The People of Wairau Bar: a Re-examination

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ABSTRACT

A new study of macroscopic evidence of health in Wairau Bar human skeletal remains (*koiwi tangata*), prior to their reburial in April 2009, generally supports the views of Houghton (1975), but reports new evidence of childhood stress, the presence of specific infectious diseases, and revises dental evidence of diet. Assessment of health parameters between spatially separated groups within the cemetery (*uruupa*) found differences in the demography, with more old females in Group 3 (Burials 12–44) or the 'southern *uruupa*'. The oral health of the burial groups was also different where individuals of Group 1 (Burials 1–7) had more evidence of periodontal disease and less extreme wear suggesting a diet different to that of Group 3. Differential health between the sexes and groups at Wairau Bar is implied. Overall parameters of health and disease indicate that the Wairau Bar people survived the observed stress during childhood and lived active, mostly healthy, lives.

Keywords: Wairau Bar, *koiwi tangata,* health and disease

INTRODUCTION

The site of Wairau Bar, at the mouth of the Wairau River, on the north coast of the South Island of New Zealand, holds a special place in the prehistory of New Zealand. Golson (1959: 37) described it as 'the most important Archaic site yet discovered' and 50 years later that opinion still prevails; it is the type-site of the earliest phase of New Zealand's prehistory (Walter *et al*. 2006: 281). The archaeological importance of Wairau Bar was based originally on richly furnished graves with material culture containing elements almost indistinguishable from Eastern Polynesian assemblages (Duff 1977). More recently, evidence of working floors, middens, cooking areas and structures show that Wairau Bar is also a rare New Zealand example of an early East Polynesian nucleated village (Walter 2004: 138). The most recent radiocarbon dating from the site suggests a brief occupation ~1288–1300 AD (Higham *et al*. 1999: 425). As the earliest secure dating of New Zealand colonisation, on the basis of multiple sources of evidence, is also of this age (Wilmshurst *et al*. 2008), Wairau Bar may be a site of the initial colonisation era.

The Wairau Bar burials provide the only large sample (n=42) of individual skeletal remains (*koiwi tangata)* from early Maori. The quality of life of Maori, and how this might have changed during prehistory as the subsistence mode adapted to extinction of moa (Dinornithiformes) and other birds and the depletion of seals, has been discussed often on indirect evidence (reviewed in Furey & Holdaway 2004), but the Wairau Bar sample of *koiwi* has the potential to provide direct biological evidence of the lives of the earliest people of New Zealand. Much of what was known previously about the biology of pre-European Maori is due to the work of Philip Houghton in case studies on individuals (e.g. Houghton 1977) and skeletal collections, including the first systematic study of Wairau Bar material (Houghton 1975), which reported briefly on the demography, physique and stature, health and disease of the sample. Houghton's large body of work, including on Wairau Bar, was condensed into the popular book *The First New Zealanders* (1980) and enlarged upon in his substantial work, *The People of the Great Ocean* (1996).

The collection of *koiwi* from Wairau Bar had been held in the Canterbury Museum until it was repatriated recently to Rangitane, the *iwi* or tribe now holding *kaitiakitanga* (guardianship) over the site. For Rangitane, the *koiwi tangata* are the remains of their *tupuna* (ancestors). As methods of recording and interpreting health and disease have progressed considerably over the past few decades, a re-evaluation of the Wairau Bar material was permitted at the University of Otago, before reburial in April 2009. Research on the *koiwi* was conducted in partnership with Rangitane as the first step in the repatriation process. This paper uses recent bioarchaeological methods and theory in order to provide a baseline of information on the health of the Wairau Bar people. The ongoing Wairau Bar *koiwi* project includes analysis of stable isotopes and ancient DNA to examine diet, migration and biological affinities of the people. Dating of the human bone will also

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be undertaken. Results of these analyses will be reported later.

THE *KOIWI* SAMPLE

The significance of Wairau Bar as a burial place became apparent in 1939 when a schoolboy, Jim Eyles, dug up a perforated moa egg and a whale tooth necklace with ivory reels, iconic Archaic items, in association with a burial (Duff 1977). In 1942 Eyles excavated a second burial with a moa egg and artefacts and, with Roger Duff, Ethnologist at Canterbury Museum, excavated another five burials the same year. There were sporadic excavations between 1943 and 1964, focussing upon burials, associated grave-goods and other artefacts along with the recovery of bone from moa and other extinct avifauna. In 1955, Robert E. Bell from the University of Oklahoma initiated a shift in excavation methodology, with the aim of gaining a better understanding of the stratigraphy and layout of the site. In the same year, Duff received the first radiocarbon dates for the site, which gave an approximate occupation age of AD 1150 (Duff 1977), offering confirmation of his original thesis on the antiquity of the site. Further excavations were carried out by Duff in 1956 and 1959 (Duff 1977) and a final excavation by Canterbury Museum in 1963–64, led by Owen Wilkes (see Trotter 1977), gathered further information about site stratigraphy and undertook the first quantitative analysis of subsistence data (analysis in Anderson 1989: 123–124).

The collection of *koiwi* received at the Department of Anatomy and Structural Biology from the Canterbury Museum in October 2008 consisted of 42 burials as well as nine catalogue items of fragmentary bones not attributed to any burial. Based on the excavation records and notes gleaned from published sources three groups of burials had been identified previously (Duff 1977; Anderson 1989) (Figure 1).

