80	574A	F	60-x	5	15	
81	576	F	40-45	25	32	6
82	580	F	20-25	24	25	
83	581	F	20-25	14	14	
84	594	F	25-35	27	27	
85	595	F	25-35	2	2	
86	603B	F	25-30	3	3	
87	609	F	40-50	11	12	1
88	619	F	50-60		10	10
89	621	F	25-30	20	24	2
90	625	F?	30-35	10	18	
			sum	1033	1292	111

M A L E S (M, M?, M??, M???)***

1	17	M	25-30	1	1	
2	50	M	30-40	28	31	
3	90	M	30-40	28	31	
4	98	M	25-35	6	9	
5	111	M	50-60	10	13	3
6	118	M	25-30	27	32	
7	128	M	20-22	10	11	
8	132	M	30-40	2	2	
9	133	M	30-35	22	22	
10	138	M	45-55	5	5	
11	141	M	40-50	4	18	
12	142	M	45-50	2	7	
13	146	M	30-45	6	7	
14	152	M	20-22	4	4	
15	175	M?	20-40	1	1	
16	178	M	50-60		16	1
17	179	M?	25-30	1	1	
18	182	M?	50-60	8	16	
19	187	M	35-45	8	14	1
20	191	M??	30-35	15	15	
21	197	M	25-35	19	24	1
22	201	M	50-x		3	3
23	205	M	45-50	15	18	2
24	214	M	25-35	18	18	
25	216	M	20-30	7	7	
26	220	M??	25-30	3	3	
27	228	M?	50-x	1	3	2

28	247	M???	30-40	14	14	
29	250	M	25-35	14	19	
30	251	M	40-50	27	29	
31	270	M?	25-30	22	25	
32	272	M	35-40	15	15	
33	276	M	60-70	5	5	
34	282B	M	25-35	13	13	
35	284	M??	25-40	1	1	
36	288	M?	35-45	3	3	
37	294	M	45-55	11	21	2
38	296	M	35-40	20	20	
39	300B1	M??	25-30	3	3	
40	300B2	M	40-50	11	14	1
41	302A	M	35-45	11	19	1
42	305A	M	65-75	9	9	
43	307	M?	45-60	13	15	2
44	319	M?	15-18	15	15	
45	329	M	30-35	12	25	6
46	342	M	25-35	31	32	
47	358-1	M	35-40	28	28	
48	359	M	50-x	15	16	1
49	372	M?	40-50	16	30	3
50	375	M?	25-30	13	13	
51	379	M	50-60		4	4
52	385	M?	30-40	4	6	
53	387	M	30-40	10	10	
54	388	M	50-x	2	6	
55	389	M	30-35	27	32	2
56	393	M	25-35	4	10	
57	400	M	40-50	30	32	
58	441	M	35-40	29	32	
59	444	M??	25-30	1	1	
60	449	M	30-35	21	27	1
61	457	M	40-50	7	17	1
62	469A	M	60-x	8	12	2
63	499	M	40-50	5	8	2
64	502	M??	30-40	20	24	
65	545	M	55-65	23	26	
66	549	M?	20-25	6	6	
67	566	M	60-x	13	15	
68	577	M	20-25	23	23	
69	584	M	30-40	11	12	
70	599A	M	30-35	29	29	
71	603A	M	20-25	17	22	

72	603C	M	25-30	5	5	
73	605	M	30-35	2	2	
74	606	M	45-55	28	28	
75	614A	M?	40-50	5	5	
76	620B	M?	25-30	7	9	
			sum	910	1119	41

CHILDREN and YOUTH****

1	101	Ch	8-10	1	1
2	124	Ch	3-5	11	11
3	140	Ch	11-13	20	21
4	168	Ch	5-6	3	3
5	309	Ch	14-15	28	30
6	354	Ch	2-3	2	2
7	364	Ch	15-18	22	25
8	494	Ch	5-6	3	3
9	523	Ch	6-7	2	2
			sum	92	98

* - Number of teeth with at least a part of a crown available for observation

** - Number of sockets available for observation

*** - F-definite female, F?- very probable female, F??-probable female, F???-probable female but estimation very difficult
M, M?, M??, M??? - as for females

**** - Measurements and other observations were made only on permanent dentition (on crowns of developing teeth)

Table 2.2-3. Dental samples used for analysis

No	Sample	Sex	No of indiv.	Age of individuals (average) years****	Teeth No	Teeth %*	Tooth sockets No	Tooth sockets %**	Teeth lost before death N	Teeth lost before death %***
1	**Pantanello**	F	104	40.4	1477	44.4	1845	55.4	145	7.9
		M	59	44.1	848	44.9	1043	55.2	78	7.5
		F+M	163		2325	44.6	2888	55.4	223	7.7
		Ch	13		148		149			
		Total	**176**	41.7	**2473**		3037		223	
2	**Crucinia**	F	90	41.6	1033	35.9	1292	44.9	110	8.5
		M	76	42.3	910	37.4	1119	46.0	41	3.7
		F+M	166		1943	36.6	2411	45.4	151	6.3
		Ch	9		92		98			
		Total	**175**	41.9	**2035**		2509			

