *et al.* 1995, 1996).

One hundred fifty-six individuals from Golovin Bay and 237 from Nunivak Island were initially examined, but only 102 individuals (65%) from Golovin Bay and 176 (74%) from Nunivak Island were used in this study.[2] Adults of known age and sex were included. Excluded were

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[2]The numbers reported here have been corrected from the original publication. The numbers for Golovin Bay and Nunivak Island were misread/misprinted from the original data calculation sheets.

children and subadults, adult skeletons that could not be reliably aged or sexed, individuals displaying severe pathological conditions, and individuals with extreme taphonomic deterioration. MSM observations were made on 45 males and 57 females from Golovin Bay, and 81 males and 95 females from Nunivak Island.[3] Sex and age classifications were based on traditional criteria as outlined in the protocol developed by the Repatriation Office of the National Museum of Natural History (Urcid and Byrd 1995; Verano and Urcid 1994).

The skeletal elements observed included the cranium, mandible, clavicle, scapula, humerus, radius, ulna, femur, and tibia. The number of MSM sites were uniform between the two populations with the exception of the *infra-* and *supraspinatus* on the humerus: 68 (34 unilateral) sites for Golovin and 70 (35 unilateral) sites for Nunivak. The *infra-* and *supraspinatus* were scored together for the Golovin collection, due to their close proximity on the greater tubercle. However in hindsight, these muscles were scored separately for the Nunivak Island remains to facilitate future comparisons with other skeletal collections (*e.g.*, Thule and Aleut; Hawkey and Merbs 1995; Hawkey and Street 1992; Street and Hawkey 1992). MSMs were scored using Hawkey's visual reference system of photographs with descriptions supplemented by descriptive information on muscle and ligament attachment sites developed to

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[3]See above footnote.

maintain consistency and comparability between observers (Hawkey and Merbs 1995; Hawkey 1988; Steen *et al.* 1996). MSMs were scored on a scale ranging from 0 to 6 with 6 being the most extreme expression. The Golovin Bay data were collected by Steen and Steven R. Street, and the Nunivak Island data were collected by Steen and Lane. Inter- and intra-observer error has proven negligible ($p<0.05$) in a variety of studies utilizing a visual reference system for scoring remains (Hawkey and Street 1992; Hawkey and Merbs 1995; Hawkey 1988; Steen *et al.* 1996; Street and Hawkey 1992; Lane and Steen 1996; Nagy and Hawkey 1993; Peterson 1994; Scott *et al.* 1993).

The objectives of this study were to determine whether significant differences existed between: (i) left and right side attachment sites; (ii) males from Golovin Bay and Nunivak Island; (iii) females from Golovin Bay and Nunivak Island; (iv) Golovin males and females; and (v) Nunivak males and females (ii-v representing four comparative subsets). Because MSM scores are recorded in an ordinal manner, nonparametric tests were employed. The Wilcoxon Matched-pairs Signed Rank test was used to ascertain whether side dominance existed while the Mann-Whitney U/Wilcoxon Rank Sum W test was used to evaluate the remaining objectives (ii-v). Alpha levels for all statistical tests were set at 0.05.

**Results**

Results are reported in Tables 3.1 to 3.3. The Wilcoxon Matched-pairs Signed Rank test failed to demonstrate a significant difference between any of the muscle and ligament attachment sites on the right and left sides for all of the group comparisons. Thus, only the muscles and ligaments from the right side of the appendicular skeleton and skull were used for comparisons.

*Muscle Insertion Sites on Crania and Mandibles:* There was no statistical significant difference in any of the MSM scores of the muscle attachment sites of the crania and mandibles for the males and females from Golovin Bay. Of the muscles that move the lower jaw only the MSM scores for the *masseter* and *pterygoid medial muscles* were significantly different between the males and females of Nunivak Island, however, the MSM scores for both of the muscles involved in moving the head were also significantly different. The mean MSM scores for the males of Nunivak Island were higher than they were for the females. When comparing the MSM scores of the males from Golovin Bay with the males from Nunivak Island there is no statistical difference among any of the muscles involved in moving the lower jaw. However, there is a significant difference in the *sternocleidomastoideus muscle* which is used to move the head. The mean MSM score of the *sternocleidomastoideus muscle* was higher for the Nunivak Island males than the Golovin Bay males. The

MSM scores of the females from Golovin Bay and Nunivak Island showed a significant difference in the *masseter* and *pterygoid medial muscles*–in both cases the mean MSM scores was high among the Golovin Bay females. However, the mean MSM score for the *sternocleidomastoideus muscle* was higher among the Nunivak Island females than the Golovin Bay females.

*Muscle and Ligament Attachment Sites on Upper Extremity Elements:* The mean MSM scores for the Golovin Bay males were higher than for the Golovin Bay females, though there was not always a significant difference between the scores. There was no difference in the expression of MSM scores between the Golovin Bay males and females for the group of muscles involved in moving the shoulder girdle and the one muscle used to move the wrist, hand, and fingers. A somewhat similar picture was seen between the males and females of Nunivak Island. When there was a significant difference in the MSM scores mean MSM scores were higher for Nunivak Island males than their female counterparts. In all cases the mean MSM scores were higher for the males than the females. When there was a significant difference in the MSM scores between the males of Golovin Bay and Nunivak Island, Nunivak Island males had higher mean MSM scores than did the males from Golovin Bay. None of the attachment sites on the upper extremities had MSM scores which were significant different between the females of Golovin Bay and their Nunivak counterparts.

*Muscle Insertion Sites on Lower Extremity Elements:* Males and females from Golovin Bay had MSM scores that were significantly different in several of the muscles that move the thigh, however, there was no difference in the muscles responsible for moving the leg. The mean MSM scores for the Nunivak Island males was higher than for the Nunivak Island females, however, none of the scores were significantly different. All of the MSM scores for the muscles that move the thigh not only had higher means for the Golovin Bay males than the Nunivak Island males, but they were also significantly different. However, there was no significant difference in the MSM scores for muscles that move the leg between the Golovin Bay and Nunivak Island males. The picture among the females of Golovin Bay and Nunivak Island is not as clear, although, when there is a significant difference between these two groups, the mean MSM scores are higher for the Golovin Bay females.

In summary, when there was a statistically significant difference in the MSM scores between the males and females, the males had the higher mean MSM scores. In the intragroup comparisons when there was a statistically significant difference in the MSM scores, the males and females of Golovin Bay had higher mean MSM scores than their Nunivak Island counterparts with one exception for both. The mean MSM score for the *sternocleidomastoideus muscle* was higher for Nunivak Island males and females than for those of Golovin Bay. The *sternocleidomastoideus muscle* is a powerful muscle used to move the head especially when using the teeth as tools or the mouth as a third hand.

**Discussion**

Merbs, in his classic study of activity-induced pathologies in a Canadian Inuit population, noted that

> [the Inuit] were predominately right-handed. In fact, no left-handed individuals could be identified with any degree of reliability. This right-side dominance may be expected to reflect itself in the patterns of degenerative and traumatic pathology observed, more in the upper limb than the lower, and more from those activities requiring precision than those requiring strength. (1983:148)

Side use dominance reported by Hawkey and Merbs (1995) for their Hudson Bay[4] Eskimo population show 80% right-side and 8% left-side dominance with 12% exhibiting no side preference. Falk (1987) reports that modern, worldwide populations exhibit a 90% right-side dominance, 8% left-side dominance and 2% no side preference, while Annett's (1992) research indicates 66%, 4% and 30%, respectively. Additionally, data on muscle and ligament attachment sites have been used to determine

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[4]'Hudson Bay' is the name for the body of water and surrounding watershed, and is used in connection with individuals living in this region. The business that flourished in this region and beyond is known as 'Hudson's Bay Company.' Therefore individual's associated with it were known, for example, as Hudson's Bay (Company) fur traders.

handedness in forensic science cases (Kennedy 1983; Krogman and İşcan 1986).

Based on MSM data, patterns of right- or left-side preferences were not detected in either the Golovin or Nunivak populations. It appears that unilateral activities performed on a regular basis may not be performed in a repetitive manner long enough to override stress markers of activities that are both bilateral and performed on a more habitual basis. That is, MSMs created by unilateral activities such as launching a harpoon, casting a net, or sewing skins may be overridden by those activities performed using bilateral actions such as paddling a *qayaq* (kayak) or *umiaq* (large open skinned boat) or scraping skins. Additionally, various activities, although performed with a preferred side, are assisted by the non-dominant side. For example, in the sewing of heavy animal skins, an individual may use a needle in either hand, while supporting and manipulating the material with the other. Thus, a palimpsest-like layering of MSMs created by both unilateral and bilateral use may obscure the signs of side preference, if they existed. It may also be possible that other markers, such as osteoarthritis, may be a better indicator of handedness than MSM, or perhaps a more holistic picture including MSMs, osteoarthritis, trauma, accessory facets, *etc.*

Ethnohistorical and anthropological accounts often make generalizations on what constitutes Eskimo subsistence activities.

Environmental conditions encountered in circumpolar regions do require a basic pattern of behavior to ensure survival, but subsistence pursuits vary considerably between Eskimo populations owing to regional differences in climate and the availability of resources. Typical male Eskimo activities include procuring and processing terrestrial, marine, riverine/riparian and avian resources; constructing and maintaining homes, kayaks, skin boats, sleds and associated hunting paraphernalia; as well as engaging in occasional warfare (Balikci 1970; Chance 1990; Damas 1984; Langdon 1993; Nelson 1983; Riordan 1990). Female activities include gathering vegetables, berries and eggs; preparing and manufacturing skins and hides for clothes, blankets, footwear, kayaks, skin boats, and houses; preparing and preserving food; caring for children; hunting small game; butchering large land and maritime animals, and procuring and processing large catches of fish and birds (Balikci 1970; Chance 1990; Damas 1984; Langdon 1993). Division of labor between the sexes began at an early age in most Eskimo communities (Lantis 1946; Nelson 1983).

Due to the seasonal availability of plants and animals, geographical and ecological constraints, as well as cultural considerations, Golovin and Nunivak males and females may have employed different habitual subsistence activity patterns. The differences between males and females, and between Golovin and Nunivak, can be seen in both the degree to which they used their muscles/ligaments (i.e., MSM scores and ranks) and in the actual group of muscles being exercised extensively. For example, the females of Golovin utilized their *pterygoid medialis* and *masseter* muscles much more than did the females of Nunivak. These two muscles are important in both mastication and the use of teeth as tools. Lantis (1946) points out that Nunivak women never chewed skins in the manufacture of footwear, which might explain the differences in craniofacial muscle use between the two groups. Eextensive use of their *sternocleidomastoideus* muscle was evident in both Nunivak males and females, which may indicate some behavioral differences in the stressing of nuchal muscles, such as in the use of tumplines for load-carrying.

The attachment sites for the costoclavicular ligaments, *pectoralis major* and *teres major*, had the highest scores among Golovin males and females, as well as Nunivak males. The use of these specific muscles and one ligament is consistent with movements requiring an alternating rotary motion of the shoulder girdle, a movement which has been interpreted as the likely result of kayaking with a double-bladed paddle (Hawkey and Street 1992; Hawkey and Merbs 1995; Hawkey 1988). Other muscles utilized in kayaking include the extensors, supinators, *deltoideus, biceps brachii* and *triceps brachii.* These muscles are used in lifting and lowering the paddle out of and into the water as well as straightening and bending the elbow in order to return the paddle to ready position. These movements may also be consistent with habitual use of the *umiaq,* used frequently in the Norton Sound region to move large groups of people and equipment (Lantis 1946; Ray 1975). Differential use of the *umiaq* may help to explain observed differences between the Golovin and Nunivak overall, as well as some of the similarities between the females from both regions (Lantis 1946; Ray 1975). Single-bladed oars, boat hooks, and ancillary equipment were also used with the kayak in open water and riverine situations, potentially leading to similar MSM expressions. Other behavioral factors, such as habitually throwing projectiles, may also account for differences in MSM expression in the upper arm (Kennedy 1983, 1989).

MSM scores for the *gluteus medius* and *minimus*, *piriformis,* and *obturator externus* sites were stronger in Golovin males and females than in their Nunivak counterparts. The *gluteus medius* and *minimus* muscles abduct the thigh and rotate it medially while the lateral rotators, the *piriformis* and *obturator externus*, act as antagonists in an adducting manner. The interaction of these muscles is important during walking, especially in balancing the body's weight over the stance leg. A number of authors have noted that the peoples of Golovin traversed considerable distances throughout the year to procure unpredictable and variable resources (Burch 1975; Koutsky 1981; Ray 1964; Sheppard 1982, 1983). Furthermore, another important activity was long treks to hot springs to relieve bone and joint disorders. Sheppard (1983:18) notes that there are "many stories about people who could barely walk having their mobility restored after soaking." Conversely, Lantis (1946) notes that Nunivak Islanders did not travel long distances on land. Ethnographic accounts coupled with MSM data may help to explain the differences seen between these two groups, especially regarding the habitual activity of walking great distances.

Overall, the MSM observations on the skeletal remains from the Golovin and Nunivak collections accord well with the recorded behaviors of traditional people in these regions. Some observations, such as the differences between males and females from both areas, suggest that, protohistorically, significant behavioral variations existed in the Bering Sea region. Identifying habitual behaviors ethnographically and testing hypotheses on skeletal remains from known cultural populations may help clarify some of these issues and help us assess the utility of MSMs in reconstructing the activities of earlier human populations.

The skeletal remains from Golovin and Nunivak represent behavioral patterns of the peri- and post-contact periods. Researchers have shown how the encroachment of modernization and Western industrialization in Arctic and sub-Arctic environments had an impact on local subsistence activities (Koutsky 1981; Ray 1975; Sheppard 1983). Although both populations were affected, the influence of mining among the peoples of the Golovin region was especially strong relative to Nunivak Island. Sheppard notes that many native people in the Golovin area "participated directly in mining and the activities that supported the mining community" (Sheppard 1983:122). Future research exploring the relationship between pre-and post- contact periods will no doubt increase our overall understanding of changing subsistence strategies of the Alaskan Eskimo people (see Chapter 4).

It is imperative that standardization of research methods, such as the recording and scoring of MSMs and other activity-related stress markers (e.g., osteoarthritis, accessory facets, trauma) be applied consistently in all skeletal studies. Implementation of standardized research methods will afford a sounder and more integrated approach for interpopulation studies, as well as provide a more complete picture of an individual's habitual activities.

