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Biological affinities among Western Siberian forest-steppe groups in the Early Iron age based on dental non-metric data*

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Abstract

The results of the study of the dental anthropology complexes of the population of the Sargat, Gorokhovo and Kashino cultures of the Early Iron Age in Western Siberia are presented. The study is based on the evaluation and statistical analysis of the frequencies of certain non-metric dental traits within each population. The source base of the study is 480 individuals from burials located in the Tobol, Ishim, Irtysh River regions, as well as on the territory of the Baraba forest-steppe zone. The aim of this study is to reconstruct the possible biological affinities between the Sargat, Gorokhovo and Kashino Cultures groups and Early Iron Age and Bronze Age tribes of Southern Urals and Western Siberia based of new dental non-metric data. The Sargat groups from the Tobol, Ishim and Irtysh regions and the Gorokhovo population reveal a weak biological affinity with the chronologically preceding population of Western Siberia of the Bronze Age. For the groups of these territories, the main component was introduced by the descendants of the carriers of the Petrovsky, Srubno-Alakul and Sintashta Cultures of the Southern Urals - the Savromats and Sarmatians. The affinities are especially strong among the Middle Sargat groups. Sargat population of Baraba demonstrated strong biological affinities to the local Late Bronze Age groups - the Fedorovo population and their descendants, Irmen Culture groups. Gorokhovo population reveals the same affinities as the Sargat groups. Relatedness between the Sargat and Gorokhovo groups and their contacts with the Sarmatians contributed to the convergence of their anthropological composition. Kashino Culture group is the most specific. Based on the results of study assumed divergence between Kashino and Sargat populations.

Keywords: non-metric dental traits; Early Iron Age; Bronze Age; Western Siberia

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Introduction

At the beginning of the 1st millennium BC, Eurasian steppes tribes began to use iron in the manufacture of tools and weapons, meanwhile, the formation of a mobile pastoral economy took place. As a result, most of the people were involved in periodic migrations. In the steppe area, new cultures are being formed everywhere. These processes lead to the new historical era - the Early Iron Age, or the era of early nomads, which covers the time approximately from the 7th-6th centuries BC to the 4th-5th centuries AD. The forest-steppe of the Trans-Urals and Western Siberia was inhabited by a population, which in archaeological systematics belong to the Sargat, Gorokhovo and Kashino Cultures (Figure 1). It is believed that their formation took place on a local basis with the active participation of alien groups (1; 2; 3). Among them, the Sargat Culture stands out, which has the largest area (from the eastern foothills of the Urals in the west to the Baraba forest-steppe in the east), and an almost thousand-year period of existence (5 centuries BC - early 4th century AD). The Sargat, Gorokhovo and Kashino Culture are often considered jointly (4), based on material culture, which unites them into a common society of cultures of the forest-steppe Western Siberia region.

The purpose of this study is to clarify the hypothesis regarding the population history of the tribes who lived in Western Siberia in the Early Iron Age, especially Sargat Gorokhovo and Kashino Culture habitats, as well as to find biological affinities between Early Iron Age and Bronze Age populations, based on the dental non-metric data. To achieve this goal, several tasks were set: introducing dental characteristics of the studied series into scientific discourse, comparing them with the available dental non-metric data and reconstructing the main biological affinities between populations.

Materials and study areas

The frequencies of thirty traits were observed using ranked traits (Zubov scheme) (5; 6) and the Arizona State University Dental System (ASUDAS scheme) (7-9) (Table 1). The study was based on the dental remains of 480 individuals of Sargat, Gorokhovo and Kashino Cultures from 82 Early Iron Age burial grounds (Figure 2, Table 2). Each trait was registered on the key teeth of its class, and the individual count method was used. The series was pooled by sex and age. The higher number of the Sargat Sample (424 individual) made it possible to separate it into 8 groups, by territory and chronology. The sites located in the area between the Tobol, Irtysh, and Ishim rivers including the Baraba forest-steppe zone of Western Siberia. The Sargat sites were divided into three chronological periods, according to the periodization of V.A. Mogilnikov: 5th – 3rd centuries BC – Early Sargat period, formation of the Culture; 2nd century BC – 2nd century AD – Middle Sargat, the maximum uniformity of Culture; 3rd – 4th centuries AD – Late Sargat period of cultural disintegration. Gorokhovo and Kashino Samples are less representative – includes dental non-metric data about 40 and 19 individuals.

Table 1. Dental features used in analysis.

Trait	Key Tooth	Breakpoints ASUDAS
Labial convexity	UI1	2-6
Shovel	UI1, UI2	2-7
Double shovel	UI1, UI2	3-6
Mesial ridge	UC	2-3
Distal acc. Ridge	UC, LC	2-5
Metacone	UM1, UM2	3-5
Hypocone	UM1, UM2	2-5
Carabelli trait	UM1, UM2	0, 2-7
C5	UM1, UM2	2-5
C6	UM1, UM2	2-5
Parastyle	UM1, UM2	2-5
Anterior fovea	UM1, LM1	+
Posterior fovea	UM1, LM1	+
Enamel extension	UM1, UM2	2-3
Multiple cusps	LP3, LP4	2-5
Hypoconulid (Cusp 5)	LM1, LM2	1-5
Entoconulid (Cusp 6)	LM1, LM2	2-5
6-cusped M1	LM1	+
5-cusped M1	LM1	+
4-cusped M1	LM1	+
6-cusped M2	LM2	+
5-cusped M2	LM2	+
4-cusped M2	LM2	+
3-cusped M2	LM2	+
Groove pattern	LM1, LM2	Y, X, +
Tami (Cusp 7)	LM1, LM2	2-4
Deflecting wrinkle	LM1	2-3
Distal trigonid crest	LM1	+
Epicristid	LM1	+
Protostylid	LM1	3-5
Protostylid pit	LM1	1

Methods

Sargat, Gorokhovo and Kashino Sample and Early Iron Age and Bronze Age dental samples were compared with two methods. First, dental samples were compared by the Principal Component analysis. The Statistica software for Windows, Version 10.0, was used. Secondary, the degree of distance between groups was determined using the mean measure of divergence (MMD) (10; 11). Microsoft Office Excel 2007 and the software package AnthropMMD from the program R (version 3.6.1)

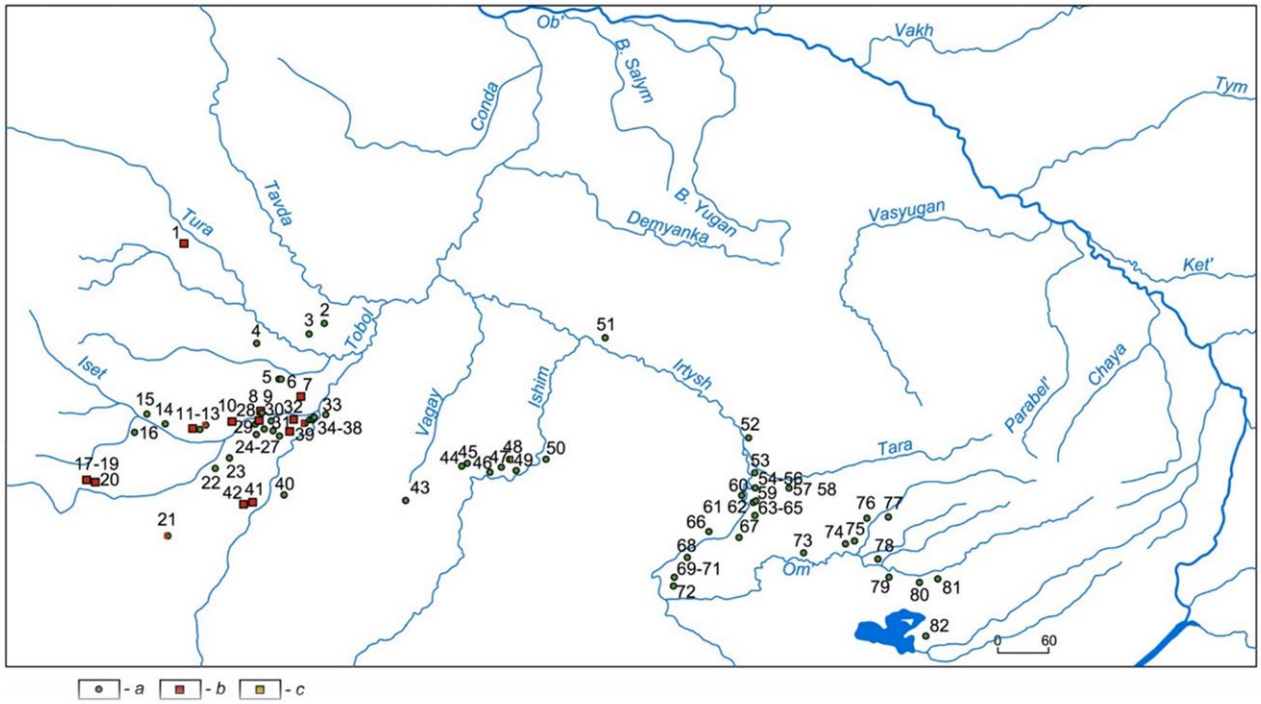

Figure 1. Discussed in the study Early Iron Age burial grounds of Sargat Culture (a), Gorokhovo Culture (b) and Kashino Culture (c) located in the southern part of Western Siberia.

