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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
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Let's skate together! Skating on bones in the past and today

Hans Christian Küchelmann and Petar Zidarov

Replicas of three different pairs of bone skates were reproduced after medieval finds and intensively tested under different conditions applying techniques described and illustrated in historical sources and ethnographic descriptions. While the main focus of this paper are the experiences from replicating and using skates, some new evidence about chronology and geographical distribution is added as well as a comparison of the surface alterations observed on archaeological bone skate finds and the replicas.

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Introduction

In spring 1998, whilst working in the archive of the Focke Museum Bremen, Germany, one of the authors, H. Ch. Küchelmann, encountered a pair of bone skates. Some months later, enjoying the pleasure of ice skating on frozen flooded meadows he started wondering "What would it be like to skate on bones instead of steel runners?" This remained conjecture, until both authors decided to experiment in 2002.

In addition to numerous publications about archaeological bone skate finds, much relevant work has been undertaken since the end of the 19th century to analyse the archaeological, historical, ethnographic and iconographic evidence, most notably the works of Barthel (1969), Becker (1990), Herman (1902) and MacGregor (1975; 1976; 1985).

We thought it would be of current interest to test the theoretical assumptions accumulated so far and to complement them with personal experience. As in every other attempt at experimental archaeology, it goes without saying, that there is no evidence that the way we see, feel and experience things and situations is consistent with the reality experienced by the people in the past. Nevertheless it is certain that in our biological ontogenesis and psycho-physiological development we are much closer to them than in our theoretical constructs and viewpoints. Hence, first hand experimental experiences should be regarded at least as valuable as any other method of approaching past realities. In this paper we would like to outline some specific issues we faced during our initial experiences with the reality of an ancient practice and in this particular case some hard touch-downs could not be avoided.

Whose foot fits this slipper?[1] – Definition of research topic

The scientific history of bone skates sheds light on the curious ways science can go when the gap between theory and practice becomes too wide. Although in many parts of Europe they were in use until the end of the 19th, in some places even well into 20th century[2] and the memory

[1] Still remembering Cinderella by the Grimm Brothers?

[2] E.g. in Bosnia, Bulgaria, England, Estonia, Finland, Germany, Hungary, Iceland, Poland, Russia and Sweden (Barthel 1969, 205; Becker 1990, 20; Berg 1943; Clason 1980, 244; Herman 1902, 220–221, 226, Pl. V; Luik 2000; MacGregor 1976, 64–66; Vazharova 1986, 50; Vilppula 1940).

of bone skates and how to use them was still alive, already by the middle of the 20th century some scientists have questioned their existence (Semenov 1957, 225–227; 1959).[3] This discussion has been settled with the overwhelming evidence presented by MacGregor (1975; 1976; 1985, 141–144) and Becker (1990). In comparison with a number of other bone artefact types with unknown or doubtful purpose, bone skates pose no mystery. They are quite common in European archaeological contexts.

Historical and iconographic sources as well as ethnographic evidence clearly illustrate what bone skates were used for and how they were used. Consequently bone skates can be regarded as a category of finds well defined by their purpose and the features arising out of their use. We would like to outline here only the basic features that would lead to identification of bones used for ice-skating when recovered in archaeological contexts.

Bones should have approximately the length of human feet and should be capable of carrying human weight. It is the bones of middle to large size ruminants that best fit these criteria. Uniquely appropriate are skeletal elements with an elongated straight shape and two approximately flat surfaces opposite to each other, which can be shaped to an even gliding and standing surface without too much effort. Therefore, metapodials and radials appear suitable while other bones such as a humerus do not.

The archaeological record is fairly consistent with these expectations: According to Becker (1990, 20) more than 90% of the bone skates monitored by her were made from radials and metapodials of cattle (*Bos primigenius taurus*) and horse (*Equus przewalski caballus*). All additional finds we came across confirm this general notion (Fig. 1). However, other species

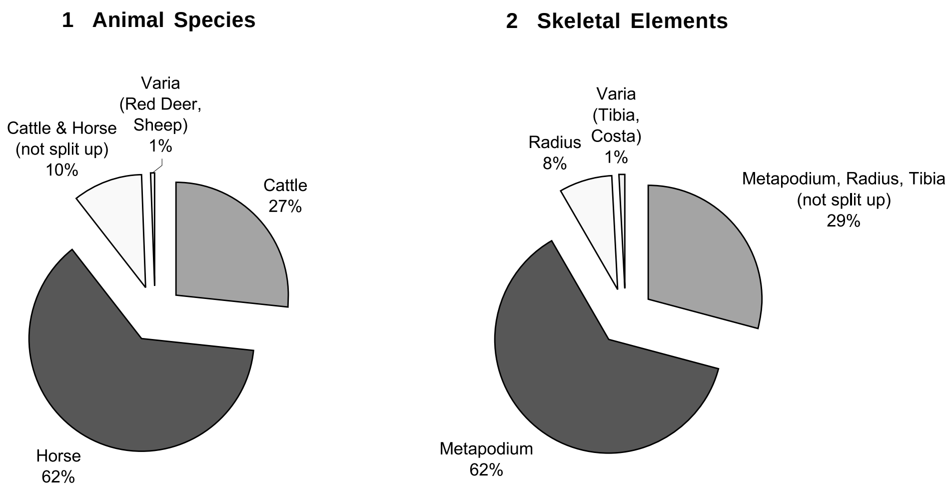

Fig. 1. *Material selected for manufacturing bone skates: 1 relative distribution of the animal species selected for manufacturing bone skates (only zoologically determined specimens are included, total 721 samples); 2 relative distribution of the skeletal elements selected for manufacturing bone skates (only zoologically determined specimens are included, total 929 samples).*

[3] See also S. T. Kjellberg, Gnida, mangla och stryka. – Kulturens årsbok 1940, 68–91; quoted in MacGregor 1976, 57.

such as elk (*Alces alces*), red deer (*Cervus elaphus*), donkey (*Equus asinus*), sheep (*Ovis ammon aries*) and goat (*Capra aegagrus hircus*) occasionally occur (Becker 1990, 19–23, 27, 29, Figs. 1; 3: g; Choyke, pers. comm. 18. 10. 2003; Wikinger 1992, 51; Herman 1902, 226, Fig. 134; Hrubý 1957, 177; MacGregor 1985, 142, 144). Most of them conform to the expected size class. Other skeletal elements were used in exceptional cases too: there are rare examples of tibiae (Becker 1990, 20; MacGregor 1976, 72; MacGregor *et al.* 1999, 1985–1987, Fig. 943; Prummel 1983, 260), ribs (Lauwerier & Villari 1995, 178–179, Fig. 3; MacGregor 1976, 58; 1985, 142; Wichers 1888, 72; Kunst & antiek revue 1985: 1, 13) and mandibulae (Herman 1902, 226, Fig. 134).

To classify an object as a bone skate, a diagnostic facet must be identified. This is situated on a side and forming an angle that is at least sub-parallel to the position the bone would deliberately have when left unsupported on the ground. As a result of movement in an axial direction, striations should be visible on the facet running mainly parallel to the axis of the bone. Oblique or even transverse scratches appear sometimes as well (see below). The location of grinding facets (Fig. 2) and the direction of the striations visible on them allow the discrimination of bone skates from objects used for other purposes (MacGregor 1975; Becker 1990; Barthel 1969).

Fig. 2. *Two red deer (*Cervus elaphus*) radii from Berlin-Spandau, Germany, with facets at different locations (from Becker 1990, 23, 29, Fig. 3). Artifact used probably as smoother (BW20 If17886, 9th–10th cent., above) and skate (BW20 If17887, 12th cent., below).*

There is a significant number of modifications observed on archaeological and historical bone skates. Among the most noteworthy are the following:

Removing of protruding parts of the epiphysial ends. This is essential on the lower side that will be in contact with the ice surface. In some cases this has been the only modification of the original shape of the bone, but mostly the upper side (which is used to stand on) is also cleared of obstacles and modifications of the sides of the skates occur frequently (Figs. 3; 4).