* - percentage of teeth recovered during excavations out of total number of teeth expected (total number of teeth expected = number of individuals x 32 teeth)

** - percentage of sockets available for examination out of total number of sockets (total number of sockets = number of individuals x 32 sockets)

*** - percentage of teeth lost during an individual's life out of number of sockets available for examination

**** - average age of individuals who already survived to 20 years of age (calculations are obtained from the life tables for each population for individuals with teeth preserved)

Figure 2.21-1. The skull of a 25-30 years old female from burial 69-11 in Pantanello. The skeleton was nearly complete and bones were in good condition. Most of the 26 teeth of this individual remained in their sockets. Almost all teeth had 1-3 hypoplastic rings and three teeth were affected by caries. Other anomalies included marked malocclusion of upper front incisors (prognathism), slight rotation of lower canines and slight crowding of lower incisors.

Table 2.2-4. Representativeness of the dental sample from Metaponto in comparison to other dental samples from archaeological sites.

Sample and source	No of individuals	%*	No of teeth	tooth/ind.** ratio
Baluchistan, Mehrgarh (7000-2000 BC) Lukacs et al. (1985)	81	44.6	1155	14.3
Late medieval Scots (1300-1600 AD) Kerr et al. (1988)	136	30.5	1148	8.4
Late medieval Finns (late med.-1650 AD) Varrela (1991)	410	39.5	5181	12.6
Preagricultur. Georgia-Florida (1000BC-1150AD) Larsen et al. (1991)	201	37.9	2438	12.1
Agricultural Georgia-Florida (1150-1550 AD) Larsen et al. (1991)	275	48.4	4260	15.5
Early Contact Georgia-Florida (1607-1680 AD) Larsen et al. (1991)	324	31.6	3274	10.1
Ra's al Hamra-5, Oman (5700-5000 BP) Mack and Coppa (1992)	89	48.9	1392	15.6
Romans, Lucus Feroniae (2nd c. AD) Manzi et al. (1997)	112	40.9	1465	13.1
Romans, Portus Romae (2nd c. AD) Manzi et al. (1997)	64	35.8	734	11.5
Metaponto, Pantanello (6th -3rd c. BC) **own data**	**176**	**43.9**	**2473**	**14.1**
Metaponto, Crucinia (7th-2nd c. BC) **own data**	**175**	**36.3**	**2035**	**11.6**
Medieval Sweden (11th-16th c. AD)*** Olsson and Sagne (1976)	122	65.8	2568	21.0

* percent of teeth recovered during excavations out of total number of teeth expected (total number of teeth expected = number of individuals x 32 teeth).
** - tooth/ind. ratio = number of teeth per individual
*** selected skulls with well preserved dentition

3. METHODS

3.1. Sex and age determination

Determination of sex and age at death of individuals from the rural skeletal sample was carried out independently by three physical anthropologists. Dr. M. Becker from the West Chester State University in Pennsylvania carried out preliminary estimations on about 80% of the material excavated until 1984, and the author with M. Henneberg carried out the final in-depth analysis of all material in 1985, 1986, and 1988.

Various methods of sex and age assessment in skeletal material were used and the assessments were repeated (Miles 1963, Gustafson 1966, Acsádi and Nemeskéri 1970, Ubelaker 1978, Krogman and İşçan 1986, Malinowski and Wolański 1988, İşçan and Kennedy 1989). In the case of fragmentary material, independent and repeated sex and age estimates increased the reliability of these determinations.

The diagnosis of the individual's sex was based on morphological observations and metric determinations combined. All morphological observations known as indicating sexual dimorphism, and possible to make on a single skeleton, were noted. For each morphological characteristic the sex was assigned according to differences between sexes described and compiled by various investigators Krogman and İşçan (1986), Acsádi and Nemeskéri (1970), Ferembach et al. (1980), Ubelaker (1978, 1991), Malinowski and Wolański (1988). For example on the skull, observations of general size, architecture of the ectocranial surface, size of mastoid processes and supra orbital ridges, shape of orbits, size, shape and architecture of the mandible and observations of many more traits were made (see Krogman and İşçan 1986, Table 6.3, p.192 and Malinowski and Wolański 1988, Table 6-13, p.212-213). Sex differences in pelvic morphology such as general size, height of the symphysis, subpubic angle, size and shape of obturator foramen, shape of the greater sciatic notch, presence of tuberosities and sulci and other characteristics were noted (see Krogman and İşçan 1986, Table 6.11, p.209 and Malinowski and Wolański 1988, Table 6-13, p.213). The characteristics most often used on long bones to discriminate between sexes were morphology of *linea aspera* on the femur, general morphology and size of the femur and humerus, collo-diaphyseal angle formed by the neck and shaft axis of the femur, size of the femoral and humeral heads, size, shape and circumference of the clavicle, surface of sigmoid notch of ulna and bicondylar width of femur (see Krogman and Isçan 1986, Chapter 6, Malinowski and Wolański 1988, Chapter 6.3). When measurements were taken on an undamaged bone, determination of sex from metric characteristics such as long bone lengths and circumferences, head's diameters, pelvic and cranial measurements and other bone measurements, was based on the demarking point method as described by Krogman and İşçan (1986, p.228 and Table 6.20). After assigning sex to the given skeleton based on each individual characteristic the multivariate approach was applied to obtain the final diagnosis (Acsádi and Nemeskéri 1970). According to this method each characteristic was described in 5 points' scale and given a rank, indicating its reliability or accuracy as an indicator of sex. For example, a very clear female wide and shallow greater sciatic notch was described as -2 in the 5 points' scale (-2 to 2) and given the rank 2 in two-point rank scale as that characteristic was considered to give very accurate results in the sex diagnosis. The points of each characteristic were then multiplied by its rank (1 or 2) and the sum of calculations for all observable characteristics was divided by the sum of ranks. The numerical result in points indicated the final diagnosis. Negative numbers indicated female sex, while a positive number indicated a male. The method can be used on fragmentary skeletal material, with accuracy similar to most reliable methods used on complete skeletons, and it is highly recommended in skeletal studies (Krogman and İşçan 1986). The pelvis, regarded as superior in the sex assessment, to other parts and bones of the skeleton

