Bone Ice Skates

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Introduction

This class covers my experience making, documenting, and experimenting with bone ice skates and poles to propel the skater wearing them. This work started last fall and ran through late winter of this year.

The first part of the project was entered into the Æthelmearc Arts & Sciences Championship on October 13 and the second part was entered into the Ice Dragon A&S competition on April 13 in the Barony of the Rhydderich Hael. The supporting documentation for those events is referenced at the end of this handout and may also be of interest because their perspectives will differ and certain details may appear in them that are not covered here for reasons of time or space.

Bone ice skates have turned up in the archaeological record of northern Europe for many years and extend back well before our period. There has been some discussion about whether or not skate-like bones were actually skates, but micro-wear analysis (MacGregor, 1975) and modern experimental archaeology have convinced the doubters that people did craft and use the bones in question as ice skates. Further, we have historical imagery and written accounts of people donning bones for use on the ice from period sources.

For my projects, I made a pair of period shoes and skates using bones of various kinds of animals. I also made several poles with different kinds of tips to be used for propelling on the ice, because bone skates lack edges for pushing as with modern metal blades. I wore period garb and tried the skates and poles both on maintained rink ice and on an iced-over pond with a variable surface. The skates and poles are available for you to examine during and after this class. Videos of these experiments are posted to YouTube for your viewing pleasure.

Period References

When the great marsh that washes the Northern walls of the city is frozen, dense throngs of youths go forth to disport themselves upon the ice. Some gathering speed by a run, glide along, with feet set well apart, over a vast space of ice.

Others make themselves seats of ice like millstones, and are dragged along by a number who run before them holding hands. Sometimes they slip owing to the greatness of their speed and fall, every one of them upon their faces.

Others there are, more skilled to sport upon the ice, who fit to their feet the shin-bones of beasts, lashing them beneath their ankles, and with iron-shod poles in their hands they strike ever and anon against the ice and are borne along swift as a bird in flight or a bolt shot from mangonel.

But sometimes two by agreement run one against the other from a great distance, and, raising their poles, strike one another. One or both fall, not without bodily harm, since on falling they are borne a long way in opposite directions by the force of their own motion; and wherever the ice touches the head, it scrapes and skins it entirely.

Often he that falls breaks arm or shin, if he fall upon it. But youth is an age greedy of renown, yearning for victory, and exercises itself in mimic battles that it may bear itself more boldly in true combats.

- William FitzStephen, *ca.* 1173, *A Description of the Most Noble City of London*. (Translated from Latin by L. Gourde.)

I did not swim for a shorter time than you, and I was not worse at underwater swimming. I could also [slide] on bone skates, so that I did not know anyone who contended with me, but you could not do that any better than a cow.

- *Magnússona Saga*, written down *ca.* 1230 (Translated from Old Norse by B. Thurber.)

The other kind of men are those who attach to the soles of their feet piece of flat, polished iron, a foot long, or the flat bones of deer or oxen, the shin bones, that is. These are slippery by nature because they have an inherent greasiness and achieve a very great speed, though only on smooth ice, and continue shooting forward without pause as long as the ice remains level.

Among this sort too there are found everywhere men who take pleasure in racing for a prize. Their race-course over frozen lakes as smooth as a mirror is fixed at eight to twelve Italian miles from one end to the other, or it can be less. The prizes are silver spoons, copper pots, swords, new clothes, and young horses, but more often the last.

The rest are outrun by those competitors in the race who attach to the soles of their feet the shin-bones of deer thoroughly smoothed and greased with pork fat, since, when the cold drops of water rise as it were through the pores of the ice during fierce cold, the bones smeared in this way cannot be hampered or kept in check, as iron can however much it is polished or greased.

For no greasing suits iron as much as it does the shin·bones of deer or bullocks, which have an innate slipperiness of their own. In this way, whenever the ice, two or three fingers thick, is clear and bared of snow, these shows are performed easily and with little fear of danger; but this is by no means the case at other times, for you are never in greater peril or nearer to death than when you set off skating while the ice is covered with even the thinnest layer of snow.