## Figure 3.1: Map of Alaska

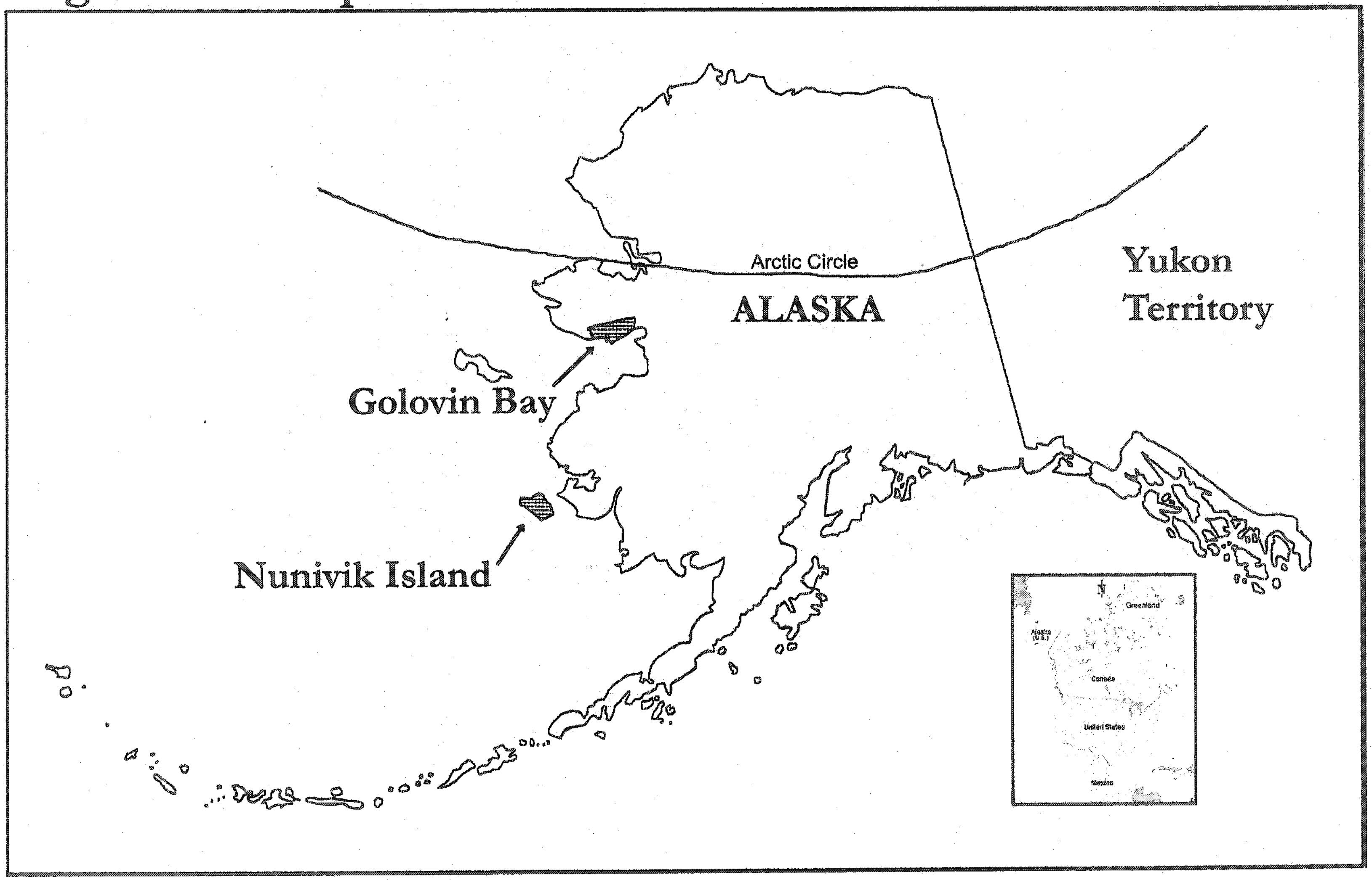

TABLE 3.1: MSM Data of Right Lateral Muscle Insertion Sites on Crania and Mandibles for Golovin Bay and Nunivak Island

| | Mean MSM Scores | | | | | | | | Significance levels based on ranks using Mann-Whitney U/Wilcoxon Rank Sum Test (Statistics: p-values) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Golovin Bay | | | | Nunivak Island | | | | | | | |
| | Males | | Females | | Males | | Females | | Males | Females | Golovin | Nunivak |
| Muscle Insertion Sites | mean | n | mean | n | mean | n | mean | n | G vs. N | G vs. N | M vs. F | M vs. F |
| **Muscles that Move the Lower Jaw/ Mandible** | | | | | | | | | | | | |
| Masseter | 2.2 | 22 | 1.9 | 31 | 1.9 | 29 | 1.1 | 22 | ns | 0.000 | ns | 0.000 |
| Pterygoid lateralis | 1.2 | 23 | 1.4 | 31 | 1.5 | 34 | 1.4 | 28 | ns | ns | ns | ns |
| Pterygoid medialis | 2.3 | 21 | 2.2 | 31 | 1.9 | 31 | 1.5 | 24 | ns | 0.001 | ns | 0.017 |
| Temporalis | 1.5 | 23 | 1.7 | 29 | 1.6 | 35 | 1.6 | 33 | ns | ns | ns | ns |
| **Muscles that Move the Head** | | | | | | | | | | | | |
| Rectus capitis | 1.8 | 34 | 1.4 | 43 | 1.9 | 46 | 1.5 | 55 | ns | ns | ns | 0.025 |
| Sternocleidomastoideus | 1.1 | 35 | 0.8 | 46 | 1.9 | 44 | 1.4 | 58 | 0.000 | 0.000 | ns | 0.000 |

Key: n=number of observations for given attachment site; G=Golovin Bay; N=Nunivak Island;
M=male; F=female; ns=not statistically significant

TABLE 3.2. MSM Data of Right Side Muscle and Ligament Attachment Sites on Upper Extremity Elements for Golovin Bay and Nunivak Island

| Muscle/Ligament Sites | Mean MSM Scores | | | | | | | | Significance levels based on ranks using Mann-Whitney U/Wilcoxon Rank Sum Test Statistics: p-values | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Golovin Bay | | | | Nunivak Island | | | | | | | |
| | Males | | Females | | Males | | Females | | Males | Females | Golovin | Nunivak |
| | mean | n | mean | n | mean | n | mean | n | G vs. N | G vs. N | M vs. F | M vs. F |
| **Muscles that Move the Shoulder/Pectoral Girdle** | | | | | | | | | | | | |
| Pectoralis minor | 2.0 | 13 | 1.5 | 23 | 1.3 | 13 | 1.8 | 8 | 0.021 | ns | ns | ns |
| Subclavius | 1.3 | 12 | 1.1 | 17 | 1.4 | 13 | 1.3 | 12 | ns | ns | ns | ns |
| Trapezius | 1.9 | 16 | 1.4 | 16 | 2.2 | 12 | 1.2 | 5 | ns | ns | ns | 0.008 |
| **Muscles that Move the Arm/Humerus** | | | | | | | | | | | | |
| Deltoideus | 2.6 | 13 | 1.9 | 23 | 2.0 | 16 | 1.4 | 20 | 0.023 | ns | 0.035 | 0.012 |
| Infraspinatus | | | | | 1.1 | 14 | 0.9 | 14 | | | | ns |
| Infra & Supraspinatus | 1.9 | 13 | 1.1 | 20 | | | | | | | 0.008 | |
| Latissimus dorsi | 2.2 | 13 | 1.2 | 22 | 1.5 | 14 | 1.2 | 20 | ns | ns | 0.006 | ns |
| Pectoralis major | 2.9 | 13 | 2.0 | 23 | 3.1 | 15 | 1.8 | 20 | ns | ns | 0.040 | 0.000 |
| Supraspinatus | | | | | 1.1 | 12 | 1.1 | 16 | | | | ns |
| Teres major | 3.0 | 13 | 2.0 | 23 | 2.5 | 16* | 1.6 | 20* | ns | ns | 0.004 | 0.003 |
| Teres minor | 1.8 | 12 | 1.4 | 20 | 1.3 | 10 | 1.0 | 13 | ns | ns | ns | ns |
| **Muscles that Move the Forearm/Ulna and Radius** | | | | | | | | | | | | |
| Anconeus | 1.9 | 16 | 1.4 | 20 | 1.9 | 15 | 1.6 | 14 | ns | ns | ns | ns |
| Biceps brachii | 2.3 | 14 | 1.5 | 19 | 1.7 | 14 | 1.3 | 16 | 0.036 | ns | 0.036 | ns |
| Brachialis | 2.2 | 15 | 1.7 | 21 | 2.4 | 16 | 1.9 | 14 | ns | ns | ns | 0.045 |
| Pronator quadratus | 1.8 | 11 | 1.3 | 18 | 0.9 | 15 | 0.6 | 12 | 0.004 | ns | ns | ns |
| Pronator teres | 1.7 | 13 | 1.3 | 19 | 1.0 | 11 | 0.9 | 10 | ns | ns | ns | ns |
| Triceps brachii | 1.9 | 11 | 1.3 | 12 | 1.7 | 9 | 1.4 | 10 | ns | ns | ns | ns |
| **Muscles that Move the Wrist, Hand, and Fingers** | | | | | | | | | | | | |
| Supinator | 1.7 | 15 | 1.1 | 21 | 0.9 | 16 | 0.8 | 15 | 0.005 | ns | ns | ns |
| **Ligament that Stabilizes the Shoulder/Pectoral Girdle** | | | | | | | | | | | | |
| Costoclavicular lig (clavicle) | 3.6 | 14 | 2.2 | 20 | 3.3 | 13 | 2.0 | 13 | ns | ns | 0.007 | 0.004 |

Key: n=number of observations for given site; G=Golovin Bay; N=Nunivak Island; M=male; F=female; ns=not statistically significant
* Reported as 7 and 6 for Nunivak Island males and females, respectively, in the IJO article.
These numbers were inadvertantly misread/misprinted from the original data caluculation sheets.
(They are the correct numbers for the left pectoralis major attachment on the humers.)

TABLE 3.3 MSM Data of Right Side Muscle Insertion Sites on Lower Extremity Elements for Golovin Bay and Nunivak Island

| | Mean MSM Scores | | | | | | | | Significance levels based on ranks using Mann-Whitney U/Wilcoxon Rank Sum Test Statistics: p-values | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Golovin Bay | | | | Nunivak Island | | | | | | | |
| | Males | | Females | | Males | | Females | | Males | Females | Golovin | Nunivak |
| Muscle Insertion Sites | mean | n | mean | n | mean | n | mean | n | G vs. N | G vs. N | M vs. F | M vs. F |
| **Muscles that Move the Thigh/Femur** | | | | | | | | | | | | |
| Adductor magnus | 2.7 | 20 | 1.7 | 27 | 2.0 | 19 | 1.7 | 20 | 0.005 | ns | 0.000 | ns |
| Gluteus maximus | 3.1 | 20 | 2.3 | 24 | 2.0 | 21 | 2.2 | 22 | 0.000 | ns | 0.000 | ns |
| Gluteus medius | 2.7 | 16 | 2.6 | 15 | 1.7 | 18 | 2.0 | 20 | 0.000 | 0.001 | ns | ns |
| Gluteus minimus | 2.5 | 16 | 2.6 | 19 | 1.9 | 17 | 2.1 | 18 | 0.016 | 0.031 | ns | ns |
| Iliacus | 1.6 | 21 | 1.0 | 27 | 0.8 | 21 | 1.0 | 20 | 0.000 | ns | 0.012 | ns |
| Obturator externus | 2.3 | 13 | 2.1 | 16 | 1.7 | 17 | 1.5 | 17 | 0.023 | 0.012 | ns | ns |
| Pectineus | 1.8 | 21 | 1.3 | 28 | 1.1 | 20 | 1.2 | 21 | 0.001 | ns | 0.020 | ns |
| Piriformis | 2.6 | 16 | 2.5 | 18 | 1.8 | 14 | 1.9 | 18 | 0.001 | 0.016 | ns | ns |
| Quadratus femoris | 2.3 | 15 | 1.7 | 18 | 1.3 | 16 | 1.4 | 16 | 0.000 | ns | 0.016 | ns |
| **Muscles that Move the Thigh (Femur) and Leg (Tibia and Fibula)** | | | | | | | | | | | | |
| Semimembranosus | 1.5 | 17 | 1.4 | 18 | 1.2 | 11 | 1.3 | 8 | ns | ns | ns | ns |
| **Muscles that Move the Leg/Tibia and Fibula** | | | | | | | | | | | | |
| Popliteus | 1.6 | 21 | 1.2 | 27 | 1.3 | 19 | 1.1 | 18 | ns | ns | ns | ns |

Key: n=number of observations for given attachment site; G=Golovin Bay; N=Nunivak Island; M=male; F=female; ns=not statistically significant

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# CHAPTER FOUR

## Introduction

From the wide array of popular magazines including *National Geographic* (Brandenburg 1991, Parfit 2000) to the myriad of scientific journals like the *American Journal of Physical Anthropology* (Costa 1982), from the plethora of coffee table books such as *The Eskimos* (Burch 1988) and *Crossroads of the Continents: Cultures of Siberia and Alaska* (Fitzhugh and Crowell 1988) to the cornucopia of academic texts such as *Ancient North Americans* (Jennings 1978), *The Arctic: Environment, People, Policy* (Nuttall and Callaghan 2000), *Living Arctic: Hunters of the Canadian North* (Brody 1987), *The Netskilik Eskimo* (Balikci 1970), and *The Greenland Mummies* (Hart Hansen 1991), people from the laity to academicians have had the opportunity to learn all they can about the lives of the first peoples of the North America. The daily lives of Alaskan Eskimos and other Arctic peoples has fascinated everyone from school children to researchers. Researchers have endeavored to explore the lives of Eskimos or Inuit through contemporary ethnoarchaeological studies (Binford 1978), paleopathological analysis (Merbs 1983), reports on Eskimo material culture (Murdoch 1988), and ethnographies (Lantis 1946, 1984; Nelson 1983).

One area of special interest in northern studies is the history of early Russian and American trade with Native peoples along the coast of

Alaska and into the interior as evidenced by the work of Gibson (1990), Haycox (1990), and Arndt (1990). For the most part, the study of the impact of foreign trade relations on Native peoples has been limited to the effects of infectious diseases such as measles and influenza, and the effects of alcohol and tobacco use and abuse (Fortunie 19989), with little attention to the effects related to the amount of work involved in creating a surplus of consumable goods in order to be a successful trader.

The purpose of this study was to compare two different cultural groups at Point Hope to see whether increased trade affected musculoskeletal stress, to compare musculoskeletal stress markers associated with different subsistence activities, and to compare sexual division of labor. To do so, I have included a comparison of the Point Hope data with similar data from Golovin Bay and Nunivak Island (Alaska; Figure 4.1) skeletal material, data which were previously published (Steen and Lane 1998) and are presented in Chapter Three. This research also allows for the independent evaluation of archaeological and ethnographic evidence which currently suggests that subsistence strategies differed between these groups and between males and females of each group.

## Materials and Methods

### *Materials*

During the summer of 1998, I studied the Point Hope skeletal collection that is housed at the American Museum of Natural History in New York City. This material was accessioned into the American Museum of Natural History collections between 1939 and 1941 as the result of a joint expedition by the Danish National Museum, Alaska State College (now the University of Alaska Fairbanks), and the American Museum of Natural History.

Point Hope, located on the Point Hope peninsula (the westernmost extension of the North American continent north of Bering Strait), is approximately 200 kilometers north of the Arctic Circle (Figure 4.1) and is one of the longest continuously occupied village sites in Alaska. Point Hope was first visited by Europeans briefly in 1826, but did not have direct and regular contact with non-indigenous peoples until the late 1850s (VanStone 1962). The Point Hope collection contains 611 skeletons, the conditions of which range from fair to excellent. The skeletal series under study spans approximately 1500 years and is thought to include three archaeological traditions, or cultural horizons: Ipiutak, Near Ipiutak, and Tigara (Larsen and Rainey 1948).