(Meindl et al.1985) is often damaged or missing in fragmentary material. In that case the multivariate approach to sex determination provides better results for the entire sample than the use of a single method in each skeleton (Acsádi and Nemeskéri 1970, Kelley and Angel 1987). Other characteristics such as parturition scars were also used in sex determination in the material studied. The sex assessment of children and juveniles below the age of 15 years was not attempted. Only in very obvious cases the sex of juveniles is indicated.

The multivariate approach was also applied to age estimation of an individual in both skeletal samples (Acsádi and Nemeskéri 1970). According to this technique the final age estimate is a composite of age estimates from observations of cranial sutures closure, morphological changes of the symphyseal surface of *os pubis*, degenerative changes on vertebrae and long bone joint surfaces, dental attrition, and involution of trabecular structure of long bones. In cases of individuals with only teeth preserved, two methods were employed. The first method was based on relative wear of molars in relation to their eruption times (Miles 1963) and the second method included morphological changes in a root as described by Gustafson (1966). The age estimation in children's and youths' skeletons was based on tooth development stages (Ubelaker 1978, 1991, El-Nofely and İşçan 1989), size and morphology of long bones including observations of the degree of skeletal development and the morphology of the bony tissue (Krogman and İşçan, 1986, Malinowski and Wolański 1988, Ubelaker 1991).

For several reasons the multivariate approach in both sex and age determinations was favoured in this study in contrast to the use of a single characteristic and discriminant function techniques preferred by American researchers (Buikstra and Mielke 1985). One of the reasons was the better results from fragmentary material, where a single method and discriminant function techniques were often useless (Kelley and Angel 1987). The other reason was the common use of such a multivariate approach by European scientists from whom came most of the comparative material in literature relevant to this study.

The detailed list of skeletons with sex and age established is given in Table 2.13-2 and the summary of sex and age assessment is shown in Table 2.13-3.

3.2. Sex and age distribution of skeletons in the sample.

Description of the sex and age distribution in the skeletal material, due to its extent, can be best done with palaeodemographic methods. These included construction of life tables for the entire rural sample and also for the reference sample from Crucinia according to methods described by Acsádi and Nemeskéri (1970), Weiss (1973) and also Strzałko et al. (1980).

A typical life table represents compilation of age at death distributions of deceased, and biometrical functions derived from the age at death distribution, in the population studied during a limited time period. The time period of study is usually a year for modern populations and for medical or insurance purposes where such tables are mostly used (Coale and Demeney 1966). For archaeological samples the constructed life table is an approximation of the real demographical dynamics in the population because it is impossible to estimate characteristics such as fertility and changes in birth and death rates, from skeletal samples. Therefore some assumptions should be made before constructing the life tables for archaeological skeletal material. It is assumed that the populations studied in the thesis were stationary and their natural increase was zero according to the method described first by Acsádi and Nemeskéri (1970) where a stationary population model was applied. Calculation of biometrical functions in these tables was based on frequency distribution of ages at death in the skeletal samples. Individuals in the skeletal samples from Metaponto were grouped in 5-year and 10-year age classes (x). An individual below age 20 years whose age was estimated in a range wider than 5 years was assigned to two or more consecutive age classes, in each as an appropriate fraction of one. For example, an individual whose age was estimated as 14-16 years was in 0.5 assigned to the age class 10-14.99, and in 0.5 to the age class 15-19.99 years. Another individual whose age was estimated as 25-45 years was assigned in 0.33 to the age class 20-29.99, in 0.33 to the age class 30-39.99, and in 0.33 to the age class 40-49.99 years. Individuals whose age was estimated only as an adult were assigned to all age classes starting with the class 20-29.99 years in smaller fractions reflecting the number of classes in an adult age distribution part of the life table (five classes - 0.2 in each class here). The D_x column in the life table shows the numbers of deceased in each age class. The first biometrical function d_x is the percentage of individuals dying during the age interval x. The function l_x is the percentage of individuals surviving to the beginning of the age interval x and is called simply a survivorship. The percentage of deceased in each age class divided by the percentage of individuals surviving to the beginning of the age class gives the probability of dying in the age class x (function q_x). When a sum of years which all individuals in the age class would still live, was divided by the percentage of individuals surviving to the beginning of the age class x , the function e_x - life expectancy has been calculated. The last function in the life tables c_x is the fraction of individuals alive in the age class x in the populations under the assumption of stationarity. The c_x biometrical function derives from dividing the total number of years lived by all individuals in the age class x, by the sum of all individuals in the sample.