Deliberate flattening of the gliding side. In most cases this is impossible to prove since the use-wear of the skates obscures any pre-grinding of the gliding surface. However, it has been described as common practice[4] and in rare cases, traces of chopping or grinding marks survived the use.[5]

[4] “The competitors who outstrip the others are the ones who wear, fastened to their feet, deer shins which they have filed down to a broad surface and greased with pork fat, ...” (Magnus 1555, book 1, chapter 25; quoted in Barthel 1969, 207 and MacGregor 1976, 63).
“*Sie wurden mit dem Taschenmesser von Fleisch und Haut sorgfältig gereinigt und dann übernahm ich es als Sohn des Müllers, die untere Seite des Knochens auf dem Mühlstein eben zu schleifen; hiernach wurden sie in Brauch genommen.*” (Brückner, Über den heutigen Gebrauch von Schlittknochen in Schlesien. – Verhandlungen der Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte 3. Berlin, 1872, 42; quoted in Becker 1990, 20). [They were cleaned accurately from meat and skin with the pocket-knife and then it was my duty as the son of the miller to grind the lower side of the bone even on the millstone; thereafter they were used.] (translation Küchelmann).
[5] See for instance Becker 1990, 29; MacGregor 1976, 58, Pl. IV: b; MacGregor *et al.* 1999, 1985–1987, 2023–2024, Figs. 943; 945: b; Ulbricht 1984, Pl. 89: 4.

Shaping of the ends. More elaborately worked skates show pointed and/or swept upward front tips to ease the movement over little obstacles on the ice (Figs. 3: a–f; 4: a–b, d). Occasionally, the rear ends are upswept as well (Fig. 3: c).

Transverse holes. Holes drilled transversely through the bone for fastening the skates to the feet with laces are registered either solely at the front or at both ends (Figs. 3: a, c–e; 4: d). At some sites with exceptionally good preservation conditions traces of (leather) thongs were found in the holes.[6]

Axial holes. Less frequently documented are axial holes in the rear end (Fig. 3: a). Remains of pieces of wood or metal inside some of these holes[7] indicate that pegs or nails were inserted to provide another way of fastening.

Iron loops. In some cases iron loops fixed at the front and/or heel ends were employed as attaching devices (Fig. 3: e).

Rough standing surfaces. Some finds show rough blows by coarse tools on the standing surface, probably to improve the traction of the shoe against the skate (Fig. 3: a, f).

Other modifications. Modifications different from the cases listed above occur occasionally indicating that scope was left for individual solutions in the preparation of bone skates (Fig. 4; see also Ulbricht 1984, 60).

Vertical holes. Objects with vertically (cranio-caudal) drilled holes and grinding facets equivalent to those of bone skates are commonly interpreted as sledge runners, having been attached to sledges with wooden plugs (e.g. Becker 1990, 26; Herman 1902, 226–232). However, these are not the subject of this work.

The standing and gliding surfaces of the skates are usually easy to recognise. This does not hold true when trying to discern the front from the back, although most skates show distinctly shaped ends that allow statements about the orientation. In the majority of the finds the cranial side of the bone is the gliding side, while the caudal (palmar, plantar) side is attached to the feet. Usually the distal end of the bone is shaped to be the front of the skate. Since the anatomical shape of metapodials and radials allows different possibilities there are also exceptions of this rule.

Most of the listed modifications are related to different modes of enhancing the attachment of the skate to the foot. It must be admitted though that the largest number of skates are devoid of any obvious devices for attachment, which poses the question how it is possible to keep one's feet on them at all! Of particular interest is a short note by Vazharova (1986, 50) who, referring to personally observed ethnographic specimens from the village of Popina on the Bulgarian side of the river Danube, describes a wooden plank fixed to the upper side of the bone skate with laces while the shoe is actually standing on the plank. Unfortunately, she does not specify how the different materials (bone, wood, leather) are held together.

Some remarks on chronology

McGregor (1976) has drawn the general picture of the chronological distribution of the bone skate finds, which was updated by Becker (1990). Additional information and considerations that emerged since are raised here.

[6] E.g. Haithabu, Germany (Ulbricht 1984, 60), Lund, Sweden (Cinthio 1976, 384) and Novgorod, Russia (Smirnova-Holden, pers. comm. 13. 8. 2003).
[7] E.g. Cinthio 1976, 383–384; MacGregor 1976, 59–61; MacGregor *et al.* 1999, 1987; Ulbricht 1984, 60.

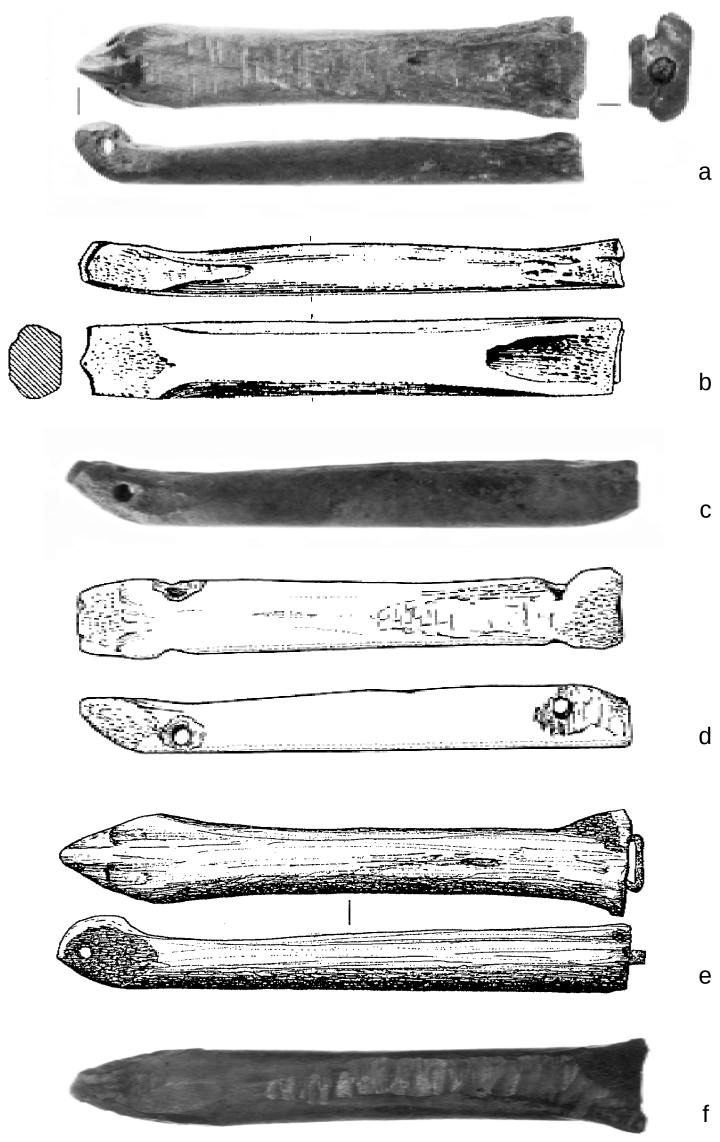

Fig. 3. *Common modifications observed on bone skates: pointed tip (a, e, f), upswept tip (a–e), upswept back (c), trimmed lateral and medial side (b, d), trimmed caudal side (b–c, f), transverse holes (a, c–e) axial hole (a), iron loop (e), roughened upper surface (a, f).*
a Schleswig, Germany, Plessenstrasse, 11th cent., horse, metacarpus (from Ulbricht 1984, Pl. 89: 1); b Dorestad, the Netherlands, Hoogstraat I, Early Middle Ages, horse, metatarsus (from Clason 1980, Fig. 169: 1); c Schleswig, Plessenstrasse, 11th cent., horse, metapodium (from Ulbricht 1984, Pl. 89: 3); d Westerwijtwerd, the Netherlands, horse, metapodium (from Miedema 2002, Fig. 158: 5, no. 1900/I 392); e London, England, Tokenhouse Yard, Roman Iron Age?, horse, metapodium (from MacGregor 1976, 59–60, Fig. 1: C); f York, England, Coppergate, 10th cent., horse, metatarsus, (from MacGregor et al. *1999, 1986, 2023, Fig. 944: c, no. 7131 / sf10629).*

