The Lives of the People from Banken 1.
A study based on muscular development and other activity markers.

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Syftet med studien har varit att undersöka vilka muskler var utvecklade och utröna hur dessa rörde sig tillsammans för att återskapa ett rörelsemönster som kan hjälpa att skapa en teori om vilka aktiviteter individerna sysslade med (arbetsuppgifter, fritidssysslor, m.m.). Analysen har gjorts med hjälp av litteratur om aktivitetsspår, paleopatologi, fysioterapi och med referensmaterialet från Osteologilaboratoriet vid Uppsala Universitet, Campus Gotland.

Keywords: Musculoskeletal anatomy, occupational stress markers, osteology, physiotherapy, Middle Ages, Viking Age.

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1. Introduction

The study of occupational stress markers is about locating changes in the skeleton that can indicate an individual’s activities or occupations. Studies that have focused on occupational stress markers, also called enthesal changes, have different points of view on how these changes should be recorded. There have been studies like Henderson et al. (2016) and Mariotti et al. (2004) and Mariotti et al. (2007) that have proposed a scoring system and a standard way to record them.

Enthesal changes often offer a list of possibilities, like those listen in the literature of Baxarias & Herrerin (2008) and Kennedy (1989). The approach to the analysis of entheses is usually based on a point system like the studies made by Steenbakker (2018), Mariotti et al. (2007), and Henderson et al. (2016). This study focuses on a different approach: To find out the most prominent activities of the individual’s life by observing the developed muscles and their movements.

The material analyzed in this study are three skeletons from a Christian cemetery dated from the end of the Viking Age to the Early Middle Ages, which was excavated in 1998 (County Board’s journal number 220-437-98). The excavation was directed by Beatrice Rydén and the site was the block Banken 1, located in central Visby, next to the ruins of the churches of S:t Hans and S:t Peter (Hedén 2012: 6).

1.1. Purpose of this study

The purpose of this study is to develop a method which could add to the current research on occupational stress markers, by reconstructing the movement patterns of the individuals. By analyzing each point of muscle attachment and learning how these muscles move, it should be possible to find out how they may have worked together and connect these to a possible activity. This method will hopefully provide information that the other stress markers cannot, especially because the causes of these are still debated (Kennedy 1989: 154-156). This method is thought as a complement to the previous researched occupational stress markers, but it could also be used by itself.

The questions that this study focuses on are:

- What were the activities of the analyzed individuals?
- Is it possible to recreate a pattern of movement that can be connected to an activity for the individuals?

This analysis also seeks to find out in what way have these movements and activities contributed to the pathologies found in the skeleton when they are activity related. For example: What did this individual do to put stress on their spine that ended up in osteoarthritis?, and where there is more than one alternative of the causes, find out the most probable of these by observing the groups of muscles that are related to the entheses and investigate which ones are developed and which are not.

To be able to find out much as possible of each individual, it is also necessary to investigate what occupations and activities existed during the Viking Age and Early Middle Ages, and through the analysis of the development of the individual’s musculature it should be possible
to deduce the movements that use these muscles and find out what this individual was doing and see if that matches an activity.

1.2. Theory
Empiricism is defined as a way to gain knowledge through the senses before any conclusions can be drawn (Witmore forthcoming). This study will have an empirical approach to the material; in which the information obtained will be based on what can be observed, in this case, physical changes on the enthesis of the skeleton.

1.3. Source Criticism
There are different theories of the causes of enthesis pathologies and not all the experts have the same conclusions (Kennedy 1989 154-156; Steenbakker 2018: 19). Another problem with the record of entheses is heterogeneity, which is a principle of the osteological paradox that can be applied to occupational stress markers: the difference in the individual’s response to stress, due to genetic factors (and others) and the analyzed material that might be composed of individuals that lived in different periods (Wood et al. 1992: 345). Genetic variations, biological factors and the difficulties they cause when classifying and scoring the development of enthese have been mentioned by Michopoulou et al. (2017: 409-410). There are also disorders like Schmorl’s nodes whose causes are also still debated and it has been proposed that there may be more than one type; one with autoimmune causes, and others caused by trauma to the vertebrae, age or intervertebral disk degeneration. The last possible cause mentioned is actually very common (Kyere et al. 2012: 2115-2116).

Another problem is that period between the Viking Age and the beginning of the Middle Ages is poorly documented; most of what is known about this period is interpreted from texts written from the middle of the twelfth to thirteen centuries, like the Icelandic Sagas, the work of Ári Thorgilsson and Saxo Grammaticus. Since these were written many years, even centuries after the end of the Viking Age it is not certain how accurate the information may be (Sawyer 2003a).

1.4. Limitations of this study
The analyzed material presented the fragmentation of many bones which did not allow to observe them and create a complete picture of the muscles developed in certain parts of the skeleton. For example, some of the scapulae, ribs, some individuals had bones missing. This could somehow have affected the information about the activities of the individuals. Only one of the individuals analyzed in the study has been dated with makes it difficult to be certain about the exact context of the two other individuals.

1 The cited version does not contain the same page numbers as the published version.
1.5. Materials and Methods

The material in this study consists of three skeletons from a cemetery dated to the end of the Viking Age to the Early Middle Ages, on the site Banken 1 located in Visby, Gotland. The analyzed individuals come from the graves 2, 3 and 20 and are stored in Gotlands Museum (County Board’s journal number 220-437-98). The material has been selected according to its level of preservation. The individuals that were too damaged to be analyzed were left aside, as well as the boxes that contained material from more than one grave. It was also important not choosing too many, because the analysis was going to be thorough and the time for the study was limited. Five were initially selected but two of them were not deemed fit for the study and were left aside.

The individuals have been examined for modifications on the bone at the points of muscle attachments and joints, using previous references on knowledge that is commonly applied in osteology like palaeopathology, research on entheseal changes (also called occupational stress markers) for example Mariotti et al. (2007), Baxarias & Herrerin (2008), and Kennedy (1989). Diseases that affect the joints and might be related to an activity or occupation have also been analyzed. Information about muscle development which does not appear in literature on stress markers nor palaeopathology was taken from works on physiotherapy by Jarmey (2018) and Calais-Germain (2008) and the reference material from the Osteology Laboratory at Uppsala University, Campus Gotland. Other methods used were techniques to determine age, sex and stature of the individuals.

The method applied on this study will be an analysis of the anatomy related to the function and movement of muscles and joints that is taught in physiotherapy. This approach involves knowledge of muscular anatomy that isn’t usually used in osteology, at least not with the focus it has been given in this research.

When a change in a point of attachment is found whether it is a developed robusticity, irregular surface or depression, it will not be observed only by itself, but together with other attachment points for muscles that might have worked together with that one, since this could help to consider or rule out certain possibilities and see also what movement pattern these muscles might have created. It is important in this analysis to know about movement anatomy because it is helpful to understand what the muscles were doing in each case, although sometimes this might not be possible because of damages in some bones. Once it has been observed which muscles were developed it will be possible to analyze how these were moving together and reconstruct the possible activities of the individuals.

1.6. Anatomical terminology for movements

To facilitate for the reader, anatomical terminology used in this study is listed below in alphabetical order:

- Abduction: Movement away from the middle plane (Jarmey 2018: 16).
- Adduction: Movement toward the middle plane (Jarmey 2018: 16).
- Dorsiflexion: Raising the dorsal part of the foot. Like when one stands on the heels (Jarmey 2018:17).
- Elevation: To raise or move upward (Jarmey 2018: 18)
- Eversion: Pointing the sole of the foot laterally (Jarmey 2018: 17).
- Extension: To return to the anatomical position from a flexion. The opposite of flexion (Jarmey 2018: 15).
- Flexion: It reduces the angle of a joint. It is usually forward, except on the knee, in which it’s backward (Jarmey 2018: 15).
Inversion: Pointing the sole of foot medially (Jarmey 2019: 17).
Lateral rotation: Turning toward the outside (Jarmey 2018: 16).
Medial Rotation: Turning toward the inside (Jarmey 2018: 16).
Plantarflexion: When the sole of the foot points backward, like for example in tiptoeing (Jarmey 2018: 17)
Pronation: When the palm of the hand is facing downward (Jarmey 2018: 16).
Retraction: Moving backward (Jarmey 2018: 18)
Supination: When the palm of the hand is facing upward (Jarmey 2018: 16).
2. Presentation of the material

The block Banken 1 has been excavated in two phases. The two excavations were part of an archaeological investigation requested by Faktab Finans AB. The first one on 1991, directed by the archaeologist Erik Swanstrom, in which about 60 graves, dated to the Early Middle Ages were discovered, and the second, on November 1998, directed by Beatrice Rydén, and executed by Länsmuseet Gotlands Fornsal. In this last excavation 29 human skeletons were discovered. The individuals studied come from the last excavation, done in 1998 (County Board’s journal number 220-437-98). The site was located north to the S:t Hans church ruin and S:t Peter’s church ruin and it has been interpreted as a Christian cemetery from the Early Middle Ages (Liebe-Harkort 1999: 3). It is surrounded by the streets Hästgatan, Mellangatan, Sankt Hansgatan, and Valters gränd (Hedén 2012: 10).

Many of the graves had been disturbed and damaged which could explain the fragility of the remains (Liebe-Harkort 1999: 3). The archaeological analysis showed a mixture of graves that contained grave goods and others that did not. The Christian tradition of the Late Middle Ages is characterized by burials without grave goods, but during the Early Middle Ages, which was a period of transition between the pagan and Christian burial customs, there was a mix of both, which is why these were interpreted as the oldest Christian burials, coming from a period in which the burial customs were changing, although the people were still influenced by pagan traditions (Rydén 1998: 12). The grave goods found were a bronze ring, two whetstones, one of them made of slate, a ceramic shard, and there were also some coffin nails (Rydén 1998: 12).

On grave 3 there was also the radius of a pig (Sus scrofa domesticus) and a fragment of the mandible or maxilla of an infant. A radiocarbon analysis was made to two of the individuals found; the individual from grave 3 (analyzed in this study) and the individual from grave 28 (not included in this study). The samples were sent to Beta Analytic Inc., Florida, USA. Grave 3 was dated to AD 890-1025 (Rydén 1998: Bilaga 2) and grave 28 to AD 985-1065 (Rydén 1998: Bilaga 3).