Group 1 (burials 1–7, see Fig 2), were found deep beneath an overburden of sand, which contributed to the superb preservation of bone tissue in this group. In Burial 1, the postcranial skeleton was reburied and not available for examination by us (Eyles 2007). In Burials 3 and 5 the

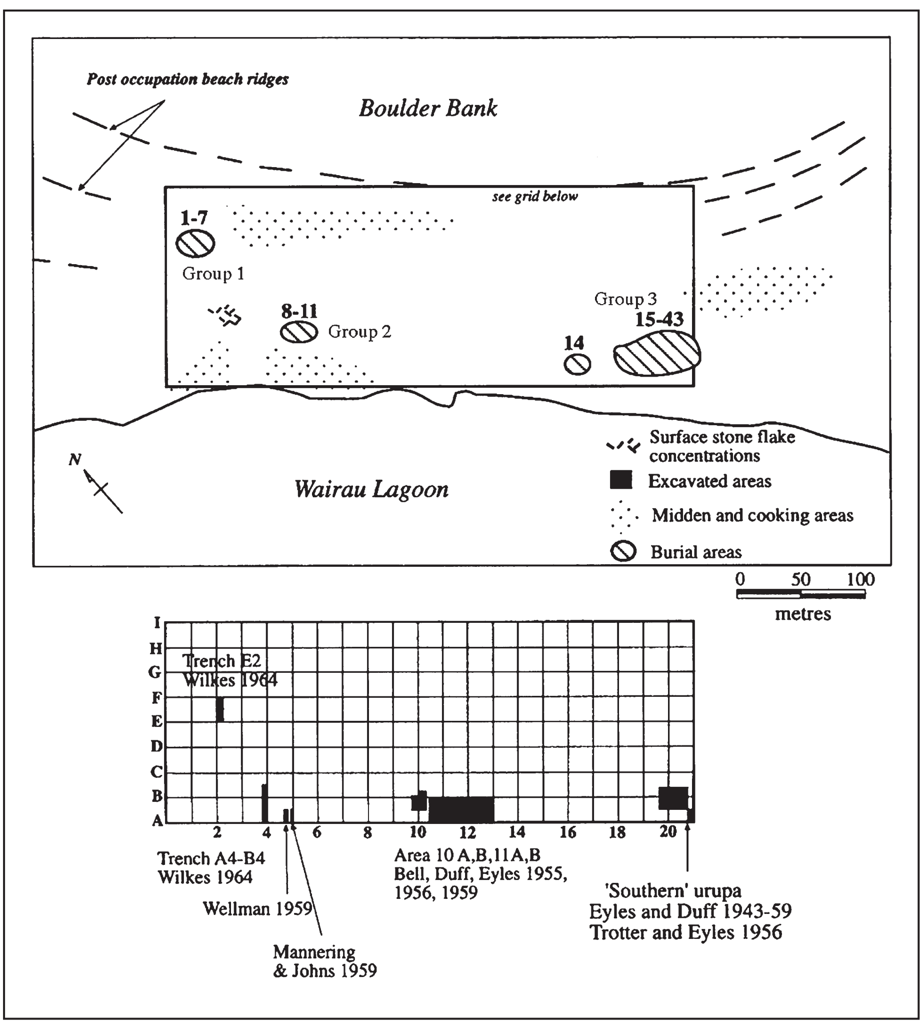

Figure 1. Plans of the Wairau Bar excavations. From Higham *et al.* (1999: 421). Note Group 3 includes Burials 12, 13 and 44.

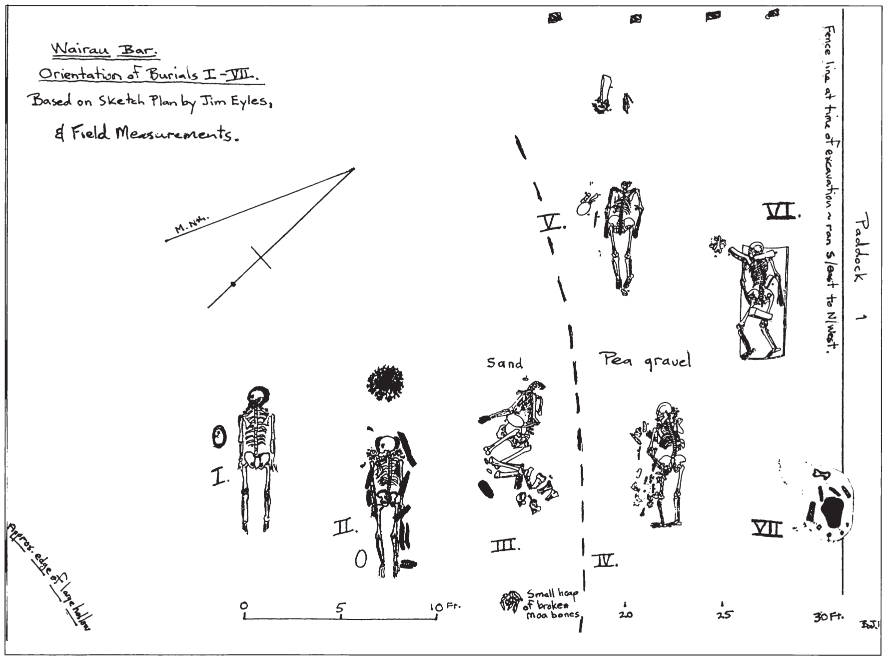

Figure 2. Layout of Group 1 at the Wairau Bar. From Eyles (2007: 87). Note that the postcranial skeleton of Burial 1 was not available for us to examine.

crania had been removed as part of the mortuary ritual, and Burial 7 is represented only by teeth, and part of the first vertebra. Duff (1977: 45) recorded this as a secondary burial, with the disarticulated bones 'representing the major part of a headless body' and the heap of large stones over the burial may have damaged the bones, contributing to their minimal recovery. *Group 2* (burials 8–11) were found southeast of Group 1. The skeletal preservation of this group was variable but generally poor. *Group 3* is described elsewhere (e.g. Anderson 1989; Higham *et al.* 1999), as consisting of Burials 15–43, which were uncovered at the eastern margins of the site and sometimes referred to as the 'southern *uruupa*'. Trotter (1977: 353) reported the total number as 44; it is not clear why B44 was excluded in the above publications but here we include it in this group along with Burials 12, 13, and 14, which were located nearby. These *koiwi* were generally in a very poor condition (fragmented and friable) and consisted mostly of cranial fragments, teeth and a few upper cervical vertebrae.