I collected data from 403 skeletons (188 males and 215 females) based on adults of known age and sex. Excluded from the study were children and subadults, adult skeletons that could not be reliably aged or sexed, individuals displaying severe pathological conditions, and individuals with extreme taphonomic deterioration.

I combined Near Ipiutak with Ipiutak because of the lack of significant statistical differences between these two groups and because Near Ipiutak represents less than 3% of the total Point Hope skeletal collection and has a sample size of less than ten (see Table 4.1). Additionally, the available radiocarbon dates for material associated with Near Ipiutak and Ipiutak overlap (Mason 1998). A further breakdown of the Point Hope collection revealed that skeletons identified as Ipiutak made up 18% of the study sample (71 out of 403), and those identified as Tigara, the largest of the groups, made up 63% (N=252). The remaining 80 skeletons (19%) were not identified as belonging to either Ipiutak or Tigara and were simply listed as "unknown" by Larsen and Rainey (1948). The "unknown" skeletons were not included in this analysis. Summaries of the Point Hope sample sizes for cultural horizons, sex and categories are given in Tables 4.1, 4.2, and 4.3 respectively.

*Methods*

Sex and age classifications were based on traditional criteria as outlined in the protocol developed by the Repatriation Office of the National Museum of History (Urcid and Byrd 1995; Verano and Urcid

1994) and the guidelines set forth in the *Arkansas Standards* (Buikstra and Ubelaker 1994). Through the use of these sex and age classification procedures, consistency was maintained between the Pt. Hope, Golovin Bay and Nunivak Island studies.

Drawing on on the work by Hawkey (1988) and Hawkey and Merbs (1995), I originally looked at nearly all of the muscle and ligament attachment sites on the skeletal system. This early pilot study proved to be very time consuming and unproductive in that many sites become obliterated over time through taphonomic processes and over-handling. From this original, and quite lengthy list, I reduced it to the muscles and ligaments from Hawkey's (1988) and Hawkey and Merbs' (1995) work, as well as prominent insertion sites of the skull and lower extremities. Thirty-five bilateral (left and right side, n = 70) muscle and ligament attachment sites per individual were scored for musculoskeletal stress markers (MSMs). Elements of the upper and lower extremities and the skull were examined, including the cranium (two bilateral sites), mandible (four sites), clavicle (two sites), scapula (two sites), humerus (seven sites), radius (four sites), ulna (three sites), femur (nine sites), and tibia (two sites).

Musculoskeletal stress markers were scored using Hawkey's visual reference system of photographs with descriptions, supplemented by descriptive information on muscle and ligament attachment sites developed to maintain consistency and comparability among and within observers (Hawkey 1988; Hawkey and Merbs 1995; Steen and Lane 1998; Steen *et al.* 1996). Musculoskeletal stress markers were scored on a scale ranging from 0 to 6, with 6 being the most extreme score (see Figures 4.2, 4.3, and 4.4; also Chapter Two for a more detailed discussion). The MSM scores are both ordinal and interval in nature, thus the distance between any two sets of MSM scores is assumed to be an equivalent distance; therefore the means are also meaningful. The visual reference system was chosen because it allows for the collection of data that could not be obtained using invasive techniques which were prohibited by Native elders.

Because musculoskeletal stress marker scores are recorded in an ordinal manner, nonparametric tests were employed. Nonparametric testing procedures do not make assumptions about the distribution (e.g., normality) of the sampled populations (Zar 1984). The Wilcoxon Matched-Pairs Signed Rank test was used to determine whether side dominance exists, whereas the Mann-Whitney U/Wilcoxon Rank Sum W test was used to assess differences within and between group comparisons. Alpha levels for all statistical tests were set at a conservative standard level of 0.05 (Sokal and Rohlf 1995). The Mann-Whitney U/Wilcoxon Rank Sum W test is, presently, the best statistical test available when dealing with ordinal data, small sample sizes, and two or more independent samples of unequal size (Kachigan 1986, Kitchens 1987, and Sokal and Rohlf 1995). With the Mann-Whitney U/Wilcoxon Rank Sum W test, it is the measure of the sum of the ranks that determines the results, not the means (Sokal and Rohlf 1995). The mean MSM scores are reported also to give the reader a better sense of the degree of expression in MSM scores recorded for each study group.

The Mann-Whitney U/Wilcoxon Rank Sum W test failed to demonstrate significant differences between the three age categories, young adult (20-34 years), middle adult (35-49 years), and old adult (50+ years) within either of the Ipiutak or Tigara groups. Because of this finding, all adult age categories were combined including those categorized as adults with an indeterminate age. The Wilcoxon Matched-pairs Signed Rank test failed to demonstrate a significant difference between any of the attachment sites on the right-side with those on the left for all comparisons. Thus, only the muscle and ligament attachment sites from the right-side of the skeleton are presented here.

The method employed in this research is the nonmetric approach, which does not call for measurements, radiography, or invasive bone samples. Inter- and intra-observer error has proven negligible ($p<0.05$) in a variety of studies utilizing this type of visual reference system for scoring human remains (Hawkey 1988; Hawkey and Merbs 1995; Hawkey and Street 1992; Lane and Steen 1996; Nagy and Hawkey 1993;

Peterson 1994; Scott *et al.* 1993; Steen and Lane 1998; Steen *et al.* 1996; Street and Hawkey 1992). For the current study a 10% random sample of individual skeletons were re-scored and compared to the original data. The Wilcoxon Matched-pairs Signed Rank test, used to compare the two samples, demonstrated no significant difference between the two samples.

As with any research design, limitations are implicit and unavoidable. The skeletal collection studied spans approximately 1500 years and may include three different cultural horizons—Ipiutak, Near Ipiutak and Tigara–however, I have collapsed Ipiutak and Near Ipiutak into one group (see discussion above). It is assumed that people from outside the Point Hope community were assimilated fully into the community and engaged in subsistence activities appropriate to their age and sex.

The validity of this method is discussed in Chapter Two. Briefly, a review of the literature (medical, sports medicine, and anthropological) confirms that the use of musculoskeletal stress marker data, whether collected by a visual reference system, radiography, or core or thin sections, is a viable method for use by physical anthropologists.

## Results

*Point Hope: Ipiutak and Tigara Comparisons*

The results of the comparisons between and among Ipiutak and Tigara males and females are presented in Tables 4.4, 4.5, and 4.6 for the skull and upper and lower extremity elements respectively.

*Muscle Insertion Sites on Crania and Mandibles:* There was no difference in MSM scores between the Ipiutak males and females for the group of muscles involved in moving the lower jaw. However, there was a significant difference in the MSM scores of the two muscles that move the head–the *rectus capitis* and *sternocleidomastoideus*. In all cases the mean MSM scores for the Ipiutak males were higher than for the Ipiutak females. There was a statistically significant difference in the MSM scores for all of the muscles of the skull between the Tigara males and Tigara females. When comparing the Ipiutak males and the Tigara males, the Tigara males had mean MSM scores which were consistently higher than their Ipiutak counterparts, however, there was a significant difference only in MSM scores for all of the muscles that move the lower jaw, but not with the muscles that move the head. There were no MSM scores for the skull muscles that were significantly different between the Ipiutak females and Tigara females.

*Muscle and Ligament Attachment Sites on Upper Extremity Elements:* Overall the Ipiutak males had higher mean MSM scores than the Ipiutak females for the muscles and ligaments of the upper extremity muscles and one ligament. There was no difference in MSM scores between the Ipiutak males and females for the muscles that move the shoulder, arm, wrist, hand and fingers. There were some differences in the MSM scores between the Ipiutak males and females for the *costoclavicular ligament* and some of the muscles that are used in moving the forearm. In all cases the mean MSM scores for the Tigara males was higher than for the Tigara females, however, only in four cases was there no significant difference between them. When comparing the Ipiutak males with the Tigara males, in most cases there was no significant difference between their MSM scores. When there was a difference (only four cases), there was no apparent pattern, for example, the Ipiutak males had higher mean MSM scores for the *pectoralis minor* (a muscle that moves the shoulder girdle) and the *teres major* (a muscle that moves the arm). The Tigara males had higher mean MSM scores than did the Ipiutak males for the *pronator quadratus* and *pronator teres*, both of these muscles are used when moving the forearm. A somewhat similar pattern is evident with the MSM scores for the Ipiutak and Tigara females. In most cases there was no significant differences in the MSM scores between them, however, when there was, no apparent pattern emerged. When there was a significant difference between the Ipiutak and Tigara females, the Ipiutak females had higher mean MSM scores for the *subclavius* (a muscle that moves the shoulder girdle), the *teres major* ( a muscle that moves the arm), and the *brachialis* (a muscle that moves the forearm). The Tigara females had a higher mean MSM score (when there was a significant difference) only for the *pronator teres* (a muscle that moves the forearm).

*Muscle Insertion Sites on the Lower Extremity Elements:* There was no statistically significant differences in the MSM scores of the muscle insertion sites on the lower extremity elements between the Ipiutak males and females. The mean MSM scores was consistently higher for the Tigara males over their female counterparts. There was a significant difference in MSM scores in a majority of muscles that move the thigh and in the one muscle observed that moves the both the thigh and leg. When there was a significant difference in the MSM scores between the Ipiutak males and Tigara males, the mean MSM scores for the Ipiutak males was higher than for their Tigara counterparts. This same pattern holds in the comparison of the Ipiutak and Tigara females.

*Multipopulation Comparison*

The results of the Mann-Whitney U/Wilcoxon W Test comparing the MSM data from the Ipiutak and Tigara with those from Golovin Bay and Nunivak Island is presented in Tables 4.7, 4.8, and 4.9 for the skull and upper and lower extremity elements respectively.

*Muscle Insertion Sites on Crania and Mandibles:* When there was a significant difference in the MSM scores between the Ipiutak males and those from Golovin Bay, the Golovin Bay males had higher mean MSM scores than did the Ipiutak males. The mean MSM scores were higher for the males of Nunivak Island than for the Ipiutak males when there was a significant difference in MSM scores between them. The pattern of significant differences in MSM scores between the Tigara and Golovin Bay males was a bit confounded, for example there was only one significant difference between them among the muscles that move the lower jaw, the *masseter muscle* which is a power muscle of mastication. In this case the mean MSM score was higher for the Golovin Bay males than the Tigara males. However, for the two muscles that move the head the mean MSM scores for the Tigara males was higher than for their Golovin Bay counterparts. There was no difference in MSM scores between the Tigara males and the Nunivak Island males with one exception. Not only was the mean MSM score of the *sternocleidomastoideus muscles* higher for Nunivak Island males than the Tigara males, there was also a significant difference between their two MSM scores.

The mean MSM scores for the Golovin Bay females was higher than for Ipiutak females, and significantly different, for all but one of the muscles involved in moving the lower jaw. There was no difference in

MSM scores between the females of Golovin Bay and Ipiutak for the muscles involved in moving the head. There were only two MSM scores that were significantly different between the Ipiutak females and those from Nunivak Island, in both cases the mean MSM scores for the Nunivak Island females was higher than for the Ipiutak females. All of the MSM scores, for the Tigara and Golovin Bay females, for the muscles that move the lower jaw were significantly different with Golovin Bay females having higher mean MSM scores over their Tigara counterparts. The mean MSM score for the *sternocleidomastoideus* muscle was not only significantly different between these two groups, but it had a higher mean MSM for the Tigara females than for the Golovin Bay females. When there was a significant difference in the MSM scores for the muscles of the skull the Nunivak Island females had higher mean MSM scores than did the Tigara females.

*Muscle and Ligament Attachment Sites on Upper Extremity Elements:* When there was a significant difference in MSM scores between the Ipiutak and Golovin Bay males, the mean MSM scores were higher for Golovin Bay than they were for Ipiutak. This same pattern holds true when comparing the males of Golovin Bay and Tigara. When there was a significant difference in MSM scores between the Ipiutak and Nunivak Island males, the mean MSM scores were higher for Nunivak Island than they were for Ipiutak. The pattern between the males of

Tigara and Nunivak Island is not as clear. In some cases when there was a significant difference in MSM scores between the Tigara and Nunivak Island males the Nunivak Island group had higher mean MSM scores, especially in the group of muscles that move the shoulder and the arm, and in one of the muscles that move the forearm. However, the Tigara males had higher mean MSM scores for two of the muscles that move the forearm and the one muscle that moves the wrist, hand, and fingers.

The females from Ipiutak and Golovin Bay were most similar in their MSM scores for the muscles and one ligament of the upper extremity elements with one exception. There was significant difference in the *deltoideus muscle* with the mean MSM score higher for the Golovin Bay females than for the Ipiutak females. Again, there was very little difference (only two muscles) in the MSM scores between the Ipiutak and Nunivak Island females. Of those MSM scores that were significantly different, the Nunivak Island females had a higher mean MSM score for the *pectoralis minor* (a muscle that moves the shoulder girdle), while the Ipiutak females had a higher mean MSM score for the *pronator quadratus* (a muscle that moves the forearm). When there was a significant difference in the MSM scores between the Tigara and Golovin Bay females, the mean MSM scores for the Golovin Bay females was higher than for the Tigara females. The pattern of MSM scores is not as clear between the Tigara and Nunivak Island females. When there was a significant difference in the MSM scores between them, the Nunivak Island females had higher mean MSM scores for the muscles that move the shoulder girdle and the arm, and in two of muscles that move the forearm. On the other hand the Tigara females had higher mean MSM scores for one of the muscles that move the forearm and in the muscle that moves the wrist, hand, and fingers.

*Muscle Insertion Sites on the Lower Extremity Elements:* There was a significant difference in the MSM scores between the males of Ipiutak and Golovin Bay, with the Golovin Bay group having higher mean MSM scores over their Ipiutak counterparts. Over all the Ipiutak and Nunivak Island males had very similar MSM scores with regard to the muscles insertion sites of the lower extremities. There was only one exception to this, the MSM score for the *iliacus* (a muscle that moves the thigh) was significantly different and it had a higher mean MSM score for the Ipiutak males than for the Nunivak Island males. All of the MSM scores for this group of muscles of the Tigara and Golovin Bay males were significantly different, with one exception. There was no significant difference in the MSM score for the *semimembranosus* (a muscle that move both the thigh and the leg). In all cases with a significant difference the mean MSM scores for the Golovin Bay males was higher than for the Tigara males. When there was a significant difference in the MSM scores between the

Tigara and Nunivak Island males, the mean MSM scores for the Nunivak Island males were higher than for the Tigara males.

In comparing the MSM scores from the Golovin Bay females with those from Ipiutak and Tigara, when there was a significant difference between them Golovin Bay females also had higher mean MSM scores than their Ipiutak and Nunivak counterparts. This same pattern holds true for the Nunivak Island females in comparisons with both Ipiutak and Tigara females.