This cemetery has been linked to the first church of Gotland, Allhelgonakyrkan, although there isn’t enough support for this hypothesis (Hedén 2012: 6-7). According to the Gutasaga Allhelgonakyrkan was built by Botair from Akebäck in the middle of the eleventh century at the place where S:t Peter’s church was built (Andrén 2011: 98-99). The churches of S:t Hans and S:t Peter were both built during the thirteenth century; S:t Hans’ Church in the middle of the thirteenth century and S:t Peter’s Church at the end of the thirteenth century. These two churches shared a common wall and the same floor (Andrén 2011: 97). There were traces that indicated that possibly another church existed in this area, and it has been proposed that this could be the first church of Visby (Hedén 2012: 6), although according to Andrén (2011: 98-99) the only remains of another church in the area belong to small stone church dated to the end of the twelfth century, and most likely belong to the first phase in the construction of S:t Hans’ Church (Andrén 2011: 98). Andrén (2011: 99-100) also affirms that there are no traces of the presence of Allhelgonakyrkan, but what could point to the existence of this church are the findings of objects from graves discovered in the surrounding area (although he does not mention exactly where) such as small picture stone with an engraved cross and a grave stone slab with a carved cross with a runic text, both which are dated to the second half of the eleventh century. However, there are many places in Scandinavia where artifacts have been found, like grave goods and runic inscriptions that mix pagan and Christian symbols, and the period in which both religions overlapped must have been of about two hundred years in some places.
There were probably already Christians in Gotland during the ninth and tenth centuries, although it was in the eleventh century that Gotland became officially Christian (Andrén 2011: 148).

The churches of S:t Peter and S:t Hans have been place to about one hundred medieval graves that can be linked to the German people who lived in Visby during the fourteenth and fifteenth centuries. These churches were officed by protestant priests during the 1520’s, but these were demolished around 1530 (Andrén 2011: 100). According to Beatrice Rydén the presence of objects that could be grave goods found on the graves indicate that the individuals from the excavation at Banken 1 are most likely Gotlanders from the Early Middle Ages (Rydén 1998: 12; Hedén 2012:38).

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3. Earlier research on occupational stress markers

Changes to the bones and teeth may develop when they are exposed to the constant stress of certain activity (Kennedy 1989: 129). There is clinical evidence that bone adapts to biomechanical stress with increased blood flow and subsequent growth (Michopoulou et al. 2017: 409). These changes are a reflection of how bone plasticity reacts to pressure from external and internal forces that are not the cause of a disease, a hormonal or chemical imbalance or any other type of disorder (Kennedy 1989: 156). These changes can be observed as changes on the surface of the bone which could become raised, depressed or irregular (Mariotti et al. 2004: 146).

Entheses are the points where tendons and ligaments attach to bone. Tendons attach muscles to the bone while ligaments attach bones to one another, and changes to these are used to find out a population’s lifestyle (Steenbakker 2018: 7), although in some cases muscles are directly attached to bone (Jarmey 2018: 19). Kennedy (1989) compiled a list of about 140 markers and the causes of these, but these still require investigation; they have been taken from archaeological, ethnological and medical sources but since they have not been confirmed, their interpretations vary and different investigators have attributed different causes to them. They are also explained by a single activity (Kennedy 1989: 154-156). Others who have written about entheseal changes and the activities that caused them are Baxarias & Herrerin (2008).

Mariotti et al. (2007) classify these changes as robusticity, proliferative enthesopathies or erosive enthesopathies. Erosive enthesopathies contain micro and macroporosities which are only recorded if they exceed 1 mm in size, (Steenbakker 2018: 22). Mariotti et al. (2007) made a study with skeletons of known age, sex and occupation which was used to create a standard of how to score 23 entheses of the post cranial skeleton, that only encompass the limbs. Pictures of the entheses and their different categories are provided to minimize subjectivity of interpretation (Mariotti 2007). Hawkey & Merbs also created a method that measures the development of these changes, and classifies them as robusticity, depression, exostosis and ossification. The approach of the studies made until now has been concerned with scoring the development of entheses. The problem with these scoring systems is that there is no standard method to apply them (Delgado García et al. 2018: 169-170). However, there are two types of entheses that react differently to these forces: fibrous that attach via the periosteum and may often show irregularities, and fibrocartilaginous that attach tendons and ligaments directly to the bone, and react only to extreme constant stress and which have been studied because they are easy to observe, so it is possible to score their level of development (Steenbakker 2018: 7-9). There is also a debate as to the reliability of entheseal changes as a method: not all the studies made show the same results; some have not found that there is a real correlation between physical activity and these changes, and some have got different results even studying the same material. Others conclude that they are ”at least” influenced by activity (Steenbakker 2018: 19). Another problem is the difference between fibrous or fibrocartilaginous entheses. Fibrous entheses normally present variations. According to Villote & Knüsel (2013: 136) since the changes to the different types of entheses have different causes, they should be classified differently; other attachments should be included like the tissues sounding the joints, and the sesamoid bones, because these also participate on mechanical stresses and do not have their effect on the entheses recorded either. Some researchers have registered entheseal changes not related to physical activity and age, but to certain pathologies and local trauma that may also cause alterations (Villote & Knüsel 2013: 135-140). It is also difficult to determine if activity alone is the cause of entheseal changes because other factors may influence this too, like age,
body mass, genetic predisposition, etc. as well as gender differences between men and women (Michopoulou et al. 2017: 409-410). Michopoulou et al. (2017) also tested the Coimbra method developed by Henderson et al. (2016) that scored fibrocartilaginous entheses and should be a more exact method with a smaller error margin. However, the test of this method showed results that contradicted their previous findings.
4. Description of the individuals in graves 2, 3 and 20.

The approximate age, stature and sex of the individuals examined has been determined and the following muscles and pathologies related to activity were found on each of them. A detailed list on the muscles by bone and body part can be found at the end of this essay (Appendix I).

4.1. Grave 2
Age: 44-50 (White & Folkens 2005: 377\(^3\)).
Stature: 1.68 m (+/- 3.72 cm) (Trotter & Glesser 1952: 483).

On the upper body there was the development of muscles that flex and extend the neck, some flex the shoulders and flex and extend the arms (Calais-Germain 2008: 81-132). On the scapula there were muscles that rotate the arm (Jarmey 2018: 163-167), and enthesopathies from ligaments on the clavicle (clavicula) (Calais-Germain 2008:113). From the distal part of the humerus and the forearm there are flexors and extensors of the wrist and second through fifth fingers and abductors and extensors of the thumb. There were also muscles that supinate and pronate the arm (Jarmey 2018: 189-215) and enthesopathies on the phalanges (Baxarias & Herrerin 2008: Enthesopathies- 17).

On the ribs (os costale) there were muscles that control respiration and stabilize the rib cage, as well as muscles that extend the spine (Jarmey 2018: 91-103), and rib osteoarthritis (Kennedy 1989: Table 1). On the vertebrae, there was cervical osteoarthritis, space narrowing (Baxarias & Herrerin 2008: Osteoarthritis-1) and thoracic and lumbar Schmorl’s nodes (Waldron 2009: 45).
On the lower extremity there were flexors, extensor, abductors and rotators of the hip, extensors and flexors of the knee, muscles that helped with dorsiflexion and plantarflexion of the foot (pedis) and extensors of the toes (Jarmey 2018: 231-271). There were also enthesopathies on the Achilles tendon (Baxarias & Herrerin 2008: Enthesopathies- 28).

4.2. Grave 3
Age: 22-26 (White & Folkens 2005: 376\(^4\)).
Sex: Male (Phenice 1969: 299).
Stature: 1.71 m (+/- 3.27 cm) (Trotter & Glesser 1952: 483).

On the upper body there were muscles that flex and extend the neck, muscles that flex the shoulders, and muscles that flex and extend the arms (Calais-Germain 2008: 81-132). On the scapula there were muscles that rotate the arm, extend the neck and elevate and retract the scapula and abduct the arm (Jarmey 2018: 147-167). There were also enthesopathies from

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\(^3\) According to White & Folkens‘ (2005: 376-377) summation of Todd’s (1920) method for pubic symphysis age determination.

ligaments on the clavicle (*clavicula*) (Calais-Germain 2008:113). On the forearm there were pronators of the forearm, supinators of the arm, extensors and flexors of the second through fifth fingers and flexors and extensors of the thumb (Jarmey 2018: 182-213), also an erosion or fracture of the styloid process (*processus styloideus*) of the left ulna, possibly due to a triangular fibrocartilage complex injury, known as TFCC injury (Ng *et al.* 2017: 448).

On the ribs (*os costale*) there was muscles that control respiration and stabilize the rib cage, as well as muscles that extend the spine, and osteoarthritis of the ribs (*os costale*) (Kennedy 1989: Table 1). On the vertebrae, there was a very slight cervical osteoarthritis (Baxarias & Herrerin 2008: Osteoarthritis- 1) and lumbar Schmorl’s nodes (Waldron 2009: 45; Kyere *et al.* 2012: 2115-2116).

On the lower extremity there were muscles that extend the hip and those that rotate it, and muscles that abduct, adduct and flex the thigh. On the feet (*pedis*) there were muscles that plantarflex and evert the foot, and those that flex and extend some of the toes (Jarmey 2018: 229-273).

### 4.3 Grave 20

**Age:** 44-50 (White & Folkens 2005: 377).

**Sex:** Male (Walker 1994: 20-21).

**Stature:** 1.79 m (Trotter & Glesser 1952: 483).

The upper body presented muscles that flex and extend the neck, some that flex the shoulder and those that flex and extend the arm (Calais-Germain 2008: 81-132). There were also robusticities on the clavicle’s (*clavicula*) sternal end (*extremitas sternalis*) (Sangal 2018), and on the clavicular scapular joints (*extremitas acromialis*) (Kennedy 1989: Table 1).

On the scapula there were muscles that elevate, retract and those that rotate it. There were also robusticities on the coracoid process (*processus coracoideus*), and the acromioclavicular joint (*articulatio acromioclavicularis*) (Kennedy, 1989: Table 1). On the arm there were muscles that rotate the arm, those that flex it and extend it and those that pronate the arm. There were muscles that flex and extend the fingers and that extend and flex the wrists (Jarmey 2018: 146-199).

On the forearm there were muscles that pronate and supinate the arm, arm flexors and extensors, flexors and extensors of the wrists and fingers. There were also enthesopathies on the phalanges, flexors, extensors and abductor muscles of all the fingers, plus enthesopathies on the first and fifth metacarpals (Jarmey 2018: 187-217) and enthesopathies and osteoarthritis on the olecranon (Baxarias & Herrerin 2008: Enthesopathies-11; Osteoarthritis- 15).

On the thoracic cage there were muscles that retract and elevate the scapula, robusticities on the spinous processes (*processus spinosus*) and transverse processes (*processus costalis*). Muscles that elevate and stabilize the ribs (*os costale*) and muscles that extend the spine (*columna vertebralis*) (Jarmey 2018: 91-151). There was also cervical osteoarthritis, thoracolumbar osteoarthritis, and lumbar Schmorl’s nodes (Waldron 2009: 45).