Despite the fact that life tables constructed in this way are only an approximation of the real demographical situation in the archaeological populations and can potentially lead to serious errors in the interpretation of individual sites (Buikstra and Konigsberg 1985, Johansson and Horowitz 1986, Wood et al. 1992), they are useful for generalisations and comparisons between populations (Acsádi and Nemeskéri 1970, Weiss 1973, Strzalko et al. 1980, Henneberg and Steyn 1994).

Details of preliminary palaeodemographic analysis for the rural sample from Metaponto were presented earlier (Henneberg and Henneberg, 1990b, 1998a, Henneberg et al. 1992).

Palaeodemographic analysis, similar to this for the rural sample, was also conducted for the urban sample from Crucinia cemetery (Henneberg et al. 1994, in manuscript).

For a comparison of rural and urban demographic dynamics in this thesis, mortality rates and life expectancy were selected from the biometrical functions of the life tables and the results were shown in graphical form.

3.21. Sex and age distribution in the dental samples

Construction of the life tables according to the same method as applied for the entire skeletal samples was undertaken to show 1) if the rural dental sample had a similar age distribution and other demographical characteristics as in the entire skeletal sample and therefore could represent the rural population as a whole in describing general health, and 2) if the reference dental sample from the urban cemetery of Crucinia was in fact a randomly selected sample despite the ongoing excavation and the description and analysis of the skeletal material, that was only in progress at the time of choosing the comparative sample.

Life tables for all individuals with teeth in rural and urban dental samples were constructed. Then, the life tables for females and males separately in both dental samples were also constructed according to the same method. Mortality profiles were compared between all individuals from the rural or urban skeletal sample and individuals with teeth in each sample respectively. The mortality was also compared between all individuals with teeth from rural and urban dental samples and then separately in sex categories. Results of comparisons are described in tables and figures.

3.3. Methods of collecting dental data

Special charts were designed to record observed tooth characteristics (Appendices 1,2,3,4).

3.31. Measurements

3.311. Dental dimensions

Two dental dimensions, mesio-distal diameter (MD) or crown length and bucco-lingual diameter (BL) or crown breadth, were measured to the nearest 0.1 mm with sharp-pointed sliding calipers and recorded on a chart (Appendix 1.). The procedures followed below were established by Martin (1928), reviewed by Schuman and Brace (1954), Moorrees 1957, Goose 1963, Zubov (1968), Wolpoff (1971) and others, and discussed by Frayer (1978), Kaczmarek (1980), and Mayhall (1992).

Two basic procedures are widely used to measure the tooth crown length. According to the first one the mesio-distal diameter is defined as the maximum distance between inter-tooth points (incisors and canines) or surfaces (premolars and molars) of contact, and measured parallel to the sagittal horizontal line on the occlusal surface of the tooth (Martin 1928, Goose 1963, Zubov 1968, Frayer 1978, Mayhall 1992). In the second procedure the MD diameters of the teeth are measured as the distances between the inter-tooth contact surfaces at their midpoints (Schuman and Brace 1954, Wolpoff 1971).

As it was advised by several authors, crown length was measured as the maximum mesio-distal dimension between inter-tooth contact points (anterior dentition) or contact surfaces (posterior dentition) regardless of he position of the contact surfaces with the reference to the midpoint, and parallel to the sagittal horizontal line on the occlusal surface of the tooth (Frayer 1978, Kaczmarek 1980, Mayhall 1992). The above described procedure was favoured by the author over a measurement at the midpoint of the tooth for several reasons: 1) according to Frayer (1978, p.22) "measurement error is reduced since in other methods the midpoint of the tooth has to be estimated", 2) in case of unworn or slightly worn down teeth the maximum mesio-distal diameter is the same or nearly identical with the measurement taken in the middle axis of the tooth, 3) in case of moderate or severe tooth wear, however, the maximum tooth length is usually greater than mesio-distal length taken at the midpoint, and then the maximum tooth length seems to be a more stable measurement than the one at the midpoint when the teeth in various stages of wear are compared, and 4) in most of the publications which the comparative dental data come from, the maximum mesio-distal dimension was measured as described by Martin (1928).

In cases of very heavy or uneven tooth wear when the crown was completely worn down at least on one side of the tooth the measurements of MD diameters were not taken.

Bucco-lingual or labio-lingual diameter (BL) or crown breadth was always measured as the greatest tooth dimension perpendicular to the tooth length following the procedure used by most researchers (Frayer 1978, Kaczmarek 1980, Mayhall 1992).

