2009

New experimental data on the distance of sling projectiles

Margaret Y Brown Vega, *Pennsylvania State University*
Nathan M Craig, *Pennsylvania State University*

Journal of Archaeological Science 36 (2009) 1264–1268

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

New experimental data on the distance of sling projectiles

Margaret Brown Vega*, Nathan Craig

Department of Anthropology, Pennsylvania State University, 409 Carpenter Building, University Park, PA 16802, USA

ARTICLE INFO

Article history:
Received 14 November 2008
Received in revised form
9 January 2009
Accepted 12 January 2009

Keywords:
Warfare
Slings
Experimental archaeology
Central Andes

ABSTRACT

The range of stones cast by slings used in the past is debated. In the Central Andes, slings are asserted to be important weapons of prehispanic war, and have been recovered archaeologically. Rolled river cobbles and stones presumed to be slingstones found at fortified hilltop archaeological sites are presented as evidence that slings were used at these fortifications. Yet sling use has not been adequately tested at hillforts. Experiments conducted in Europe by a novice slinger have attempted to illuminate the range of sling cast stones at ancient hillforts. Data acquired from native slingers is necessary to more accurately assess distances achieved by projectiles launched by slings. We present data from sling experiments carried out in Puno, Perú among Quechua-speaking herders who are experienced slingers. The results demonstrate that a prior model of the maximum theoretical distance of sling cast stones underestimates their range. Results also show significant differences in the use of slings by men and women, and by different age groups. These new data permit a better approximation of warfare that has bearing on our interpretation of fortified sites.

1. Introduction

From many times and places, slings are known as weapons of war. Their use is documented as far back as the Neolithic, and continues today. Slings were used in North and South America, Mesoamerica, Europe, the Mediterranean, the Near East, Africa, and Oceania. The sling is an ancient and cosmopolitan weapon, and yet basic knowledge of its efficacy as a long-range weapon is lacking. Reported distances traveled of projectiles cast from a sling vary considerably (Table 1), yet only one experimental archaeology project to date has been devised to specify the range of slings (Finney, 2006). This previous study produced a hypothetical model of the maximum downslope slingstone cast distance that was applied to Middle Iron Age hillforts. The horizontal distances traveled and the flight times of 90 casts ($\bar{x} = 56$ m, $s = 13$ m) made on a flat surface were used to calculate an initial slingstone velocity. This value was used to construct a hypothetical trajectory curve which was employed to predict a maximum downslope slingstone cast distance. A Central Andean sling was used to cast the stones, and the caster had little prior experience launching stones with a sling.

The lack of experience with the use of slings has been identified as a potential problem in such experiments because it is a difficult weapon to master (Griffiths and Carrick, 1994:8). Novice slingers do not sling as far or as effectively as those who are raised slinging, and thus are a poor proxy for such slingers of the past. Models resulting from such proxies may lead to erroneous interpretations of sling use at fortifications, or may bring into question their efficacy as long-range weapons. As has been documented for atlatls, skills require practice or frequent use, and data collected from skilled individuals provides for a more "naturalistic" experiment (Whittaker and Kamp, 2006). No such experiments that measure native, habituated users of weapons such as slings have been devised. This article presents data from experiments that were aimed at replicating and augmenting prior experimental research by providing a sample from experienced slingers of the Central Andes. Modern herders in the Department of Puno, Perú use slings to manage their animals and scare off threats. Experimental subjects having a life-long familiarity with slings provide a better assessment of sling use than data obtained from novice slingers.

Experiments were aimed at establishing a more realistic maximum distance that stones can be cast by slings. Using the extant experimental model for trajectories of slingstones launched from a hilltop (Finney, 2006:111) Brown Vega (2008) found that some stones would not have cleared defensive walls at one major hilltop fortified site in the Central Andes. This would seem to call into question the utility of slings in defending some hillforts, an issue raised by other scholars (Avery, 1986:225, Griffiths and Carrick, 1994:9). If true, this would raise questions as to the defensive function of this and similar sites based on criteria that posit the

* Corresponding author. Tel.: +1 217 721 1151.
E-mail address: mybvega@psu.edu (M. Brown Vega).

0305-4403/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jas.2009.01.018

Table 1
Table of reported ranges achieved for casts by slings.