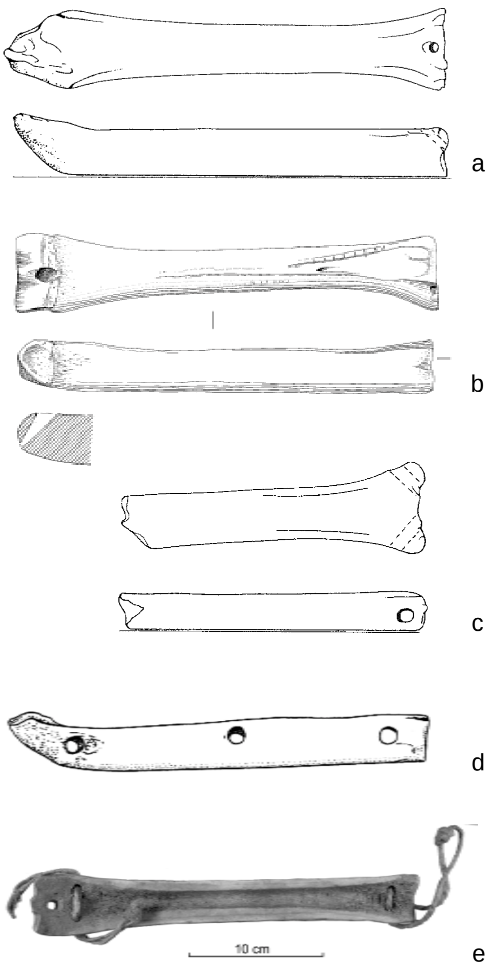

Fig. 4. *Less common regional or individual modifications: different hole types (a–e), removed caudal side (e).*
a Oost-Souburg, the Netherlands, 10th cent., horse, metapodium (from Lauwerier & van Heeringen 1995, 85–86, Fig. 9: A); b York, England, Coppergate, 9th–10th cent., horse, metatarsus, (from MacGregor et al. *1999, 1984, 2023, Fig. 942, no. 7125 / sf14001); c Oost-Souburg, the Netherlands, 10th cent., horse, metapodium (from Lauwerier & van Heeringen 1995, 85–86, Fig. 9: B); d Wester-wijtwerd, the Netherlands, horse, metapodium, (from Miedema 2002, Fig. 158: 4, no. 1900/VI 17); e Turku Archipelago, Finland, 19th cent., horse, metatarsus, (Turku Provincial Museum, no. 15053: 3; photo Hans Christian Küchelmann).*

At present, it seems that bone skates make their first appearance sometime during the second millennium BC in the steppe zone stretching from the Northern Pontic Area in the east to the Great Hungarian Plain to the west. Probably the earliest evidence is provided by the finds from Hungary. There are some newly discovered specimens from the Hungarian Early Bronze Age, another three from the Middle Bronze Age settlement at Százhalombatta-Földvár and three more were recovered in the region of Budapest dated to the Late Bronze to Early Iron Age (Choyke *et al.* 2004, 185, 187; Choyke, pers. comm. 16. 10. 2003; 1. 11. 2003). Four specimens altogether were recovered at the Late Bronze Age Sabatinovka sites of Zlatopol' and Novokievka in Ukraine (Gerskovic 1999, Pls. 10: 1; 34: 4–6). MacGregor (1976, 64) quotes the find from Verebély, Hungary, presented by Herman (1902, 222–223, Pl. V) as "doubtless" of Bronze Age origin, as one of the earliest examples. Although Herman's conclusion of bone skating invented already in "prehistoric" times is true, seen from today, we have to admit that the dating of his Neolithic or Bronze Age finds is very doubtful and can actually be proved wrong in some cases.[8] The early manifestation of this type of bone artefact is followed by total obscurity in the archaeological record for about two millennia. The only exceptions being four specimens, one of which was recently discovered in the marshes of the river Leitha, Austria, supposedly originating from the La Tène Period (Kunst, pers. comm. 26. 6. 2003). In the Roman Iron Age and Migration Period finds appear in small numbers all over Europe (Fig. 5), becoming more common and

[8] The find from a terp mound at Grimmersum, Ostfriesland, Germany, for instance, cannot be earlier than the first century AD (Roman Iron Age) since this marks the beginning of terp mound building in Ostfriesland. Further, all known finds of bone skates from Ostfriesland are from the 2nd terp mound settling period and date from the Early Middle Ages onward (Eckert, pers. comm. 17. 2. 2004; Bärenfänger 2002; pers. com. 17. 2. 2004). The same is most probably true for the terp mound find from Aalsum, Province Groningen, the Netherlands.