Besides the clear differences in grave goods and preservation between Group 1 and Groups 2 and 3, the identification of the groups was somewhat arbitrary and partly a reflection of the areas of site excavated. For example, Duff (1977: 45) describes the 29 burials comprising the third group as 'found at scattered points in paddocks 1 and 3' which covers a large and poorly defined area of the site. Nevertheless, we have used the groups as given in our analyses, despite possible limitations in group differentiation, in order to test whether there are spatial differences in demography and health represented in the site.

Apart from in Group 1, very little of the postcranial skeleton is represented, which has reduced macroscopic observations. For macroscopic analyses of health it is ideal to have both cranial and postcranial remains available for each individual. At the time these *koiwi* were excavated there was a perception that the cranium and teeth were the most 'useful' parts of the body and they were collected preferentially. This practice would explain some but not all missing elements in the Wairau Bar collection. There are discrepancies between field drawings depicting complete or near complete skeletons *in situ* which are now represented by very fragmented material in poor condition suggesting a somewhat idealised representation of burials in some drawings. In other cases it would seem there was little to be recovered. Duff (1977: 36, 47) remarks on the 'striking contrast' between the condition of the first three burials in particular and Burials 8–29. He attributes this to differences in the burial matrix and to wind erosion and plough damage as a result of the shallower depth of burial in Groups 2 and 3. He describes bones as 'completely disintegrated' (Duff 1977: 47), 'like soaked paper' and 'greatly decayed' (Duff 1977: 51) so it may be that such poorly preserved fragments were discarded. Recovery methods may also have contributed to a loss of material in some areas. In December 1943, in the southern *uruupa*, Duff (1977: 55) recorded that 'the digging was a little careless at this point' and 'it was decided therefore to use the plough as a quicker method of exploring this area' of already cultivated soil.

The complete absence in the collection of bones from some burials recorded by Duff (1977) could be attributed to a combination of selective collecting, poor preservation, and excavation damage. In particular Burials 10, 23, 32, 34, 38, 39 were not recorded by Houghton in 1975 and were not in the collection we received. A number of fragmentary human skeletal remains were accessioned to the Canterbury Museum collection in subsequent years. These cannot be attributed to any burial but were found by Eyles during the period 1945–1958, possibly after disturbance by ploughing or natural erosion.

DEMOGRAPHY AND HEALTH

The results of our re-evaluation of the health of the Wairau Bar people concern demography, growth as measured by adult stature, non-specific indicators of stress (developmental dental defects (DDE), Harris lines and signs of anaemia), degenerative joint disease (DJD) and trauma, infectious disease and oral health. It must be noted that due to variation in the presence of the skeletal and dental material, the number of observable samples varies for each of the health parameters.

Demography

Age and sex estimation. Age was estimated using tooth wear where possible, and/or morphology of specific joints in the pelvis (pubic symphysis and auricular surface) (Buikstra & Ubelaker 1994). Age estimates are reported here as relative groups, with approximate age ranges, as young (20–34 years), mid (35–49 years) and old (50+ years), with intermediate categories defined as young-mid and mid-old. Sex was estimated using the characteristics of the pelvis and cranium (Buikstra & Ubelaker 1994). Morphological changes for age and sex were independently recorded by HB, NT, and SH and final age and sex estimates were determined by consensus.

The following analysis is limited to the 42 individuals recovered as burials during the excavations and transferred to the Canterbury Museum. Table 1 and Figure 3 show the age and sex distribution of the sample. Age and sex could not be estimated for three individuals; age could not estimated for a further four and sex for a further

Table 1. *Age and sex distribution of the Wairau Bar burial sample.*

	Adolescent (15–20 y)	Young	Young-mid	Mid	Mid-old	Old	Unaged Adult	Total
Male	0	4	1	1	1	3	0	10
Male?	1	1	0	0	1	2	0	5
Female	0	5	3	1	1	5	3	18
Female?	0	0	0	0	0	2	1	3
Unsexed	0	2	0	1	0	0	3	6
Total	1	12	4	3	3	12	7	42