Range (m)	Location	Observation type	References
27	Inca Empire	account	Editors of Time Life Books, 1992:27, cited by Keeley et al., 2007:73[a]
27–45	Arabia	ethnographic	Peddie, 1997 (Ch.5, footnote 10), cited by Finney, 2006:73[a]
30	Peru	colonial account	Enriques de Guzman, 1862 [1543]:99, cited by Finney, 2006:73[a]
40–90	Britain	exploratory attempt	Griffiths and Carrick, 1994:7
46–91	Britain	exploratory attempt	Burgess, 1958:230
50	Fiji/Hawaii	ethnographic	Wheeler, 1943:49, cited by Finney, 2006:73[a]
55–91	–	exploratory attempt	Reid, 1976:21, cited by Dohrenwend, 2002:42[a]
60	Britain	estimate	Cunliffe, 2003:68–69
60	Peru	ethnographic	Burns, personal communication cited by Finney, 2006:73[a]
65–134	Britain	experiment	Finney, 2006
69	Madagascar	ethnographic	Linton, 1933:242; Lindblom, 1940:26
69–183	Old World	–	Gabriel and Metz, 1991:75
80	Britain	exploratory attempt	Time Team, 2002, cited by Finney, 2006:73[a]
91	New Britain	ethnographic	Powell, 1884:162, cited by Finney, 2006:73[a]
91	Nigeria	ethnographic	Meek, 1925:116; Finney, 2006:73[a]
100–400	Greece	general statement	Lawrence, 1979:39; Keeley et al., 2007:73
110	England and Wales	general statement, reported range for downhill cast	Dyer, 1992:23
180–200	Majorca (Ibiza)	ethnographic	Hubrecht, 1964:93
183	Old World	review of literature	Dohrenwend, 1994:86
183	New Guinea	ethnographic	Monckton, 1921:38, cited by Finney, 2006:73[a]
183	Ancient Rome	classical reference, Vegetius	Echols, 1950:228; Ferrill, 1985:25; Griffiths and Carrick, 1994:1
200	North Africa	ethnographic	Langlet, 1927:146; Lindblom, 1940:11
200	Turkey	ethnographic	Korfmann, 1973:37
274	Tibet	ethnographic	Rockhill, 1895:714; Lindblom, 1940:34
349	Old World	experiment and review of literature	Dohrenwend, 2002:42
350	Old World	general statement	Connolly, 1981:49
366	Rhodes	classical reference, Xenophon	Echols, 1950:228; Ferrill, 1985:25
457	Old World	general statement	Hogg, 1968
500	Old World	general statement, reported in paces	Demmin, 1877:466; Cowper, 1906:227

[a] Indicates references cited elsewhere that we were unable to review.

identification of slingstones as a major line of evidence for warfare. Given the ambiguous nature of hilltop or enclosed sites (Topic and Topic, 1987) the identification of slingstones alone is a weak indicator that slings were used at these sites. It must be demonstrated that they would have served as effective weapons at these locales if archaeologists are to interpret these sites as having a defensive function. In a world region where the practice of pre-Columbian lethal combat is contested (for a review see Arkush and Stanish, 2005) such an interpretation would be a significant observation. The experimental data presented here suggest the hypothetical trajectory curve of a sling cast stone ('maximum theoretical horizontal distance' 66 m, 'maximum theoretical distance' 135 m) underestimates the range of the weapon, and is not a good model for realistically assessing sling use at hilltop forts. Results from new experiments indicate that the effective range of slingstones launched from a hilltop fortification is greater than that hypothesized. We also report significant differences in distances achieved by female and male slingers, and among different age categories of slingers.

2. The experiment

2.1. The sample

A total of 142 sling casts, or throws, were recorded. Casts from 16 different slingers were measured (Table 2). There were 8 male and 8 female slingers. Slingers were assigned to one of the following age categories: Young Adult, Adult, and Elderly. There were 3 Young Adults, 12 Adults, and 1 Elderly slinger. Slingers cast anywhere from 5 to 15 stones. Some cast distances for individual slingers could not be recorded because the impact point was not observed, and it was not feasible to re-sling to get a complete set (5 or 10 casts). Of the 142 distance throws, 69 were measured for women, and 73 were measured for men.

2.2. Field methods

Sling experiments were conducted in the Rio Ramis drainage, Department of Puno, Perú in June of 2008. The conditions under which experiments were conducted varied because of the way in which we found people to sling. The first two slingers asked to cast, B. Campos and H. Tacca, were employed under the archaeological project Ch'amak Pacha as field workers. Their time, normally dedicated to other tasks, was redirected toward sling experiments. This permitted us to work all day together, which was not the case with the other 14 slingers.