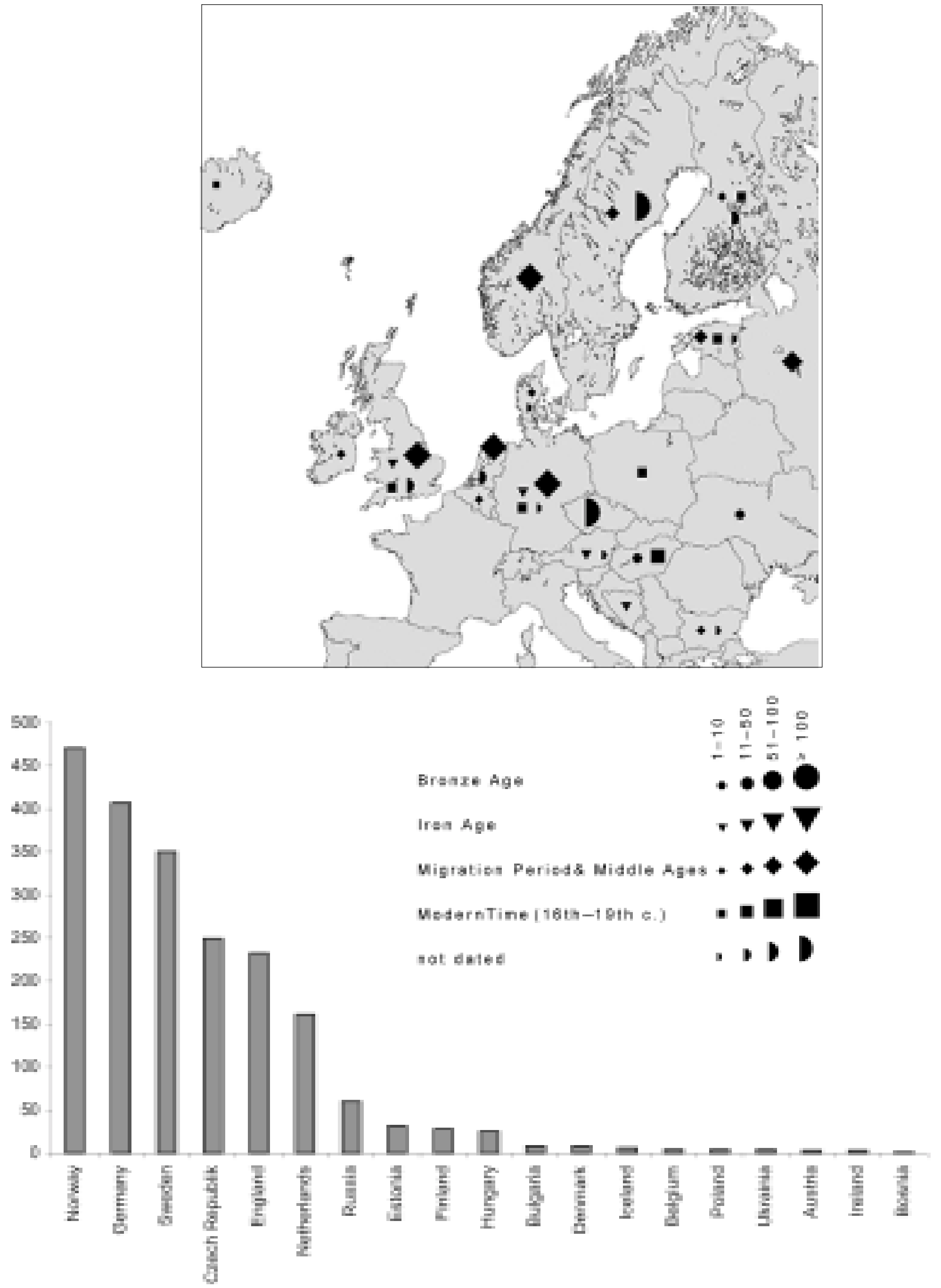

Fig. 5. *Geographical distribution of archaeological and historic bone skates from museum collections and references (only sources with known number of specimens are included, total 2040).*

numerous in the Early Middle Ages and Viking Period. It has to be noted that the data analysed so far is coming mainly from Western and Central Europe. Interesting new results are to be expected from Eastern Europe and Asia.

Fig. 6. *Children with mandibula sledge and (iron) skates on the margin of a Flemish manuscript from the early 14th century (from Blauw 2001, 11).*

Finally, worth noting are some facts relating to the appearance of iron skates, overlooked in previous discussions. The woodcut in the "*Vita Lydviniae*" (1498) and Hieronymus Bosch painting "*De Verzoeking van de Heilige Antonius*" (ca. 1490), frequently mentioned as the earliest historic illustrations of iron skates (e.g. Becker 1990, 19; MacGregor 1976, 67), are predated by a miniature painting on the rim of a Flemish manuscript, the calendar of Saint Pierre van Blandigny of Gent, dating in the early 14th century (Fig. 6; Blauw 2001, 11; Broere 1988, 9; Nieuwenburg-Bron [1996], 13). Even earlier are some archaeological finds of iron skates found in Grachten of Amsterdam and Dordrecht, the Netherlands, dating to the 13th century (Blauw 2001, 10).

You never walk alone! – Review of experimental work on bone skates

In the course of compiling reference information on bone skates, we realised that our idea of experimental bone skating is far from new. Before describing our own experiments, here is a brief account of the tests already undertaken by our forerunners.

The first experiments mentioned in literature were carried out as early as the 1890s at the National Skating Palace in London (MacGregor 1976, 66). It was tried and found possible to move on bone skates by pushing oneself forward with the tip of one skate. It is obvious that this method will only work with the skates attached firmly to the feet. Although apparently possible we found it hard to believe that this reflects the real method.

Kjellberg tested bone skates and concluded that it is impossible to use them for ice-skating and hence these artefacts must have had a different purpose (MacGregor 1976, 57).[9] Arthur MacGregor (1975, 385 ff.; 1976, 58–61) and James Rackham replicated and tested two pairs of bone skates and found them to perform "quite satisfactorily" even though the gliding surface of one pair was given only minimal preparation. A fine polish as well as characteristic axial striations on the gliding surface developed after a few hours use and were consistent with those found on archaeological specimens.

In a popular book about the Vikings, Magnus Magnusson (1980, 18–19) reported that he tried a pair of bone skates from the University Museum of Antiquities in Oslo on a lake in Norway and "found it easy to work up to very respectable speeds after a minimum of practice". He attached the skates to his feet with two laces at the toe and the heel and used two poles to move "not lifting his feet from the ice".

[9] He suggested they were used for the processing of linen (S. T Kjellberg 1940, 74 ff.; see footnote 3). Conforming opinion is held also by Tergast (Die heidnischen Alterthümer Ostfrieslands. Emden, 1879, 43, Pl. VI, Fig. 49) and Semenov (1957; 1959) who believed they were rather used in hide processing.

His experiment was repeated and far better documented by William Short,[10] a member of the Hurstwic Viking Reenactment Group in New England, USA. Short started with replicas of a find from a 9th century deposit at Birka, Sweden, which had only one transversal hole in the front. He attached them to his feet with a single leather thong and found this to be insufficient to keep the skates in the right position. Then he added a wooden peg inserted axially into the rear end, as found in specimens from 10th century York, England. Attached to the shoes with two thongs this worked well for modern boots, whose rubber soles provide enough traction to keep the skates in place, but it did not work for medieval style leather shoes. Although he tried different lacing techniques he was unable to find an easy and proper mode of binding. Nevertheless the locomotion results were quite good (see footnote 18). Short applied bees wax to the ice side surface to improve the gliding qualities, but he has not reported if it affected the performance and to what extent.

These experiments were literally "outstripped" by the Dutch: In 1991, 1995 and 1996 championships in "*schaatsen-op-dierenbotten*" (ice-skating on animal bones) were held at Ezinge, the Netherlands, inspired by bone skate finds from a medieval terp mound. About 40 people took part in the race over a 100-m distance in 1995 (Nieuwenburg-Bron [1996], 11; van Es, pers. comm. 21.–22. 8. 2003). Referring to the scarce information from two newspaper articles[11] cattle and horse bones were bound to modern boots with laces threaded through transversal holes. The movement was performed with the help of "*prikstokken*" (pricksticks).

Slippery People[12] – Replication of bone skates

The director of the Sofia Zoo kindly provided us with the raw material needed for our experiments. After scavenging four lower horse forelegs from the lions' menu, we roughly defleshed the bones. Due to lack of experience this task took us about three hours. We cooked the bones with soda (2 hours) and cleaned them thoroughly with knives (2 hours, Fig. 7: a) following the procedure practised in Lasowice (Gross-Läswitz), Poland, as described by Brückner in 1872[13] (Becker 1990, 20). Eventually we ended up with four radials and four metacarpals at our disposal. Unfortunately, the legs turned out to be from four different horses of three different sizes. Respectively we could match only one equal-sized pair of radials and one pair of metacarpals. We decided to prepare a third pair of different sized metacarpals, while the remaining two radials were completely unsuitable. Cleaning and shaping the skates we started considering issues such as "How much effort would one invest in a real-life situation?" It seemed to us that at least the metacarpals are almost ready to use right after cleaning. Further, we tried to stand on the bones on "safe" ground and found it pretty easy to keep balance. So we came to the conclusion that not much grinding is necessary.

Pair no. 1 (Fig. 8: 1) were built in the manner of a bone skate find recovered at the Slavic settlement at Berlin-Spandau, Germany. It is dated between 1100 and 1150 (Fig. 2, below; Becker 1990, Figs. 1; 3: g) and was originally made from a red deer radius. On the caudal side the ulna is cut off roughly as well as the protruding parts of the distal end. The cranial side was used as the gliding surface and both epiphyses are cut sweeping upwards in an oblique angle. The gliding surface is worn down to a certain degree indicating that this skate must have been used intensively. For the replication we chopped off the projecting parts with an axe (Fig. 7: b). Then the cranial surface was

[10] Short, William: Hurstwic Norse bone skates, http://www.valhs.org/history/articles/daily_living/text/ice_skates.htm, 2. 10. 2002.
[11] Telegraaf 18. 2. 1991 and article in unknown Dutch newspaper from 12. 2. 1996 quoted in Nieuwenburg-Bron ([1996], 11).
[12] Referring to the Talking Heads.
[13] The bones looked for by Brückner were from the feet of horses being between 250 and 330 mm long (which can be only metapodials). They were skinned and defleshed accurately with pocket knives. See also footnote 4.