Tobol River Region: 1 – Kurtuguz-1; 2 – Ipkulsky; 3 – Mysovsky; 4 – Chepkul 9; 5 – Rafaylovo; 6 – Rafaylovskoye settlement; 7 – Mohammedkul; 8 – Gaevo-1; 9 – Gaevo 2; 10 – Onufrievsky; 11 – Turushevsky; 12 – Isetskiy 4; 13 – Shadrinsky; 14 – Vorobievskiy; 15 – Sopininsky; 16 – Ust-Tersyuk-2; 17 – Berezki-5b; 18 – Berezki-9; 19 – Berezki-8a; 20 – Malyy Vishnevy; 21 – Dachnyy 2; 22 – Nechunaevo-1; 23 – Tashkovo-3; 24 – Olkhovsky; 25 – Krasnogorsky I; 26 – Tyutrinsky; 27 – Karasye 9; 28 – Khripunovskoe 1; 29 – Krasnogorsky Borok; 30 – Savinovsky;31 – Murzinsky I; 32 – Maryino Gorge-5; 33 – Krivolukskoe; 34 – Ustyug-1; 35 – Nizhne-Ingalskiy 1; 36 – Staro-Lybaevsky IV; 37 – Staro-Lybaevsky VI; 38 – Shchuchye 1; 39 – Gilevsky-2; 40 – Gladunino; 41 – Pamyatnoye 1; 42 – Skaty 1. Ishim River region: 43 – Fomintsevskiy; 44 – Ravnets; 45 – Vavilon; 46 – Kosh-Karagay-2; 47 – Abatskiy-1; 48 – Abatskiy-3; 49 – Kokuy-3; 50 – Likhachevskiy. Irtysh River Region: 51 – Krasnoyarka; 52 – Okunevo-2; 53 – Kartashovo-2; 54 – Beshchaul-2; 55 – Beshchaul-3; 56 – Beshchaul-4; 57 – Isakovka-1; 58 – Isakovka-3; 59 – Sidorovka-1; 60 – Staryy Karasuk-2; 61 – Strizhevo 1; 62 – Strizhevo 2; 63 – Bogdanovo-1; 64 – Bogdanovo-2; 65 – Bogdanovo-3; 66 – Kalachevka I; 67 – Novoobolon; 68 – Gornaya Bitiya; 69 ¬ Kokonovka-1; 70 ¬ Kokonovka-2; 71 – Kokonovka-3; 72 – Bityye Gorki. Baraba forest-steppe zone: 73 – Grishkina Zaimka; 74 – Staryy Sad-1; 75 – Gosudarevo Ozero-1; 76 – Yashkino-1; 77 – Vengerovo-7; 78 – Ust'-Tartas; 79 – Staryye Karachi-3; 80 – Markovo-1; 81 – Abramovo-4; 82 – Zdvinsk-4.

developed by Santos (12) were used for the calculation. 19 Bronze Age and 28 Early Iron Age Dental Samples from Western Siberia, Urals, Altai, Minusinsk Basin and Central Asia were used for statistical comparison (Table 3).

Results

Principal component analysis

Dental non-metric data of the Sargat, Gorokhovo and Kashino Culture samples were compared with the Early Iron Age and Bronze Age samples using principal component analysis (Table 4; Figure 2). The location of the Sargat Culture Samples on the graph (Fig. 1) showed several chronological and locational patterns. Groups of the Early period from the Tobol and Baraba are at a considerable distance from each other. The Early Sargat Sample from the Tobol river region doesn't have analogies among the Bronze Age groups involved in the comparison, and approaches the population of the Novosibirsk Ob' region - the Kulay Culture sample (Kamenny Mys) and the Bolsherechenskaya Culture sample (Bystrovka-1). The sample of the early period from Baraba is located with the series of the Kamen culture of the forest-steppe Altai and the early Sarmatians (Lebedevka) of the Southern Urals. The Sargat Culture samples of the Middle period were grouped around a series of early Sarmatians (Pokrovka X). Sargat Cuture

Table 2. Dental traits of the Early Iron Age samples of Western Siberia.

		Shovel UI1		Shovel UI2		Hypocone UM2		Carabelly trait grade 2-7, UM1		6-cusped LM1		4-cusped LM1		4-cusped LM2		Distal trigonid crest LM1		Deflecting wrinkle UM_1		Cusp C7 (Tami) LM_1	
		n (N)	%	n (N)	%	n (N)	%	n (N)	%	n (N)	%	n (N)	%	n (N)	%	n (N)	%	n (N)	%	n (N)	%
Tobol	Sargat, Early period	0 (4)	0,0	0 (4)	0,0	1 (7)	14,3	1 (7)	14,3	1 (8)	12,5	0 (8)	0,0	5 (6)	83,3	0 (7)	0,0	2 (4)	50,0	1 (8)	12,5
	Sargat, Middle period	5 (21)	23,8	6 (21)	28,6	15 (59)	25,4	11 (43)	25,6	0 (36)	0,0	4 (36)	11,1	23 (33)	70,6	0 (34)	0,0	5 (22)	22,7	4 (36)	11,1
	Gorokhovo	0 (9)	0,0	5 (11)	45,5	10 (18)	55,6	5 (24)	20,8	0 (19)	0,0	2 (19)	10,5	15 (19)	78,9	0 (16)	0,0	3 (10)	30,0	3 (18)	16,7
Irtysh	Sargat, Middle period	1 (16)	6,3	8 (31)	25,8	9 (58)	15,5	12 (43)	27,9	2 (45)	4,4	2 (45)	4,4	27 (43)	62,8	3 (41)	7,3	7 (21)	33,3	8 (41)	19,5
	Sargat, Late period	0 (14)	0,0	2 (18)	11,1	8 (29)	27,6	6 (32)	18,8	0 (29)	0,0	1 (29)	3,4	21 (24)	87,5	1 (22)	4,5	2 (7)	28,6	1(26)	3,8
Ishim	Sargat, Middle period	1 (8)	12,5	3 (10)	30,0	3 (24)	12,5	1 (16)	6,3	0 (14)	0,0	0 (14)	0,0	9 (15)	60,0	0 (14)	0,0	0 (4)	0,0	1 (14)	7,1
	Sargat, Late period	1 (6)	16,7	1 (7)	14,3	3 (19)	15,8	4 (15)	26,7	0 (11)	0,0	1 (11)	9,1	9 (11)	81,8	0 (9)	0,0	1 (3)	33,3	2 (12)	16,7
	Kashino	3 (5)	60,0	3 (8)	37,5	2 (13)	15,4	4 (9)	44,4	4 (12)	33,3	0 (12)	0,0	2 (8)	25,0	3 (10)	30,0	2 (6)	33,3	0 (8)	0,0
Baraba	Sargat, Early period	1 (7)	14,3	6 (9)	66,7	6 (20)	30,0	4 (17)	23,5	1 (12)	8,3	1 (12)	8,3	10 (14)	71,4	1 (10)	10,0	1 (5)	20,0	2 (11)	18,2
	Sargat, Middle period	4 (7)	57,1	3 (9)	33,3	7 (17)	41,2	5 (18)	27,8	0 (18)	0,0	2 (18)	11,1	18 (18)	100,0	1 (17)	5,9	0 (7)	0,0	4 (17)	23,5

samples of the Late period are located close to each other, demonstrating the continuity of odontological complexes within the Sargat population of the previous, middle stage. The series from Baraba moves away from these samples, shifting to the area of positive values and approaching the sample of the late Sarmatians (Pokrovka X), the Western Siberia Late Bronze Age population, and the Alakul people of the Omsk Irtysh region. Most of the Sargat series and the Gorokhovo sample are located in the same field as the Bronze Age series of the Southern Urals.

The most specific is the position of the Kashino Culture sample. It moves away from most of the samples used for comparison. The sample of the Ananyin Culture (Lugovskoy) of the Kama river region and the Sauromat group (Kazy-Baba) are closest to the studied Kashino sample.

MMD distances

The obtained MMD distances between the series of the Sargat, Gorokhovo and Kashino Cultures, samples of the Bronze Age and the Early Iron Age partly repeat the picture that has developed from the results of Principal Components analyses. On the dendrogram of the hierarchical clustering of MMD distances, two subclusters are clearly distinguished (Figure 3), which, in turn, are divided into subgroups.