On the lower extremity there were hip abductors, adductors, flexors, extensors, and muscles that rotate the hip, as well as muscles that flex, extend and stabilize the knee. On the foot (*pedis*) There were flexor and extensors of the toes and those that could help the toes ”grab things”, muscles that evert plantarflex and dorsiflex the foot (Jarmey 2018: 228-281) and enthesopathies on the Achilles tendon (Baxarias & Herrerin 2008: Enthesopathies- 28).

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5 According to White & Folkens’ (2005: 376-377) summation of Todd’s (1920) method for pubic symphysis age determination.
5. Interpretation

The movements of the individuals have been deduced by examining each part of the body separately.

5.1. Grave 2

5.1.1. Movements of the upper body and possible activities

In this individual the muscles developed of the upper body (*Fig 1*) show that the arms were often extended forward and this action would be done by trapezius (Jarmey 2018: 147); the upper fibers of this muscle are connected to the clavicle and keep the arms suspended (Calais-Germain 2008: 124), while the anterior fibers of deltoid, connected to the clavicle flex the arm at the shoulder joint. These two muscles act together with the clavicular head of pectoralis major brings the arm forward. Subscapularis found on the humerus could also participate of this movement as an accessory muscle (Calais-Germain 2008:132-133). There are arm flexors developed, which indicate that there may have been repeated flexion of the arms toward the body, which would be done by brachialis (Baxarias & Herrerin 2008: enthesopathies-12), one of the major flexors of the arm (Calais-Germain 2008: 146), together with biceps brachii (Jarmey 2018: 171). These would be helped by pronator teres that assists in flexion while pronating the arm (Calais-Germain 2008: 153). The spine (*columna vertebralis*) would extend by the action of the postvertebral muscles (seen on the ribs), the neck by trapezius, splenius capitis and longus capitis (Jarmey 2018: 75-147) and the hip by gluteus maximus (Jarmey 2018: 233). When the arms are being extended (by trapezius), subclavius may have worked drawing the shoulder downward (Calais-Germain 2008: 122; Jarmey 2018: 155). Triceps extends the arm, and the flexion of the back is possible because of the degenerative intervertebral disk that caused Schmorl’s nodes and the neck would be flexed by sternocleidomastoid.

*Figure 1* Muscles of the pectoral girdle. Picture by Anatomy and Physiology 2017.

The trapezoid and conoid ligaments were also visible on the clavicle (*clavícula*) (Gray 2009: 93), these connect the coracoid process (*processus coracoideus*) of the scapula to the clavicle (*clavícula*) (Calais-Germain 2008: 113). The left humerus has a bigger pectoralis major insertion than the right one. (Calais-Germain 2008: 130-133; Jarmey 2018: 157), and a bigger deltoid tuberosity; which could mean that the left shoulder and left pectoralis major have been used more than the right one. In the right arm there is, at the same time, a bigger origin of brachioradialis, which helps to flex the elbow in midpronation (Jarmey 2018: 195) together with teres major which also looks bigger on the right side in this individual. Teres major works when the arm rotates medially. The trapezoid and conoid ligaments were also visible on the clavicle (*clavícula*) (Gray 2009: 93), these connect the coracoid process (*processus coracoideus*) of the scapula to the clavicle (*clavícula*) (Calais-Germain 2008: 113).
Activities where the individual keeps the arms forward flexes and extends the arms and holds something with the fingers flexed and the thumbs abducted and extended (this grip was deduced by the muscles of the hands and will be discussed later) are not easy to find for this individual; the lack of thumb flexors makes it unlikely to include activities where the thumbs are used, which would involve activities normally expected for women, like for example baking and hand washing clothes and other household chores. The grip of the hands and the muscles are more compatible with for horse riding and rowing. Horse riding is an activity in which the arms are held suspended, and where there is flexion extension of the arms (Figs. 2 & 3); depending on the gait of the horse, the arms are held in different positions: extended during the free walk and rapid walk, semi flexed during a moderate walk and flexed during trot, and gallop (Tibblin 1988: 91-94). Horses were the common means of transportation during long trips (Wahlqvist 1993: 191), but there should also have been horse riding competitions which were a popular sport during the Viking Age; texts about that time state that both men, women and children practiced sports equally (Wieden 2006: 4-20).

Rowing (Fig. 4 & 5) during the Viking Age should not have been uncommon for long distance trade, fishing, hunting, and visit markets abroad. However, this was supposed to be the role of the men while women stayed at home (Sawyer 2003a)6 and according to Icelandic law, the role of a woman was well defined an confined to the family farm, but widows or those who had no family could be forced to take responsibilities that were normally assigned to men (Sawyer 2003b)7. One thing to consider though is that this individual has not gone through a radiocarbon analysis, so she could well be from a different period, and that there can be many activities from around that time that are not known today. What can be observed though, is that she seemed to have been in good physical shape because she had a very well developed musculature.

Another possibility that was investigated was the use of a loom. There are two problems with this activity: weaving in floor looms (the horizontal type of loom) in Europe during the Middle Ages was a masculine activity and a specialized occupation, before that, weaving was a female activity, and in Northern Europe vertical looms were used (Gejjer 1994: 103-107). These vertical looms were also used during the Viking Age in Sweden (Klessing 2015: 45-47) but weaving in that type of loom requires the manipulation of threads and other parts of the loom would require use of thumb muscles like opponens pollicis, which allows the individual to hold small objects with the thumb and the other fingers (Jarmey 2018: 217) and those types of muscles were not found on the individual.

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Taking a closer examination to rowing as an activity, the rowing stroke and the muscles used can be analyzed. The rowing stroke is divided into six different steps, which are excerpted from a description of modern sculling rowing stroke (with two oars) in a boat with a moving seat. The sweep stroke (with one oar) differs slightly in the movements of the arms (Mazzone 1998: 4), in which it is the inside hand that rotates the oar (Hannafin & Hosea 2012: 239). Viking ships had fixed seats so the actions of the lower half of the body are not considered in this explanation. The steps of the rowing stroke are the catch where the trunk is flexed, and the arms are extended (Mazzone 1988:4). The drive-legs emphasized, in which the shoulder muscles are used and those that stabilize the scapula (Mazzone: 1988: 6-7). During the drive-body swing the back extends and the arms start flexing (Mazzone 1988: 7), and next, during the drive-Arm pull through, the rower draws the oar toward the body (Mazzone 1988: 7). The next step, the finish, the muscles that started to extend the spine and flex the arms keep contracting, and the arms are medially rotated (Mazzone 1988: 8). The last step, called the recovery, happens when the arms are fully extended by triceps brachii and the wrists extensors and adductors (Mazzone 1988: 8). Most of the muscles mentioned by Mazzone (1988) are found on the individual: trapezius, deltoid, pectoralis major and biceps brachii, brachialis and brachioradialis that flex the arm, with pronator teres (Mazzone 1988: 7) triceps that extends the arm (Mazzone 1988: 6), was present on the individual, as well as erector spinae and gluteus maximus, the first one extends the spine and the second one the pelvis (Mazzone 1988: 4). Latissimus dorsi was seen only in the left arm (Mazzone 1988: 8) Teres major was present as well.

Those that could not be observed were the rhomboids, since the medial border (margo medialis) of the scapula was fragmented, serratus anterior and abdominals some of which are on the ribs, since ribs were also fragmented. Those that were not developed on the individual were coracobrachialis, the only arm flexor that was not present, as well as pectoralis minor, and teres minor.
Since the left humerus has a bigger pectoralis major insertion than the right one (Calais-Germain 2008: 130-133; Jarmey 2018: 157), a bigger deltoid tuberosity (tuberositas deltoidea), and a bigger common flexor origin. At the same time, the right humerus has a bigger origin of brachioradialis, that helps to flex the elbow in midpronation, and also may be used in activities that flex the arm, rowing or skiing, for example (Jarmey 2018: 195); which could mean that her right arm may have flexed more, or more often than the left one, maybe acting together with teres major which also looks bigger on the right side in this individual. One possible explanation is the fact that the individual may have been left-handed, using more the finger and wrist flexors and the shoulder muscles (deltoid) and breast muscles (pectoralis major) of the left arm, and flexing the right arm more. Another explanation is that the left arm could have been the inside arm in sweep rowing, which that rotates the oar, and the right arm, the outside arm (Fig. 6) (Hannafin & Hosea 2012: 239). Teres major seen in the right arm is used in activities like rowing or skiing (Jarmey 2018: 169); skiing was practiced with one pole during the Viking Age (Wieden 2006: 18).

5.1.2. Movements of the hands and activities

Hand movements and a type of grip were deduced by the developed muscles and phalanx enthesopathies. These are muscles responsible for extending and flexing the wrists, as well as some of the phalanges. The enthesopathies were located on the first, second and third phalanges (phalanges proximales, phalanges mediae, phalanges distales) of all the fingers except on thumb’s 1st phalanx. These are attributed to the use of tools (Baxarias & Herrerin 2008: Enthesopathies-17) (Fig. 7).

Extensor carpi radialis longus, extensor carpi radialis brevis and extensor carpi ulnaris which both extend, adduct and abduct the wrist (Jarmey 2018: 197-201). Flexor carpi ulnaris and palmaris longus flex the wrist (Jarmey 2018: 185), and they may also help with the flexion of the elbow (Calais-Germain 2008:172). These could have been used together with flexor digitorum superficialis and flexor digitorum profundus, which together flex the first interphalangeal joints and the distal joints of the second through fifth digits (Jarmey 2018: 187-189). Flexor carpi radialis flexes the wrist and helps with flexion and pronation of the elbow (Calais-Germain 2008: 173), and pronator teres which pronates the forearm (Jarmey 2018: 187). The left humerus has a bigger common flexor origin (Jarmey, 2018: 182). All these muscles would flex and extend the wrist and some of the fingers.
Flexor digitorum profundus (Gray 2009: 101) flexes distal phalanges (phalanges distales) of all the fingers except the thumb (Jarmey 2018: 201). Flexor digitorum superficialis and flexor digitorum profundus both flex the wrist, the metacarpophalangeal joints and the proximal interphalangeal joint of the 2nd, 3rd, 4th and 5th digits (Jarmey 2018: 189-191). On the right metacarpals (ossa metacarpi), the palmar interossei muscles help one hold something between the second and fifth digits (and the other fingers). Opponens digiti minimi on the left hand, rotates fifth metacarpal, and would help to hold small objects between the little finger and the other fingers (Jarmey 2018: 215). The grip formed by these muscles works with the object being held with the second through fifth fingers, while the thumb would be extended by extensor pollicis longus and extensor pollicis brevis, that extend both the proximal and distal joints of the thumb (Jarmey 2018: 207-205), and maybe also abducted by abductor pollicis longus (Jarmey 2018: 205).