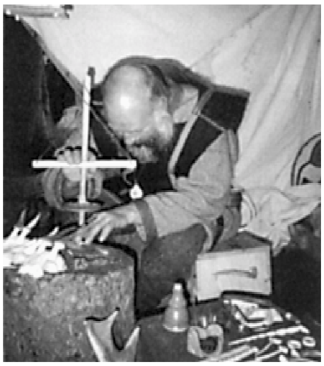

Fig. 7. *Cleaning (a), shaping (b), grinding (c) and drilling (d) bone skates; use of a medieval hand drill (e) (photos a–d Nikola Zidarov; e Archae-Projekt).*

ground on a wet grinding stone (Fig. 7: c). Initially we had in mind to try these without attaching them to the feet, but later we added transversal holes at the distal and proximal ends. Trying different orientations we came to the common understanding that the distal part of the radius feels more comfortable when put in front.

Pair no. 2 (Fig. 8: 2) were built in the manner of a scheme for processing metapodials found in the excavation at Hoogstraat I in the medieval town of Dorestad, the Netherlands published by Clason (1980, 245, Fig. 170). These skates were prepared more elaborately: First the lateral and medial sides of the metapodium were flattened, as well as the protruding parts of the dorsal and palmar/plantar side. The front of the skate had a slight sweep upwards. Then the gliding surface was ground. Finally holes were drilled transversely through the proximal and distal end. The holes observed on archaeological finds commonly range between 4 and 8 mm in diameter (e.g. Lauwerier & van Heeringen 1998, 122; MacGregor 1976, 60). We used an electric drilling machine and a 5 mm drill (Fig. 7: d). An interesting detail came to light which had previously been underestimated. The flattening of the lateral and medial sides, which did not seem to make much sense otherwise, actually eases the drilling since it provides a better grip for the drill.

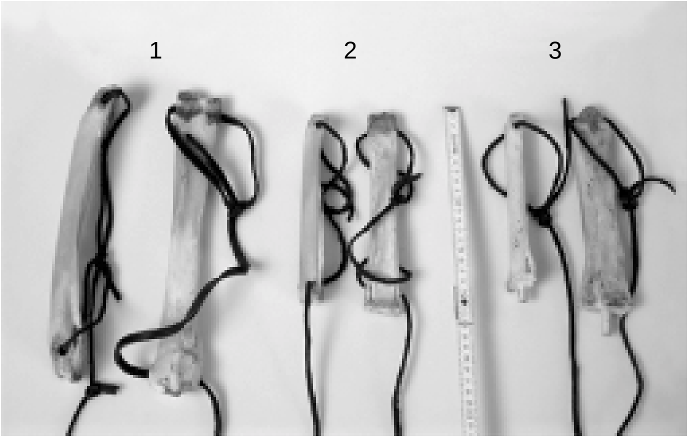

Fig. 8. *Finished bone skate replicas (Photo: H. Ch. Küchelmann).*

Pair no. 3 (Fig. 8: 3) were built in the manner of a find from a mid 13th century deposit at Coppergate, York, England (MacGregor *et al.* 1999, 1985–1989, Figs. 943; 944: e, no. 7154 / sf 908). This specimen has a roughly trimmed upswept pointed tip and a transverse hole of 6 mm diameter at the distal end of the bone. The proximal articulation surface is provided with an axial hole. This is not shown in the publication, but an axial hole of another skate from the same site (*op. cit.,* Fig. 945: a, no. 7122 / sf12208) has a diameter of 11 mm. Two of the skates from York have wooden pegs directly associated with them, one of which (no. 7122) is possibly of willow, the other (no. 7930 / sf697) of hazel wood. Since the metacarpals used for the replicas were rather small we drilled 8 mm holes and inserted pegs cut from a twig of a willow (*Salix viminalis*) shaped with a pocket knife within a couple of minutes.

It was astonishing how easy it was to shape the bones, even for inexperienced workers like us. It appears that "in case of emergency" one can prepare a pair of skates in about half an hour and be on the ice for an "urgent" competition straight away. It is hard to say how long it would take to drill the holes without an electric drill, but referring to experiences with medieval hand drills (Fig. 7: e) they are rather effective and it is doubtful if it would make much difference.

Various archaeological and historic examples for pricksticks exist, nearly all of which are simple wooden poles with a sharp iron tip.[14, 15] We tested three different variants: Pole no. 1 was manufactured from a beech shovel stick (length 127 cm, diameter 30–39 mm) spiked with a nail tip (diameter 8 mm) glued in a drilled hole at the slightly bent lower end. The tip is protruding 60

[14] E.g. from Aboa Vetus Museum Turku, Finland; Ilmajoki, Finland (Ilmajoen museo 1470; Vilppula 1940, 51–52, Fig. 2); Kézdi-Szt.-Lélek, Széklerland, Hungary (Herman 1902, Pl. V: 1); National Museum of Iceland, Reykjavik (McGovern, pers. comm. 2. 7. 2003); Urshult, Almundsryd and Boda, Sweden (Berg 1943, 87, Figs. 12–14).
Occasionally points made from bone and antler were assumed to be used as prickstick tips, e.g. from Oost-Souburg, the Netherlands (900–975 AD; Lauwerier & van Heeringen 1995, 85–87, Fig. 10; 1998, 124–125, Fig. 4) and East Anglia (N. F. Layard, Bone skates and skating stakes. – East Anglian Miscellany, 2, 1908, 74; quoted in MacGregor 1976, 66).
[15] According to Lambert van Es, archaeozoologist from Groningen and Dutch bone skating vice-champion in 1996, the prick at the end of the pole has to be very sharp and must protrude at least 1 cm to perform a good push forward (van Es, pers. comm. 21.–22. 8. 2003).

mm. Poles 2 and 3 were built from pine broom sticks (length 135 cm, diameter 28 mm) spiked with 6 mm diameter nail tips inserted in drilled holes and protruding between 25 and 35 mm. These sticks split very easily due to the smaller diameter and the weaker wood, so they had to be taped to prevent further splitting. In this case Gaffa-Tape was employed, but leather or hemp would have served this purpose as well. Pole no. 4 was a walking stick carved from a branch of an unknown tree species (length 125 cm, diameter 23–40 mm) provided with a metal socket on the conical shaped tip.

Hoch das Eisbein! – Trials

The first preliminary trials were carried out in August 2003 in an ice hockey club hall in Bremerhaven, Germany. While this gave first impressions, it was soon obvious that the polished hard and even skating hall ice is much different from outdoor ice and thus the experiment was continued in the Eläintarha Stadium in Helsinki, Finland in February 2004.

Step one: Attaching the skates to the feet

We faced the same problems Short[16] described when trying to tie the skates with two single laces not linked with each other. It was possible to solve the problem by applying the simple lacing technique shown by Herman (1902, 220, Fig. 123). Here only one leather thong is threaded through both holes. After a minimum of practice this turned out to be a quick and easy method. Once the front loop is set to the right size it is easy to remove the skates and put them on again with only one knot at the ankle to pull tight (Fig. 9: a–c). The advanced method (Herman 1902, 220, Fig. 124; Barthel 1969, 207, Fig. 2) is different only in so far that the lace is threaded through the front loop once again (Fig. 9: d–e). This allows a better tightening and results in a decent foothold. Transversal holes in the rear proved to work as good as axial pegs. The peg-variant is a little bit faster to attach compared with threading a lace through a hole and thus is more comfortable with cold fingers in an icy winter-environment.