The position of the Sargat samples is generally similar to the distribution based on the results of Principal Component analysis and correspondence analysis. The proximity of the majority of the Sargat samples to the Bronze Age series of the Southern Urals (the group of the Urals variant of the Sintashta Culture and Srubno Alakul sites) and the Middle Period series from Baraba to the samples of the Bronze Age of Western Siberia are well visualized by the dendrogram (Appendix, Table 5).

In comparison with the results of previous analyses, the position of the Gorokhovo sample is different. The matrix of phenetic distances demonstrates statistically significant differences between the Gorokhovo and Middle Sargat

Table 3. Dental samples used in present study.

№	Region	Archaeological culture	Site	Date	References
1	Western Siberia Tobol river region	Sargat Culture	Several sites	Early period 5th – 3rd cc BC	Sleptsova, Present Study
2	Western Siberia Tobol river region		Several sites	Middle period 3rd c BC – 2nd c AD	
3	Western Siberia Ishim river region		Several sites	Middle period 3rd c BC – 2nd c AD	
4	Western Siberia Ishim river region		Several sites	Late period 2nd – 4th cc AD	
5	Western Siberia Irtysh river region		Several sites	Middle period 3rd c BC – 2nd c AD	
6	Western Siberia Irtysh river region		Several sites	Late period 2nd – 4th cc AD	
7	Western Siberia Baraba forest-steppe zone		Several sites	Early period 6th – 3rd cc BC	
8	Western Siberia Baraba forest-steppe zone		Several sites	Middle period 3rd c BC – 1st c AD	
9	Western Siberia Tobol and Iset' river region	Gorokhovo Culture	Several sites	5th – 2rd cc BD	
10	Western Siberia Ishim river region	Kashino Culture	Abatsky 3	4th – 5st cc AD	
Bronze Age					
11	Western Siberia Tomsk Ob' river region	Andronovo	Elovsky-1, 2	2nd millennium BC	Zubova, 2014 (21)
12	Western Siberia	Fedorovo Culture	Several sites	2nd millennium BC	-//-
13	Western Siberia Irtysh river Omsk region	Chernoozersky type of the Andronovo Culture	Chernoozerye-1, Borovyanka-17	2nd millennium BC	-//-
14	Western Siberia Irtysh river Omsk region	Alakul Culture	Ermak-4	2nd millennium BC	-//-
15	Western Siberia	Irmen Culture	Several sites	2nd millennium BC	-//-
16	Tomsk Ob' river region	Yelovo Culture	Elovsky-1, 2	2nd millennium BC	-//-
17	Western Siberia Tobol river region and Baraba forest-steppe zone	Pahomovo Culture	Several sites	2nd millennium BC	-//-
18	South of Western Siberia Kuznetsk hollow	Korchazhka Culture	Tanay-12	2nd millennium BC	-//-
19	Western Siberia Baraba forest-steppe zone	Krotovo Culture (classic stage)	Sopka-2	Late 3rd – early 2nd millennium BC	Chikisheva, 2012 (22)
20	Western Siberia Baraba forest-steppe zone	Late Krotovo (Chernoozerskaya) Culture	Sopka-2	Early 2nd millennium BC	Chikisheva, 2012 (22)
21	South of Western Siberia Minusinsk basin	Okunevo Culture	Several sites	2nd millennium BC	Zubova, 2013b (23)
22	South of Western Siberia Khakass-Minusinsk basin	Karasuk Culture	Several sites	Late 2rd – early 1st millennium BC	Rykushina, 2007 (24)
23	Southern Urals	Sintashta Culture	Several sites	3rd – early 2nd millennium BC	Kitov, 2011 (25)
24		Ural type of the Sintashta Culture	Several sites	Late 3rd – early 2nd millennium BC	-//-
25		Petrovsky Culture	Several sites	20th – 17th cc BC	-//-
26		Srubno Alakul type	Several sites	18th – 16th cc BC	-//-
27		Alakul Culture (steppe zone)	Several sites	18th – 16th cc BC	-//-
28		Srubnaya culture (Bashkiria)	Several sites	Early 2nd millennium BC	Kufterin, Nechvaloda 2021 (26)
29		Srubno Alakul type	Neplyuevsky	21st – 17th cc BC	Karapetyan et al, 2020 (27)
Early Iron Age					
30	Western Siberia Novosibirsk Ob' river region	Kylay Culture	Kamennyy Mys	3th – 2rd cc BD	Kishkurno, Sleptsova, 2019 (32)
31	Western Siberia Upper Ob' river region	Bolsherechenskaya Culture	Verkh-Suzun-5	6th – 2rd cc BD	Kishkurno, 2022 (33)
32			Bystrovka-1	Second half of the 1st millennium BC	
33			Bystrovka-2		
34			Bystrovka-3		
35			Select sample		
36	Forest-Steppe Altai	Kamen Culture	Rogozikha-1	6th – 4th cc BC	Leibova, Tur ., 2020 (34)
37			Obyezdnoye-1, Kamen-2, Kirillovka-3, Novotroitskoye 1 and 2	5th – 3rd cc BC	
38			Maslyakha-1	3rd –2nd cc BC	
39		Staroaleyka Culture	Firsovo-14, Obskiye Plesy 2	6th –5th cc BC	
40	Altai Mountains	Pazyryk Culture	Several sites	5th – 3rd cc BC	Chikisheva, 2012 (22)
41		Karakobin Culture	Several sites		
42		Aldy-belsk Culture	Arzhan II	7th c BC	
43			Copto	5th – 4th cc BC	
44		Uyuk-Saglyn Culture	Dogee-Baary II	6th – 4th cc BC	
45	Minusinsk Basin	Tagar Culture	Chernogorka	8th – 3rd cc BC	Gulevskaya, unpubl.
46	Aral Sea region	Jetyasar Culture	Kosasar-2	5th c BC	Rykushina, 1993a (35)
47			Kosasar-3, Tompakasar, Bedaikasar	4th c AD	Rykushina, 1993б (36)
48	Central Asia	Tasmolinian Culture	Several sites	8th –5th cc BC	Kitov, 2015 (37)
49		Korgantas period	Several sites	4th –2nd cc BC	
50	Southern Urals	Early Sarmatians	Pokrovka X	4th –2nd cc BC	Suvorova, 2008 (38)
51		Late Sarmatians		2nd – 4th cc AD	
52		Sauromats	Novyy Kumak	6th –4th cc BC	Segeda, 2006 (39)
53			Kazy-Baba	5th –4th cc BC	Bagdasarova, 2000 (40)
54		Early Sarmatians	Lebedevka	5th – 3rd cc BC	Segeda, 2006 (39)
55		Ananyin Culture	Lugovskoy	8th – 3rd cc BC	Aksyanova, 2007 (41)
56	Middle Asia Tian Shan region	Saka	Several sites	5th – 2nd cc BC	Kitov et al., 2019 (42)
57	Southern Urals	Kara-Abyz Culture	Shipovo, Okhlebinino, Kara-Abyz-2	4th c BC – 1st c AD	Leibova, 2021 (43)

groups (Irtysh and Ishim River regions), as well as the Kashino sample (Appendix, Table 5). On the dendrogram, the closest groups to the Gorokhovo are a series of the Fedorovo and Korchazhka cultures of the Bronze Age and Saka of the Tien Shan.

The isolated position of the Kashino group from the Sargat and Gorokhovo groups, as well as the proximity of the Kashino and Ananyino groups, is confirmed. Statistically significant differences were recorded between the Kashino and Sargat groups of the middle and late periods (Appendix, Table 5). In addition to the Ananyino Culture sample, the group of the Aldy-Bel Culture and a combined series of sites of the Korgantas period are located in the same cluster with the Kashino Culture.

Table 4. Trait loadings on the first two Principal Components.

Trait	PC 1	PC 2
Shovel UI1	0,18	**0,68**
Carabelli trait, grade 2-7 UM1	0,45	0,41
Hypocone reduction UM2	**-0,60**	0,31
6-cusped LM1	**0,80**	0,07
4-cusped LM1	**-0,72**	0,11
4-cusped LM2	**-0,71**	-0,02
Distal trigonid crest LM1	0,06	**0,80**
Deflecting wrinkle LM1	0,49	-0,32

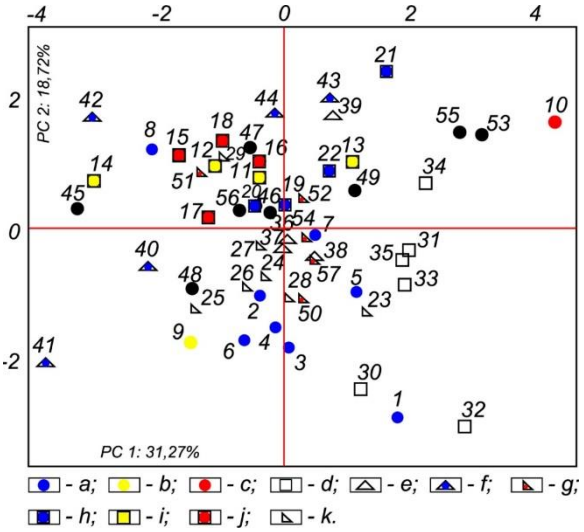

Figure 2. . The position of Sargat, Gorokhovo and Kashino Samples on the first two principal components (groups names see Table 3). a – Sargat Culture Samples; b – Gorokhovo Culture Sample; c – Kashino Culture Sample; d – Upper Ob' river region Samples; e – Forest-Steppe Altai Samples; f – Altai Mountains Samples; g – Southern Urals Nomads Samples; h –Before Andronovo period Samples; i – Andronovo period Samples; j – Late Andronovo period Samples; k – Southern Urals Bronze Age Samples.

