

PLAIN LANGUAGE SUMMARY

Harris Lines as Indicators of Physiological Stress in the Middle Holocene Cis-Baikal^{1,2}

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ABSTRACT

This article is a plain language summary of a master's thesis completed in 2022 through the Department of Archaeology and Anthropology at the University of Saskatchewan. The goal of this research was to study Harris lines (HL; transverse lines in human and animal long bones that are only visible through X-rays) in the skeletal remains of hunter-gatherers from the Middle Holocene (~9000–3000 years BP) Baikal region of the Russian Federation. HL have often been associated with stress events such as malnutrition or disease in early life. Thus, this thesis expected to highlight differences in the lived stress experiences of two distinct cultural periods from the region which had already been shown in previous studies on stress. Individuals 25 years and younger at time of death from two cemetery populations dating to the Early Neolithic (EN; 7560–6660 years BP) and one from the Late Neolithic (LN; 6060–4970 years BP) were examined for HL. The data was then compared between EN and LN individuals to determine if one population experienced greater stress than the other based on higher HL counts. This thesis demonstrated that HL are not irrefutably tied to stress in EN and LN populations from the Cis-Baikal and HL are not reliable determinants of how often or how many periods of stress they experienced during development. This thesis also challenged ongoing critiques in the study of HL, including image capture methods, to facilitate future research and discussion relating to HL.

Keywords: Bioarchaeology, Harris Lines, Physiological Stress, Osteology, Radiography, Siberia

Harris lines (HL) are horizontal lines of thickened bone that can develop in the long bones of subadult humans and animals (see

Roberts and Manchester 2005). They are not visible to the naked eye but are instead observed, recorded, and analyzed through

¹ This research was conducted in the Department of Archaeology and Anthropology at the University of Saskatchewan in 2018-2022 under the supervision of Dr. Angela Lieveise (University of Saskatchewan) with input from committee members Dr. David Cooper (University of Saskatchewan) and Dr. Tatiana Nomokonova (University of Saskatchewan), as well as external examiner Dr. Julia Boughner (University of Saskatchewan). Many thanks to the Baikal Archaeology Project (directed by Dr. Andrzej Weber; University of Alberta) for the chance to participate in and learn through the project. Ethics approval was obtained by the research ethics boards of the University of Saskatchewan (BIO-1223, May 2019). Financial support was provided by the Baikal Archaeology Project, The Norther Scientific Training Program (Polar Knowledge Canada), the Department of Archaeology and Anthropology (University of Saskatchewan), and the Department of History (University of Saskatchewan).

² The MA thesis summarized here can be found via the University of Saskatchewan Research Archive Harvest (<https://harvest.usask.ca/handle/10388/14381>).

radiography, that being image capture using X-rays. Of all the bones in the body, the tibia, the larger of the two bones in the lower leg, is thought to best display HL when radiographed (Follis and Park 1952; Park and Richter 1953; Park 1964; Garn et al. 1968). Not every skeleton will have HL. Further, HL can only form before an individual reaches maturity and their skeleton stops growing as a young adult (Lewis 2019; Hummert and Van Gerven 1985). The limit on when HL can form is because of how they form; HL are a sign of halted skeletal growth. While a disruption in the normal growth of a young person's skeleton is not unusual, a prolonged disruption is often attributed to an episode of stress to the body (Harris 1931; Park 1964; Zapala et al. 2016). Malnutrition and disease are two such examples of possible stressors that a growing individual might face (Harris 1926; Harris 1931; Park and Richter 1953). When a stress event happens, the body can prioritize certain functions over skeletal growth to compensate for a lack of nutrients or energy required to keep the body functioning normally (Park 1964). Once the individual has recovered sufficiently from the stressor to resume normal bone growth, HL can be left behind as a tell-tale sign of interrupted growth (Harris 1931; Mays 1985; Park 1964; Park and Richter 1953). For this reason, HL are often used and considered in the study and comparison of stress events in both contemporary and archaeological populations (e.g., Alfonso et al. 2005; Clarke 1982; McHenry and Shulz 1976; McHenry 1968; Papageorgopolou et al. 2011)