Step two: Trying to stand upright

The first impression when getting in contact with ice was that the bones are much more slippery than expected and that it would be absolutely impossible to stand on them (let alone to move) without tight attachment to the feet (at least for beginners like us). The metacarpals are easier to stand on than the radials. Whereas the metacarpals stay flat on the ice, an additional effort is needed to keep the ankle in balance on skates made from radials. Skates exceeding the size of the feet are more comfortable to stand on than the smaller ones. Unlike with rubber soled boots every unevenness of the upper bone surface imprints the sole of the foot through leather shoes, which means that a flat and even upper surface will improve comfort over long distances. The quality of the ice makes a great difference: The rough Finnish outdoor ice being easier to deal with than the skating hall ice.

Step three: Slip sliding away

We first applied the locomotion method shown and described by Berg (1943, 87, Fig. 11), Clason (1980, 244), Herman (1902, 220–221, Fig. 121) and Magnus (1539; 1555, book 11 chapter 36, book 20 chapter 17) grasping one single pole with both hands and pushing with the pole between the legs (Fig. 10: a–c, e). Since it was difficult enough to keep the balance anyway it felt self-evident to imprint the pole as near as possible to the centre of gravity, which in adults

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[16] Short, William: Hurstwic Norse bone skates, http://www.valhs.org/history/articles/daily_living/text/ice_skates.htm, 2. 10. 2002.

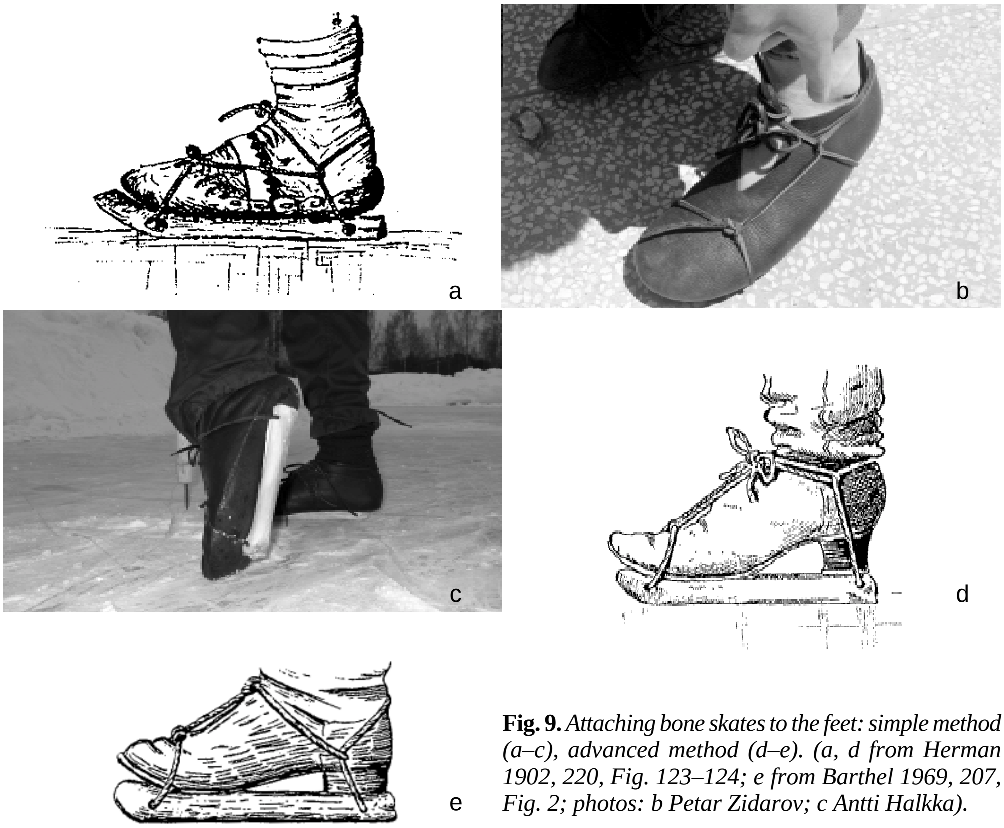

Fig. 9. *Attaching bone skates to the feet: simple method (a–c), advanced method (d–e). (a, d from Herman 1902, 220, Fig. 123–124; e from Barthel 1969, 207, Fig. 2; photos: b Petar Zidarov; c Antti Halkka).*

is situated in the lower belly region. Any pushing off the centre of gravity resulted in a loss of balance. The greatest difficulty one has to deal with if accustomed to modern skates, is the fact that bone skates do not cut a track in the ice. Hence a lot of effort is needed to keep the feet parallel while moving. However, after a few days of practice one gets used to it. Leaning slightly forward and a bending of the knees provides a reasonably stable body position. After some practising one naturally achieves a rather harmonious rhythm of movement. These experiences conform to those described by Herman[17] and Short.[18]

[17] "*Die Länge des Knochens, die auf dem Eise aufliegende ebene, abgeschliffene Fläche und die Rauhheit der, der Sohle zugekehrten Fläche machte und macht die Erhaltung des Gleichgewichtes leicht; das Fortschieben hatte aber seine besondere Bedingung: das Paar der Knochenschlittschuhe musste gegen einander parallel verbleiben; denn sobald es in eine nach vorne divergierende Stellung kam, liefen die Füße auseinander und das unfreiwillige Niedersitzen war unvermeidlich, und zwar oft mit einer Gewalt, welche in das Eis einen sogenannten "Stern" schlug. Außerdem mussten beide Füße stets in gleicher Entfernung verbleiben, damit – bei Gebrauch nur einer Schiebstelze – das Stoßen zwischen den Füßen leicht und sicher geschehen könne. Auch die Haltung des Körpers war wesentlich: man musste die Knie und den Leib etwas beugen und eben in dieser Stellung lag das ermüdende Moment, weil die betreffenden Muskeln dauernd in Spannung gehalten werden mussten.*" (Herman 1902, 220–221). [The length of the bone, the plain filed down facet laying flat on the ice and the roughness of the side facing the sole made and makes balance keeping easy; but the pushing forward had its special condition: the pair of bone skates had to be kept parallel to each other; for as soon as it came into a diverting position, the feet moved apart and the involuntary sit-down could not be avoided, often with a power that resulted in a star-shaped crack in the ice. Further both feet needed to be kept the same

Fig. 10. *Locomotion techniques. a–b woodcuts from Olaus Magnus (a: 1539; 1555, book 20 chapter 17; b: 1555, book 11 chapter 36); c–d drawings from Herman (1902, 220–222, Figs. 121, 125); e–f experimental approach (photos: e Antti Halkka, f Ralf Schauwacker).*

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distance from each other continually to provide an easy and safe push between the feet, when only one prickstick is used. Even the body position was important: One had to bend the knees and the body slightly and in this position lies the tiring factor, because the relevant muscles had to be kept in tension constantly.] (translation Küchelmann)

[18] Short describes that he "got a good glide with each push. It seemed easy to build up to a very satisfactory speed, since there was a natural rhythm to the process that was lacking with the other techniques. This approach to propulsion seemed to require less exertion than the other approaches in which I kept my feet flat on the ice, perhaps because there is more use of lower body muscles." (http://www.valhs.org/history/articles/daily_living/text/ice_skates.htm, 2. 10. 2002)

Later we tried using two poles, one in each hand, pushing simultaneously on both sides (Fig. 10: d). This turned out to work quite differently. The body position is upright, knees are straight and the whole power comes from the muscles of the arms and chest. While this feels more comfortable for the legs and makes keeping balance easier, it is very exhausting in the long run. Furthermore the poles need to be pushed in the ice with power and accurately in a certain angle, since a sideslipping pole almost immediately results in a tumble. As to the pricksticks, ours performed quite well except for pole no. 4, which was not sharp enough and slipped away instead of piercing the ice. The shovel-stick (no. 1) could be used only one way round due to the slight curve at the lower end but had a better power transmission than the straight broomsticks. Keeping in mind the experiences with the only slightly blunt point of pole no. 4 we doubt if the bone and antler points mentioned above (see footnote 14) assumed to be used as prickstick tips will be suitable for a high-duty task like this.