For rivers or brooks, silently and swiftly entering the lake from its shores, wear away the ice by their constant movement so that it cannot grow thick and firm, unless the streams themselves are held in check by a very hard frost. But sometimes rash skaters, ignorant of or scorning the properties of ice and racing with more temerity than caution, are drowned, their bodies lamentably left under the ice and on top of it their heads, which have been sliced off by the sharp edge of the ice as if by an axe.

- Olaus Magnus, 1555, *Description of the Northern Peoples*, Book I, Chapter 25. (Translated from Latin by P. Fisher and H. Higgens.) The illustrations are chapter vignettes from Book 1:25, Book 20:17, and Book 11:36, respectively, from top to bottom.

Two ice skaters on Section F of *Carta Marina*, by O. Magnus, 1539. Note that Magnus did not himself illustrate his works. He commissioned their images to be drawn by Italian artists while he was in exiled from Sweden in Rome (i.e., the artists have likely never seen skates themselves).

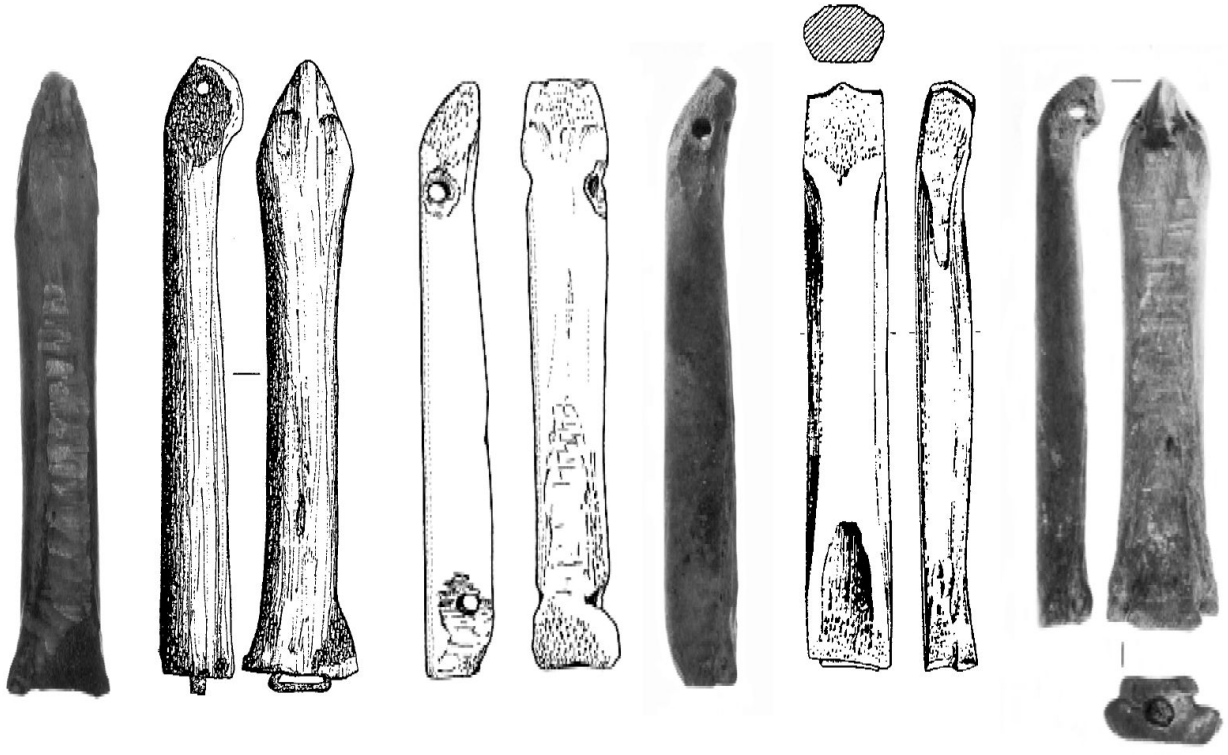
Archaeological Finds

Bone ice skates date back thousands of years in Scandinavia, the British Isles, and throughout Europe where weather allows their use, serving people until at least the late 1800s in Iceland (Balfour, 1898: 29) and even into the 1930s in Estonia (Edberg and Karlsson, 2016:13).