Our initial experiments with Doña Campos and Don Tacca were carried out on a river bank near the town of Calapuja. Pin flags were used to mark both the 'throw point' and the 'impact points'. These points were each recorded with a Trimble® GeoXH Global Positioning System (GPS) receiver. The river bank was ideal for observing where slingstones landed since they left a recognizable point of impact with an accompanying puff of sand to help identify the location. Methods for slinging and measuring were worked out under these conditions. Doña Campos and Don Tacca then facilitated finding more slingers in the adjacent communities.

Individuals attending to their herds (llama, alpaca, sheep, or cattle) were approached and asked if they would be willing to sling. Because these individuals were working, the experiment was designed to be set up quickly in the immediate vicinity of the individuals. Five of the slingers used their own slings. The others used a sling purchased from Doña Campos. All slings were made of braided camelid wool fiber, and are similar to many reported archaeological examples (see Cahlander, 1980; Means, 1919). They measured between 1.8 and 1.9 meters in length. Sling length and variability were not recorded for each cast, but would be variables to account for in future experiments.

Slingers were asked to stand at the throw point and sling projectiles as far as they could (Fig. 1). To note where the stones

Table 2
Table showing all distance measurements for each slinger. Age cat stands for age category (E-Elderly, A-Adult, YA-Young Adult).

Subject	Sex	Age cat	Individual casts														
AM	F	YA	44.12	47.86	48.13	51.20	54.45										
L	F	YA	30.61	34.25	42.93	43.14	44.95	46.39	46.55	47.12	49.04	49.86					
MS	M	YA	51.31	64.02	64.50	80.33											
AH	F	A	36.62	37.34	38.68	41.14	43.60	46.04	50.77	55.22	56.13	56.64					
SM	F	A	42.66	54.50	55.18	55.27	61.90	65.00	65.16	68.55	74.14	78.23					
JA	F	A	42.50	45.46	60.01	62.05	66.51	67.01	67.50	68.28	72.81						
AC	F	A	40.79	41.11	41.28	44.07	47.46	48.35	49.12	55.50	55.94						
FQ	F	A	56.82	62.84	63.29	73.29	76.87	82.22									
FH	M	A	60.83	68.17	68.41	69.90	73.16	76.42	78.63	83.02	83.18	83.33	84.09	93.61	96.31	101.10	101.54
FA	M	A	53.42	66.46	67.32	68.28	68.72	73.79	74.95	75.19	75.26	83.01					
HT	M	A	53.60	56.02	56.98	61.73	66.01	67.90	68.50	69.74	73.94	83.93					
BCh	M	A	95.12	97.10	102.86	106.14	107.43	112.06	122.43	126.65	129.33	130.46					
LQ	M	A	55.97	58.59	59.04	63.28	64.21	67.16	69.77	69.80	71.33	78.08					
SP	M	A	51.91	52.50	63.11	68.07	68.33	70.46	71.00	75.26	75.44						
EQ	M	A	79.04	82.45	86.37	88.41	99.46										
BC	F	E	40.73	42.64	45.70	48.00	48.81	51.20	52.69	57.05	63.63	71.25					

landed for accurate measurement, members of the crew stood in the area where the slingstone would impact. Though dangerous, it is the only way to accurately observe the impact point of the projectile. Slinging stones onto the sand on the river bank or into recently plowed fields permitted the impact points to be pinpointed with ease. A puff of sand or dirt was noted, and the impact crater clearly indicated where the stone had landed. However, in other circumstances the only option was to sling onto a hard packed surface covered with dense patches of *Stipa ichu*, the Peruvian feather bunchgrass. This surface inhibited our ability to see the impact point. If the impact point of the stone was not accurately observed, the throw was eliminated from the sample.

Slingers had different styles of slinging from the throw point, which likely contributed to variability in casting distance. Asked to sling from the pin flag at the throw point, sometimes a running start or a step meant they released from slightly beyond the throw point. We estimate this discrepancy to be no more than half a meter, but will concede a one meter error to be conservative. The sub-meter accuracy of the GPS, while good, also entails a minor amount of error. Given these issues, an estimated maximum error of 1 m was acceptable for all slinging measurements. We do not believe the margin of error contributes to any overall misunderstanding of the data. This level of accuracy is acceptable given that the standard deviations calculated for each individual slinger greatly exceed the estimated maximum error of the experiment.