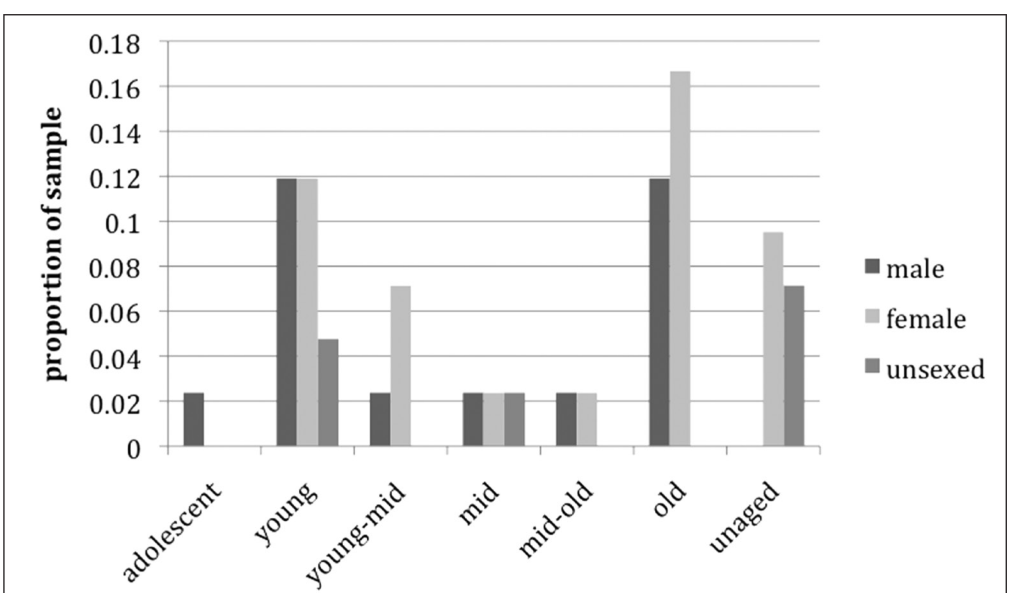

Figure 3: Age and sex distribution of the Wairau Bar burial sample.

three. All apart from one (n=41/42) are adults (>20 years of age). There are more females than males in the sample, but this difference is not statistically significant (χ^2 p-value=0.1573). The age estimates spread the adults across the three age categories with one-third 'young', one-third 'old' and the remainder spread between these groups. There is a slight imbalance of females in the young-mid and old age categories. Over 70 percent (n=5/7) of the sexed individuals from Group 1 are male compared with Groups 2 and 3, where 100.0 percent (n=3/3) and 61.5 percent (n=16/26) respectively are female. Group 1 has no old individuals, while in Group 3 44.4 percent (n=11/25) of the individuals with age estimates are old (Table 2).

Analysis of the age at which people died provides information about population growth, and forms the basis for assessing possible health differences between age and sex groups (Chamberlain 2006). It is important to identify any sampling biases, as factors such as bone preservation and/or the area excavated in a segregated cemetery can influence age and sex distribution. Three statistics are commonly used to assess the extent to which the archaeological sample represents the cemetery population. The first is the proportion of infants and children (defined as those less than 15 years of age) in the skeletal sample, which is generally expected to comprise 30–70 percent of prehistoric skeletal samples (Waldron 2007). The second is that there should be a relatively even ratio of males and females (Waldron 2007) and finally all age groups should be represented among the adult sample.

In the Wairau Bar sample there is one adolescent (B2.2), but no infants or children. Two 'children' were identified (Burials 10 and 32) during excavation but they were not included in the curated collection, probably as a result of their extremely poor preservation, as noted by Houghton (1975: 231) and Duff (1977: 47, 64). The absence of infants and children may represent an excavation or recovery bias, as it is possible that they were buried in another area, or that they were missed during excavation because of their size and fragility. However, this does not explain the absence of older children, supporting the suggestion that they were buried somewhere other than in the excavated areas. The Lapita site at Teouma, a colonising population from Vanuatu, has a similarly unusual demographic profile with no children found, although there were young infants. This pattern has also been interpreted as a segregated burial ground with possible specific areas for the children (Buckley *et al.* 2008; Bedford *et al.* 2009).

There are 1.4 females for every male in the Wairau Bar sample. The distribution across the age categories is similar in both sexes, with most of the sex imbalance in the old age group. As well as the high proportion of older individuals, there is a relatively high proportion of young adults. This could indicate that some who survived the stresses of childhood were vulnerable to death as young adults, or that this was an age at which they were more prone to accidental death.

When comparing the age and sex distributions among the Burial groups, the main differences were the high proportion of young males in Group 1 and of old females in Group 3. This suggests that the biases in sex and age distribution of the excavated sample are the result of possible age and sex segregation of the *uruupa*. This would also support the proposition that the infants and children are buried elsewhere on the site. In summary, there is a lack

Table 2. *Age and sex distribution by group of the Wairau Bar burial sample (percentages in brackets).*

	Adolescent	Young	Young-mid	Mid	Mid-old	Old	Unaged	Total
Group 1								
Male	1 (12.5)	1 (12.5)	1 (12.5)	1 (12.5)	1 (12.5)	0	0	5 (62.5)
Female	0	0	1 (12.5)	0	1 (12.5)	0	0	2 (25.0)
Unsexed	0	0	0	1 (12.5)	0	0	0	1 (12.5)
Total	1 (12.5)	1 (12.5)	2 (25.0)	2 (25.0)	2 (25.0)	0	0	8 (100.0)
Group 2								
Male	0	0	0	0	0	0	0	0
Female	0	0	1 (25.0)	0	0	1 (25.0)	1 (25.0)	3 (75.0)
Unsexed	0	0	0	0	0	0	1 (25.0)	1 (25.0)
Total	0	0	1 (25.0)	0	0	1 (25.0)	2 (50.0)	4 (100.0)
Group 3								
Male	0	4 (13.8)	0	0	1 (3.4)	5 (6.7)	0	10 (33.3)
Female	0	5 (17.2)	1 (3.4)	1 (3.4)	0	6 (20.0)	3 (6.9)	16 (55.2)
Unsexed	0	2 (6.9)	0	0	0	0	2 (6.9)	4 (13.8)
Total	0	11 (37.9)	1 (3.4)	1 (3.4)	1 (3.4)	11 (36.7)	5 (16.7)	30 (100.0)

of infants and children in the sample, a sex bias in favour of females and an age bias in favour of younger males and females and older females. This indicates that the sample is unlikely to be 'representative' of the cemetery population, so interpretations of the health data are treated with caution (Waldron 2007).