The vast majority of bones found archaeologically come from cows and horses, with perhaps 45% of each making up most of the corpus, with almost 10% being deer, and the remainder assorted other animals of smaller size such as sheep or goat (and likely meant for the use of children). In nearly all cases these are metatarsal or metacarpal (shin) bones, however sometimes other leg bones or even ribs seem to have been used (Küchelmann and Zidarov, 2005: 2).

In the archaeological record, bones used as ice skates are distinguishable from others because they have been modified to more or less extent in one or more ways:

- A hole drilled through the front perpendicular to the length of the bone side-to-side
- Angling the front upward from base to top
- Angling on each side of the front to form a point
- A hole drilled into the back of the bone toward the front to hold a wooden peg
- Flattening of top and/or bottom of the bone
- Roughening of the surface on which the skater stood to better grip the shoe sole



A selection of bone skates showing common modifications such as shaping and roughening of the top surface. (After Küchelmann and Zidarov, 2005: 5.)

Making Skates

First, I needed to acquire bones, which came from a number of sources: purchased on eBay, given by friends and friends of friends, obtained from a butcher. With bones in hand, then, I used a modern hatchet to chop off bits of bones for angling on the front and flattening on the bottom and top, and for roughening the top surface. Each strike removes slivers or chunks of bone depending on the angle of impact, the force applied, and the part of the bone struck. I definitely erred on the side of caution because of my limited supply of bones and inexperience with the material.

In some cases I knew the way the bones were defleshed but in others that information was not available. Somes bones were fresher than others. Using a wood stove in our house, I boiled out two pairs of cow bones obtained from a butcher with flesh still attached. Although they had been washed before boiling, and smelled somewhat of beef broth during boiling, I recommend this be done out of doors.

Shaping bones with a hatchet requires dexterity, patience, and some strength. It is advised to wear eye protection while chopping because flakes of sharp bone fly every which way and bounce off surfaces in every direction. I found dried bones much more susceptible to cracking and breaking in undesirable ways. It took me about 45-60 minutes to shape each pair of bones but I'm neither an experienced bone worker nor particularly practiced with a hatchet.

For two pairs of bones, for the attachment of laces, I drilled one hole laterally through the front and another longitudinally at the rear, then added a wooden peg. (The tool used was a cordless power drill because I lack access to and expertise in making and using a period bow drill.)

Large deer, cow, small deer.

Large deer bone before and after modification.


The deer bones before and after shaping, drilling, and roughening. The cow and horse bones were also shaped with the hatchet to flatten them, angle their front ends, and add texture to their top surfaces.


The three types of bones used (from left to right): horse, deer, cow.

Wooden skates. Left: roughened top surface, Right: planed bottom surface.

Making Poles

According to written accounts and medieval illustrations, people used a pole to propel themselves when on skates. One description says the pole was iron-shod and at least one image shows a small spike on the bottom of its poles. No certain pole tips have been found archaeologically.

For my first session, I purchased a conical pie pastry form and made a pointed stick to its dimensions and simply stuck it on. It worked well for a few pushes, but the very thin metal point quickly bent at such an angle as to make a blunt surface that no longer dug into the ice. After solicitation and discussion of possible alternatives, I resolved to try a number of potential solutions and test each of them for efficacy.

In the end, I made and tested seven different poles during the second ice session. Details of each follow. In sum, all of them worked far better than the original thin metal cone.

Tip #1: metal slab inserted into a slot in the pole, braced with transverse shanks through the pole
Master Bedwyr Danwyn thought of this approach and graciously hosted me in his workshop, guiding me through the process of creating a substantial metal point and anchoring it in place within the pole. In summary, we cut a piece of spring steel into a tapering point in two dimensions then ground a more rounded tip.