Because we used stones found in the immediate area of the slingers, stones varied slightly in size. Most were rectangular-shaped, although a few were more rounded. Slingers had preferences for certain size stones, which could be characterized generally as 'small' or 'large'. Measurements were taken on slingstones rapidly in the field to gain a sense of slingstone size used in the experiments. However, slingstone sizes were not consistently measured and linked to specific casts. Nevertheless, all slingers cast similar size stones within the range of 4–9 cm long and 2.5–4.5 cm wide. These stones are comparable in length to the suggested slingstone size of 5 cm (Finney, 2006:68), and to river cobbles that were found at the Central Andean hilltop fortress of Acaray and interpreted to be sling projectiles ($\bar{x} = 8.7$ cm, $n = 123$) (Brown Vega, 2008:330).

3. Analytical methods

GPS-recorded throw and impact points were processed using Trimble® Pathfinder Office to create shapefiles, which were imported into ESRI® ArcMap 9.2 software for analysis. Sling point features were converted to a raster using the Spatial Analyst extension, and 0.5 m spatial resolution distance rasters were calculated from each of the launch points. Using the Zonal Statistics function, each impact point was queried against its corresponding launch point distance raster. This spatial query provided the distance measurements for each cast (Fig. 2). These measurements were exported from the GIS and imported into PAST and R for further statistical analysis.

The maximum distance of any throw in the sample was noted. Means and standard deviations were calculated for the pooled sample, for throwers grouped by sex, and for throwers grouped by

Fig. 1. Photograph showing female slinger (left) and male slinger (right). Casts by the male slinger achieved the greatest distances.

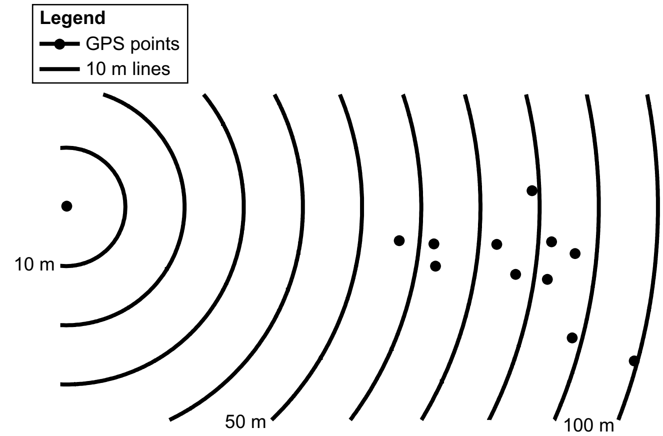

Fig. 2. Distances calculated using a distance raster.

Fig. 3. Histogram showing distance for female slingers.

age category. Prior to performing statistical comparisons, the Shapiro–Wilks W test was used to determine whether the pooled distribution of sling cast distances is normal. A normal distribution was produced by applying a natural logarithm transformation to the sample. The independent samples *t*-test was applied to the transformed distribution and used to determine if there were significant differences in the distances that males and females cast stones. One-way analysis of variance (ANOVA) was applied to the transformed distribution and used to determine if the differences in the distances that stones were cast by slingers of different age categories are significant. For both the *t*-test and ANOVA comparisons, a 90% analysis of power with a significance level of 0.05 was applied *post hoc* to determine if the sample sizes were sufficiently large to warrant statistical tests.

4. Slinging results

One Adult Male slinger cast a stone a maximum distance of 130 m. Slingers averaged a mean casting distance of 65 m ($s = 20$ m, $n = 142$). Males cast stones an average distance of 78 m ($s = 19$ m, $n = 73$) and females cast stones an average distance of 53 m ($s = 12$ m, $n = 69$) (Table 3). A comparison of male and female cast distance distributions shows that both groups have the highest number of throws landing in the 70 m range, and the same number of throws landing in the 80 m range (Figs. 3 and 4). At 90 m the frequency falls more rapidly for females than for males, and males continue to sling beyond 100 m.

The application of the Shapiro–Wilks W test to the sample of sling cast distances revealed that the distribution was not normal ($W = 0.94$, $p < 0.001$). After a natural logarithmic transformation the distribution was retested using the Shapiro–Wilks W test and was found to be normal ($W = 0.99$, $p < 0.38$). Applying the independent sample *t*-test to the transformed data shows that the difference in male and female casting distances is significant ($t = 10.1$, $p < 0.001$, d.f. $= 140$). *Post hoc* analysis of power demonstrates that the sample sizes are sufficiently large to warrant the use of the *t*-test for hypothesis testing. Young Adult slingers cast stones an average distance of 50 m ($s = 11$ m, $n = 19$), Adult slingers cast stones an average distance of 70 m ($s = 20$ m, $n = 113$), and Elderly slingers cast stones an average distance of 52 m ($s = 10$ m, $n = 10$). Applying one-way ANOVA to the natural logarithmic transformed data shows that the differences in the casting distances between the three age groups are significant ($F = 15.86$, $p < 0.001$, d.f. $= 2$). The Levenes homogeneity of variance test applied to the natural logarithmic transformed distances shows that the samples are not significantly different ($p = 0.15$), they are homoscedastic. *Post hoc* analysis of power shows that the sample sizes are sufficiently large to warrant ANOVA hypothesis testing.