Several authors emphasised the importance of measurement error estimations in anthropometric data, especially when the data were used for interpopulation comparisons (Utermohle and Zegura 1982, Sokal and Rohlf 1988, Calcagno 1989, Kieser et al. 1990). Many universally used textbooks of statistics specifically written as compendia to statistical methods did not include measurement error calculations, assuming that the analysis of variance or its special cases such as

Student's t-test, sufficiently and universally addressed the problem of error (or errors) in research (Blalock 1960, Snedecor and Cochran 1982, Steel and Torrie 1980). Other textbooks of statistics addressed to users in specific disciplines like medical research, engineering, etc. included various formulae for measurement error calculations (Hald 1952, Berry 1978, Sachs 1982). However, some researchers felt that in specific biological investigations the emphasis on measurement error was inadequate and the need for assessment of the measurement error alone in such investigations still existed. In response to these opinions various methods assessing the measurement error in particular biological research problems have been published recently (Altman and Bland 1983, Johnston and Mack 1985, Sokal and Rohlf 1988, Kieser et al. 1990, Ulijaszek and Lourie 1994).

Two categories of measurement error were identified: 1) intra-observer error, made by the same investigator remeasuring the same object, and 2) inter-observer error associated with measurements of one object conducted by two or more investigators. Because all the dental measurements in this study were taken by the author only the intra-observer measurement error was of interest.

To estimate the measurement error, ten sets of complete or almost complete dentitions from both samples were measured twice by the author at time intervals usually greater than a week. In most cases the measurements were repeated after a year. To calculate the mean intra-observer error the following procedure was adopted from Sokal and Rohlf (1988). A percentage difference between two measurements of the same diameter was calculated by subtracting the smaller measurement from the bigger one, dividing the value of the difference by the bigger measurement of the two and multiplying the result by one hundred. The sum of all values obtained in above calculations was then divided by the number of pairs of measurements. The formula for mean percentage intra-observer error is given below.

$$r = (1/N)\Sigma((a_1 - a_2)/a_1)100\%$$

where
r - mean intra-observer error
a_1 - bigger measurement
a_2 - smaller measurement
N - number of repeated measurements

The smaller the measurement was the greater the error would be in percentages if the difference between two measurements was constant. To avoid bias of the tooth size on the results of mean measurement error calculations, all tooth categories were represented in the sample and the number of teeth in each category was similar. Results of calculations of mean intra-observer measurement error for BL and MD diameters are shown in Table 3.311-1.

Table 3.311-1. Mean intra-observer measurement error for BL and MD diameters of each tooth category (in %).

	Maxilla				Mandible			
Tooth	**N**	**BL**	**N**	**MD**	**N**	**BL**	**N**	**MD**
I1	20	1.69	20	1.46	18	1.98	17	1.67
I2	17	1.71	17	1.72	19	1.79	19	1.81
C	20	1.58	20	1.80	18	1.40	18	2.06
P1	19	1.16	19	2.06	18	1.57	18	2.02
P2	18	1.15	18	2.20	20	1.40	20	2.05
M1	20	1.06	20	1.56	20	1.05	20	1.39
M2	19	1.25	19	1.30	19	0.85	19	1.11
M3	16	1.10	16	1.90	17	1.30	16	1.56
AVG		**1.34**		**1.74**		**1.41**		**1.71**

The mean intra-observer error, averaged over 32 bucco-lingual and mesio-distal dimensions for teeth from ten individuals was 1.55 percent and ranged from 0.85 for mandibular M2 breadth (BL) to 2.20 for maxillary P2 length (MD). The percentage of error was similar for maxillary and mandibular teeth and averaged 1.54 and 1.56 respectively. For bucco-lingual measurements it was 1.37%, and for mesio-distal one was 1.72%. Better access to the buccal and lingual tooth surfaces with calipers, when a tooth was in the jaw most probably accounted for the lesser measurement error. Precision of the tooth diameters remeasurements in this study (1.55% mean intra-observer error) was similar to the intra-observer errors of measurement reported by other authors, and estimated to be between 1 and 5% (Schuman and Brace 1954, Frayer 1978, Calcagno 1989).

3.3.12. Root exposure

Root exposure of the teeth was measured for all the individuals with preserved mandibles and maxillae according to methods described by Davies et al. (1969), and Goldberg et al. (1976). The distance from the alveolar crest (AC) to the cemento-enamel junction (CEJ) on the tooth was measured over the midline of the tooth on the labial (or buccal) tooth surface (measurement AB), and on one of the interproximal surfaces (measurement CD), usually a mesial one (Davies et al. 1969). If the measurement was impossible to take on the mesial surface, the distance was measured on the distal one. If both interproximal measurements (CD) could be taken, and there was a considerable macroscopically noticed difference between mesial and distal distances, the greater measurement was recorded on the chart (Appendix 2). The measurements were taken with sliding calipers with sharpened tips with 0.1 mm accuracy. Individuals with severe loss of alveolar bone and its structure, which suggested periodontal disease were additionally marked on the recording chart (Muller and Perizonius 1980, Costa 1982, Whittaker et al. 1985, Molnar and Molnar 1985, Clarke 1990, Clarke and Hirsch 1991).