*Same Data, Different Perspective*

I have presented the percentage of individual MSM scores (0 through 6) for each of the four populations based on sex. These are displayed in Tables 4.10 through 4.15. In looking at the overall picture based on this representation the most enlightening find is the spread, or lack thereof, of MSM scores. For example, in Table 4.10 the MSM scores for Ipiutak is centered between the score of one and two with a few individuals who received a score of three. The Tigara males had MSM scores between one and three. A similar pattern is found among the males from Nunivak Island with one exception--a few individuals received a score of zero for the *pterygoid lateralis muscle*. On the other hand the Golovin Bay males had MSM scores between zero and three. A very similar pattern of MSM scores is seen for both the males and females and the three different body portions (skull, upper extremities, and lower extremities). That is, the MSM scores for Ipiutak and Tigara appear to center around a few of the MSM scores (for example, between an MSM score of one and two in Table 4.11), while the MSM scores for Golovin Bay and Nunivak Island are spread over a wider range of MSM scores.

**Discussion: Background Information on the Ipiutak and Tigara**

If nothing else were known about any of these people, a discussion of the study results would be very limited. At best, without further information, one could conclude that the data provided indicate that the people of Golovin Bay and Nunivak Island appear to be more robust than the Ipiutak or Tigara people and that males appear to be more robust than females. If indirect and direct evidence (*e.g.,* oral histories, ethnographies, and archaeological records) were absent, then perhaps we would not be able to explain the reasons behind the distinctive skeletal morphology. Fortunately, a wealth of anthropological information does exist about these peoples. New findings can either refute past understandings (for example, not all Eskimo women routinely chewed hides and skins to soften them for clothing manufacture; see Chapter Three) or can strengthen previous findings. Before the results are given, a discussion of the Ipiutak and Tigara cultures is necessary. Golovin Bay and Nunivak Island trade relationships are briefly discussed below. For a discussion of the Golovin Bay and Nunivak Island subsistence practices, see Chapter Three.

Point Hope is one of the longest continuously occupied village sites in Alaska, with the Near Ipiutak culture dating back to approximately 365 BC, and a terminal date for the Ipiutak culture of roughly AD 1400 (Costa 1980, 1982; Mason 1998). Costa (1980, 1982) and Hosley (1968) assert that the dates for the Tigara culture, also at Point Hope, may extend back to approximately 300 to 400 years BP (ca. AD 1600-1700) and may have lasted until modern times (ca. late-800s to early-1900s). In the intervening years, between the habitations of the Ipiutak and Tigara, Point Hope was most likely inhabited by Birnirk and perhaps Western Thule peoples. However, these two groups were not represented in the skeletal collections and thus are not part of this study (Larsen and Rainey 1948).

*The Ipiutak People*

The Ipiutak peoples of Point Hope thrived long before the arrival of European whalers and traders (365 BC to AD 1400). The first officially recorded European contact with the people of Point Hope was by Captain Beechey, an event which did not occur until 1826–a date consistent with the Tigara culture at Point Hope, not that of the Ipiutak. It would take another 25 years, however, before this contact could be considered direct and continual (Chance 1966, VanStone 1962). Langdon notes that the relatively isolated location of the North Coast Eskimos "made them one of the last groups of Alaskan Natives to encounter European and Americans" (1989:33). Therefore, there was no commerce activity between European concerns and the Ipiutak of Point Hope. This lack of European contact among the Ipiutak provides a unique opportunity to use the Ipiutak people of Point Hope as an anthropological constant to further evaluate the effects of contact on other indigenous populations of Alaska, specifically the people of Golovin Bay, Nunivak Island, and Tigara, all of whom lived during post European contact times.

The people of Point Hope, including both Ipiutak and Tigara, have been called the *Tareumiut*, or people of the sea (Langdon 1989) because of their heavy dependence on maritime resources for subsistence. The Ipiutak peoples are known as a whale hunting culture, subsisting primarily on sea mammal resources such as bowhead whales, bearded and hair seals, belugas, and walruses. Secondary resources included birds and caribou. Rainey and Larson (1948) noted that typical fishing equipment was either not represented or greatly under-represented in the Ipiutak tool kit, indicating that they did not readily rely on fish as a sustainable resource.

Although there is no direct ethnography of the Ipiutak people the use of an ethnographic analogy is possible. Asher (1961) noted that five conditions should be met in order for an ethnographic analogy to be considered a good fit. These conditions are that the two cultures under comparison 1) exploited similar environments in similar manners, 2) had similar economies; 3) had comparable technological developments; 4) lived in the same geographic region, and 5) were relatively close in time. (1961). Hudecek-Cuffe noted that "the greater the similarity in the entire context between the two examples being compared, the greater was the plausibility of the analogy" (1998:58). The work of Burch (1998, 1988) Spencer (1959), Nelson (1969), Boas (1964), Chance (1966), and others (Binford 1983, Langdon 1989, Nelson 1983, and Ray 1992) provide the means for an ethnographic analogy between Arctic peoples and the Ipiutak people for whom there is no direct ethnography available.

The division of labor among Ipiutak males and females was complementary, yet strictly divided as well as being very hierarchical; males were dominant. In the simplest sense of the term, "division of labor" meant that women were responsible for hide and skin preparation (*e.g.,* tanning, sewing, manufacturing and repairing clothes and boots), food preparation (*e.g.,* butchering, storing, cooking), childcare and other household duties including the gathering and chopping of fire wood–drift wood collected on the beaches, since there are no trees in the Arctic. Men, on the other hand, were responsible for providing food resources such as those listed above, keeping their families and the village safe from outsiders, including other Eskimo groups or neighboring Athabaskan peoples. Although there was a strong division of labor, Chance (1966) noted that men and women knew how to perform each other's tasks and could do so when required. Knowledge of how to perform duties typically done by men would have, no doubt, been a very beneficial cultural adaptation for women, especially in times of poor harvests resulting in food scarcity. This very brief description of the subsistence patterns of the Ipiutak does not do justice to the complexity of their culture which was replete with complex social organizations, beliefs and religious customs, seasonal and sexual taboos, and ceremonies such as the Messenger Feast, *Nalukataq* (a celebration of a successful whale hunt), and the other multifaceted aspects of their culture.

Upon death, it was common for Ipiutak people to be buried with items that served them well in life for their journey into the afterworld (Larsen and Rainey 1948). Perhaps, if Ipiutak women did engage in hunting activities, then the tools associated with these activities may be found among their grave goods (Conkey 2001). Indeed, Ipiutak tools associated with harvesting or hunting small animals such as birds and other small mammals (*e.g.,* foxes and squirrels) were found in association with some female burials. For example Burial 108 contains a female skeleton along with a variety of harpoon heads, including those used in whale hunting. Other items include bird darts, gull hooks, salmon spears, and other small stone tools such as projectile points (referred to as "arrowheads;" Larsen and Rainey 1948). Other grave goods associated with female burials are more consistent with the prevailing stereotype of "women's tools" such as scrapers for cleaning and preparing skins; a variety of knives used in butchering; sewing kits; lamps; and ornamental pieces. Likewise, tools associated with hunting large sea mammals–whales, walruses, belugas and seals–such as harpoons and foreshafts have been found in connection with male burials.

Both men's and women's burials associated with the Ipiutak lacked pottery and other items of foreign trade that were frequently associated with Tigara burials. The Ipiutak people did engage in trading activities, typically with well-established trading partnerships between the coastal Eskimos (*Tareumiut*) and inland Eskimos (*Nunamiut*, people of the land). Langdon reports that "seal oil and *muktuk* (whale skin) were prized by interior peoples who provided caribou and other fur skins in exchange for them" (Langdon 1989:28).

*The Tigara People*

First contact with the people of Point Hope occurred in 1826. Larsen and Rainey stated that the village site of "Tigara was discovered by Captain F.W. Beechey, commander of H.M.S. 'Blossom,' in [August of] 1826 during his cruise through Bearing Strait and along the northwest coast of Alaska in search of the lost Franklin expedition to arctic America"

(1948:25). At the time of contact, the Tigara people were engaged in subsistence strategies thought to be very similar to those of the Ipiutak, which included hunting the primary ocean resources of sea mammal (*i.e.*, whales, bearded and hair seals, belugas, and walruses), and relying on secondary resources including fish, as well as birds and caribou. Fishing paraphernalia were considerably more common in the Tigara than in the Ipiutak tool kit (Rainey and Larson 1948), indicating an increased reliance on fish resources for subsistence.

Although a division of labor among the Tigara was evident, it may have been more flexible in specific areas, such as child care and housekeeping (Chance 1990, 1966, Nelson 1969 and Spencer 1959)--a reflection of changing times as influenced by outside sources such as trading partners and religious missionaries. However, for the most part men engaged in the more traditionally "men's work" of hunting, fishing and otherwise providing for the family. Meanwhile women engaged in "women's work," which included traditional hide and skin preparation, food preparation, childcare and other household duties. A new duty or task not seen at this level before among the peoples of Point Hope was engaging in foreign trade activities, which may have strengthened the division of labor for other chores; for example hunting and sewing.

By the time Beechey and his crew reached the village site of Tigara in 1826, an elaborate and far-reaching trade network with other

Eskimo groups, interior Athepaskans, and Russians was already well developed. Writing in his journal, Beechey noted that the local peoples "had copper kettles, and were in several respects better supplied with European articles" than other people he had encountered on his voyage (in Chance 1996:12). Beechey also noted that it was most likely that the copper kettles had originally come from trade with the Russians (in Chance 1996). John Simpson, a ship's doctor on the Blossom, learned of the elaborate and wide-spread Eskimo trading system while the ship and its crew over-wintered at Point Barrow, roughly 600 km northeast of Point Hope. Chance (1966) pointed out that Simpson wrote about the details of four great Eskimo trade centers: Cape Prince of Wales, Kotzebue, Point Barrow, and Barter Island. Simpson noted that it was through Cape Prince of Wales that items from Asia seemed to enter the Eskimo trading system. Point Hope, one of many secondary trade centers, witnessed its fair share of trading activity. For example, during the winter months when travel by dog sled was easy, people from Point Barrow routinely traveled to Point Hope to trade goods that they had traded for with people from various villages in the Mackenzie delta region (Chance 1966). Typical trade goods that the Tigara people desired included iron and copper kettles, black tobacco, liquor, beads, knives, guns, ammunition, and matches, as well as foodstuff such as flour, sugar, and molasses, all of which could be bartered for with whale and seal oil, whalebone, walrus tusks, seal skin, consumable maritime products, caribou meat, fur clothing and boots, and a variety of tanned furs (Chance 1966). Chance maintains that at one time "as much as $200 worth of furs and other goods might be exchanged for one bottle of whiskey" (1966:14). By the late 17$^{th}$ century, after the establishment of Russian outposts in Siberia, trade was indeed a very important part of Eskimo life, including the Tigara's. These early Russian outposts made tobacco and other European goods (*e.g.*, pottery, beads, knives, guns, and ammunition) available through initial exchange with the Chukchi and throughout the elaborate Eskimo trading system.

*Trade Relationships with Golovin Bay and Nunivak Island*

Like the Tigara and other coastal Eskimos, the people of Nunivak Island and Golovin Bay used local resources for barter with early Russian explorers and traders. Typically, the items that people from Golovin Bay and Nunivak Island used for trade included bearded-seal skin, fox furs, seal oil, and seal and walrus line. In exchange for these items, they desired leaf tobacco, flour, rifles and ammunition (lead and gunpowder), matches, knives, needles, and, later, calico print cloth. Ray (1992) notes that Captain Cook traded with the people of the Golovin Bay region, and at one stop bartered four knives for approximately four hundred pounds of fresh fish. Likewise, Fortuine wrote that "the Native people were not without greed themselves in their willingness to trade their abundant furs for the tools and trinkets of a different culture" (1989:102). From these and other accounts it is clear that trade between Eskimo (and perhaps other Native Alaskan groups) and outsiders was perhaps not always equal.

*Summary*

It may not be clear the extent of the effect contact with Russian and European American traders had on indigenous peoples, like the Alaskan Eskimos; however, it is clear that there was a lasting effect. Rifles, ammunition, and knives may have improved certain subsistence activities; however, tobacco, beads, decorative items, and non-indigenous foodstuffs (*i.e.,* tea and flour) could only unbalance the economy as these items did not support the basic necessities of life–shelter, food (including fresh water), and clothing. Eskimo people who traded with early Russian explorers and later European Americans not only had to be successful hunters who could obtain surpluses for trading purposes, but also still had to provide their families with an adequate level of food and hides for survival. It is important to recognize that the items used by Russians, Europeans and Americans for trade were not products related to subsistence, meaning that they could not be consumed for their nutritive value, and none of these items were produced or grown locally. On the other hand, the items used by Alaskan Natives for trade had three things in common. First, they were all products of subsistence–food, clothing, and tools (*e.g.*, meat and fish, furs, hides and skins, and bone and antler). Second, they were all locally available; however, their supply fluctuated with annual cycles, yearly climate changes, and rate of harvesting. Third, much work was required to obtain and prepare various items for trade–successfully hunting a caribou, butchering it, tanning the hide, making various articles of clothing or ornamentations, not to mention traveling to one of the major Eskimo trade centers.

Richard Lee (1968) argued that hunter-gatherers had more free-time than agricultural or industrial groups; that is, they did not spend every waking hour of every day engaged in strenuous hunting and gathering activities. Lee (1968) suggested that after a successful hunt, the hunters and their extended families could, to some extent, sit back and relax. Hunter-gatherers had a lifestyle that required less work per day, or per season than those engaged in other forms of subsistence such as nomadic herding or agriculture–termed the original affluent society by Sahlins (1968, 1972). Although Lee (1968) and Sahlins (1968, 1972) discussed African hunter-gatherers, this may have been the case for various Alaskan Eskimo peoples prior to the period of contact with traders from distant lands. However, with the trade activities in the forefront, the people of Golovin Bay and Nunivak Island, and the Tigara of

Point Hope were no longer solely hunter-gatherers; they were also actively engaged in trade commerce. Their desire and need to engage in trade required them to work longer hours per days and more days per season, or both, in order to fulfill the dual responsibilities of trading and meeting the needs of their families. Hence, the question begs to be asked, "If trade activities required Eskimo people to work harder and longer, would this type of activity be evident in their skeletal remains?" The answer to this may be found in a discussion of musculoskeletal stress marker data collected from pre- and post-contact Alaskan populations.

**Discussion of Results**

*Point Hope Intra-population: Differences Between the Sexes*

It is not surprising that the overall mean scores for males were higher than those for females and that some significant differences exist between males and females in both the Ipiutak and Tigara groups. This is due in large part to the human sexual dimorphism–differences in physical characteristics between males and females; that is, males, in general, are larger (*e.g.,* taller and heavier) and stronger than females. Through ethnographic analogy it appears that both Ipiutak and Tigara sociocultural rules called for the separation of men's and women's work. With these two things in mind (that is, sexual dimorphism and sexual division of labor) it is not surprising that the MSM data showed differences between the scores of males and females.

The current study suggests two plausible scenarios that, together, may explain the similarities in the MSM data between Ipiutak men and women. First, they may have engaged more frequently in each others' duties or in similar activities. Second, as Lee (1968) and Sahlins (1972, 1968) claimed life for hunter-gatherers was not as stressful as it was for others engaged in different forms of subsistence. By extension, this may also be plausible for the Ipiutak who were hunter-gatherers, but did not actively engage in rigorous trading activities–procuring a surplus for future trade. The first scenario may be difficult to substantiate because there are no first-hand accounts for the Ipiutak people. For example, Chance (1990, 1966) pointed out that although there was a strict sexual division of labor, it was imperative for men and women to be able to perform the others' duties in times of need. However, Hickey (personal communication 2002) feels that men and women rarely, if ever, performed each others' duties mainly due to their strict social structure as noted by Langdon (1989) and Spencer (1959).