When compared with other prehistoric Polynesian skeletal samples, the demographic profile of the Wairau bar *koiwi* is distinctive (Table 3), particularly in the under-representation of infants and children and adult males. Other prehistoric New Zealand samples are also likely to have sampling issues, given the small sample sizes, although both Waihora and Palliser Bay have good representation of infants and children. The difference in proportions of males and females at Wairau Bar is not unusual among comparable South Pacific skeletal samples. For example, the Sigatoka sample is similar to Wairau Bar, with an over-representation of females, whereas the other samples are skewed to an over representation of males. These imbalances may suggest that segregation of burial grounds based on age and sex is a distinctive Polynesian mortuary trait or it may simply reflect a more mundane explanation of sampling error in these small samples.

Differences between the 1975 and 2009 age and sex estimations. There are some differences between our age and sex estimates and those of Houghton (1975) as shown in Table 4. We erred on the side of caution when estimating sex and age. If we considered that there was not enough material or the evidence was too equivocal to make a confident estimate we chose not to make a sex estimate. The main differences in the sex estimates are that we identified as females five individuals that Houghton considered males. These were all based on the skull alone, relying on robusticity, and with Polynesian robusticity in mind, we appear to have set our standards for females at a more robust end of the continuum than Houghton. Houghton employed discriminant functions of mandibular (unpublished data) or long bone dimensions (Houghton & de Souza 1975) in a few of the cases in question, but in most he either included or relied on the assessment of cranial morphology (Houghton 1975). With the age estimates, four regarded by Houghton as aged in their 20's were considered by us as 'old'. There is no discernible pattern in the basis of Houghton's estimates to explain these inter-observer differences.

Stature

The stature (height) of an adult is a culmination of the extent to which environmental influences during childhood have allowed achievement of genetic potential for growth (Bogin 1999). From skeletal collections a person's height is estimated using regression equations based on the length of their limb bones. As populations have different body proportions, for example Polynesians have long trunks but short lower limbs compared with long-legged populations such as Africans, it is important to use stature equations that are specific to the population under study. Houghton *et al.* (1975) developed such equations for Polynesians and these have been applied to the Wairau Bar *koiwi*.

Figure 4 shows the mean stature of the Wairau Bar men compared with other Pacific Island populations. The Wairau Bar males are among the taller of Pacific peoples, which may be a reflection of the ability to recover from the childhood stress described below. These heights were

Table 3. *Age and sex of the Wairau Bar sample and other comparative New Zealand and Polynesian skeletal samples.*

Sample and date	Subadults (%)	Adults (%)	Males (%)**	Females (%)**	Unsexed adults	Total	Source
Wairau Bar, ca. 650 BP	1 (2.4)	40 (95.2)	15 (35.7)	21 (50.0)	6	42	This study
Palliser Bay, New Zealand ca. 650–450 BP	8 (50.0)	8 (50.0)	4 (50.0)	4 (50.0)	0	16	Sutton (1979)
Waihora, Chatham Islands, New Zealand, ca. 400 BP	4 (28.6)	10 (71.4)	7 (70.0)	3 (30.0)	0	14	Houghton (1976)
Sigatoka, Viti Levu, Fiji ca. 1550 BP	11 (19.6)	45 (80.4)	18 (40.0)	27 (60.0)	0	56	Visser (1994)
Hane Dune, Marquesas Islands ca. 500–300 years BP	18 (41.9)	25 (58.1)	17 (68.0)	8 (32.0)	0	43	Pietrusewsky (1976)
Tonga (To-At-1 and 2) ca. 1000–300 years BP	41 (41.4)	58 (58.6)	17 (44.7)	21 (55.3)	20	99	Buckley (2001)

**= percentage of adult sample able to be sexed.
BP= before present

Table 4. *The collection of koiwi from the Wairau Bar showing the burial numbers and corresponding Canterbury Museum catalogue (SK) number and the age and sex estimates by Houghton (1975) and the present study. Burial numbers in bold indicate those we have designated as individual burials (n=42).*

		University of Otago 2009		Houghton 1975	
Burial	**SK**	**Age**	**Sex**	**Age**	**Sex**
1	n/a	Young-Mid	Female	24	Female
2.1	409	Young	Male	On display at the Canterbury Museum at the time of Houghton's analysis	
2.2	410	15–20	Male?	On display at the Canterbury Museum at the time of Houghton's analysis	
3	395	Mid	Male	27	Male
4	394	Mid-Old	Male	41	Male
5	379	Mid-Old	Male?	30–36	Male
6	377, 570	Young-Mid	Male	25	Male
7	574	Mid	?	Not recorded	
8	408, 376, 571	Old	Female	Not recorded	
9	407	Adult	?	27	Female
10	Not in Collection (remains of a child burial that had largely disintegrated during excavation (Houghton, 1975: 231)				
11.1*	387	Adult	Female	27	Female
11.2	575	Identified as the vertebral column of Burial 4 based on the perfect matching of the degenerative changes of the spine with the cranium. Recorded by Houghton as a vertebral column of an adult female			
12	385	Young-Mid	Female	25	Male
13	386	Young	Female	20	Female
14	384	Old	Male?	22	Male
15	382	Old	Female?	29	Male
16.1	400, 401	Young	Female	26	Female
16.2	400, 401	Old	Female	39	Female
17	398	Young	Female	23	Female
18	399	Young-Mid	Female	24	Female
19	383	Young	Male?	24	Male
20	406	Adult	Female?	Adult	Male
21	388	Mid	Female	32	Male?
22.1	397	Young	Female	21	Female
22.2	397	Old	Female	40	Female
23	Not in Collection				
24	374	Old?	Male	35	Male
25	381	Young	Male	23	Male
26	380	Young	?	19	Female
27	396	Young	?	23	Male
28	375	Adult	Female	30	Male
29.1	393	Old	Male	31	Male
29.2	393	Adult	Female	?	Female
30	403	Old	Female	39	Female
31	402	Young	Female	23	Female
32	Not in Collection (remains of a child burial that had largely disintegrated during excavation (Houghton, 1975: 231)				
33	405	Adult	?	25	Male
34	Not in Collection				
35	378	Young	Male	20	Male
36	404	Young	Male	23	Male
37	438	Mid-Old	Female	38	Female
38	Not in Collection				
39	Not in Collection				
40	418	Old	Male	<29	Male
41.1	390	Old	Female	36	Female
41.2	Not in Collection. Recorded by Houghton as femur of adult male				
42	389	Old	Female	21	Female
43	392	Old	Male?	21	Male
44	391	Adult	?	24	Female