Table 3
Summary of n, minimum and maximum casting distances, $\bar{x}$, and s values for slingers by sex and age categories, and for the prior study.

		n	Min	Max	$\bar{x}$	s
All		142	31	130	66	20
Sex	female	69	31	82	53	12
	male	73	51	130	78	19
Age_Cat	young adult	19	31	80	50	11
	adult	113	37	130	70	20
	elderly	10	41	71	52	10
Prior study		90	38	102	56	13

5. Discussion of results

In the present study, the maximum distance recorded, 130 m, is 28 m farther than the farthest throw from the aforementioned sling study (Finney, 2006:100). Comparing the measurements of novice sling casts from the prior study to our results, we find that the mean distance of the novice male caster ($\bar{x} = 56$ m, $s = 13$ m, $n = 90$) is only slightly above that for experienced female slingers, and more than twenty meters shy of the mean distance for male slingers. Nearly half of the casts from the present sample (48%, $n = 68$) exceeded the hypothesized maximum horizontal distance (66 m) of the earlier study (Finney, 2006:111). In the present sample, the maximum horizontal distance cast by an experienced

Fig. 4. Histogram showing distance for male slingers.

male slinger (130 m) is nearly twice as far as the earlier hypothesized maximum horizontal distance (66 m) and is nearly as far as the hypothesized maximum downslope estimate (135 m). The difference in the maximum horizontal casting distance between a novice male slinger and experienced male slingers demonstrates that the prior study underestimates the maximum downslope distances of stones cast by slingers.

In our sample of experienced slingers, the *t*-test showed that on average males cast stones significantly farther than females. We presently lack a model to account for this. However, we suspect that these observed differences may be related to sex based variation in body dimensions of the casters. In future sling experiments, we will record variables to assess how differences in body dimensions influence casting distances.

The ANOVA test showed that the difference between mean distances by age categories was significant. All Adult slingers could sling farther than Young Adults and Elderly slingers. Young Adults do not perform as well as Adult slingers, and the one experienced Elderly slinger (a female) on average cast slingstones farther than Young Adult slingers. If slingers are more effective as adults, why might that be? Perhaps experience requires time to build, and the best slingers are to be found in the Adult category. Performance then falls off once slingers are at an advanced age (estimated at 60+ years). Based on interviews with all slingers, Young Adults (estimated at $\leq$20 years of age) use slings much less than older generations, and we can suggest they may not be as experienced using them now.

6. Conclusions

Much more experimental work on slings is needed. Yet, the present sample of experienced slingers allows one to draw some initial conclusions. The previous maximum downslope distance model very significantly underestimates the range that an experienced adult male slinger can cast stones.

Based on a theoretical trajectory developed from a previous experimental study, slingstones cast from parapets along the uppermost defensive wall of Acaray would not clear the lowest defensive wall at this fort. Such results would suggest that slings are not effective for defense against approaching attackers, and would call into question the function of hilltop fortifications as defensive. Our results, however, demonstrate that experienced adult male slingers casting stones from the parapets along the uppermost defensive wall at Acaray could have consistently cleared the lower defensive walls. However, like the novice male slinger, Young Adults, Elderly, and female slingers from all age groups would not have consistently cleared the lower defensive walls.

There is a strong tradition of slinging among Andean women, especially in Puno where the experimental study was collected. Andean women used slings in pre-Columbian times, and early chroniclers report having seen women on the battlefield (Dransart, 1988:65). Virtually all of the individuals in the present study reported that women more commonly use slings today. Some women we worked with reported having used slings in battle during recent land disputes.

The data we present suggests Young Adults, Elderly, and women probably did not use slings in defending Acaray from along the parapets of the upper defensive wall. Yet, this should not be taken to imply that these same groups were not using slings in other contexts. Variability in sling use has been under recognized, and our data suggests it is an important avenue of further research. By considering how members of various sectors of society tend to exhibit different patterns of performance, it becomes possible to envision how specific groups may have been deployed for defense.