However, there is an archaeological record for the Ipiutak of Point Hope. As previously mentioned, based on grave goods found in association with female burials, there is evidence that Ipiutak women may have been engaged in a variety of non-traditional female activities. The second scenario (more leisure time) appears equally plausible because rest is very important for general overall health, and body maintenance (Tortora 1995, Tortora and Grabowski 1993). If, as Lee (1968) and Sahlins (1972, 1968) argued, hunter-gatherers had more free time, this may account for fewer overall differences within the Ipiutak population. Citing Balikci as a possible ethnographic analogy, "the Netsilik Eskimos had plenty of leisure time for gossiping and playing games" (1970:46). Rest or leisure time is needed for bone, muscle and ligament maintenance and repair as well as for the fostering of overall good health (Tortora 1995, Tortora and Grabowski 1993). Giardini and Eggers (2002) did not find any significant differences between Ipiutak males and females based on health indicators (*e.g.,*cribra orbitalia and oral health) and selected activity markers (*e.g.,* osteoarthritis and trauma). This study supports their findings, suggesting that based on health indicators and activity markers, including MSMs, Ipiutak men and women had fairly equal access to nutritious foods, proper hygiene, and adequate amounts of rest. Currently, it is not possible to delineate further between these two plausible scenarios; *i.e.,* more frequent engagement in duties performed by the opposite sex and increased periods of rests. Perhaps a more realistic view is a holistic one which incorporates components of both.

The differences in MSM scores between the males and females of Tigara may be related to a combination of sexual dimorphism and sexual division of labor. However, overall health may have also played an important role in the number of differences seen among the Tigara. Giardini and Eggers (2002) claimed to have found a substantial number of differences in *cribra orbitalia* , antemortem tooth loss, and dental wear, with females having been more affected than males. From this evidence, Giardini and Eggers (2002) contend that females had poorer diets (*e.g.,* they ate foods that were lower in nutritional values and that were harder to masticate) than males. On the other hand, Giardini and Eggers (2002) also found evidence, based on lumbar arthritis, suggesting that, among other things, men engaged more frequently than females in strenuous activities that also included carrying heavy objects. This coincides with the current MSM data suggesting that Tigara males exhibited greater muscular development than Tigara females.

*Point Hope Inter-population: Differences Between Ipiutak and Tigara*

The most interesting aspect of the differences is in the pattern of statistically significant difference–Tigara males and females have higher mean MSM scores than Ipiutak in nearly all of the MSM sites on the cranium, mandible and the elements of the upper extremities, showing significant differences. This pattern does not hold true for the MSM scores of the lower extremities, in which the mean MSM scores are higher for the Ipiutak males and females than for their Tigara counterparts.

Giardina and Eggers (2002) describe similar findings among Tigara males and Ipiutak males for appendicular arthritis and spondylolyses–both of which have been used as markers of occupational stress by Merbs (1983).

At present, no single logical explanation has emerged so a more reasonable multi-causal approach may be more appropriate, especially when focusing on subsistence activities and the introduction of foreign trade goods. For example, Tigara males used various muscles of the upper extremities (*i.e., pronator quadratus, pronator teres*, and *supraspinatus*) to a greater extent than the Ipiutak. The *pronator quadratus* and *pronator teres* muscles are used in the pronation of the forearm and hand, and the *supraspinatus* is used in strengthening the shoulder joint. As noted by Lai and Lovell (1992), Hawkey and Merbs (1995), and Capasso, *et al.* (1999) these muscles are used in the manual operation of various watercraft, such as the *umiak* (a large open skin boat) used by the Ipiutak and the Tigara. Tigara males also used various muscles of mastication (*e.g.* the *temporalis, masseter,* and the *pterygoids*) to a greater extent than Ipiutak males. These same muscles are used when employing the teeth as tools. Costa (1980) asserts that anterior antemortem tooth loss was greater among Tigara males than the Ipiutak males, and this fact combined with the higher MSM scores for muscles of mastication, supports the hypothesis for the more frequent use of teeth as tools among the Tigara. What might account for this? Larsen and Rainey's (1948) archaeological evidence suggests that the Tigara people relied more heavily on a combination of sea mammals and fish, activities that would require more time spent in *umiaks* than the Ipiutak. Additionally, verification of foreign trade activity among the Tigara (Chance 1964) suggests that they had to work harder to secure a surplus for trade and to maintain adequate supplies for their families. These two factors most likely contribute to the differences seen between the Tigara and Ipiutak males as evidenced in the MSM scores of the skull and upper extremities.

One might assume that if various muscle attachment sites were more robust for one group over another in one part of the body, the same should hold true for other parts of the body. This was not the case with the Ipiutak and Tigara males with regard to the muscles of the lower extremities. Overall, Ipiutak males had higher mean MSM scores than Tigara males for those muscle attachment sites which were statistically different, primarily the muscles used in walking long distances over uneven terrain (Capasso 1999). This anomaly may be a reflection of a migratory subsistence strategy. Larsen and Rainey (1948) assert that the Ipiutak people migrated on a seasonal basis, spending the summer on the coast and the winters further inland. The archaeological material which supports Larsen and Rainey's (1948) assertion is based on the presence of open fire pits versus lamps, which require wood rather than oil, a reliance on caribou hunting as evidenced by the quality and quantity of projectile points, and a preference for antler in tool making over walrus ivory (1948:146). The annual migration pattern coupled with caribou hunting most likely account for the differences seen in MSM scores of various lower extremity muscle attachment sites.

There are several factors that may contribute to the seemingly random higgledy-piggledy results comparing all four groups. Three of the groups, Tigara, Golovin Bay and Nunivak Island, were roughly contemporaneous with each other, while Ipiutak is the outlier, as far as the time-frame is concerned. On one hand, two of the four groups, Golovin Bay and Nunivak Island, appear to have been more heavily involved, than either Tigara or Ipiutak, in trade relationships between Russians, Europeans, Eskimos, and interior Athapaskan. On the other hand, Tigara was definitely more involved in foreign trade than Ipiutak, because Ipiutak culture disappeared prior to the onset of Russian and European trade. Ipiutak and Tigara were from the same geographical region which was different from that of either Nunivak Island or Golovin Bay. Point Hope, home of the Ipiutak and Tigara, is located north of the Arctic Circle, while both Golovin Bay and Nunivak Island are south of the Arctic Circle. Three of the four groups, Ipiutak, Tigara and Golovin Bay, were located on the mainland, while the people from Nunivak were island dwellers. All four groups had different subsistence strategies ranging from heavy reliance on sea and land mammals (Ipiutak) to the readily incorporation of fish into a subsistence strategy which included seals, walrus, belugas, and birds (Nunivak Island), to an economy based on sea and land mammals, fish, birds and other smaller land mammals (Tigara) and to a highly mixed economy (Golovin Bay). The people of Golovin Bay may have been more influenced by foreign intruders who set up mining operations in their area that employed local people in a cash-based economy. All four groups traveled on a somewhat seasonal basis, but Golovin Bay and Ipiutak people most likely traveled more frequently and over longer distances than either the people of Nunivak Island or the Tigara people of Point Hope. Although all four groups exhibit both similarities and differences in social organization, all groups adhered to, to varying degrees, the sexual division of labor.

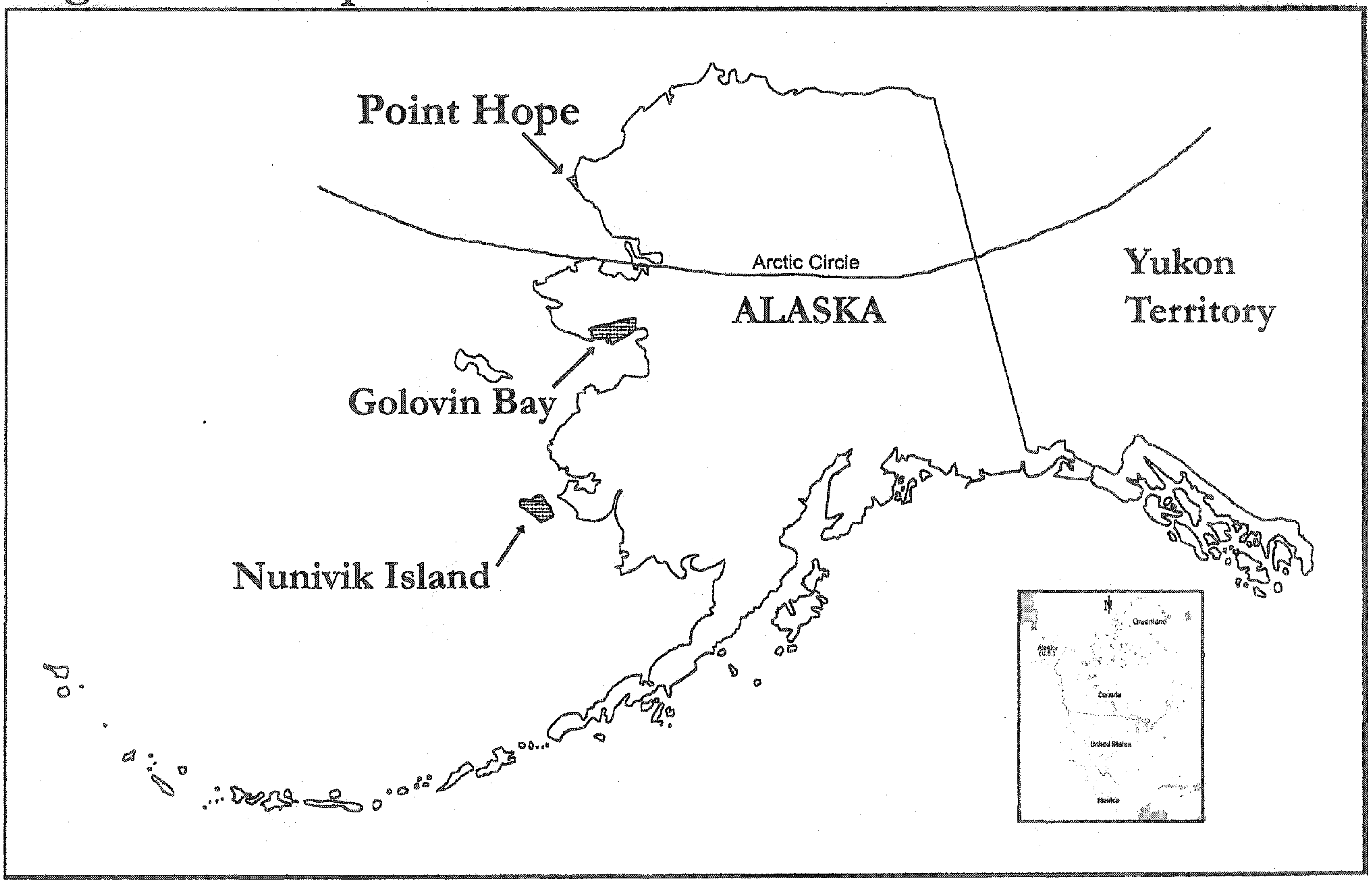
Although some of the actual mean MSM scores may seem low, with MSM scores between one (Faint Expression: Slightly visible and palpable; slightly enlarged) and two (Moderate Expression: Definitely visible and palpable; somewhat enlarged, see Table 2.3), the most notable conclusions concern the statistically significant differences between various groups and the range of MSM scores for each group under study.

## Conclusion

Overall, the MSM observations on the skeletal remains from the Point Hope collections (Ipiutak and Tigara), as well as those from Golovin Bay and Nunivak Island, help us better understand the effects of increasing foreign trade activities among Alaska Native groups. It appears as if the Ipiutak people may have engaged more frequently in tasks traditionally associated with the other sex, and had more leisure time to rest and recover from strenuous daily activities, or a combination of both. Using the Ipiutak as a pre-contact constant to compare post-contact peoples, it seems as if increased trade activities from foreigners (*i.e.,* Russians, Europeans and non-Native Americans) may have not only stimulated the local economy but may have added to health related stresses (also see Fortunie 1989, Giardini and Eggers 2002).

The scope of this research focuses on entire populations. However, populations are comprised of many individuals. Thus, the few individuals whose MSM scores fell outside the rest of the group are interesting, simply because they are outliers. Future research which will look more closely at these individuals with regard to an entire suite of osteological criteria may provide us additional insights into the lives of these people.

Figure 4.1: Map of Alaska



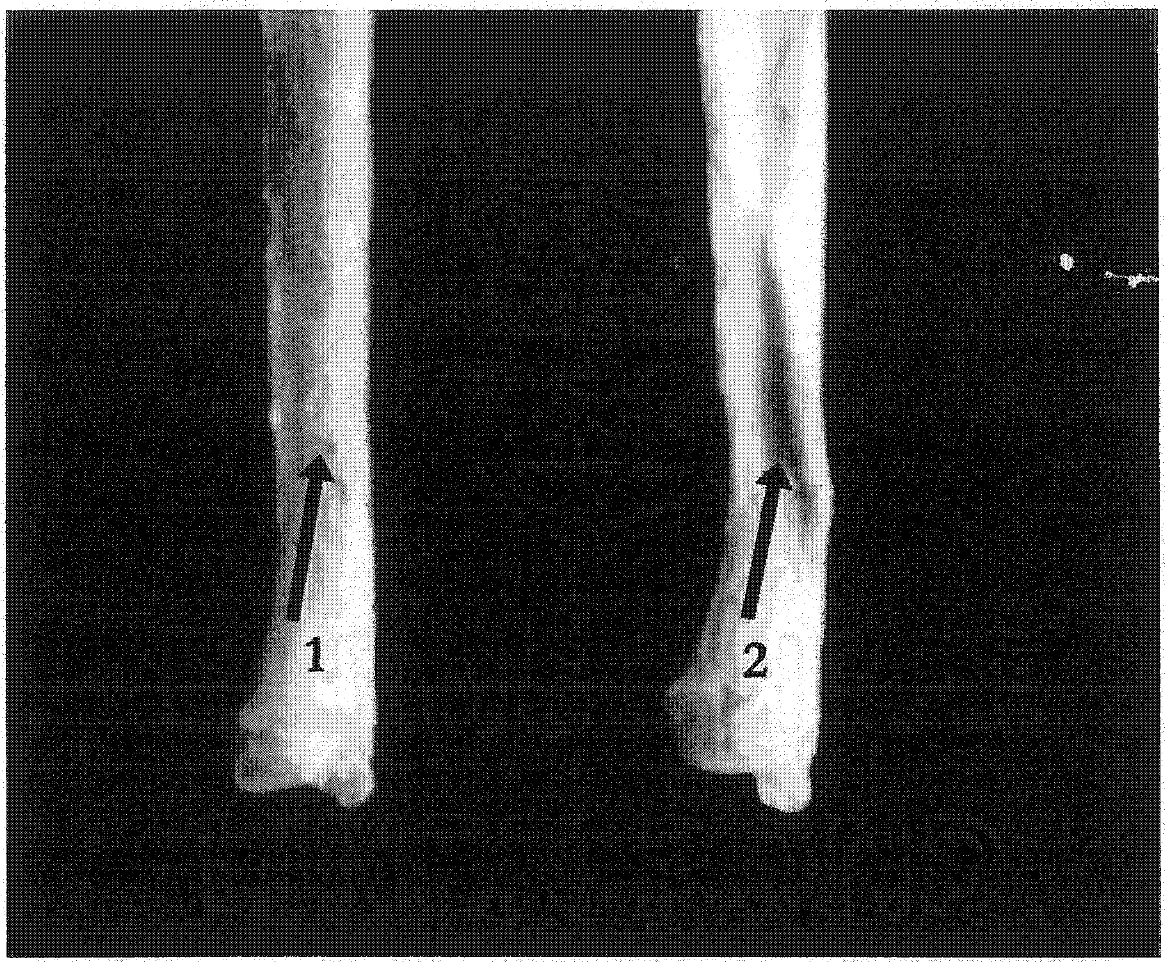



**Figure 4.2 : MSM scores for the attachment site of the *pronator quadratus* on two right ulnae for an adult female (left) and adult male (right).**