Table 4. *Continued*

		University of Otago 2009		Houghton 1975	
Burial	**SK**	**Age**	**Sex**	**Age**	**Sex**
	440	n/a	n/a	n/a	n/a
	441.1	n/a	n/a	n/a	n/a
	441.2	n/a	n/a	n/a	n/a
	442	n/a	n/a	n/a	n/a
	443	n/a	n/a	n/a	n/a
	491	n/a	n/a	n/a	n/a
	444	n/a	n/a	n/a	n/a
	664	n/a	n/a	n/a	n/a
	573 – Limb bones of a child with no burial number.				

* Houghton mentions a tibia of a newborn infant with this female. This was not found in the collection.

based on the five males (range 173.5–176.6) from Group 1 with complete limb bones, as there were no males with complete bones in the other two groups. However, given that they all came from Group 1, these males may not be representative of the rest of the population. A single female (Burial 11.1, 160.6cm) with complete long bones contributed to height estimates of females shown in this graph. Houghton (1975) saw Burial 9 as a female but we were not convinced and excluded this individual. The third female height shown by Houghton in 1975 was based on the estimated length of an incomplete limb bone. We chose not to estimate stature based on estimated long bone lengths as it introduces too much error. Despite these minimal data, the Wairau Bar female fits within the range of female heights in other Eastern Polynesian groups.

Skeletal pathology: non-specific indicators of stress

Some indicators in bones and teeth may not relate to any specific disease but rather reflect a time of pressure or 'stress', due to dietary insufficiency and/or infectious disease. These are the so-called non-specific indicators of stress: developmental dental defects of the enamel (DDE), cribra orbitalia, porotic hyperostosis, and Harris lines. DDE are caused by disruption in either the production of enamel (hypoplasia) or in its mineralisation or calcification (hypocalcification) (Goodman *et al*. 1984). Both record either infection and/or malnutrition during childhood. Enamel hypoplasia will be present in either the form of a horizontal furrow or line or as pits across the tooth enamel and

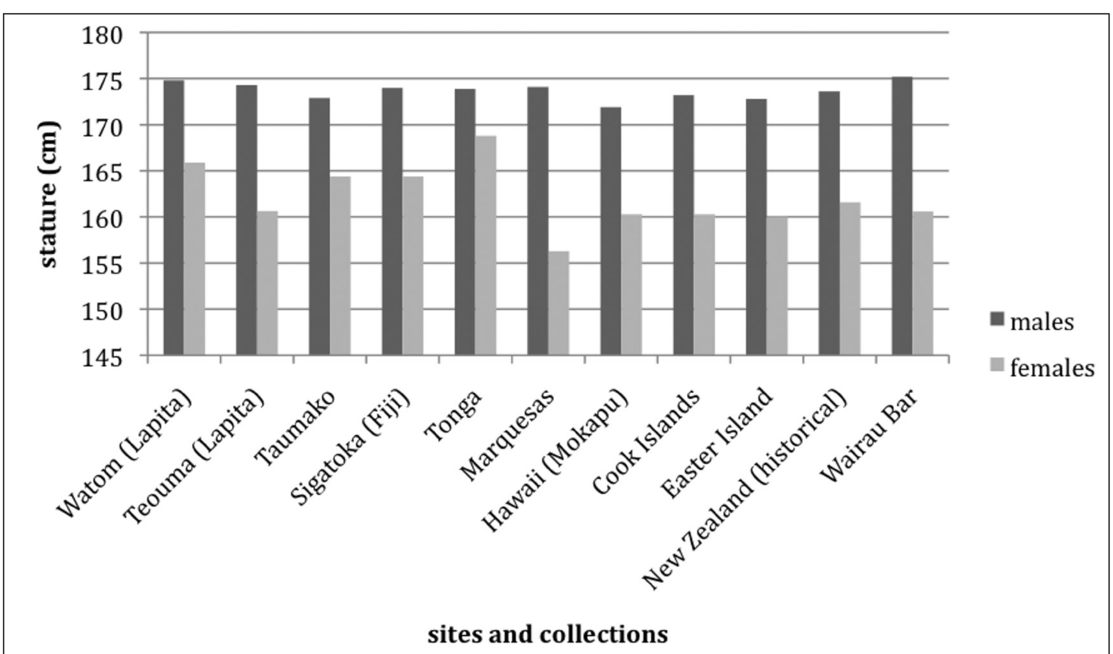

Figure 4. Mean stature estimates for males and females from the Wairau Bar koiwi compared with a number of Pacific Island skeletal samples, and historic data from NZ Maori (data from Houghton 1996, Buckley 2001 and Buckley n.d for Teouma stature and Watom data from burials excavated by Anson and Buckley in 2008).

hypocalcifications as areas of opacity and chalkiness on otherwise smooth and translucent enamel (Hillson 1996). Other indicators of stress in childhood are cribra orbitalia, porosity in the bone of the eye sockets, and porotic hyperostosis, porosity and expansion of the skull bones (Ortner 2003). These bony changes result from marrow expanding in response to a lack of iron in the blood (Roberts and Manchester 2005, Ortner 2003) as a result of diet, high parasite loads or infectious disease (Roberts, 2005). Because of the multifactorial causes of iron-deficiency anaemia it is a non-specific indicator of stress. Another means of investigating growth disruption in human skeletons includes evidence of 'Harris lines'. These are seen on radiographs as transverse bands of increased density of bone tissue in the shaft of long bones, especially in the tibia. Harris line formation has been linked to periods of stress, including dietary insufficiencies, disease and other stresses such as weaning (Ribot & Roberts 1996).