After three days of practising we reached a maximum speed of 3:05 minutes for 400 m[19] and we got the feeling that there are a lot of details to improve in locomotive technique as well as in the shaping of the skates. For instance, next time we would take longer bones and file broader facets for stable standing. Minimum preparation of the gliding surface noted as satisfactorily by MacGregor (1976, 58) and van Es (pers. comm. 21.–22. 8. 2003) is obviously something for advanced skaters. Nevertheless we got the impression that it would manageable to run long distances like Magnus describes for 16th century Sweden.[20] Van Es prefers radials since the bent cranial side results in less friction on the ice than the flat dorsal side of metapodials and hence they are faster. On the contrary, in our experience the metacarpal skates worked better because balancing was much easier. Obviously this is a matter of practice and personal style. We did not reach the "dexterity", being the "only requirement" described by Friedel in 1898[21] (Herman 1902, 221) as necessary for skating without the bones attached to the feet and we still cannot imagine how this works. However, it was obviously often the case judging by the high number of archaeological examples lacking attachment devices. A practice reported from Russia should be mentioned here as well, where – like in modern skate boards – the skater glides only on one skate and uses the other (skateless) foot to push (Luik 2000, 149–150).

From the ergonomic point of view pushing directly downwards seems to be the most effective way of power transmission for a locomotion method where the feet stay on the ground constantly, as opposed to Nordic skiing for instance. Unlike modern ice-skating the limiting factor would not be the power needed for the locomotion itself, but the power needed for the constant tension necessary to keep the legs in the parallel and bent position.

One disadvantage of bone skates is the difficulty of changing direction.[22] However, it is possible to slightly control the direction of movement by applying the pole and thus we assume that the scene shown on the woodcut of Magnus using one pole on one side (1539; 1555; Fig. 9: a, right) may be a representation of correcting or changing direction.

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[19] The only published exact specification of speed we were able to find is given by Brückner in 1872 (see also footnotes 4, 13). He describes that trained persons cover "a good half mile in 15 minutes" (Clason 1980, 244). One german geographic mile was defined as 7420,44 m until 1872.

[20] "The length of a lap over the frozen, mirror-like lakes is set at eight or twelve Italian miles [approximately 5–8 km] or less, each way." (Magnus 1555, book 1, chapter 25; quoted in MacGregor 1976, 63).

[21] Friedel, Brandenburgia, 6. Berlin, 1898, 318 ff.

[22] This is consistant with the description by Herman (1902, 221): "*Alle diese Momente zusammengenommen brachten es mit sich, dass das Laufen nur in gerader Linie erfolgte [...] wonach auf den Knochenschlittschuhen das Ausweichen unmöglich war.*" [All together this caused the skating to be possible only in a straight direction [...] which means that dodging was impossible on bone skates.] (translation Küchelmann).

Another problem is the inability to break (gracefully). One way of breaking is to turn the feet transverse to the direction of movement, another to use the pole as a kind of anchor. However, both methods are not very effective and will not lead to a rapid slow down in case of an emergency. A vital memory of this sometimes dangerous problem was supplied by the Finnish smith Antti Juvel, interviewed in 1915, then 75 years old. He recalls "if there was open water ahead, you had no choice but going into it, for it would be too dangerous to fall on the ice in such a great speed and turning was impossible."[23] After our tests the question arose if it might be possible to break by lifting one foot and pushing the tip or back of the skate on the ice while gliding on the other, similar to modern inline-skating, but this is something that has to be tried another time.

Step four: Getting up again and recovering

The greatest fear we had in the beginning was the danger of pushing the sharp point of the pole into our feet. Especially when becoming faster and pushing the ice with more energy we would have preferred to wear steel cap boots instead of thin leather shoes. Furthermore it was apparent that – like in modern ice- and inline-skating – there is a great danger of crash-fractures, especially of the wrists and the sacrum (Fig. 10: b, left, f). The vivid descriptions of fractures and injuries given by FitzStephen (see below) are easy to imagine.

One day after the experiments we observed light muscular aches in the muscles of the thighs and the seat, showing which parts of the body were stressed most. Further, the soles of the feet ached a little bit due to the small surface one has to stand on, so we recommend thick socks or something similar to increase the comfort.

Pure hedonism or hard work? – The question of use

A frequently asked question is, were bone skates used mainly for sports and fun or were they also utilised in everyday situations. The aspect of sportive competition, fun, leisure and recreational activities is quite well documented due to descriptions in Snorri Sturlusons "*Heimskringla*" (ca. 1225),[24] Olaus Magnus "*Historia de gentibus septentrionalibus*" (1555),[25] Herman (1902, 218)[26] and most of all that of William FitzStephens[27] lively report about the youth of London enjoying skating at Moorfields:

> "Others, more skilled at winter sports, put on their feet the shin-bones of animals, binding them firmly round their ankles, and, holding poles shod with iron in their hands, which they strike from time to time against the ice, they are propelled swift as a bird in flight or a bolt shot from an engine of war. Sometimes, by mutual consent, two of them run against each

[23] "*...useasti oli maa silti mustana silmissä, kun niilä kaatui ... jos oli sula edessä, ei auttanut muuta kuin mennä siihen, vauhdista oli vaarallista jäällekään pitkälleen heittäytyä...*" (Katajisto 2002, 4; translation Auli Touronen, Turku University, Finland).

[24] The Norse king Eystein (between 1103 and 1122) claiming "I could swim as far as you, and could dive as well as you; and I could skate so well that nobody could beat me, and you could no more do it than an ox." (Sturluson ca. 1225, Heimskringla, Book XIII, chapter 24; quoted in MacGregor 1976, 63; http://sunsite.berkeley.edu/OMACL/Heimskringla/crusaders.html, 19. 8. 2003).

[25] "Where this sort of competition is held, you will everywhere see men enthusiastically racing to and for competing for prizes." (Magnus 1555, book 1, chapter 25; quoted in MacGregor 1976, 63); see also footnote 4.

[26] Hero Harold moaning in an undated rune poem that a Russian maid is scorning him although he is perfect in several disciplines like swordfighting, riding, swimming, lance throwing, rowing and ice skating ("I glide along the ice on skates").

[27] W. FitzStephen. Life of Thomas Becket. 1170–1183, preamble; quoted e.g. in MacGregor 1976, 61–62; 1985, 142; Hermann 1902, 219.

> other in this way from a great distance, and, lifting their poles, each tilts against the other. Either one or both fall, not without some bodily injury, for, as they fall, they are carried along a great way beyond each other by the impetus of their run, and wherever the ice comes in contact with their heads, it scrapes off the skin utterly. Often a leg or an arm is broken, if the victim falls with it underneath him; but theirs is an age greedy for glory, youth yearns for victory, and exercises itself in mock combats in order to carry itself more bravely in real battles.”