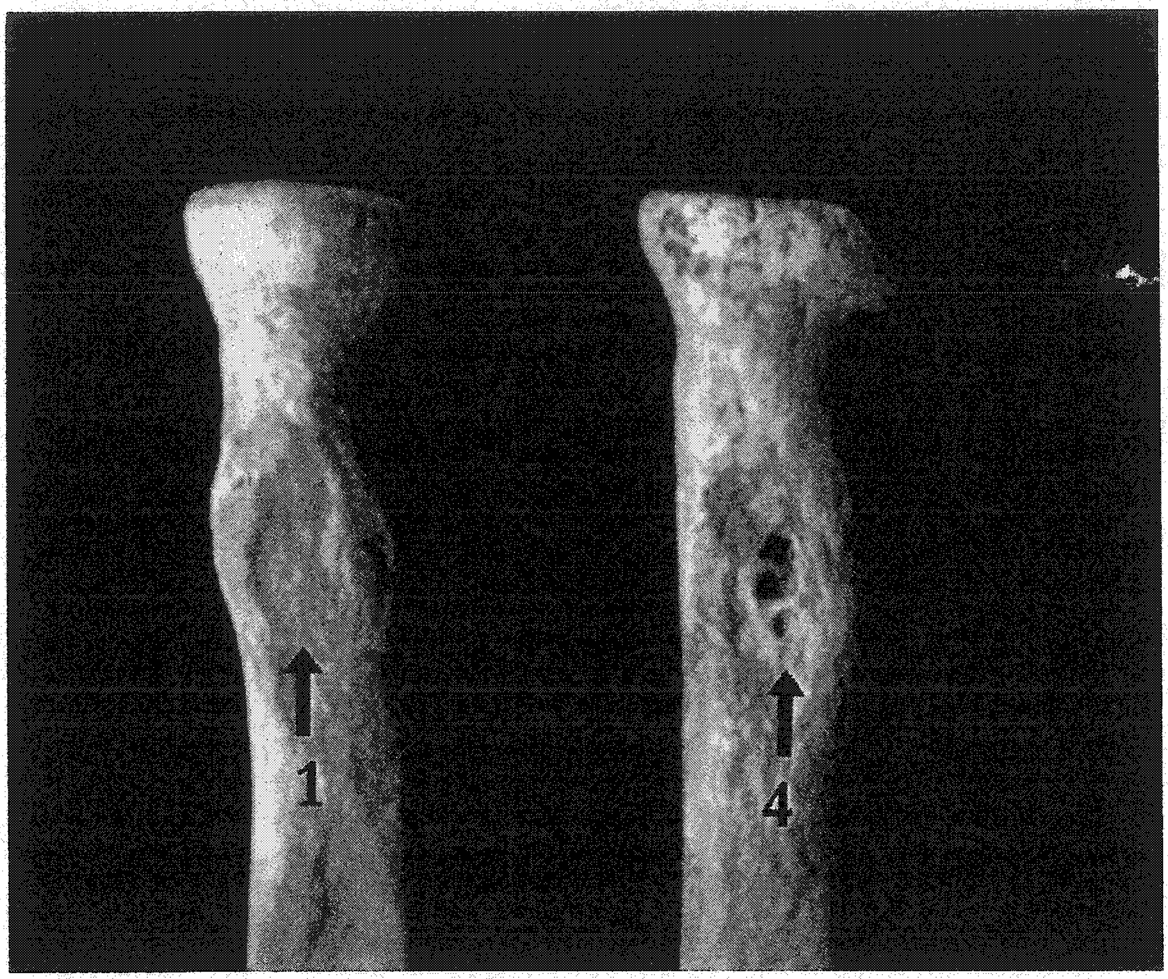



**Figure 4.3: MSM Scores of 1 and 4 for the *Biceps brachii* of the left radius for two adult males from Point Hope, Alaska.**

**Figure 4.4: MSM scores for the costoclavicular ligament on right adult male clavicles.**

Table 4.1: Sample Sizes of the Cultural Horizons from the Point Hope Archaeological Site

| | Skulls | | Upper Extremities | | Lower Extremities | |
|---|---|---|---|---|---|---|
| | N | % of Total | N | % of Total | N | % of Total |
| Ipiutak | 56 | 14.7 | 46 | 17.9 | 46 | 17.6 |
| Near Ipiutak | 9 | 2.4 | 6 | 2.3 | 7 | 2.7 |
| Tigara | 238 | 62.5 | 196 | 76.3 | 199 | 76.2 |
| Unknown | 78 | 20.5 | 9 | 3.5 | 9 | 3.4 |
| Totals | 381 | 100 | 257 | 100 | 261 | 100 |

Table 4.2: Sample Size Based on Sex of the Point Hope Skeletal Collection

| | Skulls | | Upper Extremities | | Lower Extremities | |
|---|---|---|---|---|---|---|
| | N | % of Total | N | % of Total | N | % of Total |
| Males | 178 | 46.7 | 125 | 48.6 | 127 | 48.7 |
| Females | 203 | 53.3 | 132 | 51.4 | 134 | 51.3 |
| Totals | 381 | 100 | 257 | 100 | 261 | 100 |

4.3: Sample Size Based on Age of the Point Hope Skeletal Collection

| | Skulls | | Upper Extremities | | Lower Extremities | |
|---|---|---|---|---|---|---|
| | N | % of Total | N | % of Total | N | % of Total |
| Young Adult | 120 | 31.5 | 97 | 37.7 | 97 | 37.2 |
| Middle Adult | 157 | 41.2 | 120 | 46.7 | 122 | 46.7 |
| Old Adult | 28 | 7.3 | 23 | 8.9 | 23 | 8.8 |
| Adult* | 76 | 19.9 | 17 | 6.6 | 19 | 7.3 |
| Totals | 381 | 100 | 257 | 100 | 261 | 100 |

* Not identifiable as to specific age category

Table 4.4: MSM Data of Right Lateral Muscle Insertion Sites on Crania and Mandibles for Ipiutak and Tigara

| | Mean MSM Scores | | | | | | | | Significance levels based on ranks using Mann-Whitney U/Wilcoxon Rank Sum Test (Statistics: p-values) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ipiutak | | | | Tigara | | | | | | | |
| | Males | | Females | | Males | | Females | | Males | Females | Ipiutak | Tigara |
| Muscle Insertion Sites | mean | n | mean | n | mean | n | mean | n | I vs. T | I vs. T | M vs. F | M vs. F |
| **Muscles that Move the Lower Jaw/Mandible** | | | | | | | | | | | | |
| Masseter | 1.12 | 25 | 1.19 | 27 | 1.73 | 95 | 1.13 | 104 | 0.000 | ns | ns | 0.000 |
| Pterygoid lateralis | 1.12 | 26 | 1.19 | 26 | 1.33 | 95 | 1.13 | 107 | 0.021 | ns | ns | 0.001 |
| Pterygoid medialis | 1.69 | 26 | 1.56 | 27 | 2.14 | 97 | 1.54 | 105 | 0.006 | ns | ns | 0.000 |
| Temporalis | 1.15 | 26 | 1.10 | 29 | 1.42 | 100 | 1.21 | 111 | 0.015 | ns | ns | 0.001 |
| **Muscles that Move the Head** | | | | | | | | | | | | |
| Rectus capitis | 2.04 | 24 | 1.38 | 26 | 2.07 | 107 | 1.55 | 108 | ns | ns | 0.000 | 0.000 |
| Sternocleidomastoideus | 1.47 | 19 | 1.00 | 26 | 1.60 | 95 | 1.12 | 103 | ns | ns | 0.000 | 0.000 |

Key: n=number of observations for given attachment site; I=Ipiutak/Near Ipiutak; T=Tigara
M=male; F=female; ns=not statistically significant

Table 4.5: MSM Data of Right Side Muscle and Ligament Sites on Upper Extremity Elements for Ipiutak and Tigara

| Muscle/Ligament Sites | Mean MSM Scores | | | | | | | | Significance levels based on ranks using Mann-Whitney U/Wilcoxon Rank Sum Test (Statistics: p-values) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ipiutak | | | | Tigara | | | | | | | |
| | Males | | Females | | Males | | Females | | Males | Females | Ipiutak | Tigara |
| | mean | n | mean | n | mean | n | mean | n | I vs. T | I vs. T | M vs. F | M vs. F |
| **Muscles that Move the Shoulder/Pectoral Girdle** | | | | | | | | | | | | |
| Pectoralis minor | 1.43 | 7 | 1.00 | 6 | 1.09 | 43 | 1.05 | 39 | 0.019 | ns | ns | ns |
| Subclavius | 1.27 | 22 | 1.31 | 16 | 1.21 | 86 | 1.10 | 78 | ns | 0.028 | ns | ns |
| Trapezius | 1.36 | 11 | 1.00 | 8 | 1.45 | 56 | 1.07 | 57 | ns | ns | ns | 0.000 |
| **Muscles that Move the Arm/Humerus** | | | | | | | | | | | | |
| Deltoideus | 1.38 | 21 | 1.24 | 17 | 1.39 | 71 | 1.15 | 78 | ns | ns | ns | 0.001 |
| Infraspinatus | 1.14 | 14 | 1.00 | 10 | 1.06 | 67 | 1.00 | 67 | ns | ns | ns | 0.043 |
| Latissimus dorsi | 1.11 | 19 | 1.00 | 18 | 1.21 | 70 | 1.03 | 77 | ns | ns | ns | 0.000 |
| Pectoralis major | 2.10 | 21 | 1.65 | 17 | 1.68 | 68 | 1.52 | 73 | ns | ns | ns | ns |
| Supraspinatus | 1.00 | 12 | 1.00 | 9 | 1.09 | 69 | 1.06 | 63 | ns | ns | ns | ns |
| Teres major | 2.52 | 21 | 2.11 | 19 | 1.68 | 74 | 1.44 | 79 | 0.001 | 0.001 | ns | 0.036 |
| Teres minor | 1.29 | 7 | 1.00 | 8 | 1.09 | 55 | 1.00 | 54 | ns | ns | ns | 0.024 |
| **Muscles that Move the Forearm/Ulna and Radius** | | | | | | | | | | | | |
| Anconeus | 1.63 | 19 | 1.23 | 22 | 1.63 | 71 | 1.46 | 61 | ns | ns | 0.020 | 0.045 |
| Biceps brachii | 1.40 | 20 | 1.06 | 18 | 1.47 | 79 | 1.21 | 80 | ns | ns | 0.032 | 0.002 |
| Brachialis | 1.91 | 22 | 1.64 | 22 | 1.73 | 81 | 1.35 | 78 | ns | 0.026 | ns | 0.000 |
| Pronator quadratus | 0.94 | 18 | 1.00 | 14 | 1.22 | 81 | 1.05 | 76 | 0.010 | ns | ns | 0.002 |
| Pronator teres | 1.14 | 14 | 0.92 | 13 | 1.55 | 51 | 1.22 | 37 | 0.007 | 0.027 | ns | 0.002 |
| Triceps brachii | 1.50 | 18 | 1.06 | 17 | 1.29 | 72 | 1.08 | 62 | ns | ns | 0.020 | 0.000 |
| **Muscles that Move the Wrist, Hand, and Fingers** | | | | | | | | | | | | |
| Supinator | 1.15 | 20 | 1.00 | 18 | 1.13 | 79 | 1.01 | 80 | ns | ns | ns | 0.009 |
| **Ligament that Stabilizes the Shoulder/Pectoral Girdle** | | | | | | | | | | | | |
| Costoclavicular lig (clavicle) | 3.75 | 16 | 1.92 | 13 | 3.06 | 80 | 1.74 | 69 | ns | ns | 0.001 | 0.000 |

Key: n=number of observations for given attachment site; I=Ipiutak; T=Tigara
G=Golovin Bay; N=Nunivak Island; ns=not statistically significant

Table 4.6: MSM Data of Right Side Muscle Insertion Sites on Lower Extremity Elements for Ipiutak and Tigara

| Muscle Insertion Sites | Mean MSM Scores | | | | | | | | Significance levels based on ranks using Mann-Whitney U/Wilcoxon Rank Sum Test (Statistics: p-values) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ipiutak | | | | Tigara | | | | | | | |
| | Males | | Females | | Males | | Females | | Males | Females | Ipiutak | Tigara |
| | mean | n | mean | n | mean | n | mean | n | I vs. T | I vs. T | M vs. F | M vs. F |
| **Muscles that Move the Thigh/Femur** | | | | | | | | | | | | |
| Adductor magnus | 1.84 | 19 | 1.55 | 22 | 1.66 | 91 | 1.25 | 88 | ns | 0.017 | ns | 0.000 |
| Gluteus maximus | 2.00 | 19 | 1.91 | 22 | 1.67 | 84 | 1.55 | 82 | 0.042 | 0.004 | ns | ns |
| Gluteus medius | 1.36 | 14 | 1.18 | 17 | 1.22 | 73 | 1.06 | 64 | ns | ns | ns | 0.016 |
| Gluteus minimus | 1.70 | 10 | 1.41 | 17 | 1.43 | 69 | 1.14 | 63 | ns | 0.042 | ns | 0.000 |
| Iliacus | 1.11 | 18 | 1.05 | 22 | 1.23 | 86 | 1.07 | 86 | ns | ns | ns | 0.003 |
| Obturator externus | 1.78 | 9 | 1.77 | 13 | 1.65 | 55 | 1.51 | 59 | ns | ns | ns | ns |
| Pectineus | 1.26 | 19 | 1.17 | 23 | 1.21 | 87 | 1.04 | 91 | ns | 0.030 | ns | 0.001 |
| Piriformis | 1.67 | 9 | 1.36 | 14 | 1.21 | 68 | 1.07 | 58 | 0.016 | 0.004 | ns | 0.029 |
| Quadratus femoris | 1.17 | 12 | 1.00 | 17 | 1.03 | 67 | 1.00 | 64 | 0.048 | ns | ns | ns |
| **Muscles that Move the Thigh (Femur) and Leg (Tibia and Fibula)** | | | | | | | | | | | | |
| Semimembranosus | 1.45 | 11 | 1.13 | 8 | 1.39 | 75 | 1.10 | 69 | ns | ns | ns | 0.000 |
| **Muscles that Move the Leg/Tibia and Fibula** | | | | | | | | | | | | |
| Popliteus | 1.37 | 19 | 1.16 | 19 | 1.15 | 89 | 1.06 | 88 | 0.024 | ns | ns | ns |