It is desirable in analyses of these parameters to present prevalence data based both on the individual as a unit of analysis and on the element in question but the preservation of the Wairau Bar skeletons is so variable that data are presented here using only the individual as the unit of analysis.

Developmental defects of enamel. Over 70 percent of the 21 people with observable teeth had DDE on at least one tooth (table 5) meaning a high proportion was affected by at least one episode of growth disruption during infancy or early childhood. Three individuals had both forms of defect; 22.1 (young female) B27 (young adult of unknown sex) and B35 (young male). A higher proportion of males was affected with DDE than females. All three of the individuals from Group 1 with teeth had DDE (Burials 1, 2.1 and 6), no individuals from Group 2 had observable teeth, so the remaining 12 with defects were from Group 3. Of the 18 individuals from Group 3, 60% of the females with teeth had defects (n= 6/10), four of the five males were affected (80%) and two of the three of unknown sex also had defects.

Anaemia. Seven people (n=7/23, 30.4%) had bony changes in the orbits that may indicate iron-deficiency during childhood. Twenty-one individuals with orbits were assigned a sex estimate. Of the female sample with orbits (n=12), four (33.3%) were affected, and 3/9 of males were affected (33.3%). Burial 1, the single female in Group 1, (Figure 5) was the only one of the seven outside of Group 3. Burial 18, also from Group 3, was the only individual with evidence of porotic hyperostosis. Previous analysis of anaemia in Maori skeletal series show that this was common among prehistoric Maori (Green 1999).

Harris lines. The investigation of Harris lines in the Wairau Bar sample was limited due to the incomplete preservation of the burials in Groups 2 and 3. All burials in Group 1, apart from Burials 1 and 2.2 had at least one tibia present. Two of the five (40.0%) burials with complete tibiae (Burials 2.1 and 3), had Harris lines, indicating stress during growth in childhood.

In summary, the evidence from the non-specific indicators of stress during the childhood growth period suggests high levels of growth disruption during early life which are discussed in relation to diet below.

Specific pathology

Degenerative Joint Disease (DJD). The most common disease found in prehistoric skeletal remains is degenerative joint disease (DJD), in particular osteoarthritis (OA) (Larsen 2002). In a normal joint there is cartilage between the bones that acts as a shock absorber and aids with the smooth movement of the joint. As DJD develops, the cartilage between the bones degrades and may be destroyed entirely so that when the joint is moved bone is rubbing on bone, which produces a distinctive polishing to the surface known as 'eburnation'. As well as eburnation, the cells within the bone respond to the functional loss of the cartilage by producing more bone around the margins of the joints, creating a lip known as an osteophyte. The onset of joint degeneration is age-related but whether or not an individual will develop the condition depends to some extent on genetic predisposition (Rogers and Waldron 1995). Many other factors contribute to DJD in current research so it is considered to be present only when eburnation (Rogers & Waldron 1995) and/or severe osteophytosis (Tayles 1999) are observable in the joint surfaces.

The only individuals preserved sufficiently to enable determination of the pattern of degeneration were from five males in Group 1 (Burials 2.1, 3, 4, 5 and 6). All had degenerative changes in the joints of the spine and/or limbs,

Table 5. *Dental developmental defects of the enamel in the individuals from the Wairau Bar.*

	Overall A/O (%)	Males A/O (%)	Females A/O (%)	Unsexed A/O (%)
DDE	15/21 (71.4)	6/7 (85.7)	7/11 (63.6)	2/3 (66.6)
Hypoplasia	8/21 (38.0)	4/7 (57.1)	3/11 (27.2)	1/3 (33.3)
Hypocalcification	10/21 (47.6)	5/7 (71.4)	5/11 (45.4)	2/3 (66.6)

A=affected individuals; O=number of individuals with observable teeth.

Figure 5. Orbits with cribra orbitalia (Burial 1).

including the hands and feet. The upper limbs were more affected than the lower limbs, with more joints involved and the degeneration more severe. In the spine, the cervical vertebrae were most affected and to a lesser extent the lumbar vertebrae. The joint between the skull and mandible, the temporomandibular joint (TMJ), was affected in only two men, more severely on the left in both cases. In the younger men, the degeneration of the limbs was slight and probably not symptomatic but it illustrates early onset of the process, so that hard physical labour was likely to be a contributor. In the older men the degeneration was widespread through both the spine and limbs and would have probably caused pain and stiffness.

In Groups 2 and 3 the representation of joints was very limited so no pattern was discernible. The joints present in any numbers were the TMJ in four individuals (Burials 13, 22.1, 41.1, 43), and incomplete cervical vertebrae in four individuals (Burials 8, 22.2, 35, and 41.1). The only significant degeneration was severe degeneration in the cervical vertebrae in Burials 22.2 and Burial 41.1, both old females. Burial 11.1, a female of unknown age, had fragmented thoracic and lumbar vertebrae with osteophytes.

The near absence of TMJ degeneration appears at odds with a recent assessment of DJD of the TMJ among Maori and Moriori samples that revealed a very high frequency (75.3%; n=67/89) (Latimer 2001). However, as eburnation was observed in only four of the 67 individuals in the series, most of the changes were slight.