Discussion

The results of MMD values and comparative statistical analysis suggest a close affinity between Sargat Culture and Gorokhovo culture populations of Western Siberia. Besides that, examined samples located close to Early Sarmatians (Southern Urals). There is craniometrical and dental non-metric characteristics data indicate affinity of Sargat and Sarmatians populations (3).

In the formation of the Early Iron Age population of the Tobol and Baraba, autochthonous groups had a more important role than in the Ishim and Irtysh regions, with the dominance of the migrant component common to all Sargat groups. The chronological differences between the Sargats are complex. At different stages of the existence of the Sargat culture, the degree of variability of dental non-metric characteristics differs. Early period Sargat samples reveal a weak biological affinity between each other and Middle period groups. Middle Sargat groups reveal more similarity. It seems even stronger in the Late Sargat period. Irtysh and Ishim River region Sargat groups demonstrated strong biological affinities in Middle and Late period.

The Sargat groups from the Tobol, Ishim and Irtysh regions and the Gorokhovo population reveal a weak biological affinity with the chronologically preceding population of Western Siberia of the Bronze Age. For the groups of these territories, the main component was introduced by the descendants of the carriers of the Petrovsky, Srubno-Alakul and Sintashta Cultures of the Southern Urals - the Savromats and Sarmatians. The similarity with the latter is especially strong among the Middle Sargat groups. Previously, researchers noted that a large role in the formation of the Sargat population was assigned to the previous Andronovo population of Western Siberia, a smaller one - to the Irmen population (1; 2; 3). According to dental non-metric data, these conclusions are valid for the population of the early Iron Age of the Baraba forest-steppe. Sargat population of Baraba demonstrated strong biological affinities to the local Late Bronze Age groups - the Fedorovo population and their descendants, Irmen Culture groups. According to archaeological data (1), from the 5th century BC there is a process of gradual "sarmatization" of the forest-steppe population of Western Siberia, which is confirmed by the results of current study. Starting from the 3rd century BC the constant migration of the Sarmatian groups of the Southern Urals to the forest-steppe of Western

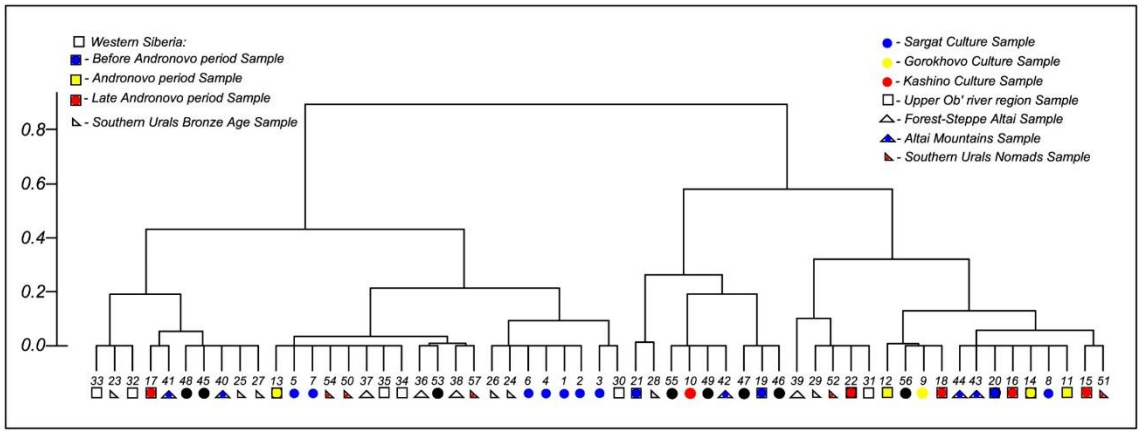

Figure 3. Dendrogram of the distances of the s Sargat, Gorokhovo and Kashino culture and Early Iron Age and Bronze Age groups based on the MMD values in Table 5 (Appendix) (groups names see Table 3).

Siberia significantly influenced to the Sargat population.

Besides Sarmatian and Sauromatian, several biological affinities of the Sargat population and Early Iron Age groups were recorded: the closest one with the Kara-Abyz Culture group, Saka populations of the Tien Shan region and Bolsherechenskaya culture groups of the Upper Ob region.

The Gorokhovo population reveals the same affinities as the Sargat groups. Relatedness between the Sargat and Gorokhovo groups and their contacts with the Sarmatians contributed to the convergence of their anthropological composition. According to archaeological data, the Gorokhovo population migrated to the Southern Urals and entered the political union of the Sarmatians. Dental non-metric data could support this hypothesis (13).

The Kashino Culture group is the most specific. Based on the results of current study assumed divergence between Kashino and Sargat populations. However archaeological data suggests numerous cultural relations (14; 15; 16). The results of the MMD and PC analysis allow us to support the hypothesis of the Kama groups migration (Ananyino Culture) and suggest affinities between Ananyino and Kashino populations (17; 18; 19). Relatedness between the Kashino population and autochthonous taiga-zone groups of the Bronze Age can be assumed, however, there is only archaeological evidence for this (17; 20; 15).

Conclusions

1. Early period Sargat sample reveal a weak biological affinity between each other and Middle period groups. Middle Sargat groups reveal more similarity. It seems even stronger in the Late Sargat period. Irtysh and Ishim River region Sargat groups demonstrated strong biological affinities in Middle and Late period.
2. Sargat groups of the Tobol, Irtysh and Ishim River regions shown strong biological affinities with Southern Ural groups, especially with the Savromats and Sarmats. Baraba Sargat Sample demonstrated close affinities with Western Siberia Bronze Age groups.
3. Besides Sarmats, Sargat group reveal closure with Saka of Tian Shan, Kulay and Bolsherechenskaya groups of the Upper Ob River region.
4. Gorokhovo and Sargat groups are very similar; reveal the same affinities with Southern Ural Bronze Age and Early Iron Age tribes.
5. It can be assumed that the formation of the population of the Kashino and Sargat Cultures are based on different substrates, and numerous interactions were of a cultural rather than population nature. The results of the analysis make it possible to speak in favor of the hypothesis about the penetration of the Kama population (Ananyino Culture) into the Trans-Urals and to suggest the contribution of the Ananyino groups in the formation of the Kashino population.

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Declaration of Interest

None

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Table 5. The degree of distance between the Sargat, Gorokhovo and Kashino culture and Bronzw Age and Early Iron Age Samples indicated by the mean measure of divergence (MMD).