In order to evaluate intra-observer error associated with remeasurement differences ten specimens were selected to repeat measurements of distances between the alveolar crest (AC) and cemento-enamel junction (CEJ) on the tooth. The measurements were repeated after time intervals ranging from one week to one year. Usually they were repeated in the next year of the study. The same formula as for mean intra-observer error calculated for the dental dimensions was used to calculate mean intra-observer measurement error of the AC - CEJ distances (Sokal and Rohlf 1988). Younger and healthier individuals usually had smaller AC - CEJ distances than older ones and those with periodontal disease. Thus the error calculated for measurements taken from only young individuals or only the older ones would not be the same. To avoid bias of age and disease on calculated error the specimens were selected according to two criteria: 1) they represented all adult age groups and 2) the individual sets of dentitions were as complete as possible. For example a 20-25 years old female without traces of inflammatory reaction of alveolar bone, and the 60-x years old female with pitting of alveolar bone, a remodelled alveolar margin and well exposed roots of teeth remaining in their sockets were among the selected individuals.

The mean intra-observer measurement error calculated for all 482 repeated measurements was 4.4% and did not exceed values reported by other researchers irrespective of methods used in measuring the AC-CEJ distance (Barker 1975, Goldberg et al. 1976, Albandar et al. 1986, Hildebolt et al. 1990, Shrout et al. 1990). Moreover, the mean intra-observer measurement error in millimetres was between 0.1 and 0.2 mm, and approached the accuracy of the measuring instrument (0.1 mm). Measurements on the buccal or labial surface of the tooth (AB) were easier to take than on interproximal surfaces (CD) where it was sometimes difficult to see cemento-enamel junction. The mean measurement error for all remeasured CD distances was bigger than the average error for AB distances (5.8% and 2.9%

respectively). This difference is statistically significant (Chi-squared, p<0.05). The measurements on upper and on lower dentition were taken with similar accuracy irrespective of the surface on which the AC-CEJ distance was measured. The mean intra-observer measurement errors for AB distances ranged between 1.7% (lower third molar) and 4.3% (lower second molar), and for CD distances between 3.0% (lower third molar) and 7.9% (lower canine). The highest result of intra-observer error calculations for the tooth category, was smaller than the intra-observer error limit of 10% accepted in investigations of this nature (Goldberg et al. 1976), or if converted to millimetres, similar (0.3 mm) to other reports (less than 0.5mm) (Barker 1975). The mean intra-observer measurement error for each tooth category and for the buccal and interproximal distances is shown separately in Table 3.312-1.

Table 3.312-1. Mean intra-observer measurement error of root exposure measurements on buccal (AB) and interproximal (CD) tooth surfaces in each tooth category.

	Maxilla				**Mandible**			
Tooth	**N**	**AB**	**N**	**CD**	**N**	**AB**	**N**	**CD**
I1	8	2.6	8	4.8	13	2.7	13	5.0
I2	15	3.2	16	7.0	15	2.8	15	6.5
C	16	2.6	16	6.6	17	3.6	19	7.9
P1	16	2.8	17	4.6	18	1.8	18	6.5
P2	17	3.0	18	6.3	15	3.1	17	7.4
M1	14	2.3	15	4.6	18	3.6	19	4.3
M2	11	2.9	14	4.8	15	4.3	16	4.3
M3	10	2.8	14	7.5	14	1.7	15	3.0
AVG	**107**	**2.8**	**118**	**5.8**	**125**	**3.0**	**132**	**5.7**

3.313. Distance between hypoplastic rings and CEJ

The distance between the cemento-enamel junction (CEJ) and the midpoint of each hypoplastic ring or pitting on the previously cleaned tooth surface, was measured to the nearest 0.1 mm with sliding calipers with sharpened tips (Goodman et al. 1980, Goodman and Armelagos 1985) (Appendix 2). The measurements were taken on all teeth with macroscopically observed hypoplasia and for all individuals with hypoplasia in both dental samples studied. The distances between CEJ and all distinguished macroscopically rings or pitting were measured without discriminating between their types or severity as such grading proved impractical and confusing (Goodman et al. 1980). Recently it was argued that all types of linear hypoplasia such as strong well visible and distinguishable rings, fine lines close to each other and pitted rings, have similar aetiology, and thus should be regarded as the same developmental disruptions and treated equally in the analyses (Berti and Mahaney 1995). Teeth with unusual wear or with surface damage caused by chemicals in the soil, or covered with extensive calculus were eliminated from the observation, measurements and all further calculations. Such teeth were treated as absent from the sample. In fieldwork conditions magnifying glasses were used instead of a microscope, but only when it was particularly difficult to count and separate the rings from each other. The examination of the tooth surface and the measurements were always taken in the strong direct light from a desk lamp placed approximately 15-20 cm from the measured object.

To evaluate mean intra-observer error of measurements of distances between cemento-enamel junction (CEJ) and each hypoplastic ring or pitting, the same procedure as for dental dimensions and for AC - CEJ measurements was applied (Sokal and Rohlf 1988). Ten lower right canines and ten upper right first incisors, each from one individual, with at least two hypoplastic rings were selected for remeasurement. The distances between CEJ and the rings were measured twice in time intervals more than a week long and usually after a year. Results of the measurement error calculations are shown in the Table 3.313-1.

Table 3.313-1. Mean intra-observer measurement error for distances between CEJ and hypoplastic rings on the lower right C, and the upper right I1 (%).