Possible activities found in the flexors of the hands are a "hook grip" (Jarmey 2018: 189) these are the muscles that flex the second through fifth digits; these could act while holding an object with a handle, maybe acting together with the thumb extensors to hold an object like a bucket or something similar, like a cauldron (Fig. 11). Cauldrons with bucket-like handles have been found in archaeological material discovered in Mästermyr dated to the Viking Age (Arwidsson & Berg 2017: 10-11). The Other activities with a similar grip are holding the reins of a horse, which uses the second through fifth fingers and keeps the thumbs straight; it may include flexion of the wrist as well, according to Tibblin (1988: 70-71). The problem with this grip is that it does not abduct the thumbs, it simply does not flex them (Fig. 10). Another activity that flexes the fingers and abducts the thumbs can be peeling a fruit or vegetable (Fig. 9).

One of the possible grips happens when holding an oar handle. According to Hannafin & Hosea (2012: 239) abductor pollicis longus, extensor pollicis brevis and extensor carpi radialis longus and brevis are muscles that act during feathering (Fig. 8). These are thumb and wrist extensors and abductors (Jarmey 2018: 197-205). Finger flexors and thumb extensor and abductors are mentioned in sweep rowing (Hannafin & Hosea 2012: 239). At the catch the finger flexors hold the oar while the wrist flexors rotate it (Mazzzone 1988: 6). Flexor and extensor carpi ulnaris adduct the wrist and help to pull the oar toward the body, then the wrist extensors raise the oar blade from the water (Mazzzone 1988: 7-8 10). The wrist extensors keep the wrists extended and then the wrists flex to rotate and return the oar blade back into the water (Mazzzone 1988: 8-9). All of these are found on this individual together with other flexors and extensors.

Figure 8 Hand holding the oar in sweep rowing. Hannafin & Hosea 2012.

Figure 9 Hands peeling an apple. The fingers are flexed and the thumbs are abducted. By Healthy Living.

Figure 10 Example of a "hook grip" from hands carrying buckets. Wikimedia commons.

Figure 11 Grip of the hands in horse riding. By Liz Goldsmith.
5.1.3. Other muscles of the hands.

Supinator which looks bigger on the right side, supinate the arm and may act on turning movements of the arm (Jarmey 2018: 203). Extensor indicis extends the index finder (Jarmey 2018: 215). There is no activity found that could be related to these last two muscles.

5.1.4. Changes and pathologies of the axial skeleton related to activity

Certain activities can be related to movements deduced from changes on the spine (columna vertebrales) which are related to flexion of the cervical and thoracic vertebrae (vertebrae cervicales, vertebrae thoracicae), flexion of the rib cage, and related pathologies.

On the mastoid process (processus mastoideus) of the temporal bone (os temporale) there was the development of sternocleidomastoid (Jarmey 2018: 81), splenius capitis (Gray 2009: 47) and longissimus capitis (Jarmey 2018: 93). Sternocleidomastoid is used for flexion of the neck (on a bilateral contraction) (Calais-Germain 2008: 88). Splenius capitis extends the neck together with longissimus capitis (Jarmey 2018: 93-97). The repeated flexion of the neck could have put stress on the cervical vertebrae (vertebrae cervicales) and caused the space narrowing found there on C4 through C6. Space narrowing is a result of intervertebral disk deterioration (Baxarias & Herrerin 2008: Osteoarthritis-1). According to Calais-Germain (2008:42) intervertebral disk deterioration is caused by repeated pressure of the intervertebral disks due to flexion, which coincides with the development of these muscles. There was also osteoarthritis on the cervical vertebrae (vertebrae cervicales) (Baxarias & Herrerin, 2008: Osteoarthritis-10). Cervical osteoarthritis is common in the elderly and could therefore have been accentuated or caused by the age of the individual (Baxarias & Herrerin 2008: Osteoarthritis- 10).

Schmorl’s nodes were found on both cranial and caudal surfaces of many of the thoracic vertebrae, from T4 through T10, except for T9 (Sten, Personal communication 2019-04-09). One of the possible causes of Schmorl’s node is putting a big stress on the lower spine, which compresses the intervertebral disks to the point of rupturing (Waldron 2009: 45). Intervertebral disk deterioration may happen by excessive wear or aging (Calais-Germain 2008:42). Schmorl’s nodes have mostly appeared on the thoracic vertebrae, especially on the lower thoracic in a number of studies (Kyere et al. 2012: 2116). These nodes would then have the same possible cause as the space narrowing found in the cervical vertebrae, in other words, there probably was repeated pressure put on the neck and thoracic spine, causing intervertebral disk deterioration (Calais-Germain 2008:42). Schmorl’s nodes are common, and many times asymptomatic, but in other occasions they may cause a significant amount of pain on the back. These are commonly associated with lumbar disk disease (Kyere et al. 2012: 2115).

The lumbar vertebrae (vertebrae lumbales) were too fragmented; only three small fragments and the body of one vertebra (corpus vertebrales) were observable. The body of the vertebra could be observed seemed to have a very slight Schmorl’s node.

Another trait found in this individual is the development of the caudal edges of the ribs, possibly because of the intercostal muscles, believed to be used in breathing. These muscles are innermost intercostals, which may fix the rib cage during breathing, and external and internal intercostals which may also stabilize the rib cage during trunk movements (Jarmey 2018: 107-109). There was also osteoarthritis on the tubercles of the ribs (Sten, personal communication, 2019-04-09). Rib osteoarthritis also produces loss of movement and may be caused by excessive rotation and flexotension of the spine (Baxarias & Herrerin 2008: Osteoarthritis-13). Movements of the spine affect the position of the ribs, they come closer together during flexion, farther from one another on extension (Calais-Germain 2008: 63).

Muscle growth on the posterior portion of the ribs could be attributed to the postvertebral muscles, maybe also to the iliocostalis portion of erector spinae, responsible for extension, side flexion of the spine and inhalation (Jarmey 2018: 91-93). It is during extension of the spine, that the postvertebral muscles endure the biggest amount of stress (Sonesson & Sonesson 2006: 100). There was also calcification of the spinous ligaments (ligamentum spinosus) of the sacrum
(Geber, personal communication 2019-04-18). The causes of this are debated, it could be when that part of the vertebral column (columna vertebralis) endures much tension or as healing for a lesion (Oppenheimer 1942: 160).

Possible activities to explain these changes of the rib cage are those which cause stress on the ribs, in which the rib cage and the lumbar spine are bent and it makes the individual more susceptible to intervertebral disk herniation on the lumbar vertebrae, for example sweep rowing (Hannafin & Hosea 2012: 238-242), where the spine endures rotation, flexion and hyperextension (Clay et al. 2016: 346). Rowers have shown to have a major incidence of disk herniation than the rest of the population, from 60% up to 95.2% (Hannafin & Hosea 2012: 242). Compensating for strength one may need and the amount of years rowing have been found to increase the risk of injury (Clay et al. 2016: 346-347). Rowing injuries are due to poor technique and overtraining and injuries are focused on the lower spine (Hannafin & Hosea 2012: 237). The articles do not refer to damage in the thoracic vertebrae (vertebrae thoracicae) but they do show that flexion in this section of the spine occurs at the catch (Fig. 4), and the thoracic and lumbar paraspinous muscles stabilize the spine to transfer force to the oar (Hannafin & Hosea 2012: 237). There is also a back flexion of 30° and a hyperextension of 30° as well (Hannafin & Hosea 2012: 237-242). The occurrence of multiple Schmorl’s nodes has been associated with lumbar disc disease (Kyre et al. 2012: 2115). Activities in which the spine (columna vertebralis) rotates put much pressure on the spine like skiing, sitting down too much or bearing weight often (Sobotta 2009: 115).

Changes found on the ribs, like the development of the caudal edges could have happened because the intercostal muscles stabilize the rib cage during trunk movements (Jarmey 2018: 107). Unfortunately, the lumbar vertebrae (vertebrae lumbales) of this individual were too fragmented to have an accurate idea of their condition. Rib fractures are another type of injury that occurs in people who do activities like weightlifting, rowing and skiing (Hannafin & Hosea 2012: 238). The ribs of this individual were too fragmented to discern if there had ever been any fractures; but it is worth mentioning that rib fractures were found in the material from Banken I excavated in 1991 (Hedén 2012: 12).

Other possible activities that may have caused the changes in the axial skeleton is picking up and carrying heavy objects. The elevation of ribs that may have cause rib osteoarthritis may be caused by lifting heavy loads (Kennedy 1989: Table 1). Standing up from a flexed position while picking up heavy objects can also be the cause of damage in the intervertebral disks found on the individual’s thoracic vertebrae (vertebrae thoracicae) (Calais-Germain 2008: 48). Carrying a heavy object while standing up may also put pressure on the lumbar vertebrae and use the post vertebral muscles which extend the spine (Sonesson & Sonesson 2001: 100-101). Another cause of intervertebral disk degeneration may happen at any age, although age may also affect the intervertebral disks (Sobotta 2009: 114).

Other changes found on the thoracic cage are the shape of both first ribs which are thicker and flatter than in other cases and the sternum which looks shorter and wider. There are no visible muscular attachments in either of them. There is though no known reason why this happened and cannot be linked to neither pathology nor activity.
5.1.5. Activities deduced by the muscles of the lower extremity

The enthesopathies and muscles found on the lower extremity are consistent with movements like flexion of the knees and hip, rotation of the hip and movements of the feet like dorsiflexion and plantarflexion.

The enthesopathies found could be explained by walking on slopes, which would be done by different muscles; those that flex and extend the femur at the hip joint, those that flex and extend the knee, and those that help support the foot (Fig. 12 & 13).

The hip (or the femur at the hip joint) would be flexed by obturator externus (Calais-Germain 2008: 232; Jarmey 2018: 245) and would be extended by gluteus maximus, which acts while going upstairs or going uphill, like in this case (Jarmey 2018: 229). Vastus medialis would extend the knee (Jarmey 2018: 241). On the patella, there were enthesopathies from the tendon of quadriceps femoris, which could be from walking and trekking (Baxarias and Herrerin, 2008: Enthesopathies- 24). The muscles that conform quadriceps femoris flex the hip and extend the knee (Jarmey 2018: 241). Other muscles like Obturator internus (for movements like side stepping) and biceps femoris rotate the hip laterally but biceps femoris also extends it (Jarmey 2018: 237-249). Gemellus superior and quadratus femoris abduct the femur when it’s flexed and rotate the hip (Jarmey 2018: 237). Some of these muscles were earlier noticed in the study made by Stefanie Hedén and by Dr. Staffan Jennerholm (radiologist), and he referred to muscles like obturator internus and externus, and gemellus superior and attributed their development to the landscape of Gotland which was composed of numerous slopes, and the fact that people must have moved by foot quite much during the period in which the individuals lived (Hedén 2012: 39-40) (Fig. 13 & 14).
There were also muscles that control and support movements of the foot like dorsiflexion and plantarflexion which are movements that normally happen during walking (Calais-Germain 2008: 298). Tibialis anterior supports the arch of the foot while walking. Fibularis tertius helps with dorsiflexion of the foot. Soleus on the tibia would help with plantarflexion of the foot and keep a standing posture. Extensor digitorum brevis which extends second, third and fourth toes and helps in walking. Other muscles that would assist while walking, would be popliteus and tensor fasciae latae, both which stabilize the knee during walking (Jarmey 2018: 231-282). The feet show enthesopathies on the calcaneus on the insertion of the Achilles tendon which could be related to sheep herding, long distance running, or walking and running on uneven terrain (Baxarias and Herrerin, 2008: Enthesopathies- 28).