	1**	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0.000	0.000*	0.000	0.000	0.000	0.000	0.000	0.037	0.073	0.087	0.020	0.070	0.000	0.059	0.013	0.110	0.007	0.000	0.110
2	0.109	0.000	0.000	0.000	0.035	0.000	0.060	0.060	0.022	**0.498**	**0.153**	**0.107**	**0.087**	0.047	**0.102**	**0.167**	**0.206**	0.084	**0.288**
3	0.134	0.002	0.000	0.000	0.026	0.000	0.067	0.138	**0.133**	**0.512**	**0.170**	**0.250**	0.083	**0.159**	**0.090**	**0.284**	0.035	0.204	**0.250**
4	0.147	0.003	0.099	0.000	0.000	0.000	0.000	0.002	0.045	**0.289**	0.059	**0.071**	0.000	0.015	0.045	0.128	**0.125**	0.044	**0.185**
5	0.107	0.004	0.058	0.072	0.000	0.000	0.000	0.024	**0.157**	**0.169**	0.045	**0.114**	0.000	0.064	**0.072**	**0.141**	**0.138**	0.082	**0.140**
6	0.117	0.005	0.068	0.082	0.041	0.000	0.000	0.000	0.008	**0.374**	0.031	**0.060**	0.022	0.000	0.000	0.060	**0.068**	**0.044**	**0.106**
7	0.142	0.006	0.094	0.108	0.067	0.077	0.000	0.000	0.057	0.043	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.000	0.000
8	0.147	0.007	0.099	0.113	0.072	0.083	0.108	0.000	0.001	**0.223**	0.000	0.000	0.008	0.000	0.000	0.000	**0.112**	0.000	0.000
9	0.128	0.008	0.079	0.093	0.052	0.062	0.088	0.094	0.000	**0.576**	**0.130**	0.012	**0.214**	0.000	0.051	0.017	**0.207**	0.000	**0.227**
10	0.155	0.009	0.106	0.119	0.079	0.088	0.114	0.119	0.100	0.000	**0.143**	**0.288**	0.098	**0.315**	**0.320**	**0.263**	**0.421**	**0.216**	**0.192**
11	0.103	0.010	0.053	0.067	0.026	0.037	0.062	0.068	0.048	0.074	0.000	**0.056**	0.021	0.000	0.010	0.000	**0.109**	0.037	0.000
12	0.097	0.011	0.048	0.062	0.021	0.031	0.057	0.063	0.042	0.069	0.017	0.000	**0.123**	0.000	**0.070**	0.000	**0.272**	0.000	**0.147**
13	0.112	0.012	0.063	0.076	0.036	0.046	0.071	0.078	0.057	0.083	0.032	0.026	0.000	0.066	**0.080**	0.131	**0.159**	0.103	**0.101**
14	0.129	0.013	0.080	0.093	0.053	0.063	0.088	0.093	0.074	0.101	0.049	0.043	0.058	0.000	0.000	0.000	**0.169**	0.000	0.057
15	0.096	0.014	0.047	0.061	0.020	0.030	0.056	0.062	0.041	0.068	0.016	0.010	0.025	0.042	0.000	0.017	**0.049**	0.043	**0.035**
16	0.123	0.015	0.074	0.087	0.047	0.057	0.082	0.088	0.069	0.094	0.043	0.037	0.053	0.069	0.036	0.000	**0.202**	0.000	0.038
17	0.107	0.016	0.059	0.072	0.031	0.041	0.067	0.073	0.053	0.079	0.027	0.021	0.036	0.053	0.020	0.048	0.000	**0.215**	**0.088**
18	0.125	0.017	0.076	0.089	0.049	0.059	0.084	0.089	0.071	0.097	0.045	0.039	0.055	0.071	0.038	0.066	0.050	0.000	**0.129**
19	0.102	0.018	0.054	0.067	0.026	0.036	0.062	0.068	0.047	0.074	0.022	0.016	0.031	0.048	0.015	0.042	0.026	0.045	0.000
20	0.120	0.019	0.071	0.083	0.044	0.054	0.079	0.085	0.065	0.091	0.040	0.034	0.049	0.066	0.033	0.061	0.044	0.063	0.039
21	0.112	0.020	0.063	0.077	0.036	0.046	0.072	0.078	0.057	0.083	0.031	0.026	0.041	0.057	0.025	0.052	0.036	0.054	0.031
22	0.097	0.021	0.048	0.062	0.020	0.031	0.057	0.063	0.042	0.068	0.016	0.010	0.026	0.042	0.010	0.037	0.021	0.039	0.016
23	0.124	0.022	0.075	0.088	0.048	0.058	0.083	0.089	0.069	0.095	0.044	0.038	0.053	0.070	0.037	0.064	0.048	0.066	0.043
24	0.132	0.023	0.083	0.096	0.056	0.066	0.091	0.097	0.077	0.103	0.051	0.046	0.061	0.078	0.045	0.072	0.056	0.074	0.051
25	0.129	0.024	0.080	0.093	0.052	0.063	0.088	0.094	0.074	0.100	0.049	0.043	0.058	0.075	0.042	0.069	0.053	0.071	0.048
26	0.108	0.025	0.059	0.073	0.032	0.042	0.068	0.074	0.053	0.080	0.028	0.022	0.037	0.054	0.021	0.048	0.032	0.050	0.027
27	0.105	0.026	0.056	0.069	0.028	0.038	0.064	0.070	0.050	0.076	0.024	0.018	0.034	0.051	0.017	0.045	0.029	0.047	0.024
28	0.105	0.027	0.055	0.069	0.028	0.038	0.064	0.070	0.050	0.076	0.024	0.018	0.034	0.051	0.017	0.045	0.029	0.047	0.024
29	0.127	0.028	0.078	0.090	0.051	0.061	0.085	0.091	0.072	0.098	0.047	0.041	0.056	0.073	0.040	0.067	0.051	0.070	0.046
30	0.146	0.029	0.097	0.110	0.070	0.080	0.105	0.110	0.091	0.118	0.065	0.060	0.075	0.092	0.059	0.086	0.070	0.088	0.066
31	0.138	0.030	0.090	0.103	0.063	0.072	0.098	0.103	0.084	0.110	0.058	0.053	0.067	0.084	0.052	0.078	0.063	0.080	0.058
32	0.166	0.031	0.120	0.133	0.092	0.102	0.128	0.132	0.113	0.138	0.087	0.082	0.096	0.113	0.081	0.107	0.093	0.109	0.087
33	0.105	0.032	0.056	0.070	0.029	0.039	0.065	0.071	0.050	0.076	0.024	0.019	0.034	0.050	0.018	0.045	0.029	0.047	0.024
34	0.110	0.033	0.062	0.075	0.034	0.044	0.070	0.076	0.055	0.081	0.029	0.024	0.039	0.056	0.023	0.050	0.034	0.052	0.029
35	0.149	0.034	0.103	0.117	0.076	0.086	0.112	0.119	0.097	0.122	0.072	0.067	0.081	0.096	0.066	0.091	0.077	0.092	0.071
36	0.105	0.035	0.057	0.070	0.029	0.039	0.065	0.071	0.050	0.077	0.025	0.019	0.034	0.051	0.018	0.046	0.029	0.048	0.025
37	0.100	0.036	0.051	0.064	0.023	0.033	0.059	0.065	0.045	0.071	0.019	0.013	0.028	0.046	0.012	0.040	0.024	0.042	0.019
38	0.108	0.037	0.060	0.073	0.032	0.042	0.068	0.074	0.053	0.080	0.028	0.022	0.037	0.054	0.021	0.048	0.032	0.050	0.028
39	0.107	0.038	0.058	0.070	0.030	0.040	0.065	0.071	0.052	0.078	0.026	0.021	0.036	0.053	0.019	0.047	0.031	0.049	0.026
40	0.102	0.039	0.053	0.066	0.026	0.036	0.061	0.068	0.047	0.073	0.022	0.016	0.031	0.048	0.015	0.042	0.026	0.044	0.021
41	0.173	0.040	0.125	0.138	0.097	0.108	0.133	0.138	0.119	0.144	0.093	0.088	0.102	0.119	0.087	0.113	0.098	0.115	0.093
42	0.136	0.041	0.087	0.100	0.060	0.070	0.095	0.100	0.081	0.107	0.056	0.050	0.065	0.082	0.049	0.076	0.060	0.078	0.055
43	0.154	0.042	0.105	0.118	0.078	0.088	0.113	0.118	0.099	0.125	0.073	0.068	0.083	0.100	0.067	0.093	0.078	0.096	0.073
44	0.131	0.043	0.081	0.094	0.054	0.065	0.089	0.095	0.076	0.102	0.051	0.045	0.060	0.077	0.044	0.071	0.055	0.074	0.050
45	0.103	0.044	0.054	0.068	0.027	0.037	0.062	0.069	0.048	0.074	0.022	0.017	0.032	0.049	0.016	0.043	0.027	0.045	0.022
46	0.125	0.045	0.077	0.091	0.050	0.060	0.086	0.093	0.071	0.097	0.046	0.040	0.055	0.071	0.039	0.066	0.050	0.067	0.045
47	0.131	0.046	0.083	0.096	0.055	0.065	0.091	0.097	0.076	0.103	0.051	0.045	0.060	0.077	0.044	0.071	0.056	0.073	0.051
48	0.131	0.047	0.082	0.096	0.055	0.065	0.091	0.096	0.076	0.102	0.050	0.045	0.060	0.076	0.044	0.070	0.055	0.073	0.050
49	0.173	0.048	0.124	0.137	0.097	0.107	0.132	0.137	0.119	0.144	0.093	0.087	0.103	0.119	0.086	0.114	0.098	0.116	0.093
50	0.137	0.049	0.088	0.101	0.061	0.071	0.096	0.102	0.082	0.109	0.057	0.051	0.066	0.083	0.050	0.077	0.061	0.079	0.057
51	0.128	0.050	0.080	0.092	0.053	0.062	0.087	0.093	0.073	0.101	0.048	0.043	0.058	0.074	0.042	0.068	0.053	0.070	0.048
52	0.163	0.051	0.115	0.128	0.087	0.098	0.123	0.128	0.109	0.135	0.083	0.077	0.092	0.109	0.076	0.103	0.088	0.106	0.083
53	0.107	0.052	0.058	0.072	0.031	0.041	0.067	0.073	0.052	0.079	0.026	0.021	0.036	0.053	0.020	0.047	0.031	0.049	0.026
54	0.157	0.053	0.108	0.121	0.082	0.092	0.116	0.122	0.104	0.128	0.079	0.073	0.088	0.104	0.072	0.100	0.083	0.101	0.078
55	0.121	0.054	0.072	0.085	0.044	0.055	0.080	0.086	0.066	0.092	0.040	0.034	0.050	0.067	0.033	0.061	0.045	0.063	0.040
56	0.111	0.055	0.063	0.076	0.035	0.045	0.071	0.077	0.056	0.082	0.030	0.025	0.040	0.056	0.024	0.051	0.035	0.053	0.030
57	0.102	0.056	0.054	0.067	0.026	0.036	0.062	0.068	0.047	0.074	0.022	0.016	0.031	0.048	0.015	0.043	0.026	0.045	0.022