Distance	N	LRC	N	URI1
CEJ - first ring	10	3.2	10	2.8
CEJ - second ring	10	2.1	10	3.5
CEJ - third ring	10	2.7	10	2.7
CEJ - fourth ring	7	1.9	7	2.3
CEJ - fifth ring	3	2.9	3	2.1
AVG	**40**	**2.6**	**40**	**2.8**

The mean intra-observer error for all measurements of the distances between CEJ and hypoplastic rings was 2.7%. There was no statistically significant difference between the average measurement error for the CEJ - hypoplastic ring distances on the lower right canine and on the upper right incisor (2.6% and 2.8% respectively). The greatest intra-observer error for an individual measurement was 9.1% for the first ring on the LRC. Most of the remeasurement results were the same as the first obtained figures or differed by the accuracy of the measuring instrument (0.1 mm).

3.32. Observations of pathological conditions, anomalies and dental wear

Both new and traditional methods of collecting data on caries, dental wear, periodontal disease, hypoplasia, calculus, abscesses and other pathological conditions were chosen to broaden an opportunity to use comparative material in the literature on classical Greek and Italian sites where various methods were applied. It was expected that the use of both older and the more recent methods would help improve interpretation of the results.

3.321. Dental caries

Macroscopic observations of dental caries were conducted with the help of a dental probe according to recommendations for dentists and adopted by researchers studying skeletal collections (Metress and Conway 1975, Koritzer 1977, World Health Organisation 1977, Henneberg 1991a). Number of carious teeth, site of carious lesions and the degree of carious lesions development on the tooth were registered for each individual (Henneberg 1991a) (Appendix 1). Carious lesions were observed on tooth surfaces cleaned with a dry tooth brush. The potential carious lesion was explored by applying moderate pressure on a sharp dental probe end placed in the dark spot on the tooth surface or on the discoloured area on the enamel. If the explored area was softer than surrounding healthy looking enamel as a result of dissolution of inorganic structures of the hard dental tissues, the dental probe end penetrated the surface under applied pressure and the area was scored as a carious lesion. According to the anatomical location carious lesions were described as occlusal, buccal, lingual, distal, mesial, and neck surface caries (Metress and Conway 1975, Henneberg 1991a). A four points' scale was used to describe the degree of caries penetration. If in the carious process only the enamel surface was destroyed without touching the dentine, the enamel carious lesion was described as the first degree caries and recorded as 1. If the caries penetrated into the dentine, the dentinal carious lesion was described as the second degree caries and recorded as 2 on the chart. Pulpal caries were the third degree caries (3 on the chart) and the fourth degree caries (4) indicated completely decayed crown with only remnants of a root or roots left. If several surfaces of the tooth were attacked by caries all lesions were recorded with underlining of the most severe lesion (with the highest degree of penetration). In case of only one carious lesion present on several surfaces of the tooth all surfaces were recorded with underlining of the surface on which the lesion was most probably initiated or simply on which the lesion occupied the biggest area. This latter carious surface was included in calculations. In case of separate carious lesions on the same tooth all carious lesions were included in some calculations as separate entities.

Teeth lost before death due to pathological processes were scored as lost *ante mortem* (a.m.loss or ext. on the individual charts). Empty tooth sockets without macroscopically observable bony changes indicating pathological or remodelling healing processes were also scored, and on the individual chart marked as tooth loss after death (p.m. loss - post mortem loss).

The occurrence of caries in a population was described by two measures, caries frequency (or prevalence) and caries incidence. These measures were adapted to skeletal material from indices commonly used to describe the epidemiology of the disease in living populations (Nikiforuk 1985, Henneberg 1991a). Caries frequency was the percentage of individuals affected by caries in the population. Caries incidence was calculated as the percentage of carious teeth in total number of examined teeth, or in total number of examined alveoli in cases where the teeth lost before death were considered carious (Lukacs 1992). Only dentitions of adults were included in calculations.

An example of carious lesions found among ancient Metapontines is shown in the Figures 3.321-1 and also in 3.323-1.

Figure 3.321-1. Occlusal and interproximal caries in the mandibular teeth of a 20-25 years old male from burial 94 at Pantanello. All three molars on both sides are affected by caries. Distal part of the left first molar is destroyed by caries most probably initiated on the distal side and affecting the mesial surface of the second molar. Slight rotation of lower first incisors also present.

3.322. Periapical abscesses

Presence and location of periapical abscesses, chronic periapical abscesses with sinuses, and alveolar abscesses was recorded on the chart according to description given by Tyldesley (1978). Only abscesses of considerable size, macroscopically observable without any special instruments or techniques like radiology, were recorded. Because the author had limited access to a radiological laboratory and equipment in the fieldwork conditions the systematic radiological screening of all maxillae and mandibles was not possible. Only a few jaw fragments with already diagnosed abscesses were analysed radiographically to assess the extent of bone destruction.

Severe bone damage caused by periapical infection is shown in the Figures 3.322-1 and 3.322-2.