I cut a slot in the pole, drilled holes through the wood and the metal, then secured it in place with a nail that I peened over hand-cut rivets made from sheet metal. Master Bedwyr helped me through the process of heating the metal to make it soft, then tempering it to make it hard. I learned a great deal about working metal in this process and ended up with a substantial pole tip.

Crafting the custom blade: cutting from found spring steel; cut, gound, polished, and drilled ready to mount; mounting in progress; successfully mounted.

Tip #2: Thicker metal cone
Such hardware can be purchased from various online replica weapon storefronts in different dimensions where they are labelled as spear butt caps. I chose a substantial one of 2mm-thick mild steel, with a length of 6.25”/16cm. The cone is simply a curved piece of metal with two unsealed butted edges. I carved and sanded a pole end to fit well within the cone and simply jammed it onto the pole (i.e., neither glue nor mounting hardware was used to secure it).

Tip #3: Fire-hardened wood
I carved and sanded a point onto a green pole. I repeatedly inserted and slowly turned the tip of the pole into a bed of glowing coals in a home wood-burning stove until it started to turn a bit brown and smoke a little. A thermometer on the stove read about 400 degrees F., but no doubt the bed of coals was substantially hotter. This process took about 10 minutes. I have never attempted this before, and proceeded after researching the topic online, with results of numerous methodologies being promoted.

The one I chose seemed simplest. After the pole cooled down I found it to be noticeably harder than before the heat treatment.

Tips #4-6: Tapered metal nails driven into the pole then beheaded and ground to a point
I obtained three different sizes of square metal nails, first finding a very small, short one (1”/2.5cm), then a medium one (2”/5cm), then a large, long one (4.5”/11.4cm). These all appear to be hand-forged iron and were easily cut with a standard hacksaw. I drove the nails into the pole with a hammer, then ground points on the beheaded end with a modern grinding wheel.

Tip #7: Hard metal spike inserted into pole
While shopping in a used-hardware store, I came across a metal object of unknown purpose, but which had a long metal spike on one end. Trying to cut it to suitable length resulted in a broken hacksaw blade, but a Sawzall reciprocating blade made short work of it, ending up with a spike 5.7”/14.5cm long. I drilled a hole into the pole about 3”/7.6cm deep, then inserted the metal spike down into it. It fit very snugly within its hole and I pounded it against a cement floor to ensure it was solidly mounted. I then touched up the point with a stone grinding wheel.



Spike and nails before and after beheading, along with the spear butt cap.

The complete set of seven pole tips. From left to right: large nail, custom mounted blade, medium nail, fire-hardened wood, hardened metal spike, spear butt cap, small nail.

Taking to the Ice

On October 11, 2018, I took the shoes, deer and cow skates, and metal-tipped pole to a local ice rink in order to test them. I inserted thick felt insoles into the shoes and put on thick socks and donned garb to look the part.

It became clear that it's entirely feasible to skate on bones but a sturdier pole tip is necessary. The deer bones worked better than the cow bones, but seemed too short for my feet. Laces are not necessary. It should be noted that many skates have no holes, and at least one post-medieval reference indicates that laces were used only by children and novice skaters; experienced skaters simply stood on the bones (MacGregor, 1976: 65).

I found that laces made little difference to keeping the bones in position, but it's possible that my particular choice of lacing pattern was suboptimal. Certainly simply standing on them works well enough. The laces seem to hold best when they come up over the upper part of the shoe from the front holes, then go around the ankle under the heel beneath the wood peg, then come up over the instep and back around the ankle to tie again in front.

Perhaps my balance is better than average, but I did not fall at all. I poled around the rink twice and went back and forth a few times at one end. It's not particularly hard to skate, but it is a bit awkward though because of the pole pushing. If you're used to modern blades, you need to remember to not push with your feet. I believe additional practice will allow me to relax and find a good rhythm for pushing and gliding. The deer bones have absolutely no side grip at all, they slip all over the place.

For a final session observation, I noted that the push-to-glide ratio is poor. I suspect with a better pole tip and more practice this will improve a great deal. I did get up some speed on my second rink circuit. Many small pushes seem to work better than larger ones. With practice and relaxation it might be possible to use leg muscles more and reduce the use of arms. Or perhaps a better upper-body technique might be found that involves shoulder or back muscles. Also, I found it necessary to hitch up my tunic because it kept tangling the pole when pushing backward between my legs.