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	0.000	**0.552**	0.012	0.000	0.000	0.000	0.000	0.000	**0.337**	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	**0.154**	**0.706**	**0.117**	0.076	0.000	0.075	0.000	**0.112**	**0.409**	**0.109**	0.085	0.125	**0.247**	**0.133**	**0.171**	0.022	0.035	**0.051**	0.043
3	**0.166**	**0.891**	**0.247**	0.028	0.022	0.024	0.014	**0.086**	**0.555**	**0.327**	0.000	**0.269**	0.099	0.100	**0.128**	0.039	0.017	0.059	**0.125**
4	0.069	**0.574**	0.026	0.000	0.000	0.067	0.000	**0.093**	**0.324**	0.056	0.000	0.048	0.120	0.033	0.008	0.000	0.000	0.000	0.000
5	0.052	**0.464**	**0.046**	0.039	0.050	**0.152**	**0.065**	**0.152**	**0.277**	**0.126**	0.000	0.086	0.114	0.050	0.000	0.000	0.000	0.000	0.000
6	0.025	**0.508**	**0.093**	0.071	0.000	0.028	0.000	0.038	**0.244**	**0.164**	0.005	**0.154**	0.203	**0.106**	**0.108**	0.031	0.000	0.018	0.039
7	0.000	**0.250**	0.000	0.000	0.000	0.042	0.024	0.019	0.098	0.072	0.000	0.000	0.022	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	**0.163**	0.019	0.159	0.008	0.097	0.050	0.051	0.000	0.121	0.078	0.124	**0.304**	**0.148**	**0.115**	0.083	0.000	0.038	0.034
9	0.089	**0.575**	**0.142**	0.128	0.000	0.000	0.000	0.002	0.276	0.113	**0.239**	0.124	**0.316**	**0.175**	**0.354**	**0.164**	**0.142**	**0.180**	**0.160**
10	0.129	**0.180**	0.122	**0.239**	**0.368**	**0.547**	**0.477**	**0.466**	**0.229**	**0.265**	0.155	0.132	0.166	0.154	0.051	0.084	**0.238**	**0.169**	**0.165**
11	0.000	**0.208**	**0.070**	**0.150**	0.072	**0.153**	**0.132**	**0.107**	**0.067**	**0.206**	0.047	**0.158**	**0.222**	**0.130**	**0.088**	0.085	0.030	**0.063**	**0.080**
12	0.027	**0.287**	**0.038**	**0.155**	0.018	**0.133**	**0.072**	**0.102**	**0.115**	0.048	**0.215**	0.048	**0.306**	**0.152**	**0.227**	**0.102**	**0.118**	**0.124**	**0.085**
13	0.035	**0.353**	0.038	0.092	0.105	**0.224**	**0.126**	**0.202**	**0.210**	**0.151**	0.000	0.112	0.160	**0.083**	0.000	0.000	0.000	0.000	0.000
14	0.000	**0.248**	0.035	**0.161**	0.000	0.082	0.029	0.048	0.050	0.089	0.145	0.105	**0.332**	**0.164**	0.187	0.104	0.038	0.077	0.058
15	0.000	**0.388**	**0.138**	**0.122**	0.011	0.043	**0.062**	0.027	**0.166**	**0.253**	0.055	**0.205**	**0.209**	**0.134**	**0.169**	**0.124**	**0.045**	**0.100**	**0.134**
16	0.000	**0.164**	0.068	**0.206**	0.035	**0.122**	0.109	0.068	0.010	**0.139**	**0.214**	0.123	**0.338**	**0.187**	**0.249**	**0.176**	**0.122**	**0.157**	**0.138**
17	**0.071**	**0.674**	**0.332**	**0.122**	0.085	0.038	**0.144**	0.054	**0.402**	**0.515**	0.000	**0.393**	0.113	**0.155**	**0.212**	**0.203**	**0.108**	**0.183**	**0.285**
18	0.000	**0.309**	0.008	0.051	0.000	0.054	0.022	0.035	**0.133**	0.002	0.160	0.000	0.160	0.051	**0.189**	0.037	0.105	0.096	0.063
19	0.000	**0.211**	**0.191**	**0.251**	**0.160**	**0.203**	**0.241**	**0.142**	**0.079**	**0.393**	0.093	**0.316**	**0.284**	**0.220**	**0.172**	**0.221**	**0.106**	**0.166**	**0.215**
20	0.000	**0.194**	**0.064**	0.111	0.028	0.092	**0.104**	0.048	0.049	**0.194**	0.046	0.128	0.166	**0.092**	**0.106**	0.085	0.041	0.074	**0.095**
21	0.049	**0.000**	**0.282**	**0.713**	**0.574**	**0.770**	**0.683**	**0.614**	0.012	**0.455**	**0.577**	**0.444**	**0.811**	**0.597**	**0.436**	**0.517**	**0.449**	**0.458**	**0.409**
22	0.034	0.026	0.000	**0.121**	**0.085**	**0.250**	**0.126**	**0.216**	**0.165**	0.000	**0.140**	0.000	**0.238**	**0.103**	**0.088**	0.000	**0.079**	**0.045**	0.000
23	0.061	0.053	0.037	0.000	0.000	0.020	0.023	0.063	**0.476**	**0.131**	0.000	0.016	0.000	0.000	**0.103**	0.000	**0.094**	0.064	**0.090**
24	0.069	0.061	0.045	0.073	0.000	0.000	0.000	0.000	**0.300**	0.084	0.064	0.031	0.064	0.012	**0.189**	0.018	0.063	0.076	0.084
25	0.066	0.057	0.042	0.070	0.078	0.000	0.000	0.000	**0.437**	**0.281**	0.104	**0.196**	0.084	**0.083**	**0.316**	**0.150**	**0.148**	**0.193**	**0.241**
26	0.045	0.037	0.022	0.049	0.057	0.054	0.000	0.020	**0.382**	**0.115**	0.093	0.091	0.156	**0.079**	**0.215**	0.042	**0.071**	**0.089**	**0.092**
27	0.042	0.033	0.018	0.045	0.053	0.050	0.030	0.000	**0.327**	**0.271**	**0.120**	**0.192**	0.130	**0.104**	**0.298**	**0.165**	**0.143**	**0.189**	**0.229**
28	0.042	0.033	0.018	0.046	0.053	0.050	0.030	0.026	0.000	**0.308**	**0.369**	**0.310**	**0.608**	**0.408**	**0.320**	**0.349**	**0.245**	**0.282**	**0.253**
29	0.064	0.055	0.040	0.068	0.075	0.073	0.052	0.048	0.049	0.000	**0.290**	0.000	**0.297**	**0.133**	**0.213**	0.006	**0.186**	**0.118**	0.027
30	0.083	0.074	0.060	0.086	0.095	0.091	0.071	0.068	0.067	0.090	0.000	0.185	0.000	0.014	0.000	0.000	0.000	0.000	0.050
31	0.075	0.067	0.052	0.079	0.087	0.084	0.064	0.060	0.060	0.082	0.101	0.000	0.096	0.013	**0.142**	0.000	**0.162**	0.086	0.025
32	0.104	0.097	0.082	0.108	0.116	0.113	0.093	0.089	0.089	0.110	0.129	0.124	0.000	0.000	0.120	0.000	0.191	0.148	**0.212**
33	0.041	0.034	0.019	0.045	0.054	0.050	0.030	0.026	0.026	0.048	0.067	0.061	0.091	0.000	**0.087**	0.000	**0.107**	**0.072**	**0.091**
34	0.047	0.039	0.024	0.051	0.059	0.056	0.035	0.031	0.031	0.053	0.072	0.066	0.096	0.032	0.000	0.000	0.018	0.000	0.018
35	0.087	0.081	0.067	0.092	0.100	0.097	0.078	0.073	0.073	0.094	0.112	0.107	0.137	0.075	0.080	0.000	0.000	0.000	0.000
36	0.042	0.034	0.019	0.046	0.054	0.051	0.030	0.027	0.027	0.049	0.069	0.061	0.090	0.027	0.032	0.074	0.000	0.000	0.009
37	0.036	0.028	0.013	0.040	0.048	0.045	0.024	0.021	0.021	0.043	0.063	0.055	0.084	0.021	0.026	0.069	0.022	0.000	0.000
38	0.045	0.037	0.022	0.049	0.057	0.054	0.033	0.030	0.030	0.052	0.071	0.064	0.093	0.030	0.035	0.077	0.031	0.025	0.000
39	0.044	0.035	0.020	0.047	0.055	0.052	0.032	0.028	0.028	0.051	0.070	0.062	0.091	0.028	0.033	0.074	0.029	0.023	0.032
40	0.039	0.030	0.015	0.043	0.051	0.048	0.027	0.023	0.023	0.046	0.065	0.057	0.087	0.023	0.029	0.071	0.024	0.018	0.027
41	0.110	0.102	0.087	0.114	0.122	0.119	0.099	0.095	0.095	0.117	0.135	0.129	0.159	0.096	0.101	0.142	0.096	0.090	0.099
42	0.073	0.065	0.049	0.077	0.085	0.082	0.061	0.057	0.058	0.080	0.099	0.091	0.120	0.058	0.063	0.103	0.058	0.052	0.061
43	0.090	0.083	0.067	0.094	0.102	0.099	0.079	0.075	0.075	0.097	0.117	0.110	0.139	0.076	0.081	0.122	0.076	0.070	0.079
44	0.068	0.059	0.044	0.072	0.079	0.077	0.056	0.052	0.053	0.075	0.094	0.086	0.114	0.052	0.057	0.097	0.053	0.047	0.056
45	0.040	0.032	0.016	0.044	0.052	0.048	0.028	0.024	0.024	0.047	0.066	0.058	0.088	0.025	0.030	0.072	0.025	0.019	0.028
46	0.062	0.055	0.040	0.066	0.075	0.071	0.051	0.048	0.047	0.069	0.089	0.081	0.110	0.048	0.053	0.096	0.048	0.043	0.051
47	0.068	0.060	0.045	0.072	0.080	0.077	0.056	0.053	0.052	0.074	0.094	0.086	0.115	0.053	0.058	0.100	0.054	0.048	0.057
48	0.067	0.060	0.044	0.071	0.079	0.076	0.056	0.052	0.052	0.074	0.093	0.087	0.116	0.053	0.058	0.100	0.053	0.047	0.056
49	0.111	0.102	0.087	0.114	0.122	0.119	0.098	0.095	0.095	0.117	0.136	0.128	0.156	0.095	0.100	0.140	0.096	0.090	0.099
50	0.074	0.066	0.051	0.078	0.086	0.083	0.062	0.059	0.059	0.081	0.101	0.091	0.119	0.059	0.064	0.104	0.060	0.054	0.063
51	0.065	0.057	0.042	0.069	0.077	0.074	0.054	0.050	0.050	0.072	0.092	0.083	0.111	0.050	0.055	0.095	0.051	0.046	0.054
52	0.100	0.092	0.077	0.104	0.112	0.109	0.089	0.085	0.085	0.107	0.126	0.119	0.148	0.085	0.091	0.132	0.086	0.080	0.089
53	0.044	0.036	0.021	0.048	0.056	0.053	0.032	0.028	0.028	0.050	0.070	0.062	0.092	0.029	0.034	0.077	0.029	0.024	0.032
54	0.096	0.087	0.073	0.100	0.107	0.105	0.084	0.080	0.081	0.102	0.119	0.113	0.142	0.080	0.085	0.125	0.081	0.075	0.083
55	0.058	0.049	0.034	0.061	0.069	0.066	0.046	0.042	0.042	0.064	0.084	0.076	0.105	0.042	0.048	0.089	0.043	0.037	0.046
56	0.047	0.040	0.025	0.051	0.060	0.056	0.036	0.032	0.032	0.054	0.074	0.067	0.096	0.033	0.038	0.081	0.033	0.027	0.036
57	0.039	0.031	0.016	0.043	0.051	0.048	0.027	0.024	0.024	0.046	0.065	0.058	0.087	0.024	0.029	0.071	0.025	0.019	0.028