The Lake Baikal region of Siberia, Russian Federation has yielded several large cemetery populations of Middle Holocene (~9000–3000 years BP; Weber and Bettinger, 2010) hunter-gatherers dating across thousands of years and whose stress experiences are of significant interest for study. For several decades, the Baikal Archaeological Project (BAP; <https://baikalproject.artsrn.ualberta.ca>) has

focused on reconstructing and interpreting the lived experiences and differences in stress that these populations faced during life by way of studying the skeletal remains they left behind. As a result of the BAP's findings, a fascinating depiction of life for hunter-gatherer populations during the Early Neolithic (EN; 7560–6660 HPD cal. BP) and Late Neolithic (LN; 6060–4970 HPD cal. BP; Bronk Ramsey et al. 2021; Weber et al. 2021) has emerged. Separated from the LN population by a temporal gap of approximately 600 years, previous studies have shown that the EN population experienced higher levels of stress including malnutrition and disease (Lieverse et al. 2007, 2011; Lieverse 2010; Osipov et al. 2020; Purchase 2016; Temple et al. 2014; Waters-Rist 2011). As a result of these findings, this MA thesis study was conducted to determine if HL, as signs of stress, would be more common in EN individuals than those from the LN (Michelman 2022).

This study was also a chance to address some current and emerging issues surrounding with the study and analysis of HL in general. HL have been and continue to be a subject of debate in their validity for interpreting stress events that manifest on the skeleton for a few reasons (Papageorgopolou et al. 2011). First, not every stress event experienced by a young person will result in HL formation (Larsen 2015, 42–44). A young individual may not recover sufficiently to form HL, or the event may not last long enough for formation to occur (Harris 1931; Mays 1985; Park 1964; Park and Richter 1953).

Second, as an individual ages, their skeleton does not continue to grow but rather undergoes bone turnover to maintain bone health known as remodeling (Frost 1990; Ruff et al. 2006; Turner 1998). As such, the older a person gets, the more remodeling their skeleton will undergo (Mays 1999, 1985; Steinbock 1976; Park 1964; Park and Richter 1953). Any HL formed during early life will slowly be erased as this marked bone tissue is

gradually replaced from medial to lateral through normal bone remodeling processes (Garn et al 1968; Harris 1931; Hummert and Van Gerven 1985; Lewis 2019). If a person dies before HL are remodeled away the HL will still be visible radiographically, however, radiograph orientation affects HL visibility. Because bone remodels from medial to lateral, radiographs taken in medial-lateral view (M-L), rather than standard anterior-posterior (A-P) view are thought to best capture HL (Garn et al 1968; Michelman 2022; Scott and Hoppa 2015). Logically, younger people have a higher likelihood of displaying HL than older people.

Third, critics of HL as indicators of stress events argue that bone growth can often stop and start not simply as a result of stress but also as a part of normal skeletal maturation. Ergo, an individual does not necessarily have to be stressed for HL to form (Alfonso et al. 2005; Papageorgopoulou et al. 2011; Roberts and Manchester 2005, 240-242). As a result of these critiques, continued work on HL, including this study, focuses on the following three aims: (1) optimizing image capture (i.e., X-ray techniques), (2) clearly defining what counts as a single HL and therefore a single growth interruption event, and (3) accounting for the potential problem of bone remodeling (Michelman 2022).

Using the tibiae of individuals from three Lake Baikal cemetery populations, two from the EN and one from the LN, this study examined and compared HL frequencies between them with the expectation that HL would be more common in the more-stressed EN individuals. To account for bone remodeling only individuals aged 25 years and younger at death were analyzed. Also, X-ray images were taken in two orientations to address possible differences in the visibility of HL therein (see Scott and Hoppa 2015). X-rays were collected from 82 individuals: 34 from Shamanka II, 22 from Lokomotiv, and 24 from Ust'-Ida I. Shamanka II and Lokomotiv are EN

cemetery sites. Ust'-Ida I is a cemetery site spanning the LN and subsequent Early Bronze Age, but only individuals dating to the LN were used for this study. Contrary to what was expected, EN individuals did not display more HL than those from the LN. Statistically, there was no distinction between the two time periods nor the three cemeteries among them. Instead, age at death affected the severity of HL. Individuals aged 6–12 years had the highest HL counts regardless of the archaeological site or time period they came from. There was also no significant difference between males and females.

This study is of value both to the ongoing research of the BAP and to the future study of HL in both contemporary and archaeological populations. While the results were not as expected, this research highlights how important it is to address and incorporate critiques relating to the capture and analysis of HL and to avoid forming robust conclusions of stress experiences based on HL alone. Future HL studies must incorporate existing information on stress for a given population and ensure consistency in the methods used to capture and study HL. This study also advocates for the use of strict age categories when choosing individuals for analysis. HL are not all-encompassing signs of stress. Rather, they are a fascinating and dynamic part of reconstructing the lived experiences of some young individuals.

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