Some of these muscles rotate and abduct the hip and they are tensor fasciae latae (Jarmey 2018: 231) which flexes and abducts the hip and may work together with gluteus maximus (Calais-Germain 2008: 250-252). Adductor Magnus which medially rotate the thigh and adducts it, these are related to horse riding but adductor magnus also to breaststroke swimming (Jarmey 2018: 247; Calais-Germain 2008: 247). To these can be added other hip rotators that were previously mentioned: obturator internus, biceps femoris, gemellus superior and quadratus femoris (Jarmey, 2018: 237-249) (Fig. 13, 14 & 15).

5.2. Grave 3

5.2.1. Movements of the upper body and possible activities

The development of the muscles of the scapula, clavicle (clavicula), cranium and upper arms is similar to that of the individual from grave 2, and there are also pathologies on the spine, for which activities that keep the arms suspended, and where there is flexion, extension of the arms, and stress maybe flexion of the spine and the neck are possible. There are though small differences, for example the trapezius was found to be not only developed on the clavicle (clavicula), but also on the scapula and on the superior nuchal line (linea nuchalis superior) (Jarmey 2018: 147). There were also fewer arm flexors as well, and neither pronator teres, latissimus dorsi nor subscapularis were present, but supraspinatus was developed.

The fibers of trapezius that are connected to the scapula act when a force need to be applied or absorbed (Calais-Germain 2008: 124). This could happen in activities in which the shoulders are used to exert force or bear it. The middle fibers seen in scapula also retract it (Jarmey 2018: 124).
At the same time there were fewer arm flexors; which could suggest that he did not flex the arms as much as the previous individual; and that he did not hold the arms in a pronated position, since pronator teres isn’t developed. He could have worked lifting something and or applying some sort of force or pressure with the shoulders, which means that he could have used the upper and lower trapezius to lift the arms above the head, since this muscle also works in actions where the arms are lifted above the head (Jarmey 2018: 147); this action is also supported by supraspinatus, which starts abduction of the arm, lifting it up to 15° before deltoid takes over and continues with this movement (Wirhed 2002: 71; Jarmey 2018:161-163). Supraspinatus also works in sports where the arm swings a bat or racket (or something similar) (Jarmey 2018: 163). Pronator quadratus suggests twisting movements with both wrists and it is also used in modern racket sports (Jarmey 2018: 193), and together with pectoralis major, inner rotation of the arms by manipulating objects (Jarmey 2018: 157). Triceps works by extending the arm and the scapular head of this muscle also retracts the arm (Jarmey 2018: 175). Biceps flexes the shoulder and the elbow (Jarmey 2018: 171) and brachialis the elbow (Jarmey 2018: 173). This could mean he lifted objects above the shoulders or on the shoulders (which could flex the arms) and extended the arms with triceps brachii; applying force from the shoulders with trapezius to hit a ball with a bat or for example an axe to fell trees (Fig. 16 & 17). During the Viking Age, only axes were used for felling trees, and axes for that purpose have been found in Mästermyr (Arwidsson & Berg 1999: 34). There is also the possibility that bats were used during the Viking Age; texts like Grettis saga, Hord Grimkelssons saga and Eyrbyggja saga mention a sport called knattleikr which used bats and balls and should be similar to the nordic game brännboll. What could point to the existence of this game in the archaeological record are some balls found in Århus Cathedral and a drawing of people playing this sport in a gold horn found in Denmark (Wieden 2006: 15-25).

5.2.2. Movements and pathologies of the hands and activities

There are activities deduced by the muscles and pathologies found on the hands, which include muscles that flex and extend the wrists, the second through fifth fingers and the thumbs. There was also an erosion or fracture of the styloid process (procesus styloideus) of the left ulna.

Like in the previous case there are also muscles that flex and extend the wrist. The wrist flexor muscles are: Common flexor origin, more developed on the right side; place for origin of flexor carpi ulnaris and palmaris longus (Jarmey 2018: 182-185), and flexor carpi radialis. Flexor pollicis longus which flexes the thumb but also the wrist. (Calais-Germain 2008: 186). The wrist extensors are extensor carpi radialis longus (more developed on the left side), and
extensor carpi radialis brevis, extensor carpi ulnaris, and extensor digitorum, which extends the wrist and all the fingers except the thumb (Jarmey 2018: 187-201). There seems to be more flexion on the right wrist and more extension of the left wrist, maybe holding objects with one wrist flexed and the other extended. The act of swinging an axe of bat could have caused flexion and extension of the wrists, like the man with the axe has the right wrist extended and the left wrist flexed (Fig. 17). The action of using a tool like a hammer, axe or others may cause extension and flexion of the wrists. A twisting movement also uses the wrist extensors and flexors. Manipulating different kinds of tools that keep the hands moving will use both wrist flexors and extensors, as well as those of the fingers.

The flexor muscles of the fingers are: flexor digitorum superficialis, which acts on the second phalanx of the second through fifth digits (Jarmey 2018: 189), flexor digitorum profundus (more developed on the left side) (Gray 2009: 101; Jarmey 2018: 201), which flexes distal phalanges of the same fingers except the thumb (Jarmey, 2018: 201), flexor pollicis longus, which flexes the joints of the thumb (Calais-Germain 2008: 186), it would be used for gripping something with the thumb, which could be any type of object, weapon or tool with a handle. Palmaris brevis which could be assisting all the other muscles that help the fingers grip things and lastly, the lumbricals flex the metacarpophalangeal joints but extend the interphalangeal joints. The extensor muscles are: extensor digitorum which extends all the digits except the thumb, extensor pollicis brevis that extends metacarpophalangeal and carpometacarpal joint of the first digit, extensor pollicis longus and abductor pollicis longus abduct and extend the thumb. These would help the thumb release the grip of something, and lastly, extensor indicis that extends the index finger (Jarmey 2018: 193-213). All these muscles could have helped the individual to hold and release the grip of things. If he was someone who worked with different kinds of tools could be using the finger flexors to grab one tool, and then extensors to release it and then the flexors to grab another one and so on.

On the hands there is osteoarthritis on the phalanges, more pronounced on the proximal (phalanges proximales) and distal phalanges (phalanges distales). This type of osteoarthritis is attributed to manipulating and holding tools (Baxarias & Herrerin 2008: Enthesopathies: 17). There was also pitting on distal phalanges (phalanges distales) and on many of the carpals (ossa carpi), which could also be related to erosive enthesopathies (Mariotti et al. 2004: 150) these erosive enthesopathies could indicate stress put on the wrists and the distal phalanges (erosive enthesopathies were common in this individual, many of the enthesal changes he presented were of the erosive type). The shaft of the right ulna was flatter than the left one, which could mean that the individual used both hands differently.

The difference between the development of the muscles of this individual and the woman from grave 2 is the presence of flexors of the thumbs and extensors of the fingers, which would help the individual hold and release some kind of tool or weapon (or other objects). There is also the development of pronator quadratus on both ulnae. This muscle pronates the forearm and would create turning movements of the wrists, for which it could be acting together with supinator, which supinates the arm (Jarmey, 2018: 203). This turning motion could be explained by the use of an auger, a type of drill which is a tool used during the Viking Age, mostly by carpenters but it has been found in graves belonging to blacksmiths, as well (Arwidsson & Berg 1999: 23). There is a toolbox from the Viking Age, found in Mästermyr, Gotland which is believed to have belonged to a farm and with tools used by smiths and carpenters, and which contained many different types of tools. Among them hammers, axes, augers, and more (Berg & Arvidsson 1999: 5). Similar tools were also used from the beginning or the Iron Age, as well. Despite the presence of tools for both smithing and carpentry, it cannot be concluded that these two occupations were practiced by the same person (Arwinsson & Berg 1999: 21).

Another indication of activities done with the hands is an apparent injury on the styloid process (processus styloideus) of the left ulna which seems to have degenerated or to have been fractured. A possible cause for this is a TFCC injury (triangular fibrocartilage complex injury), which in some cases can cause a fracture of the styloid process. This type of fracture is called a type 1B tear and is traumatic in origin (Ng et al. 2017: 452, 460) it may be caused by falling onto an outstretched hand or hyperpronation of the forearm (twisting excessively) (Ng et al. 2018: 203).
Vertebræ thoracicae (2017: 443). Hyperpronation of the forearm may be connected to the muscle pronator quadratus which pronates the forearm and is developed in both ulnae of this individual. Swinging a racket or bat is also a risk factor to develop this type of injury, so maybe an object with a handle similar to that of a modern racket, which could suggest a hammer, axe, etc. could have been the causes (Casadei & Kiel 2019). In a study by El-Sayed et al. (2017: 2110) among the men studied carpenters were the biggest group to present this injury with 28% compared to other occupations like 8% of builders and only 4% of athletes. Tools like hammers and axes could be associated to occupations like boat builders, blacksmiths and carpenters during the Viking age (Arwidsson & Berg 1999: 5). Augers especially, are associated with boat building; this has been concluded in investigations made in sunken ships found in Skuldelev (Arwidsson & Berg 1999: 34-35), and also with carpentry (Arwidsson & Berg 1999: 23). Other instances in which the wrists could have done twisting motions are during the manufacture of iron loops with a twisted end that were said to be trace rings (Arwidsson & Berg 1999: 25-Pl.18) (Fig. 18), as well as plenty of iron and metal objects that are curved and may have needed to be twisted like iron rings, objects with hooks like a steel yard or a fire grid and iron chains (Arwidsson & Berg 1999: 27- Pl. 2-3).

5.2.3. Changes and pathologies of the axial skeleton related to activity

Cervical osteoarthritis, development of the caudal edges of the ribs, rib osteoarthritis, and lumbar Schmorl’s nodes were found on the individual.

On the superior nuchal line (linea nuchalis superior) the trapezius acts as a neck extensor (Calais-Germain, 2008: 83). And could have been working together with sternocleidomastoid, splenius capitis and longissimus capitis on the mastoid process (processus mastoideus) while extending the neck (Calais-Germain 2008: 78-81; Jarmey 2018: 81-97).