In the second session at the pond, and the third back at the rink, I tried other bones and the new poles. Various aspects affect the bones' performance characteristics. These include their length, their width, their mass, and their smoothness. Each type tested varies in these four factors. See Table 1 below for a listing of lengths and weights.

Some bones are easier to stand on: the massive horse bones are the most comfortable simply because they offer more area to support the foot, extending past the shoe sole in both the front and the rear. However, their larger surface area greatly expands the area of friction and increases inertia making it harder to get going when standing on them. Countering that, however, is the larger area able to take force from the pole as transmitted down through the body and the feet.

The deer bones, being the narrowest, felt the most like modern skates. In my experience they offered the most directional control, but the least stability, with the lowest ice-contact profile and the least support for the foot. Given their lack in the archaeological record, perhaps there were not as readily available, or people simply preferred more substantial bones for skating.

In the middle I place the cow bones: too short for comfort and least controllable for direction. I found myself spinning quickly and easily while attempting to use them in many cases. They were not great to stand on because of their bumpy ends under my sole. For children, however, I suspect they are more comfortable.

Video stills showing trials with cow, horse, and deer bones (left to right).

All of these factors will be felt differently by people with different sizes of feet and body weights, and perhaps different senses of agility or control. It's certainly possible that adults, youth, and children preferred different types of bones based on their shoe size and experience with skates.

One particularly interesting point of speculation arose during testing: how do the sizes of the modern animals' bones compare to those found archaeologically, especially for horses. The size of animals, both now and in the past, can vary according to their breed, environment, health, diet, age, living conditions, care and treatment, etc. We assumed that the modern horse bone's length and mass would greatly surpass those of medieval horses, often thought to be more like modern ponies. Perhaps many medieval horses were diminutive, and perhaps their bones were sometimes made into skates. However, according to Küchelmann and Zidarov (2005: 6) who illustrates several horse bone skates dated to the 9th/10th centuries, the size of the one I tested does not differ significantly from the medieval ones.

During the experimental process, it occurred to me that a simple wooden skate should also be tried for comparison. Accordingly, I cut two spans of a hardwood sapling to fit within the size range of the bones being tested, both in length and diameter. I used a plane to flatten one side of each to a width of about 1” (2.5cm) to form the top, and the opposite side to be about .75” (2cm) wide as the bottom. I roughened the top surface with a hatchet as with the bones. I used a saw to angle the front tips upward and inward, and left them undrilled. On the very slippery ice, they worked well, but perhaps not quite as well as bones. It will be interesting to try a pair made from dried, plain seasoned wood as well as greased.

With regard to trying different animals’ bones, as well as bones of different conditions, for me in my trials, deer work the best, cow offers the least control, and horse bones need especially smooth ice. Fresh bones seem to work better than dry ones, but applying pig grease to dry bones by rubbing with a cloth appears to freshen them up quite a bit. More testing is needed to confirm these observations, and to observe whether other people have different experiences.

Table 1: Summary of skate characteristics.

Skate Type	**Deer* Bone**	**Horse Bone**	**Cow Bone**	**Wood**
Length	9.75” (24.5cm)	13.5” (34cm)	8.25” (21cm)	10.5” (26.5cm)
Width	.75-1.25” (2-3.5cm)	2-3.5” (5-9 cm)	1.5-2.5” (4-7cm)	1.5” (4cm)
Weight (pair)	8.65 oz. (245g)	52.7 oz. (1494g)	19.7 oz. (560g)	12.9 oz. (366g)
Comments	Most directional control, least friction	Most comfortable, most friction	Least directional control	Moderate in all ratings, perhaps not quite as fast as bone

* white-tailed deer, rather than red deer as found in archaeological deposits.

As for the new poles, all of them worked much better than the first one.

However, some of these tips worked better than others:

-The spear butt cap and hard metal spike worked best.