Acknowledgements

We would like to recognize the important work by Jon Bryant Finney that prompted this study. Mark Aldenderfer graciously allowed us to use the Ch'amak Pacha GPS equipment, project infrastructure, and Blanca Nieves in particular. We express profound thanks to the slingers who participated, especially Bitaliana Campos Vilca and Honorato Tacca. We also thank Luis Flores Blanco, Randy Haas, Virginia Incacoña, and Albino Pilco Quispe for research support. This manuscript was greatly enhanced by the comments, suggestions, and corrections made by three anonymous reviewers. Lastly we are grateful for the critiques that Mercedes Verástegui Xesspe made of early drafts of the manuscript. Any errors or flaws in the present paper are entirely our own.

References

Arkush, E.N., Stanish, C., 2005. Interpreting conflict in the ancient Andes. Current Anthropology 46, 3–28.
Avery, M., 1986. 'Stoning and fire' at Hillfort entrances of southern Britain. World Archaeology 18, 216–230.
Brown Vega, M., 2008. War and Social Life in Prehispanic Perú: Ritual, Defense, and Communities at the Fortress of Acaray, Huaura Valley. Department of Anthropology, University of Illinois at Urbana-Champaign, Urbana-Champaign.
Burgess, E.M., 1958. An ancient Egyptian sling reconstructed. Journal of Arms and Armour Society 2, 226–230.
Cahlander, A., 1980. Sling Braiding of the Andes. Colorado Fiber Center, Boulder.
Connolly, P., 1981. Greece and Rome at War. Prentice-Hall Inc., Englewood Cliffs, New Jersey.
Cowper, H.S., 1906. The Art of Attack: Being a Study in the Development of Weapons and Appliances of Offence, from the Earliest Times to the Age of Gunpowder. W. Holmes, Lt., Printers, Ulverston.
Cunliffe, B.W., 2003. Danebury Hillfort. Tempus.
Demmin, A., 1877. An Illustrated History of Arms and Armour, from the Earliest Period to the Present Time. George Bell & Sons, London.
Dohrenwend, R.E., 1994. The sling: forgotten firepower of antiquity. Arms Collecting 32, 85–91.
Dohrenwend, R.E., 2002. The sling: forgotten firepower of antiquity. Journal of Martial Arts 11, 28–49.
Dransart, P., 1988. Women and ritual conflict in Inka society. In: Images of Women in Peace and War: Cross-Cultural and Historical Perspectives.
Dyer, J., 1992. Hillforts of England and Wales. Shire Publications, Princes Risborough BUCKS.
Echols, E.C., 1950. The ancient slinger. The Classical Weekly 43, 227–230.
Ferrill, A., 1985. The Origins of War. Thames and Hudson, London.
Finney, J.B., 2006. Middle Iron Age Warfare of the Hillfort Dominated Zone c. 400 B.C. to c. 150 B.C. Archaeopress, Oxford.
Gabriel, R., Metz, K., 1991. From Sumer to Rome: the Military Capabilities of Ancient Armies. Greenwood Press, Westport, CT.
Griffiths, W.B., Carrick, P., 1994. Reconstructing Roman slings. Arbeia Journal 3, 1–11.
Hogg, O.F.G., 1968. Clubs to Cannon: Warfare and Weapons before the Introduction of Gunpowder. Gerald and Company, Ltd., London.
Hubrecht, A.V.M., 1964. The use of the sling in the Balearic Isles. Bulletin Antieke Beschaving 39.
Korfmann, M., 1973. The sling as a weapon. Scientific American 229, 34–42.
Lindblom, K.G., 1940. The sling, especially in Africa; Additional notes to a previous paper. Statens Etnografiska Museum, Smarre Meddelanden N:r 17.
Linton, R., 1933. The Tanala: a Hill Tribe of Madagascar, Field Museum of Natural History. Chicago.
Means, P.A., 1919. Distribution and Use of Slings in Pre-Columbian America, with Descriptive Catalogue of Ancient Peruvian Slings in the United States National Museum. Government Printing Office, Washington.
Topic, J.R., Topic, T.L., 1987. The archaeological investigation of Andean militarism: some cautionary observations. In: Haas, J., Pozorski, T., Pozorski, S. (Eds.), The Origins and Development of the Andean State. Cambridge University Press, Cambridge, pp. 47–55.
Whittaker, J.C., Kamp, K.A., 2006. Primitive weapons and modern sport: atlatl capabilities, learning, gender, and age. Plains Anthropologist 51, 213–221.