The pathologies and changes of the vertebrae include the cervical vertebrae (vertebrae cervicale) in which there is a very slight osteophyte formation (Baxarias & Herrerin, 2008: Osteoarthritis-10). On the thoracic vertebrae (vertebrae thoracicae) there were ten visible bodies (corpus vertebrae) that did not have any pathologies. The lumbar vertebrae had Schmorl’s nodes, on both cranial and caudal surfaces. Like previously seen, pathologies on the lower back may be related to activities which cause intervertebral disk degeneration on the lumbar vertebrae (vertebrae lumbarum) which is associated with sweep rowing (Hannafin & Hosea 2012: 237-242), carrying heavy objects, sitting down too much and rotation of the spine (Sobotta 2009: 114-115).

There was also osteoarthritis on one the joints of the ribs (as costale) (Sten, personal communication 2019-04-09). This could be an osteoarthritis on the beginning stages, also due to the low age of the individual. Rib osteoarthritis, is caused by excessive flexotension (Baxarias & Herrerin 2008; Osteoarthritis-13) and elevation of ribs by carrying heavy objects (Kennedy 1989: Table 1). Like in the case of the previous individual, there is the development of the innermost intercostals, external and internal intercostals (Jarmey, 2018: 107-109). These muscles could also stabilize the rib cage in activities where there is flexion of spine or activities where there is rotation, forward or side flexion or extension of the rib cage (Calais-Germain 2008: 63).

Other muscles of the ribs could be anterior scalene, used in inspiration (Jarmey, 2018: 179) on the right side (the left one was fragmented). Also, possibly iliocostalis thoracis that works on extension and flexion of the spine and inhalation (Jarmey, 2018: 91).
5.2.4. Activities deduced by the muscles of the lower extremity

The muscles found on the lower extremities flex and extend the toes, others act with eversion and plantarflexion, some flex the knees and the femur and others rotate the hip.

The next muscles would act during walking uphill by flexing and extending the hip and femur: Pectineus which abducts and the flexes the hip. Gluteus maximus which extends the hip and femur (Jarmey 2018: 229-243). Other muscles would act on the foot by flexing and extending the toes and by helping in dorsiflexion, plantarflexion and eversion: On the fibula, extensor digitorum longus dorsiflexes the foot and extends all the toes except the big toe. Flexor digitorum longus, flexes the second through fifth toes and helps to keep a firm grip. Tibialis posterior (also known as Flexor digitorum longus) everts the foot and helps to walk on uneven terrain. Soleus on the tibia which helps with plantarflexion of the foot and keep a standing posture. There was also gastrocnemius which plantarflexes the foot and flexes the knee (Jarmey 2018: 259-273). Obturator internus and obturator externus laterally rotate hip and obturator internus also flexes the femur (Jarmey 2018: 237-245). These muscles could help with walking uphill (Hedén 2012: 40), which was deduced in the previous individual, as well.

The next muscles could act during horse riding by rotating the hip: Obturator internus and obturator externus (Jarmey 2018: 237-245) may have acted together with adductor magnus that medially rotates the hip (Calais-Germain 2008: 247; Jarmey 2018: 247).

Only a small portion of the right patella 3.5 x 3.0 cm in size is preserved, but there are no visible enthesopathies. The feet were not preserved with the rest of the skeleton.

5.3. Grave 20

Like the two previous individuals, the man from grave 20 has the many of the same muscles developed that are used in activities in which the arms are suspended, flexed and extended, that use the shoulders, plus other muscles and enthesopathies that indicate other activities. For more details see the list at the end of this essay (Appendix 1).

He has though subscapularis which rotates the arm medially (Jarmey 2018: 167), rhomboid minor which rotates and elevates the scapula (Jarmey 2018: 151), teres minor which rotates the arm laterally (Jarmey 2018: 165) and possibly pectoralis minor which draws down the shoulder, protracts the scapula and raises the ribs (Jarmey 2018: 155). There are robusticities of the sternoclavicular and clavicular scapular joints, anconeus which abducts the ulna (in midpronation) and extends the elbow (Jarmey 2018: 201). There were more extensors and flexors of the fingers and thumbs than on the other individuals; but fewer arm flexors than on the individual from grave 2. He has though latissimus dorsi in both arms which is used to raise or swing the arms; this muscle is used in activities like rowing but also in rock climbing and swimming, and many other activities that involve rotation, adduction and extension of the arms and it acts on the shoulders by sinking and retracting them (Jarmey 2018:159). But there are variations that indicate other activities as well.
5.3.1. Movements of the upper body and possible activities

The muscles of the upper body of the individual also indicated flexion, extension of the arms and other possible activities that are deduced from robusticities in some bones:

The trapezius was also developed on the posterior nuchal line (linea nuchalis superior) and on the scapula. But the absence of supraspinatus suggests that he probably did not abduct the arms above 15°, which could mean they did not do the same movement to use the shoulders or trapezius as the individual from grave 3. The first indications are robusticities on the clavicular scapular joints, attributed to carrying heavy loads with arms extended (Kennedy 1989: Table 1). There is also the enthesopathy from brachialis; this muscle flexes the arm acting together with biceps brachii and is attributed to labor stress (Baxarias & Herrerin, 2008: Enthesopathies-12). The enthesopathies on the radial tuberosities (tuberculum radii) from biceps brachii happen when the arm flexes repeatedly or when one carries weight with the arms flexed (Baxarias & Herrerin 2008, enthesopathies-13). The coracoid process has robusticities corresponding to the origin of coracobrachialis and biceps brachii which flex the arm (Baxarias & Herrerin 2008: Enthesopathies-12; Calais-Germain 2008: 129), and maybe also to the insertion of pectoralis minor (Jarmey 2018: 155). This could be one more indication of stress caused by flexion of the arms. Another indication is anconeus whose function is to extend the arm while carrying something (Healthline 2014). Anconeus together with supinator (Jarmey 2018: 203) and the enthesopathy of the radial tuberosity, could indicate the action of carrying weight with flexed and supinated arms. Deltoid which was also developed in this individual also participates of lifting heavy weights (Jarmey 2018: 161). On the scapula and the superior nuchal line (linea nuchalis superior), trapezius could work while extending the neck (Calais-Germain, 2008: 83) or raising the shoulders (Jarmey 2018: 147) and the spine would have been extended by the postvertebral muscles while lifting something from a position in which the back was flexed. This action puts more pressure on the intervertebral disks, which can be connected to the pathologies of the spine that were found on the individual. Flexing and extending the spine while lifting weight damages the intervertebral disks, and it is also detrimental for the spine (columna vertebralis) to lift weight with extended arms (Sonesson & Sonesson 2006:100-101) like the enthesopathies from the clavicle (clavicula) suggest. All this could indicate that the individual bore heavy weights, by holding the objects with the arms flexed and extended; although not above the shoulders like the individual from grave 3, because supraspinatus which is a muscle that initiates the action of abducting the arms (Jarmey 2018: 163) is not developed, so maybe the object would probably be held at the height of the stomach or the chest. This could either be heavy labor like Baxarias & Herrerin (2008: Enthesopathies-12) suggest, maybe even some form of weight training (Wiedén 2012: 10) which was a popular sport during both the Viking Age and the Early Middle Ages (Västmanlands Läns Museum 2019-08-04).

Another possible activity for this individual is casting or throwing an object. This one has been deduced by enthesopathies and muscles from the upper body.

The bilateral robusticity of the acromioclavicular joints (articulatio acromioclavicularis), could be explained by a throwing movement. According to Kennedy (1989: Table 1) this marker appears on a population which does harpoon throwing and kayak paddling; so it is possible that this robusticity is caused not only by throwing but also in combination with other activities where there is rotation and movement on the arms at the acromioclavicular joints (articulatio acromioclavicularis). Throwing or casting an object could also be related to the enthesopathies of the olecranon from triceps brachii in both ulnae, which indicate extension of the arm or activities which put pressure on the elbows (Baxarias & Herrerin 2008: Enthesopathies-11). Other muscles that support throwing movements are subscapularis on the scapula (which looks bigger on the right side); this muscle and trapezius both retract the scapula, but trapezius also elevates it. The flexor muscles of the arm, biceps brachii and brachialis flex the arm (Jarmey, 2018: 147-173), which would happen before throwing an object. Muscles that act during throwing are pectoralis major on the clavicle, which would contract to bring the arm forward, together with deltoid which flexes the shoulder (Calais-Germain 2008: 133). Triceps brachii as an elbow extensor would then extend the arm (Jarmey 2018: 175). There was also elbow osteoarthritis, on the right ulna caused by overuse (Baxarias & Herrerin, 2008: 28).
Osteoarthritis -15), which may indicate that this was the dominant arm of the individual. The clavicle (*clavicula*) presented robusticities at the sternal end (*extremitas sternalis*), which could have happened because it follows the movements of the arms and shoulders (Sangal 2018).

One common weapon that was used during the Viking Age was the spear (Bröndsted 1962: 91), but spear casting was also practiced as a sport in which there were two categories: Long casting and casting toward a target (Wiedén 2006: 19). These robusticities are bilateral; which could indicate that casting was done with both arms. There is a book about the Viking Age called *Kungaspegeln* that encouraged to practice a skill with both hands in order to become really skillful both in sports and battle (Wiedén 2006: 15). This book was written in Norway in the middle of thirteenth century (Wiedén 2006: 6). Wahlqvist (1993: 106-112) mentions that during the Viking Age there was casting of spears, stones and hammers which was practiced with both arms. These competitions should also have happened during the Early Middle Ages (Västmanlands Läns Museum 2019-08-04).

5.3.2. Movements of the hands and activities

There were muscles of the hand that could help the individual hold an object like a weapon, tool or something he could have worked with or cast: Flexor pollicis brevis flexes the metacarpophalangeal joint of the thumb and helps hold something between the thumb and the other fingers (Jarmey 2018: 216-217). Flexor pollicis longus which flexes the interphalangeal joint of the thumb but may also assist in the flexion of the metacarpophalangeal joint. It helps hold things between the thumb and other fingers as well by keeping a firm grip on things (Jarmey 2018: 193). Extensor pollicis longus extends the carpometacarpal and interphalangeal joints of the thumb (Jarmey 2018: 207). Opponens digitii minimi works on the little finger by helping it to hold a small object with the other fingers and could have worked together with opponens pollicis which works on the thumb and these two together would grasp objects between the little finger and the thumb (Jarmey 2018: 215-217), which is a movement that would be supported by the lumbricals that extend the interphalangeal joints but flex the metacarpophalangeal joints, and it is used in rock climbing and sports like volleyball (Jarmey 2018: 213). Flexor digitorum profundus flexes the interphalangeal and metacarpophalangeal joints of the second through fourth digits, and flexor digitorum superficialis which does the same, also flexes the wrists (Jarmey 2018:189-191). These muscles would create a pinching movement, which is used in modern rock climbing in a grip called "pinch grip" (Hörst 2003: 77-78) (Fig. 19). The dorsal interossei spread the middle, ring and index fingers. All the above mentioned muscles are known for their use in rock climbing (Jarmey 2018: 209-217). This grip could also have happened while grabbing small objects with the tip of the fingers. Rock climbing is one of the sports mentioned in texts about the Viking Age; but this information isn’t supported by any archaeological material (Wiedén 2006: 10).