-The smallest and the largest nails bent after only a few minutes’ use (the middle one was therefore not tried).

-The pointed metal slab worked if properly oriented, otherwise it sliced the ice. (That is, if parallel to the push it didn’t set well; if perpendicular it did; adding a reference notch on the pole would help in keeping it set correctly.)

-The fire-hardened tip worked much better than expected, but occasionally slipped. It became somewhat dulled.

At this point I believe we have no further questions about the tips, so long as metal was available. Embedding the nails further into the pole so that they barely protrude might suffice to keep them from bending, and thus do well with minimal metal work and metal investment. A good cone or hard-metal spike work the best for the least amount of work for someone putting together a push-pole, but of course they would need access to a metal worker or funds to acquire the metal.

All the poles used in this experiment were made from small hardwood saplings cut green about 4-6 weeks before they were used on the ice. They vary from 1-1.5 inches (2.5-3.8cm) diameter along their approximately six-foot (1.8m) length with the thicker end at the bottom.

It should be noted that using the poles resulted in many spots of chipped-out ice, thus destroying the smooth surface needed by the bone skates. It seems that too much poling in one area would roughen it quickly and ruin it for other skaters.

The author on cow bones poling along, as in the manuscript images above.

Conclusions

After three sessions on the ice with various kinds of skates and pole tips, I have reached several conclusions so far, and pose some points for consideration.

First, and most important, the smoothness of the ice makes a significant difference to the performance of the skates. In my experience, any but the glassiest of ice will work against the skates and make them difficult if not impossible to use. Using a metal-tip pole quickly creates a surface hostile to the skates because of the divots they make (this can be seen in the videos linked below, especially the outdoor ones). Thus, people using the skates will desire a large surface of smooth ice.

Second, many solutions of pole tips suffice. Thus, one might expect most poles to have had a minimal amount of metal in order to reduce any associated cost. Indeed, it may be the case that many skates were used without any metal at all, especially as bone skates from the Bronze Age survive. It's difficult to believe that rare metal would have been used for trivial pastimes such as recreational skating. On the other hand, if one has a spear (bronze, iron, steel) readily available for hunting or weaponry, one can simply flip it around and use it for propulsion across the ice.

Third, all of the kinds of bones tested work, and can be used without laces. Greasing them does appear to improve their speed at least for a while. Perhaps more interestingly, the wooden skates worked nearly as well as the bone ones, and took only minutes to make. One wonders how many wooden skates once existed alongside their enduring bone cousins. Even if they survived archaeologically, they might not be recognized as skates. Of course, when they wore out or broke, they would be used for firewood.

Fourth, they are fun to use. When asked whether skates were used for transport or entertainment, or both, I would hypothesize more for fun than for travel. After all, we do have two medieval texts that describe their use during leisure time, and ethnographic reports of kids enjoying them into the 1930s (Edberg and Karlsson, 2016:13), but there are also reports of people using them for travel, hunting, and fishing (MacGregor, 1976: 65-66). With more practice and a willing partner, as well as protective gear, I would like to *run one against the other from a great distance, and, raising [our] poles, strike one another.*

Fifth, It's quite clear that using a pole to push forward requires arm and upper-body strength for pushing and much agility and leg strength to stay atop the skates. If one wants to go any serious distance, endurance will be necessary as well. In my short trials, I found that once at speed it was easier to stay at speed, and it was impossible to change course in any intentional manner. Even though skating requires significant effort, the energy expended may fall below that expended trying to traverse an alternative route on land (Formenti and Minetti, 2007, 2008).

Sixth, I found that one needs to wear appropriate clothing. I had to hitch up my knee-length tunic into my belt in order to get it out of the way of the pole. Obviously past skaters would need to do that too, or wear something more suitable to the activity in the first place. Note that in the 16th-century manuscript images, the skaters appear to be wearing tight-fitting clothes all over. Perhaps the drawing accurately depicts actual skaters of the time, although that seems unlikely because the art was created in Italy.