	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
1	**0.301**	0.002	0.053	0.080	0.101	0.180	0.000	0.109	0.092	0.000	0.000	0.000	0.000	0.048	0.000	0.000	0.064	0.000	0.000
2	**0.258**	0.043	0.124	**0.305**	**0.177**	**0.194**	**0.067**	**0.341**	**0.321**	0.016	**0.205**	0.073	0.016	**0.223**	0.000	0.057	**0.411**	0.026	**0.079**
3	**0.542**	0.016	0.059	**0.293**	**0.181**	**0.321**	0.000	**0.271**	**0.217**	0.000	0.085	0.116	0.013	**0.379**	0.026	0.120	**0.433**	**0.117**	**0.135**
4	**0.235**	0.026	0.144	0.148	0.140	0.119	0.028	0.209	0.170	0.012	0.050	0.000	0.000	0.076	0.000	0.000	**0.256**	0.000	0.000
5	**0.282**	**0.110**	**0.231**	0.070	**0.147**	**0.114**	**0.095**	**0.136**	0.100	**0.117**	0.000	0.000	0.000	0.047	0.000	0.000	**0.162**	**0.057**	0.000
6	**0.234**	0.000	0.036	0.136	0.016	0.070	0.000	0.137	0.124	0.000	0.047	0.044	0.000	**0.189**	0.000	0.000	**0.269**	0.000	0.051
7	**0.146**	0.038	0.081	0.000	0.000	0.002	0.028	0.000	0.005	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
8	0.053	0.035	0.079	0.000	0.000	0.000	0.058	0.001	0.025	0.062	0.000	0.028	0.000	0.063	0.013	0.000	0.106	0.000	0.037
9	**0.120**	0.000	0.000	**0.341**	0.018	0.128	0.049	**0.309**	**0.364**	0.000	**0.262**	**0.214**	0.096	**0.309**	0.083	0.064	**0.378**	0.000	**0.219**
10	**0.387**	**0.532**	**0.679**	0.000	**0.353**	**0.214**	**0.486**	0.117	0.117	**0.610**	0.000	0.026	**0.245**	0.000	**0.240**	0.000	0.000	**0.320**	**0.156**
11	**0.189**	**0.111**	**0.156**	0.000	0.000	0.000	**0.106**	0.000	0.003	**0.141**	0.000	0.038	0.000	0.080	0.062	0.000	**0.064**	0.034	**0.075**
12	0.035	**0.113**	**0.147**	**0.156**	0.036	0.021	**0.158**	**0.190**	**0.242**	**0.134**	0.152	**0.093**	**0.075**	0.086	0.073	0.000	**0.169**	0.000	**0.125**
13	**0.272**	**0.162**	**0.303**	0.001	0.141	0.068	**0.142**	0.082	0.043	**0.186**	0.000	0.000	0.000	0.001	0.000	0.000	**0.110**	**0.082**	0.000
14	0.033	0.035	0.065	0.087	0.000	0.000	0.074	0.098	0.135	0.051	0.089	0.072	0.000	0.106	0.030	0.000	**0.178**	0.000	0.080
15	**0.248**	0.024	0.015	0.088	0.000	0.052	0.024	0.053	0.070	0.026	0.004	**0.118**	0.000	**0.229**	**0.070**	0.000	**0.184**	0.016	**0.141**
16	0.038	**0.097**	0.090	0.075	0.000	0.000	**0.134**	0.071	0.135	0.128	0.084	0.135	0.060	0.123	0.115	0.000	**0.111**	0.000	**0.163**
17	**0.588**	**0.055**	0.000	**0.177**	0.028	**0.266**	0.007	0.081	0.071	0.032	0.000	**0.238**	0.080	**0.461**	**0.169**	**0.130**	**0.287**	**0.164**	**0.276**
18	0.035	0.071	0.079	0.144	0.019	0.047	**0.107**	**0.170**	**0.229**	0.084	0.098	0.061	0.077	0.060	0.041	0.000	0.101	0.000	**0.116**
19	**0.317**	**0.164**	0.165	0.000	0.000	0.026	**0.142**	0.000	0.000	**0.199**	0.000	**0.154**	0.050	**0.212**	**0.178**	0.015	**0.086**	**0.123**	**0.192**
20	**0.168**	**0.074**	0.082	0.000	0.000	0.000	0.070	0.000	0.000	0.101	0.000	0.053	0.000	0.093	0.065	0.000	0.027	0.005	**0.099**
21	**0.230**	**0.670**	0.771	0.086	**0.251**	0.063	**0.694**	**0.179**	**0.242**	**0.783**	**0.265**	**0.335**	**0.369**	0.140	**0.495**	**0.168**	**0.138**	**0.385**	**0.386**
22	**0.085**	**0.213**	**0.337**	**0.098**	**0.174**	0.058	**0.237**	**0.204**	**0.218**	**0.246**	0.101	0.000	0.060	0.000	0.030	0.000	**0.106**	**0.040**	**0.028**
23	**0.384**	**0.082**	**0.103**	**0.248**	**0.207**	**0.319**	0.062	**0.265**	**0.266**	0.058	0.046	0.051	**0.115**	**0.185**	0.030	0.000	**0.191**	0.073	**0.138**
24	**0.192**	0.000	0.000	**0.233**	0.021	0.153	0.000	0.210	**0.243**	0.000	0.091	0.094	0.045	**0.214**	0.007	0.000	**0.228**	0.000	**0.136**
25	**0.382**	0.000	0.000	**0.347**	0.030	**0.284**	0.000	**0.255**	**0.292**	0.000	0.138	**0.253**	0.127	**0.445**	**0.114**	0.101	**0.354**	0.032	**0.290**
26	**0.243**	0.000	0.004	**0.305**	0.099	**0.200**	0.018	**0.298**	**0.311**	0.000	0.171	0.117	0.052	**0.261**	0.017	0.038	**0.347**	0.000	**0.141**
27	**0.317**	0.000	0.000	**0.266**	0.000	**0.203**	0.000	**0.186**	**0.230**	0.000	0.103	**0.231**	**0.112**	**0.379**	**0.123**	0.066	**0.280**	0.024	**0.269**
28	**0.118**	**0.354**	**0.408**	0.039	0.042	0.000	**0.385**	**0.079**	**0.135**	**0.428**	0.148	**0.219**	**0.164**	0.126	**0.283**	0.053	**0.126**	**0.163**	**0.243**
29	0.042	**0.270**	**0.402**	**0.306**	**0.323**	**0.178**	**0.327**	**0.443**	**0.476**	**0.290**	**0.309**	0.037	**0.181**	0.000	0.065	0.000	**0.242**	0.056	**0.096**
30	**0.489**	0.089	0.169	0.046	0.134	**0.203**	0.031	0.063	0.007	0.082	0.000	0.000	0.000	0.159	0.000	0.000	0.150	**0.122**	0.036
31	0.101	**0.227**	**0.319**	**0.235**	**0.275**	**0.202**	**0.256**	**0.345**	**0.383**	**0.243**	0.176	0.002	**0.173**	0.000	0.046	0.000	0.117	0.044	0.093
32	**0.611**	0.192	0.182	**0.267**	**0.301**	**0.481**	0.130	0.263	0.259	0.168	0.000	0.122	0.235	**0.273**	0.141	0.055	0.149	**0.214**	**0.252**
33	**0.356**	**0.136**	**0.170**	**0.189**	**0.204**	**0.280**	**0.114**	**0.221**	**0.227**	**0.129**	0.019	0.037	**0.125**	0.129	0.052	0.000	**0.123**	**0.091**	**0.132**
34	**0.402**	**0.265**	**0.432**	0.028	**0.266**	**0.177**	**0.223**	0.132	0.075	**0.292**	0.000	0.000	0.022	0.011	0.037	0.000	**0.113**	**0.183**	0.003
35	**0.255**	**0.144**	**0.283**	0.114	**0.245**	0.184	**0.130**	0.219	0.189	**0.148**	0.008	0.000	0.011	0.000	0.000	0.000	0.116	0.052	0.000
36	**0.291**	**0.087**	**0.196**	0.061	0.096	0.078	**0.074**	0.106	0.067	0.093	0.000	0.000	0.000	0.101	0.000	0.000	**0.204**	**0.056**	0.002
37	**0.275**	**0.145**	**0.281**	0.081	**0.180**	**0.119**	**0.133**	**0.163**	0.125	**0.155**	0.012	0.000	0.000	0.032	0.000	0.000	**0.173**	**0.073**	0.000
38	**0.175**	**0.183**	**0.346**	0.107	**0.219**	0.095	**0.193**	**0.224**	**0.197**	**0.203**	0.082	0.000	0.000	0.000	0.000	0.000	**0.177**	**0.056**	0.000
39	0.000	**0.330**	**0.411**	**0.283**	**0.194**	0.052	**0.414**	**0.377**	**0.453**	**0.377**	**0.389**	**0.203**	**0.233**	0.085	**0.215**	0.061	**0.278**	**0.083**	**0.227**
40	0.026	0.000	0.000	**0.276**	0.012	**0.190**	0.000	**0.212**	**0.229**	0.000	0.125	**0.200**	0.052	**0.381**	**0.079**	**0.084**	**0.359**	0.022	**0.214**
41	0.097	0.092	0.000	**0.378**	0.000	**0.271**	0.000	0.228	**0.284**	0.000	0.169	**0.373**	0.152	**0.587**	**0.188**	0.166	**0.417**	0.040	**0.391**
42	0.059	0.055	0.126	0.000	0.056	0.000	**0.243**	0.000	0.000	**0.337**	0.000	0.015	0.020	0.013	0.131	0.000	0.000	**0.158**	0.072
43	0.077	0.073	0.144	0.107	0.000	0.000	0.022	0.000	0.027	0.025	0.002	**0.208**	0.024	**0.290**	**0.142**	0.011	0.155	0.000	**0.222**
44	0.055	0.050	0.121	0.084	0.101	0.000	**0.221**	0.036	0.064	**0.243**	0.069	0.079	0.006	0.048	0.111	0.000	**0.120**	0.039	0.087
45	0.026	0.022	0.093	0.056	0.074	0.051	0.000	**0.173**	**0.176**	0.000	0.065	**0.189**	0.046	**0.393**	**0.083**	**0.086**	**0.333**	**0.056**	**0.213**
46	0.049	0.045	0.116	0.078	0.096	0.073	0.046	0.000	0.000	**0.256**	0.000	0.139	0.054	**0.193**	**0.196**	0.013	0.041	**0.169**	**0.188**
47	0.055	0.050	0.121	0.084	0.102	0.078	0.051	0.075	0.000	**0.270**	0.000	0.105	0.022	0.192	**0.174**	0.029	0.075	**0.205**	0.148
48	0.054	0.049	0.122	0.084	0.102	0.078	0.051	0.074	0.079	0.000	0.153	**0.229**	0.062	**0.448**	0.078	0.115	**0.422**	0.023	**0.240**
49	0.097	0.092	0.163	0.126	0.144	0.121	0.093	0.115	0.121	0.121	0.000	0.000	0.000	0.075	0.053	0.000	0.000	0.104	0.056
50	0.061	0.056	0.126	0.090	0.107	0.085	0.057	0.080	0.086	0.084	0.127	0.000	0.000	0.000	0.000	0.000	0.071	0.069	0.000
51	0.053	0.048	0.118	0.081	0.099	0.076	0.049	0.072	0.077	0.076	0.118	0.084	0.000	0.093	0.000	0.000	**0.189**	0.019	0.000
52	0.087	0.082	0.154	0.116	0.134	0.111	0.083	0.106	0.111	0.111	0.154	0.117	0.108	0.000	0.058	0.000	0.006	0.124	0.000
53	0.030	0.026	0.097	0.060	0.078	0.054	0.027	0.051	0.056	0.055	0.097	0.061	0.053	0.087	0.000	0.000	**0.207**	0.017	0.000
54	0.082	0.078	0.148	0.111	0.128	0.107	0.078	0.100	0.105	0.106	0.149	0.111	0.102	0.138	0.082	0.000	0.000	0.000	0.000
55	0.044	0.039	0.111	0.074	0.091	0.068	0.040	0.064	0.069	0.068	0.111	0.075	0.066	0.101	0.045	0.096	0.000	**0.192**	**0.180**
56	0.034	0.030	0.102	0.063	0.082	0.058	0.031	0.054	0.060	0.059	0.101	0.065	0.056	0.091	0.035	0.086	0.048	0.000	**0.096**
57	0.026	0.021	0.093	0.055	0.073	0.050	0.022	0.045	0.051	0.050	0.093	0.057	0.048	0.083	0.026	0.078	0.040	0.030	0.000