Other activity is playing board games; the "pinch grip" could also have happened while picking pieces of board games which were very popular during the Viking Age. These were chess, checkers, rävspel and Hnefatafel. Pieces of these games do exist in the archaeological record (Wiedén 2006: 11-12). Other small objects can be iron nails and small objects that could indicate work with the hands (Arwidsson & Berg 1999: 17). There are also other muscles that would help the individual grip big objects: Adductor pollicis on the right hand which adducts the thumb (Jarmey 2018: 211). Abductor pollicis brevis which abducts the thumb like when one climbs or

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**Figure 19** Pinch grip used in rock climbing. By Rockclimbing.com

| Image removed due to copyright restrictions. |
holds a large object (Jarmey, 2018: 217). Adductor pollicis (Jarmey 2018: 211) adducts the thumb, like when one opens a jar or holds a rock, for example while climbing or even casting a stone. Maybe also acting together with flexor digiti minimi and abductor digiti minimi which abducts little finger which also would help one to hold a big or round object and are also used in rock climbing (Jarmey 2018: 215).

There is osteoarthritis on all the phalanges (Baxarias & Herrerin 2008: Enthesopathies- 17), but these are more pronounced on the medial (phalanges mediae) and distal phalanges (phalanges distales); the osteoarthritis is very pronounced, so it gives the impression that he had to grip something using a lot of strength, from appearance of the medial (phalanges mediae) and distal phalanges (phalanges distales). Palmaris brevis as a muscle is used for grip (Jarmey 2018: 209).

Other muscles extend the digits and the wrists and would help release an object: Common extensor origin (Jarmey 2018: 182) which is the place for extensor carpi radialis longus and brevis, and extensor carpi ulnaris which extend wrist (Jarmey, 2018: 197-201). Extensor digitorum extends the second through fifth digits and the wrist (Jarmey, 2018: 199). Abductor pollicis longus, which is more noticeable on the right hand, and very little on the left one abducts the thumb to help release an object (Jarmey, 2018: 205). The finger flexors would act while the individual is holding an object and the finger extensors while he releases it. The thumb abductors could act while he releases an object but also while he holds a thick or round object, like a stone, a ball, some tool or weapon with a thick handle, maybe an oar handle (Fig. 8) (Hannahin & Hosea 2012: 239).

There are other muscles on the forearm like pronator quadratus on the right ulna, which pronates the forearm and causes turning movements of the wrist (Jarmey 2018: 193). In the previous case this explained by the use of a tool like an auger or any other tool or technique that could have caused the individual to turn the wrist. On the right hand there was extensor indicis, but not on the left. This muscle could not be linked to an activity.

5.3.3. Changes and pathologies of the axial skeleton related to activity

The spinous processes (processus spinosus) and transverse processes (processus costalis) of the thoracic vertebrae that appear very long and very thick and present numerous robusticities. These can be due to the development of the postvertebral muscles, some of which help to extend the spine and keep it straight. These are inserted or have their origin on the spinal (processus spinosus) and transverse processes (processus costalis) of the vertebrae, and some portions of them on the ribs (os costale), sacrum (os sacrum) and occipital bone (os occipitale). Others help extend the neck, while others work with flexion and rotation (Jarmey, 2018: 91-103). These robusticities are much easier to appreciate on the thoracic (vertebrae thoracicae) and lumbar vertebrae (vertebrae lumbales) than the cervical vertebrae (vertebrae cervicale). Another possible reason for these robusticities could be the interspinous and intertransverse ligaments (Calais-Germain 2008: 39). There might be the development of levatores costarum, which works by raising the ribs and flexing the spine (Jarmey 2018: 111) and possibly the insertion of rhomboid minor on C7 and T1, which is used in activities where the shoulders are retracted, like archery, rowing and modern racket sports (Jarmey 2018: 150-151). These robusticities could be caused by lifting weight with the back flexed, which stresses the post vertebral muscles (Sonesson & Sonesson 2006:100-101) or because of activities that put stress on the back. Like in the previous two cases there was rib tubercle osteoarthritis, although barely found on one of the ribs (os costale) but not all of them were present (Kennedy 1989: Table 1). The postvertebral muscles were visible and there was the development of the caudal edge of the ribs (os costale) which have previously been explained by stress to the thoracic cage maybe from flexion of the spine (columna vertebralis).

Pathological changes on the vertebrae, like osteoarthritis on the cervical vertebrae
vertebrae cervicale) went from C4 through C7. According to Baxarias & Herrerin (2008: Osteoarthritis-10), cervical osteoarthritis is mostly caused by age. There was also osteoarthritis on the lower thoracic and upper lumbar vertebrae, also called thoracolumbar osteoarthritis caused by the degeneration of the intervertebral disks which causes narrowing of the space between the vertebrae and the contact between vertebral bodies (corpus vertebrae) leads to osteophyte formation. On the thoracic vertebrae (vertebrae thoracicae) there is generalized osteoarthritis but it’s most severe on T5 through T12. On the lumbar vertebrae (vertebrae lumbales) there was osteoarthritis on all the vertebrae, but more severe on L1 through L3 (Baxarias & Herrerin 2008: Osteoarthritis-11). There were Schmorl’s nodes on the caudal surfaces of T8, T9 and T10 which are also believed to be caused by intervertebral disk deterioration (Waldron 2009: 45). Intervertebral disk deterioration may be a consequence of repeated flexion of the spine (Calais-Germain 2008: 42), rotation, carrying weight or aging (Sobotta 2009: 114-115).

There was also calcification of the spinous ligaments (ligamentum spinosum) of the sacrum (Geber, personal communication 2019-04-18). The causes to this are debated, but it could be when that part of the column endures much tensions, when the ligaments are torn or as healing for a lesion, or independent of the aforementioned causes (Oppenheimer 1942: 160).

5.3.4. Activities deduced by the muscles of the lower extremity

A series of muscles are associated with horse riding: Gluteus medius and tensor fasciae latae, gracilis, adductor longus, adductor magnus which adduct the hip and adductor brevis, which adducts and medially rotates the hip (Jarmey 2018: 231-247).

Some muscles are used in running and are those that flex and extend hip and the knee: Semitendinosus and biceps femoris extend the hip and flex the knee, while rectus femoris flexes the hip but extends the knee. Gluteus maximus extends the hip. Sartorius flexes the knee and hip. Popliteus unlocks the knee joint. The hamstrings on the ischial tuberosities, are used during running since they slow down the leg and keep the trunk from flexing (Jarmey 2018: 229-279). The enthesopathy from quadriceps femoris on the patella is caused by activities that use the knees (Baxarias & Herrerin: Enthesopathies, 24). There were also flexor and extensor muscles of the toes: Flexor digitorum brevis, which flexes the second through fifth toes. Flexor hallucis longus which flexes the big toe and flexor digitorum longus which flexes the rest of the toes and may be used, for example, for tiptoeing. Abductor hallucis mostly helps with foot stability in activities like walking and running. The dorsal interossei abduct the second through fifth toes (Jarmey 2018:259-281). Muscles that evert, invert, plantarflex and dorsiflex the foot are: Fibularis brevis, which everts of the foot, while plantaris, soleus and gastrocnemius help to plantarflex the foot and flex the knee. Fibularis longus both everts and plantarflexes it. Tibialis anterior dorsiflexes and inverts the foot (Jarmey, 2018: 257-273). The enthesopathy on the Achilles tendon is also related to running, herding or walking on uneven terrain and even to lifting heavy weights (Baxarias & Herrerin, 2008: Enthesopathies-28).

There were also muscles on the feet that would help the toes “grab things” like quadratus plantae on the calcaneus, phalanges and the lumbricals (Jarmey 2018: 276-277), which could help during climbing by helping the feet grip the rocks, maybe even while walking uphill. There were also the enthesopathies on the tibial tuberosities (tuberositas tibiae) which are related to trekking (Baxarias & Herrerin, 2008: Enthesopathies -25). Extensor muscles like extensor digitorum longus and extensor hallucis longus extend the toes and helps with, for example, walking uphill. Other indications of activities that used the feet considerably are foot phalanx osteoarthritis which affected the distal phalanges (phalanges distales) (four of them were preserved) and is attributed to walking long tracks (Baxarias & Herrerin, 2008: Osteoarthritis-33). The following muscles are hip abductors, adductors and rotators, and can also be associated with climbing: Quadratus femoris which flexes the hip (Jarmey 2018: 237). Adductor longus, adductor magnus and adductor brevis which adducts and medially rotate the hip (Jarmey 2018: 247). Obturator externus and gemellus superior rotate the hip laterally (Baxarias & Herrerin.
2008: Enthesopathies- 20; Jarmey 2018: 236). Gluteus medius abducts the hip (Jarmey 2018: 233) (Fig. 13) maybe during trekking or walking on slopes. Abduction, lateral and medial rotation of the hip and flexion of the knees can be associated with rock climbing postures (Cha et al. 2015: 54). Walking on slopes appears like a possible activity on the two previous cases, but also climbing and alpinism are mentioned by Wahlqvist (1993: 186) which was practiced during the Viking Age as a sport.
5. Discussion and Conclusion

The three individuals presented a pronounced developed musculature on the upper body which included the shoulders, arms, chest and neck; which at first sight looked like they could have performed similar activities, but there were small differences, like some muscles that were developed in one individual and not in the other which then helped to establish a difference among the possible activities. It wasn’t always easy to link the muscles to activities; it was easier to find a certain movement which could be connected to more than one action, in most cases. It can be said though that the three individuals performed activities that were physically demanding and focused on the upper body and arms, back and legs. The three individuals presented also pathologies on the vertebrae, like Schmorl’s nodes and osteoarthritis possibly caused by activity, and their muscular development indicated possible stress on the lower spine, since the three of them had lumbar Schmorl’s nodes. The lower extremities indicated rotation and flexion of the hip and knees. This could have been caused by walking uphill, maybe horse riding. The older individual from grave 20 was the one who had the most pronounced muscular development in this part of the body, which could indicate that he was more physically active than the other two individuals. The individuals from grave 3 and 20 also presented more musculature on the hands than the female from grave 2, which seemed to mean that they may have worked with the hands or used the hands more than the female.

There were many similarities in the muscular development of the three individuals, despite them being from different sex and age. The youngest individual from grave 3 who was in his twenties, had very well defined activity markers and some pathologies that seemed to be recently forming, like cervical osteoarthritis and osteoarthritis on the ribs (os costale). The osteoarthritis found on the ribs (os costale) and the cervical vertebrae (vertebrae cervicale) looked like it was just in its beginning stages.