No doubt with more practice people can become much better at moving in the direction they wish to go with less energy devoted not only to pole-pusing but also to maintaining an upright relaxed position. Trying to skate this way with a backpack or pulling a sledge, as one might if traveling with purpose, seems to be a tough way to move material. On the other hand, if the terrain and weather conditions favor it, and one has the choice to go over ice to save time or distance and can carry a couple of bones and a stick, it's likely worth the minimal effort to have them available during a trek to pay a visit, attend gatherings, or just enjoy the outdoors.

Further Experiments

At some point it will be interesting to hold further trials that consider various other aspects of the skates, including these:

- Invite children to wear them and compare their results to mine.
- Use them more extensively to determine how the bones wear.
- Try longer sessions with pig grease to learn how long it lasts.
- Attempt to use two poles instead of one.
- Hold up a cloth or piece of leather stretched between sticks as a sail.
- Simply practice with them to gain comfort and control.
- Try tilting against someone else using them. Helmets will be worn.

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References

Balfour, H. 1898. "Notes on the Modern Use of Bone Skates" in *Reliquary 4*, 29-37.

Edberg, R. and J. Karlsson. 2016. "Bone skates and young people in Birka and Sigtuna" in *Fornvännen 111:1*. 7-16.

FitzStephen, W. *ca.* 1173. *A Description of the Most Noble City of London* in *An Annotated Translation of the Life of St. Thomas Becket by William Fitzstephen.* Trans. L. Gourde, 1943, Master's Thesis. Paper 622. 15-16.

Formenti, F., and A. Minetti. 2007. "Human locomotion on ice: the evolution of ice-skating energetics through history" in *The Journal of Experimental Biology* 210. 1825-1833.

Formenti, F., and A. Minetti. 2008. "The first humans travelling on ice: an energy-saving strategy?" in *Biological Journal of the Linnean Society 93*. 1–7.

Küchelmann, H. C., and P. Zidarov. 2005. "Let's Skate Together! Skating on Bones in the Past and Today" in *From Hooves to Horns, from Mollusc to Mammoth: Manufacture and Use of Bone Artefacts from Prehistoric*

Times to the Present, Proceedings of the 4th Meeting of the ICAZ Worked Bone Research Group at Tallinn, 26th-31st August 2003, H. Luik et al., eds., Tallinn: Ajaloo Instituut. 425-45.

Küchelmann, H. C., and P. Zidarov. [Accessed 2018-09-19]. "Bone Skates Database" at http://www.knochenarbeit.de/en/index.php?page=bone_skates.

MacGregor, A. 1975. "Problems in the Interpretation of Microscopic Wear Patterns: The Evidence from Bone Skates" in *Journal of Archaeological Science 2*. 385-90.

MacGregor, A. 1976. "Bone Skates: A Review of the Evidence" in *Archaeological Journal 133*. 57-74.

Magnus, O. 1539. *Carta Marina et descriptio septemtrionalium terrarum*. [Map with legend depicting ice skaters in Section F. Several versions linked via Wikipedia at https://en.wikipedia.org/wiki/Carta_marina.]

Magnus, O. 1555. *Description of the Northern Peoples*. [*Historia de Gentibus Septentrionalibus*, trans. P. Fisher and H. Higgens, ed. P. Foote, The Hakluyt Society, London, 1996. Second Series, Nos. 182, 187, 188.] 182: 57-59, 86; 187: 560; 188: 1048.

Mygland, S. 2007. *The Bryggen Papers, Main Series, No. 7: Children in Medieval Bergen.* Bergen. 41.

Thurber, B. 2013. "The Similarity of Bone Skates and Skis" in *Viking and Medieval Scandinavia 9.* 197-214.

Further sources and related readings are listed in my earlier A&S documentation at https://www.academia.edu/37589426/10th-Century_Embroidered_Turnshoes_on_Bone_Ice_Skates and https://www.academia.edu/39326673/Bone_Ice_Skates_Experiments on Academia.edu.

Videos

The first-session video can be viewed on YouTube at https://youtu.be/lqxlzanHsWQ and it lasts about one minute. The other sessions are accessible at http://tinyurl.com/yy6flg6w as a series of very short clips.