**MMD values of 8 dental non-metric traits (upper triangular part) and associated SD values (lower triangular part), calculated with AnthropMMD.*

***Name of the Sample. Sargat Culture:* 1 –Tobol river region (Early period); 2 – Tobol river region (Middle period); 3 – Ishim river region (Middle period); 4 – Ishim river region (Late period); 5 – Irtysh river region (Middle period); 6 – Irtysh river region (Late period); 7 – Baraba forest-steppe zone (Early period); 8 – Baraba forest-steppe zone (Middle period); 9 – Gorokhovo Culture; 10 – [illegible] 27 – Alakul Culture (steppe zone); 28 – Srubnaya culture (Bashkiria); 29 – Srubno Alakul type; 30 – Kylay Culture; 31-35 – Bolsherechenskaya Culture; 36-38 – Kamen Culture; 39 – Staroaleyka Culture; 40 – Pazyryk Culture; 41 – Karakobin Culture; 42, 43 – Aldy-belsk Culture; 44 – Uyuk-Saglyn Culture; 45 – Tagar Culture; 46, 47 – Jetyasar Culture; 48 – Tasmolinian Culture; 49 – Korgantas period; 50 – Early Sarmatians; 51 – Late Sarmatians; 52, 53 – Sauromats; 54 – Early Sarmatians; 55 – Ananyin Culture; 56 – Saka Tian Shan region; 57 – Kara-Abyz Culture.