Key: n=number of observations for given attachment site; I=Ipiutak; T=Tigara; M=male; F=female; L=left; R=right; ns=not statistically significant

Table 4.7: P-values Based on MSM Scores of Right Lateral Muscle Insertion Sites on Crania and Mandibles for Ipiutak, Tigara, Golovin Bay, and Nunivak Island

| | P-values Based on Mann-Whitney U/Wilcoxon W Test | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Males | | | | Females | | | |
| Muscle Insertion Sites | I vs. G | I vs. N | T vs. G | T vs. N | I vs. G | I vs. N | T vs. G | T vs. N |
| **Muscles that Move the Lower Jaw/Mandible** | | | | | | | | |
| Masseter | 0.000 | 0.000 | 0.003 | ns | 0.000 | ns | 0.000 | ns |
| Pterygoid lateralis | ns | 0.002 | ns | ns | ns | ns | 0.010 | 0.004 |
| Pterygoid medialis | 0.005 | ns | ns | ns | 0.002 | ns | 0.000 | ns |
| Temporalis | 0.015 | 0.003 | ns | ns | 0.004 | 0.001 | 0.001 | 0.000 |
| **Muscles that Move the Head** | | | | | | | | |
| Rectus capitis | ns | ns | 0.026 | ns | ns | ns | ns | ns |
| Sternocleidomastoideus | 0.046 | 0.026 | 0.000 | 0.014 | ns | 0.004 | 0.000 | 0.002 |

Key: n=number of observations for given attachment site; I=Ipiutak/Near Ipiutak; T=Tigara G=Golvin Bay; N=Nunivak Island; ns=not statistically significant

Table 4.8: P-values Based on MSM Scores of Right Side Muscle and Ligament Sites on Upper Extremity Elements for Ipiutak, Tigara, Golovin Bay, and Nunivak Island

| | P-values Based on Mann-Whitney U/Wilcoxon W Test | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Males | | | | Female | | | |
| Muscle/Ligament Sites | I vs. G | I vs. N | T vs. G. | Tvs. N | I vs. G | I vs. N | T vs. G. | Tvs. N |
| **Muscles that Move the Shoulder/Pectoral Girdle** | | | | | | | | |
| Pectoralis minor | ns | ns | 0.000 | ns | ns | 0.007 | 0.006 | 0.000 |
| Subclavius | ns | ns | ns | ns | ns | ns | ns | 0.034 |
| Trapezius | ns | 0.004 | ns | 0.000 | ns | ns | 0.007 | ns |
| **Muscles that Move the Arm/Humerus** | | | | | | | | |
| Deltoideus | 0.000 | 0.009 | 0.000 | 0.001 | 0.019 | ns | 0.000 | 0.011 |
| Infraspinatus | 0.001 | ns | 0.000 | ns | ns | ns | ns | ns |
| Latissimus dorsi | 0.001 | 0.032 | 0.000 | ns | ns | ns | 0.026 | 0.004 |
| Pectoralis major | 0.049 | 0.005 | 0.000 | 0.000 | ns | ns | 0.016 | ns |
| Supraspinatus | 0.000 | ns | 0.000 | ns | ns | ns | ns | ns |
| Teres major | ns | ns | 0.000 | 0.000 | ns | ns | 0.003 | ns |
| Teres minor | ns | ns | 0.005 | ns | ns | ns | 0.016 | ns |
| **Muscles that Move the Forearm/Ulna and Radius** | | | | | | | | |
| Anconeus | ns | ns | ns | ns | ns | ns | ns | ns |
| Biceps brachii | 0.000 | ns | 0.000 | ns | ns | ns | ns | ns |
| Brachialis | ns | 0.033 | 0.007 | 0.000 | ns | ns | 0.049 | 0.001 |
| Pronator quadratus | 0.000 | ns | 0.002 | 0.016 | ns | 0.020 | ns | 0.000 |
| Pronator teres | ns | ns | ns | 0.020 | ns | ns | ns | ns |
| Triceps brachii | ns | ns | 0.014 | ns | ns | ns | ns | 0.002 |
| **Muscles that Move the Wrist, Hand, and Fingers** | | | | | | | | |
| Supinator | 0.013 | ns | 0.000 | 0.035 | ns | ns | ns | 0.017 |
| **Ligament that Stablizes the Shoulder/Pectoral Girdle** | | | | | | | | |
| Costoclavicular lig (clavicle) | ns | ns | ns | ns | ns | ns | ns | ns |

Key: n=number of observations for given attachment site; I=Ipiutak; T=Tigara
G=Golovin Bay; N=Nunivak Island; ns=not statistically significant

Table 4.9: P-values Based on MSM Scores of Right Side Muscle Insertion Sites on Lower Extremity Elements for Ipiutak, Tigara, Golovin Bay, and Nunivak Island

| | P-values Based on Mann-Whitney U/Wilcoxon W Test | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Males | | | | Females | | | |
| Muscle Insertion Sites | I vs. G | I vs. N | T vs. G | T vs. N | I vs. G | I vs. N | T vs. G | T vs. N |
| **Muscles that Move the Thigh/Femur** | | | | | | | | |
| Adductor magnus | 0.001 | ns | 0.000 | 0.032 | ns | ns | 0.001 | 0.003 |
| Gluteus maximus | 0.000 | ns | 0.000 | 0.019 | ns | 0.048 | 0.000 | 0.000 |
| Gluteus medius | 0.000 | ns | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Gluteus minimus | 0.010 | ns | 0.000 | 0.007 | 0.000 | 0.004 | 0.000 | 0.000 |
| Iliacus | ns | 0.017 | 0.036 | 0.000 | ns | ns | ns | ns |
| Obturator externus | ns | ns | 0.001 | ns | ns | ns | 0.001 | ns |
| Pectineus | 0.016 | ns | 0.000 | ns | ns | ns | 0.000 | 0.011 |
| Piriformis | 0.010 | ns | 0.000 | 0.000 | 0.000 | 0.011 | 0.000 | 0.000 |
| Quadratus femoris | 0.000 | ns | 0.000 | 0.007 | 0.000 | 0.006 | 0.000 | 0.000 |
| **Muscles that Move the Thigh (Femur) and Leg (Tibia and Fibula)** | | | | | | | | |
| Semimembranosus | ns | ns | ns | ns | ns | ns | ns | ns |
| **Muscles that Move the Leg/Tibia and Fibula** | | | | | | | | |
| Popliteus | ns | ns | 0.001 | ns | ns | ns | ns | ns |

Key: n=number of observations; I=Ipiutak; T=Tigara; G=Golovin Bay; N=Nunivak Island; ns=not statistically significant

Table 4.10: Percentage of MSM Scores for Right Side Muscle Insertion Sites of the Cranium and Mandible for Males

| Muscle Insertion Sites | Ipiutak | | | | Tigara | | | | Golovin Bay | | | | Nunivak Island | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| **Muscles that Move the Lower Jaw/Mandible** | | | | | | | | | | | | | | | | |
| Masseter | | 88.0 | 12.0 | | | 34.7 | 57.9 | 7.4 | 9.1 | 9.1 | 36.4 | 45.5 | | 31.0 | 48.3 | 20.7 |
| Pterygoid lateralis | | 92.3 | 3.8 | 3.8 | | 68.4 | 30.5 | 1.1 | 21.7 | 47.8 | 17.4 | 13.0 | 2.9 | 47.1 | 47.1 | 2.9 |
| Pterygoid medialis | | 38.5 | 53.8 | 7.7 | | 21.6 | 42.3 | 36.1 | | 14.3 | 42.9 | 42.9 | | 29.0 | 51.6 | 19.4 |
| Temporalis | | 84.6 | 15.4 | | | 59.0 | 40.0 | 1.0 | 4.3 | 43.5 | 47.8 | 4.3 | | 48.6 | 40.0 | 11.4 |
| **Muscles that Move the Head** | | | | | | | | | | | | | | | | |
| Rectus capitis | | 16.7 | 62.5 | 20.8 | | 14.0 | 64.5 | 21.5 | | 38.2 | 44.1 | 17.6 | | 39.1 | 30.4 | 30.4 |
| Sternocleidomastoideus | | 57.9 | 36.8 | 5.3 | | 43.2 | 53.7 | 3.2 | 17.1 | 60.0 | 20.0 | 2.9 | | 31.8 | 43.2 | 25.0 |

# Table 4.11 Percentages for MSM Scores for Right Side Muscle and Ligament Sites of the Upper Extremities for Males

| | Ipiutak | | | | | | | Tigara | | | | | | | Golovin Bay | | | | | | | Nunivak Island | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muscle/Ligament Sites | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| **Muscles that Move the Shoulder/Pectoral Girdle** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pectoralis minor | | 57.1 | 42.9 | | | | | | 90.7 | 9.3 | | | | | | 23.1 | 53.8 | 23.1 | | | | 7.7 | 53.8 | 38.5 | | | | |
| Subclavius | | 72.7 | 27.3 | | | | | | 79.1 | 20.9 | | | | | 25.0 | 33.3 | 25.0 | 16.7 | | | | | 61.5 | 38.5 | | | | |
| Trapezius | | 63.6 | 36.4 | | | | | | 55.4 | 44.6 | | | | | | 43.8 | 18.8 | 37.5 | | | | | 8.3 | 66.7 | 25.0 | | | |
| **Muscles that Move the Arm/Humerus** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Deltoideus | | 71.4 | 19.0 | 9.5 | | | | | 60.6 | 39.4 | | | | | | 7.7 | 23.1 | 69.2 | | | | | 25.0 | 50.0 | 25.0 | | | |
| Infraspinatus | | 85.7 | 14.3 | | | | | | 94.0 | 6.0 | | | | | | 23.1 | 61.5 | 15.4 | | | | 7.1 | 78.6 | 14.3 | | | | |
| Latissimus dorsi | | 89.5 | 10.5 | | | | | | 78.6 | 21.4 | | | | | | 30.8 | 46.2 | 7.7 | 7.7 | 7.7 | | | 73.1 | 23.5 | 1.7 | 0.8 | 0.8 | |
| Pectoralis major | | 38.1 | 33.3 | 14.3 | 9.5 | 4.8 | | | 39.7 | 55.9 | 1.5 | 2.9 | | | | 7.7 | 38.5 | 23.1 | 15.4 | 15.4 | | | | 26.7 | 40.0 | 26.7 | 6.7 | |
| Supraspinatus | | 100.0 | | | | | | | 91.3 | 8.7 | | | | | | 23.1 | 61.5 | 15.4 | | | | 8.3 | 75.0 | 16.7 | | | | |
| Teres major | | 14.3 | 52.4 | 4.8 | 23.8 | 4.8 | | | 54.1 | 32.4 | 5.4 | 8.1 | | | | 7.7 | 15.4 | 53.8 | 15.4 | 7.7 | | | 6.3 | 56.3 | 18.8 | 18.8 | | |
| Teres minor | | 71.4 | 28.6 | | | | | | 90.9 | 9.1 | | | | | 16.7 | 25.0 | 25.0 | 33.3 | | | | | 70.0 | 30.0 | | | | |
| **Muscles that Move the Forearm/Ulna and Radius** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Anconeus | | 42.1 | 52.6 | 5.3 | | | | | 36.6 | 63.4 | | | | | 6.3 | 18.8 | 50.0 | 25.0 | | | | | 33.3 | 53.3 | 6.7 | 6.7 | | |
| Biceps brachii | | 60.0 | 40.0 | | | | | | 55.7 | 43.0 | | 1.3 | | | | 7.1 | 57.1 | 35.7 | | | | | 42.9 | 42.9 | 14.3 | | | |
| Brachialis | | 27.3 | 54.5 | 18.2 | | | | | 30.9 | 65.4 | 3.7 | | | | 6.7 | 13.3 | 33.3 | 46.7 | | | | | | 62.5 | 37.5 | | | |
| Pronator quadratus | 5.6 | 94.4 | | | | | | | 77.8 | 22.2 | | | | | | 36.4 | 45.5 | 18.2 | | | | 26.7 | 60.0 | 13.3 | | | | |
| Pronator teres | | 85.7 | 14.3 | | | | | | 45.1 | 54.9 | | | | | 7.7 | 38.5 | 30.8 | 23.1 | | | | 27.3 | 45.5 | 27.3 | | | | |
| Triceps brachii | | 61.1 | 27.8 | 11.1 | | | | | 70.8 | 29.2 | | | | | 9.1 | 27.3 | 27.3 | 36.4 | | | | | 44.4 | 44.4 | 11.1 | | | |
| **Muscles that Move the Wrist, Hand, and Fingers** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Supinator | | 85.0 | 15.0 | | | | | | 88.6 | 10.1 | 1.3 | | | | | 46.7 | 40.0 | 13.3 | | | | 25.0 | 62.5 | 12.5 | | | | |
| **Ligament that Stabilizes the Shoulder/Pectoral Girdle** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Costoclavicular lig (clavicle) | | 6.3 | 12.5 | 18.8 | 31.3 | 25.0 | 6.3 | | 10.0 | 27.5 | 21.3 | 31.3 | 7.5 | 2.5 | | 7.1 | 28.6 | | 28.6 | 28.6 | 7.1 | | | 23.1 | 38.5 | 23.1 | 15.4 | |