In case you have the impression that some things never change, we have to admit that any similarities with real existing situations or attitudes are a matter of coincidence (Fig. 11). The other aspects are documented to a lesser degree, although the sheer distance of 5 to 8 km described by Magnus (1555) for competitions shows that the skates are suitable for longer journeys. A Viking Age grave of a young man in Ihre, Gotland, Sweden, containing bone skates and fishing equipment, indicates that they may have had significance in ice fishing (Stenberger 1961, 18–20, 39, 51, 116). This is also reported for 19th century Hungary (Herman 1902, 225–226) and Sweden (Berg 1943, 82–83). A historic document from 1253 supports a connection of bone skating with hunting in Siberia[28] (MacGregor 1976, 61). For further impressions in this field it may be helpful to take a look at more recent documents. The rivers, lakes, marshes, bogs and flooded plains in many of the flat and wet coastal regions of Europe often pose a limiting factor for traffic most of the year. But in a cold winter they could turn into arterial roads thus making distances shorter and certain aspects of life like travelling, trade, smuggling, etc. much easier (Berg 1943, 82–83). In fact this notion came as an unexpected side effect of our trip to Finland: Walking from island to island over the frozen Baltic Sea, crossing channels or bays without any effort, which would have been but a long journey in summer, gave a real experience of the advantages of winter. This is supported by various 19th century paintings showing for instance a shopping family, a fire brigade, a funeral procession, soldiers or a postman (Fig. 12) on (modern) skates (Holz & Hammer 2000, 4–23).

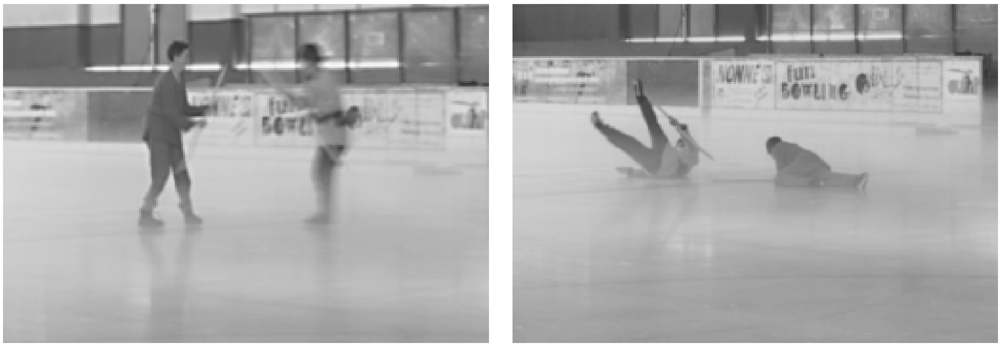

Fig. 11. *“Mock combats” (photos Ralf Schauwacker).*

Plain to see – The question of use-wear

Analysing the gliding facets after several hours of skating reveals two aspects:
The characteristic grinding facets develop rather instantly, thus raising the question of the degree of wear in relation to duration or intensity of use.

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[28] W. W. Rockhill, The Journey of William of Rubruck to the Eastern Parts of the World. London, 1900, 198.

Fig. 12. *Postman on skates, woodcut by C. Koch, 1885 (from Holz & Hammer 2000, 18).*

The striations on the facets are often very irregular and not always as parallel to the bone axis as shown by MacGregor (1975), Semenov (1959, 356, Fig. 3) and Becker (1990, 24, Fig. 4). The main direction of the striations is usually axial, but oblique and even some transverse scratches can be observed rather frequently (Fig. 13; see also Becker 1990, 29). The same was visible on some historic skates from the Turku Provincial Museum, Finland. Without questioning the general fact of axially directed grinding marks being a diagnostic feature of bone skates, it can be stated that the reversal – objects with oblique striations cannot be skates at all (see Barthel 1969, 211) – has to be critically revised.[29] Seen from a mechanical point of view the skating movement is a permanent grinding action. Sand grains or other particles harder than the bone cause little scratches that are superimposed by the following actions again and again. Consequently, the last influence imposed on the bone surface is most visible. If for instance the foot slips away to the side – which happens rather frequently – this can cause oblique or even transverse scratches. In a similar sense the turning of the feet perpendicular to the direction of movement with the intention to stop or change direction, would produce such transverse striations as well. Keeping this in mind, the overall pattern of the use-wear as well as other features of a piece of worked bone should be taken into account before determining a certain object as a skate or not.

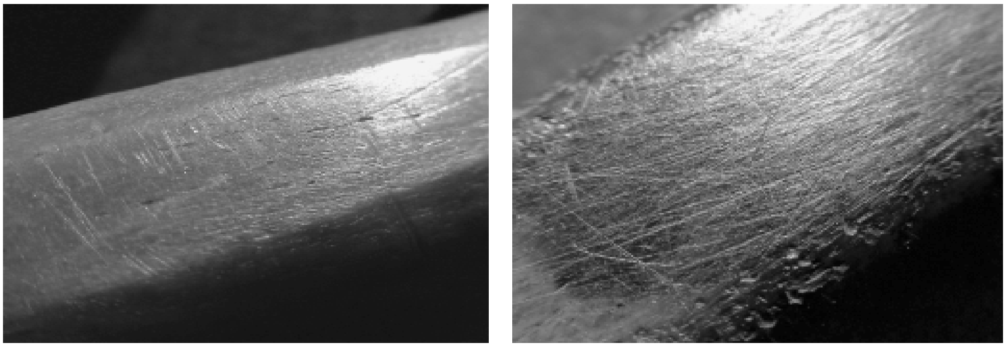

Fig. 13. *Striations on the gliding surfaces of bone skate replicas (photos Carl-Christian von Fick).*

[29] This refers especially to the four objects from Oberdorla, Germany (Barthel 1969, 211–212, 222–224, Pls. XXXII; XXIV; XLI), which Barthel rejects to be skates because of oblique or transverse scratches, although they combine various features of bone skates like pointed and upswept tips, flattened and roughened upper sides and in one case even an axial hole.

Summary

To conclude:

- Skating on bones is doubtless possible.
- Beginners will need broad gliding surfaces and tight attachments to the feet.
- To attach the skates tightly to the feet a single long lace needs to be threaded through the attachment devices in the front and the rear. Two separate laces do not work properly. We could not find significant advantages or disadvantages between two transverse holes per skate in the front and rear *versus* one hole in the front plus a wooden peg at the rear.
- The spikes at the end of the skating poles need to be really sharp to perform well. Thus, bone points occasionally assumed to be used for this purpose may not be durable enough.
- Provided a little bit of practice, bone skating appears to be a decent way of travelling even for long distances with a quite good ratio between power invested and distance covered.
- The weak points of this locomotion method are the difficulties in changing direction and breaking.
- The greatest amount of energy exerted is to keep the legs permanently parallel and at the same distance to each other.
- The muscles most stressed are those of the thighs and the seat.
- In case of crashes the possible resulting injuries will be similar to those suffered frequently from modern ice- and inline-skating.
- Finally the aspect of fun is obvious and should not be underestimated.

The next step is to test the bone skates on long distances on the uneven ice of frozen meadows, lakes and rivers in the countryside. We are really looking forward to the next favourable occasion, maybe even organising competitions like the ones described so vividly by Magnus (1555, book 1, chapter 25).

A view over the recorded material reveals a great homogeneity in the species and skeletal elements used, reflecting the availability of the raw material as well as a functional choice. On the other hand the modifications show a great variety of different possibilities. This as well as the experimental experience makes clear that bone skates certainly were household products which do not require special craftsman skills or specialisation (Lauwerier & van Heeringen 1998, 124), unlike the iron ones in later periods. Their popularity is based on the abundance of the raw material and the simplicity of manufacture and they grew out of fashion only after the industrialisation of the western society.

Invitation for the next experiment

Potential for future research lies in the possibility of accumulating a greater body of evidence about bone skates which would allow a more detailed picture as far as chronology and geographical distribution are concerned. The fact that skates are a typical example of environmental adaptation may make it possible to use them as an additional indicator of microclimatic fluctuations especially at the southern border of their distribution. We intend to publish online (at www.knochenarbeit.de) the current version of our database which already contains over two thousand bone skates (too large to include in an article) and to design it in a way that would not only be useful as a source of reference, but would allow everybody to submit contributions, which would be updated giving credit to the contributors. In this way we hope to find it interesting to estimate the potential of the Internet for generating scientifically useful reference databases. It is another "of those ideas" that one cannot evaluate without trying.

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