Small in size periapical abscesses, not accessible for the macroscopical observation because the tooth remained in the socket and with no sinuses opened to the bone surface, had to be omitted from the analysis. In earlier studies Swardstedt (1966) reported a good agreement between the frequency of periapical lesions in dry skulls observed with a naked eye and the frequency of lesions shown in radiological examination. Studies by Linn et al. (1987) showed that macroscopical observations without an aid of radiography resulted in underestimation of the presence of periapical abscesses. Around 50% of abscesses, mostly those of smaller size were not detected. To minimalise the underestimation of the periapical abscesses, empty tooth sockets or sockets with loose teeth easy to remove without any damage to the alveolar bone were examined for presence of bone remodelling following a granuloma (Clarke 1990, Hillson 1996, pp.284-286, Alt and Turp 1998a) . The same procedure was applied to both rural and urban dental samples. Among the

Figure 3.322-1. Periodontal disease and a periapical abscess (periapical granuloma) in the dentition of a 25-30 years old female from the tomb 210 at Pantanello. Tooth roots were exposed more than 2mm above the alveolar margin and pitting and remodelling of alveolar bone around the roots of lower and upper teeth indicates mild periodontitis. Around the roots of lower left first molar inflammatory process, probably initiated by caries, destroyed the alveolar bone on the buccal side and around the roots.

Figure 3.322-2. Radiograph of the mandible of a 25-30 years old female from the tomb 210 at Pantanello. Resorption of alveolar margin indicates possible mild form of periodontal disease. Radiolucency around the roots of lower left first molar (rounded dark spot with sclerotic radioopaque border) indicates a periapical granuloma probably caused by pulpal caries (long arrow). Diffuse radiolucency present around lower left canine and both premolars indicates chronic osteomyelitis (short arrow).

individuals in rural sample with teeth loose in the sockets only one out of twenty one (4.8%) had a periapical abscess around the lower first molar roots, which would have been unnoticed if the tooth had been firmly supported by alveolar bone and set in the socket. One out of sixteen individuals in the urban sample (6.3%) with loose teeth had a periapical abscess around the lower second molar which could have been omitted in macroscopic observation if the teeth remained firmly in the sockets. In most cases periapical changes followed by alveolar bone destruction loosened the tooth in the socket. Such tooth was usually missing from the socket. Only sockets with a still clearly visible shape of the root apex and beginning of the healing process were scored for the presence or absence of periapical abscesses. By adopting this scoring procedure the error of underscoring periapical abscesses in macroscopical observations in the present study was diminished, but not completely eradicated.

Figure 3.322-2 shows a radiograph of one of the "would be" omitted cases of osteomyelitis which probably spread after periapical infection.

3.323. Dental calculus

Before additional cleaning for counting of hypoplastic rings and measurements of CEJ-ring distances the teeth were examined for presence of calculus on their surfaces.

Layers of calculus on teeth were evaluated according to the Dobney and Brothwell's (1987) five-degree scale (Appendix 2). The method was developed for scoring mineralised deposits attached to the crowns of the teeth above the gingival margin and called supra-gingival calculus. One type of mineralised deposit, sub-gingival calculus differentiated by location on the tooth and covering tooth surfaces below the gingival margin in gingival pockets and on the roots, was not included in the scoring method. According to the scale, teeth with normal calculus deposits or no calculus present on the tooth surfaces were scored as grade zero. Grade 1 was given to slight calculus, less than 1mm thick, on any of the crown surfaces. Calculus deposits 1-2 mm thick were graded as 2, and grade 3 was assigned when the deposits were between 2 and 3 mm thick. The last grade in the scoring system, grade 4 described teeth with calculus 3-5 mm or thicker. Very thick calculus deposits on mandibular teeth classified as grade 4 are shown in the Figure 3.323-1.

The second method, also developed by the same authors (Dobney and Brothwell 1987), and describing the relative position of the calculus on the tooth in three horizontal zones, was found impractical by the author. The archaeological material analysed here was mostly excavated by non-anthropologists and then cleaned in the laboratory with the help of students and non-professionals. It was then possible that some of the less firmly adherent deposits especially from the occlusal part and near the cutting edge were lost in the cleaning process. If the distribution of calculus on the teeth was described in horizontal zones, greater error would be made if the upper zone was incorrectly scored as without calculus. To avoid that type of error the simpler scoring was employed where the location of the remaining calculus was described by the name of the tooth surface it covered. For example, if the calculus was on all tooth surfaces recorded information for that tooth was o,b,l, or i (o-occlusal, b-buccal, l-lingual, or i-interproximal if both interproximal surfaces were involved). The surface with the thickest deposits or the surface with the greatest area covered was underlined. Additional information about the shape of the calculus, its colour and its location below the cemento-enamel junction was also recorded if applicable. More detailed description of the calculus seemed useless in view of mentioned circumstances of handling the skeletal material.

Figure 3.323-1. Periodontal disease and calculus on the dentition of the 30-35 years old female (burial 356 at Pantanello). Lower front teeth are covered with a layer of calculus thicker than 3 mm (long arrows). The roots of the lower front teeth are exposed in 2/3 of their length. Some pitting of alveolar bone also present. The crown of the lower left second premolar destroyed by caries revealing the pulp and root canal (short arrow). Caries present on all lower molars and on lower right first premolar.