The slight osteoarthritis found on the cervical vertebrae (vertebrae cervicale) and ribs (os costale) of the individual from grave 3, and the more outspread developed osteoarthritis found on the same bones on the older individuals from grave 2 and 20 helps reinforce the assumption that these could be either activity or age related, or maybe a combination of both. The osteoarthritis on the ribs (os costale) of the man from grave 20 was also very slight, so this could mean a difference in activity compared to the other two individuals. The female from grave 2 was the one who had the most pronounced rib osteoarthritis.

The assumption by Michopoulou et al. (2017) was that entheseal changes were dependent on sex, age and body mass, seem to not have been correct in this case. The muscular development of the younger individual aged about 22-26 (from grave 3) and those from graves 2, a female of about 44-50 and from grave 20, a male about the same age, were just as well formed as theirs. The differences that one could argue that could belong to age and maybe years of activity were on the joints, the older individual from grave 20 was the only one to present osteoarthritis on the right ulna and robusticities on the joints of the clavicle (clavicula) and the coracoid process (processus coracoideus) of the scapula. These have, however, been linked to activities, suggested by Kennedy (1989: table 1), and it is impossible to know if this individual developed these robusticities from age, activity or a combination of both. It will have to be assumed in this case, that this has been caused by an activity, although it is worth mentioning that he had the most pronounced muscular development, in general; but the younger individual from grave 3 presented markers than the older woman from grave 2 did not have and she had markers that the younger did not have, so in this case it looks like these were neither gender nor age related.

In this study it has been useful to combine knowledge of physiotherapy with occupational
stress markers. It was often the case that the movements and activities (like sports) found on the literature supported both the occupational markers or pathologies found, for example the cause of neck osteoarthritis found on the individuals and the development of neck flexor and extensor muscles. A similar case happened with the styloid process (processus styloideus) and the possible TFCC injury and its relationship to the use of tools, while at the same time there was a muscle (pronator quadratus) which was also attributed to the use of a tool, or even a technique used in possible occupation like the one which may have caused the TFCC injury. The muscles observed also helped to figure out possible grips of the hands and actions which could have used them.

The different ages of the individuals did not seem to cause any difficulties in the interpretations, but they helped reinforce the assumption that certain pathologies could be related to the length of time in which certain activities were performed; for example the slight cervical osteoarthritis and rib osteoarthritis on the younger individual which was probably starting to form in comparison to the more advanced ones found on the older individuals, from grave 2 and 20.

When it is about the questions, if it is possible to create movement patterns, in this case it has been possible to theorize on actions for these movements, but it was possible to link them to more than one activity. It was also possible to find likely causes for the pathologies of the individuals, from cervical and thoracolumbar osteoarthritis to a TFCC injury, and Schmorl’s nodes.
6. Bibliography

6.1. Literature


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6.2. Oral sources


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Figure 2 & 3. By CKR Training 2015.  
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Figure 6. By Tripadvisor.  

Figure 7. By Anatomy and Physiology 2017.  


Figure 9. By Healthy living.  

Figure 10. By Liz Goldsmith.  

Figure 11. Wikimedia Commons.  

Figure 12. By Jupiter Images.  

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Figure 15. Wikimedia Commons.  

Figure 16. By Brösarp.  

Figure 17. By Wholewoods.  

Appendix 1

List of muscles and pathological changes found on the individuals.

<table>
<thead>
<tr>
<th>Location</th>
<th>Grave 2</th>
<th>Grave 3</th>
<th>Grave 20</th>
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<tbody>
<tr>
<td>Cranium</td>
<td>Sternocondylomastoid</td>
<td>Trapezius</td>
<td>Trapezius</td>
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<tr>
<td></td>
<td>Longissimus capitis</td>
<td>Sternocondylomastoid</td>
<td>Sternocondylomastoid</td>
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<td></td>
<td>Splenius capitis</td>
<td>Longissimus capitis</td>
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<td>Splenius capitis</td>
<td>Splenius capitis</td>
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<td>Masseter</td>
<td>Masseter</td>
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<tr>
<td>Clavicle (clavicula) /Sternum</td>
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<td>Deltoide</td>
<td>Deltoide</td>
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<td>Trapezius</td>
<td>Trapezius</td>
<td>Pectoralis major</td>
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<td>Sternocondylomastoid</td>
<td>Subclavius</td>
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<td></td>
<td>Costoclavicular ligament</td>
<td>Conoid ligament</td>
<td>Robusticity of the sternoclavicular joints</td>
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<td>Trapezioid ligament</td>
<td>Costoclavicular ligament</td>
<td>Robusticity of the clavicular scapular joints</td>
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<td></td>
<td>Conoid ligament</td>
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<td>Trapezius</td>
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<td>Triceps brachii</td>
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<td>Deltoid</td>
<td>Deltoid</td>
<td>Brachioradialis</td>
</tr>
<tr>
<td></td>
<td>Brachioradialis</td>
<td>Triceps brachii</td>
<td>Teres major</td>
</tr>
<tr>
<td></td>
<td>Teres major</td>
<td>Brachialis</td>
<td>Teres minor (right side)</td>
</tr>
<tr>
<td></td>
<td>Common flexor origin</td>
<td>Common flexor origin</td>
<td>Triceps brachii</td>
</tr>
<tr>
<td></td>
<td>Latissimus dorsi (possibly on the left side)</td>
<td></td>
<td>Pronator teres</td>
</tr>
<tr>
<td></td>
<td>Pronator teres</td>
<td></td>
<td>Extensor carpi radialis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Extension carpi brevis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Latissimus dorsi</td>
</tr>
<tr>
<td>Location</td>
<td>Grave 2</td>
<td>Grave 3</td>
<td>Grave 20</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| **Radius and Ulna** | Pronator teres  
Supinator  
Brachialis  
Biceps brachii (slight robusticity)  
Extensor indicis  
Flexor digitorum superficialis  
Extensor pollicis longus  
Extensor pollicis brevis  
Flexor digitorum profundus  
Possibly Abductor pollicis longus | Pronator Quadratus  
Supinator  
Brachialis  
Biceps brachii (slight robusticity)  
Extensor indicis  
Extensor carpi ulnaris  
Flexor pollicis longus  
Flexor digitorum superficialis  
Abductor pollicis longus  
Extensor pollicis brevis  
Extensor pollicis longus  
Erosion of styloid process of the ulna, possibly due to a TFCC injury. | Pronator teres  
Pronator quadratus  
(right side)  
Supinator  
Biceps brachii  
Brachioradialis  
Abductor pollicis longus  
Extensor pollicis longus  
Flexor pollicis longus  
Flexor digitorum profundus  
Flexor digitorum superficialis  
Extensor indicis (right side)  
Olecranon enthesopathy from triceps brachii  
Olecranon osteoarthritis (right ulna). |
| **Manus** | Enthesopathies on 1st, 2nd and 3rd phalanges, except the thumb’s proximal phalanx  
Extensor indicis  
Extensor pollicis longus  
Extensor pollicis brevis  
Flexor digitorum profundus  
Flexor digitorum superficialis  
Extensor Carpi radialis Longus  
Extensor carpi radialis brevis  
Palmar interossei, right hand.  
Opponens digiti minimi  
Extensor Carpi Ulnaris | Enthesopathies on 1st, 2nd and 3rd phalanges, less pronounced on medial phalanges.  
Lumbricals  
Palmaris Brevis  
Pitting on carpals | Enthesopathies on 1st, 2nd and 3rd phalanges, less pronounced on proximal phalanges.  
Abductor pollicis brevis  
Flexor pollicis brevis.  
Flexor digit minimi  
Abductor digit minimi  
Palmaris brevis  
Dorsal interossei  
Flexor pollicis longus  
Adductor pollicis (right side)  
Opponens digit minimi  
Opponens pollicis  
Flexor pollicis brevis  
Lumbricals  
Enthesopathies in 1st and 5th metacarpals. |
<table>
<thead>
<tr>
<th>Location</th>
<th>Grave 2</th>
<th>Grave 3</th>
<th>Grave 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertebrae/ Ribs (os costale)</td>
<td>Space Narrowing on cervical vertebrae Cervical Osteoarthritis Post vertebral muscles. Rib osteoarthritis Thoracic Schmorl’s nodes. Lumbar Schmorl’s nodes (very slight) Intercostal muscles</td>
<td>Slight osteoarthritis on one cervical vertebra. Rib osteoarthritis (very slight) Lumbar Schmorl’s nodes Intercostal muscles Llocostalis thoracis Anterior scalene</td>
<td>Rhomboid Minor Robusticity of spinal and transversus processes Rib osteoarthritis (very slight) Levatores costarum Lumbar Schmorl’s nodes Thoracolumbar osteoarthritis Cervical osteoarthritis Intercostal muscles Post vertebral muscles Subclavius Middle scalene Anterior scalene</td>
</tr>
<tr>
<td>Pelvis/Sacrum</td>
<td>Gluteus maximus Tensor fasciae latae Gemellus superior Calcification of ligamentum spinosus Obturator Internus</td>
<td>Gluteus maximus Obturator internus Obturator externus Pectineus</td>
<td>Gluteus maximus Gluteus medius Tensor fasciae latae Gracilis Quadratus femoris Semitendinosus Biceps femoris Rectus femoris Adductor longus Adductor magnus Obturator externus Obturator externus Pectineus</td>
</tr>
<tr>
<td>Femur (os femoris) /Patella</td>
<td>Gluteus maximus Quadriceps femoris Gemellus superior Ligamentum patellae Obturator externus and internus Adductor magnus Vastus medialis Biceps femoris</td>
<td>Gluteus maximus Pectineus Obturator internus Adductor magnus Gastrocnemius</td>
<td>Gluteus medius Adductor brevis Gemellus superior Popliteus Patella enthesopathies from quadratus femoris.</td>
</tr>
<tr>
<td>Location</td>
<td>Grave 2</td>
<td>Grave 3</td>
<td>Grave 20</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------</td>
<td>----------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
</tbody>
</table>
| Tibia/Fibula | Tibialis anterior  
Popliteus  
Soleus  
Fibularis tertius | Soleus  
Flexor digitorum longus  
Extensor digitorum longus  
Fibularis brevis | Fibularis tertius  
Fibularis brevis  
Quadratus femoris  
Tibialis anterior  
Extensor digitorum longus  
Extensor hallucis longus  
Soleus  
Gastrocnemius  
Plantaris  
Flexor hallucis longus  
Flexor digitorum longus |
| Pedis      | Achilles tendon  
Extensor digitorum brevis | (Not preserved)                              | Achilles tendon  
Foot phalanx  
Osteoarthritis  
Fibularis brevis  
Fibularis longus  
Flexor digitorum brevis  
Quadratus plantae  
Lumbricals  
Dorsal interossei  
Abductor hallucis  
Flexor digitorum brevis |