Table 4.12 Percentages for MSM Scores for Right Side Muscle Insertion Sites of the Lower Extremities for Males

| | Ipiutak | | | | | | Tigara | | | | | | Golovin Bay | | | | | | Nunivak Island | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muscle Insertion Sites | 0 | 1 | 2 | 3 | 4 | 5 | 0 | 1 | 2 | 3 | 4 | 5 | 0 | 1 | 2 | 3 | 4 | 5 | 0 | 1 | 2 | 3 | 4 | 5 |
| **Muscles that Move the Thigh/Femur** | | | | | | | | | | | | | | | | | | | | | | | | |
| Adductor magnus | | 21.1 | 73.7 | 5.3 | | | | 36.3 | 61.5 | 2.2 | | | | 5.0 | 30.0 | 60.0 | 5.0 | | | 21.1 | 57.9 | 21.1 | | |
| Gluteus maximus | | 21.1 | 57.9 | 21.1 | | | | 38.1 | 57.1 | 4.8 | | | | | 5.0 | 90.0 | | 5.0 | | 14.3 | 71.4 | 14.3 | | |
| Gluteus medius | | 64.3 | 35.7 | | | | | 79.5 | 19.2 | 1.4 | | | 6.3 | | 12.5 | 81.3 | | | | 38.9 | 50.0 | 11.1 | | |
| Gluteus minimus | | 40.0 | 50.0 | 10.0 | | | | 56.5 | 43.5 | | | | | | 50.0 | 50.0 | | | 5.9 | 17.6 | 58.8 | 17.6 | | |
| Iliacus | | 88.9 | 11.1 | | | | | 76.7 | 23.3 | | | | | 57.1 | 28.6 | 14.3 | | | 19.0 | 81.0 | | | | |
| Obturator externus | | 22.2 | 77.8 | | | | | 34.5 | 65.5 | | | | | 7.7 | 53.8 | 38.5 | | | 41.2 | 47.1 | 11.8 | | | |
| Pectineus | | 73.7 | 26.3 | | | | | 79.3 | 20.7 | | | | | 33.3 | 52.4 | 14.3 | | | 10.0 | 75.0 | 15.0 | | | |
| Piriformis | | 44.4 | 44.4 | 11.1 | | | | 79.4 | 20.6 | | | | | 6.3 | 31.3 | 62.5 | | | | 28.6 | 71.4 | | | |
| Quadratus femoris | | 83.3 | 16.7 | | | | | 97.0 | 3.0 | | | | | 6.7 | 60.0 | 33.3 | | | 6.3 | 62.5 | 31.3 | | | |
| **Muscles that Move the Thigh (Femur) and Leg (Tibia and Fibula)** | | | | | | | | | | | | | | | | | | | | | | | | |
| Semimembranosus | | 54.5 | 45.5 | | | | | 62.7 | 36.0 | 1.3 | | | 5.9 | 47.1 | 35.3 | 11.8 | | | | 81.8 | 18.2 | | | |
| **Muscles that Move the Leg/Tibia and Fibula** | | | | | | | | | | | | | | | | | | | | | | | | |
| Popliteus | | 63.2 | 36.8 | | | | | 85.4 | 14.6 | | | | 9.5 | 33.3 | 42.9 | 14.3 | | | | 68.4 | 31.6 | | | |

Table 4.13: Percentage of MSM Scores for Right Side Muscle Insertion Sites of the Cranium and Mandible for Females

| | Ipiutak | | | | Tigara | | | | Golovin Bay | | | | Nunivak Island | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muscle Insertion Sites | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| **Muscles that Move the Lower Jaw/Mandible** | | | | | | | | | | | | | | | | |
| Masseter | | 81.5 | 18.5 | | | 87.5 | 12.5 | | 3.2 | 25.8 | 51.6 | 19.4 | 4.5 | 77.3 | 18.2 | |
| Pterygoid lateralis | | 80.8 | 19.2 | | | 87.9 | 11.2 | 0.9 | 16.1 | 35.5 | 38.7 | 9.7 | 3.6 | 57.1 | 35.7 | 3.6 |
| Pterygoid medialis | | 48.1 | 48.1 | 3.7 | | 51.4 | 42.9 | 5.7 | | 19.4 | 45.2 | 35.5 | | 58.3 | 37.5 | 4.2 |
| Temporalis | | 89.7 | 10.3 | | | 79.3 | 20.7 | | 13.8 | 27.6 | 31.0 | 27.6 | | 48.5 | 42.4 | 9.1 |
| **Muscles that Move the Head** | | | | | | | | | | | | | | | | |
| Rectus capitis | | 61.5 | 38.5 | | | 49.1 | 47.2 | 3.7 | 11.6 | 41.9 | 37.2 | 9.3 | | 56.4 | 32.7 | 10.9 |
| Sternocleidomastoideus | | 100.0 | | | | 89.3 | 9.7 | 1.0 | 32.6 | 54.3 | 10.9 | 2.2 | 5.2 | 58.6 | 31.0 | 5.2 |

Table 4.14 Percentages for MSM Scores for Right Side Muscle and Ligament Sites of the Upper Extremities for Females

| Muscle/Ligament Sites | Ipiutak | | | | | | Tigara | | | | | | Golovin Bay | | | | | | Nunivak Island | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 0 | 1 | 2 | 3 | 4 | 5 | 0 | 1 | 2 | 3 | 4 | 5 | 0 | 1 | 2 | 3 | 4 | 5 |
| **Muscles that Move the Shoulder/Pectoral Girdle** | | | | | | | | | | | | | | | | | | | | | | | | |
| Pectoralis minor | | 100.0 | | | | | | 94.9 | 5.1 | | | | 8.7 | 47.8 | 30.4 | 13.0 | | | | 25.0 | 75.0 | | | |
| Subclavius | | 68.8 | 31.3 | | | | | 89.7 | 10.3 | | | | 29.4 | 41.2 | 23.5 | 5.9 | | | 8.3 | 50.0 | 41.7 | | | |
| Trapezius | | 100.0 | | | | | | 93.0 | 7.0 | | | | 18.8 | 25.0 | 56.3 | | | | | 80.0 | 20.0 | | | |
| **Muscles that Move the Arm/Humerus** | | | | | | | | | | | | | | | | | | | | | | | | |
| Deltoideus | | 76.5 | 23.5 | | | | | 85.9 | 12.8 | 1.3 | | | 13.6 | 18.2 | 36.4 | 31.8 | | | | 60.0 | 40.0 | | | |
| Infraspinatus | | 100.0 | | | | | | 100.0 | | | | | 35.0 | 25.0 | 40.0 | | | | 14.3 | 78.6 | 7.1 | | | |
| Latissimus dorsi | 5.6 | 88.9 | 5.6 | | | | | 97.4 | 2.6 | | | | 9.5 | 61.9 | 28.6 | | | | | 80.0 | 20.0 | | | |
| Pectoralis major | | 41.2 | 52.9 | 5.9 | | | | 50.7 | 46.6 | 2.7 | | | | 31.8 | 40.9 | 22.7 | 4.5 | | | 40.0 | 45.0 | 15.0 | | |
| Supraspinatus | | 100.0 | | | | | | 95.2 | 3.2 | 1.6 | | | 35.0 | 25.0 | 40.0 | | | | 6.3 | 81.3 | 12.5 | | | |
| Teres major | | 31.6 | 42.1 | 10.5 | 15.8 | | | 70.9 | 21.5 | | 7.6 | | 4.5 | 27.3 | 45.5 | 18.2 | 4.5 | | 10.0 | 35.0 | 50.0 | | 5.0 | |
| Teres minor | | 100.0 | | | | | | 100.0 | | | | | 26.3 | 21.1 | 47.4 | 5.3 | | | 15.4 | 69.2 | 15.4 | | | |
| **Muscles that Move the Forearm/Ulna and Radius** | | | | | | | | | | | | | | | | | | | | | | | | |
| Anconeus | | 77.3 | 22.7 | | | | | 54.1 | 45.9 | | | | 25.0 | 20.0 | 45.0 | 10.0 | | | 4.1 | 53.3 | 39.3 | 3.3 | | |
| Biceps brachii | 5.6 | 83.3 | 11.1 | | | | | 78.8 | 21.3 | | | | 21.1 | 26.3 | 31.6 | 21.1 | | | 18.8 | 50.0 | 25.0 | | 6.3 | |
| Brachialis | | 40.9 | 54.5 | 4.5 | | | | 66.7 | 32.1 | 1.3 | | | 14.3 | 23.8 | 42.9 | 19.0 | | | | 21.4 | 64.3 | 14.3 | | |
| Pronator quadratus | | 100.0 | | | | | | 94.7 | 5.3 | | | | 27.8 | 27.8 | 27.8 | 16.7 | | | 50.0 | 41.7 | 8.3 | | | |
| Pronator teres | 7.7 | 92.3 | | | | | | 78.4 | 21.6 | | | | 10.5 | 52.6 | 31.6 | 5.3 | | | 40.0 | 30.0 | 30.0 | | | |
| Triceps brachii | | 94.1 | 5.9 | | | | | 96.8 | 1.6 | | 1.6 | | 25.0 | 25.0 | 50.0 | | | | | 70.0 | 20.0 | 10.0 | | |
| **Muscles that Move the Wrist, Hand, and Fingers** | | | | | | | | | | | | | | | | | | | | | | | | |
| Supinator | | 100.0 | | | | | | 98.8 | 1.3 | | | | 38.1 | 19.0 | 38.1 | 4.8 | | | 40.0 | 40.0 | 20.0 | | | |
| **Ligament that Stabilizes the Shoulder/Pectoral Girdle** | | | | | | | | | | | | | | | | | | | | | | | | |
| Costoclavicular lig (clavicle) | | 30.8 | 46.2 | 23.1 | | | | 42.0 | 47.8 | 5.8 | 2.9 | 1.4 | | 30.0 | 40.0 | 20.0 | 5.0 | 5.0 | 7.7 | 15.4 | 53.8 | 15.4 | 7.7 | |

Table 4.15 Percentages for MSM Scores for Right Side Muscle Insertion Sites of the Lower Extremities for Females

| | Ipiutak | | | | | Tigara | | | | | Golovin Bay | | | | | Nunivak Island | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muscle Insertion Sites | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 |
| **Muscles that Move the Thigh/Femur** | | | | | | | | | | | | | | | | | | | | |
| Adductor magnus | | 50.0 | 45.5 | 4.5 | | | 75.0 | 25.0 | | | 7.4 | 29.6 | 48.1 | 14.8 | | | 45.0 | 40.0 | 15.0 | |
| Gluteus maximus | | 13.6 | 81.8 | 4.5 | | | 46.3 | 52.4 | 1.2 | | | 20.8 | 33.3 | 45.8 | | | 9.1 | 59.1 | 31.8 | |
| Gluteus medius | | 82.4 | 17.6 | | | | 93.8 | 6.3 | | | 6.7 | | 20.0 | 73.3 | | | 15.0 | 75.0 | 10.0 | |
| Gluteus minimus | | 64.7 | 29.4 | 5.9 | | | 85.7 | 14.3 | | | | 5.3 | 31.6 | 63.2 | | | 16.7 | 55.6 | 27.8 | |
| Iliacus | | 95.5 | 4.5 | | | | 93.0 | 7.0 | | | 29.6 | 48.1 | 18.5 | 3.7 | | 20.0 | 65.0 | 15.0 | | |
| Obturator externus | | 23.1 | 76.9 | | | | 49.2 | 50.8 | | | | 12.5 | 68.8 | 18.8 | | 47.1 | 52.9 | | | |
| Pectineus | | 82.6 | 17.4 | | | | 95.6 | 4.4 | | | 7.1 | 53.6 | 39.3 | | | 9.5 | 57.1 | 33.3 | | |
| Piriformis | | 64.3 | 35.7 | | | | 93.1 | 6.9 | | | | 50.0 | 50.0 | | | | 16.7 | 16.7 | 66.7 | |
| Quadratus femoris | | 100.0 | | | | | 100.0 | | | | 11.1 | 5.6 | 83.3 | | | | 62.5 | 31.3 | 6.3 | |
| **Muscles that Move the Thigh (Femur) and Leg (Tibia and Fibula)** | | | | | | | | | | | | | | | | | | | | |
| Semimembranosus | | 87.5 | 12.5 | | | | 89.9 | 10.1 | | | 16.7 | 44.4 | 22.2 | 16.7 | | | 75.0 | 25.0 | | |
| **Muscles that Move the Leg/Tibia and Fibula** | | | | | | | | | | | | | | | | | | | | |
| Popliteus | | 84.2 | 15.8 | | | | 94.3 | 5.7 | | | 14.8 | 59.3 | 18.5 | 7.4 | | 11.1 | 72.2 | 16.7 | | |

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# CHAPTER 5

The purpose of this study was to analyze occupational markers associated with subsistence activities within and between different indigenous groups of Alaskan Natives. For example, the analyses of the muscles of mastication (*i.e.*, the *temporalis, masseter*, and *pterygoids*) are compatible with Lantis' (1946) and Curtis' (1930, as cited in VanStone 1989) studies indicating that the Eskimo women of Nunivak Island did not routinely chew hides and skins to soften them for the manufacture of boots and other clothing. Although not news to most Alaskan and Arctic anthropologists, this finding goes against the grain of current and popular generalized knowledge concerning Eskimo women and their daily activities.

Second, this study assessed the effects of increased foreign trade, as a subsistence activity, on these groups. For example, the overall analysis between the pre-contact (*e.g.*, Point Hope's Ipiutak) and post-contact (*e.g.*, Point Hope's Tigara, Nunivak Island, and Golovin Bay) people has confirmed accounts that goods acquired through trade (*i.e.*, tobacco, rifles, ammunition, glass beads) may not have provided Native peoples with an easier life; instead, they had to work harder to have enough resources for personal consumption, shelter and clothing, plus a surplus of resources for trading purposes.

An important aspect of this study was to evaluate critically the use of a visual reference system in the analysis of MSMs. Based on the findings of my studies, the use of a visual reference system to analyze musculoskeletal stress markers is a valid method. Further, the evaluation of musculoskeletal stress markers is a reliable indicator of generalized habitual activity patterns, such as those associated with subsistence activities. This finding supports earlier enthesopathy findings.

This study contributes to the current research on musculoskeletal stress markers and their use in assessing occupational markers in the following manner: provides a comparison of MSM data from four different skeletal populations; provides a comparison of MSM data across time and space; demonstrates that MSM data can support or refute existing claims of occupational or habitual activities based on subsistence strategies; demonstrates that MSM data can add to the current understanding of the effects of increased foreign trade activities among Alaskan Eskimo populations; enhances the general knowledge of musculoskeletal stress marker data and knowledge; and enhances the general acceptance of visual reference systems as a valid research approach.

Based on the data and the subsequent analysis and interpretation I have concluded that the women of Nunivak Island did not stress their muscles of mastication to the same degree that the women of Golovin Bay and Point Hope did. This suggests that although some of the women may have chewed hides and skins on an occasional basis, most of the women did not do so on any regular basis. From the interpretation of the MSM data it appears as if the Ipiutak males did not stress their muscles to the same degree as those from Golovin Bay, Nunivak Island, and Tigara. This suggestions that the Ipiutak males may have had more time to recover after strenuous activities and/or may not have engaged in strenuous subsistence activities than the males from the other groups. I also found that the MSM data of the Ipiutak males and females was surprisingly similar (*i.e.*, fewer cases of significant differences) which may suggest that the males and females may have engaged in similar activities and/or each others' traditional activities.

At the onset of this study, I had hoped that through the use of MSM data I would have been able to clearly delineate between a variety of subsistence patterns associated with Arctic coastal people; this was not the case. I suggest that the Tigara people of Point Hope, and the people of Golovin Bay and Nunivak Island did engage in different subsistence economies, albeit they were more similar to each other than to those of the Ipiutak people also of Point Hope. It would be useful to compare these findings with similar data collected from people such as horticulturalist, pastoralists or early intensive agriculturalists who engaged in a completely different subsistence strategy. This research could extend our understanding of the transition from hunter-gatherer economies to those associated with the early Neolithic mixed economies. Another possible area for further investigation would be a more holistic picture of Ipiutak and Tigara cultures tying in a complete skeletal analysis with archaeological records. This may not be possible for the people from Golovin Bay and Nunivak island because the skeletal remains have been repatriated.

A more holistic approach that includes a detailed skeletal pathological analysis, dental characteristics, material remains, and mortuary practices might provide a more comprehensive description of the people from Golovin Bay, Nunivak Island, and Point Hope. It may also prove useful to look at the skeletal material on an individual basis to tweak out similar musculoskeletal stress marker patterns which may be unique to a specific individual or group within the larger skeletal population.