The greater involvement of the upper limb in the Wairau Bar people found in this study may reflect activities involving strenuous use of the arms. The spines of early prehistoric Maori have previously been reported to show early and extreme degeneration (Sutton 1979, Houghton 1996). Observations on a Pacific Island skeletal series from Tonga have suggested similarly that degeneration of the cervical vertebrae reflect strenuous use of the arms particularly in males (Pietrusewsky 1969). DJD in the limbs and spine has been reported in other prehistoric New Zealand skeletal case studies, for example Waihora (Houghton 1976), Coromandel (Houghton 1977) and North Canterbury (Trotter 1975), although as Houghton (1996) points out, little attention has been paid to the systematic recording of DJD in the limbs.

As part of this project, data on the size of muscle and ligament insertions into the bone (entheses), known as 'musculoskeletal stress markers' (MSM) have been collected in all available material from the Wairau Bar to assess normal activity patterns. Coupled with the evidence of DJD and trauma in the sample, the enthesis data are likely to be more informative of activity patterns than the DJD data alone. This analysis will be published later.

Erosive arthritis. Other types of arthritis, such as rheumatoid arthritis and gout, create 'erosions' or holes in bone (Rogers *et al.* 1987). Erosive joint lesions were observed in the feet and/or hands of Burials 2.1, 2.2, 3, 4, 5 and 6, all the males from Group 1. The lesions are more pronounced in some than in others, but the pattern and type of bone change is consistent with gout as the cause. Gout is a disease caused by an inflammatory response to the accumulation of urate crystals that form in humans with an elevation of serum urate acid concentrations (hyperuricaemia) (Poor and Mituszova 2003) caused by inadequate renal urate excretion, excessive uric acid production, or a combination of the two. Clinical gout attacks may be precipitated by excessive consumption of purine rich foods (e.g. shellfish, liver, brains and kidneys) and alcohol (McLean 2003). The disease causes extreme pain in affected joints, commonly restricted to the metatarsophalangeal joint of the big toe. A high incidence of severe, chronic gout has been noted in some Polynesian populations, including Maori (Gibson *et al.* 1984).

Skeletal evidence of gout has been reported amongst the prehistoric Chamorro of Guam, Micronesia, with 5.6% of the skeletal sample affected (Rothschild & Heathcote 1995) and in a 3000 year old Lapita sample from Vanuatu (Buckley 2007). Anecdotal evidence of gout was reported in prehistoric New Zealand Maori (Houghton 1980), although later doubted (Houghton 1996).

Periosteal reactions of limb bones. A number of conditions, including infection, metabolic disease and trauma, can cause bone cells to respond by producing 'new bone' on the outer subperiosteal surfaces of the shaft (periosteal reactions) (Ortner 2003). Seven of the 17 (41.2%) burials with one or more limb bone present had periosteal reactions on one or more bone. Five of those affected were male (Burials 2.2, 3, 4, 5 and 6), comprising 62.5% (n=5/8) of the male sample and two of the females (Burials 16.1 and 20), comprising 28.6% (n=2/7) of the female sample. The apparent differences in prevalence of periosteal reactions between the sexes and the groups may be reflective of the better preservation of the postcranial elements in Group 1 rather than a real difference.

Four of the five affected males from Group 1 (Burials 2.2, 3, 4 and 5) also had periosteal reactions on their feet at the insertion points of muscles responsible for balance when walking and running over rough ground. The periosteal reactions are most likely an inflammatory response at the tendon insertion to some kind of repetitive strenuous activity causing microtrauma to the bone. The same kind of bone changes have also been observed in the Teouma Lapita people from Vanuatu (Buckley *et al.* 2008). Two individuals (Burials 5 and 6) also had new bone on the palmar aspect of the proximal phalanges of the hands, a lesion also observed in the Teouma sample. These bone changes to the hands and feet have not been reported in other Pacific Island groups.

Based on the limited data available and the type and pattern of lesions present, the cause of the periosteal reactions is most likely non-systemic infection or trauma rather than a chronic infectious disease such as the treponemal disease yaws observed in other Pacific Island skeletal series (e.g. Buckley & Tayles 2003). Yaws is, however, a disease of the tropics (Trembly 1996) so its presence would not be expected in temperate New Zealand. However, if treponemal disease was present in the Wairau Bar people lesions would be expected on the crania, as the most frequently present element of the collection, but none were observed.

Lesions of the thoracic cavity. Some infectious diseases, such as tuberculosis, brucellosis and other infectious diseases affecting the lungs, can cause bone cells to produce cavities or lytic lesions in the bone (Ortner 2003). These diseases cause a destructive cellular response inside the bone of the vertebral bodies, eventually leading to the collapse of the bone (Ortner 2003). Also as a response to inflammation in the lungs, pulmonary diseases can cause new bone to form on the inside or pleural aspect of the ribs (Santos and Roberts 2006). There are a number of individuals from Group 1 who have lesions of the spine and ribs suggestive of a pulmonary disease such as tuberculosis. Those with the most severe expression of lesions are Burials 3 and 4 with extensive destruction of a number of vertebral bodies (Figure 6, a & b). Burials 5 and 6 also have lytic lesions in one or more vertebrae. Burials 3 and 6 have new bone lesions on the pleural aspects of their ribs, lesions which are also attributed to pulmonary diseases (Santos & Roberts 2006) (Figure 7).

Abnormal pacchionian depressions. Houghton (1975) noted deep eroded areas on the internal aspect of the cranial bones in Burial 26, which he interpreted as due to the Histiocytosis-X group of diseases. However, we concluded that these depressions were due to postmortem damage rather than true lesions. We did however observe very deep pacchionian depressions in the parietals of four other people (Burials 25, 27, 28 and 40, two males, one female, one unknown, all from Group 3) and in two of the individuals the lesions have penetrated the outer table of

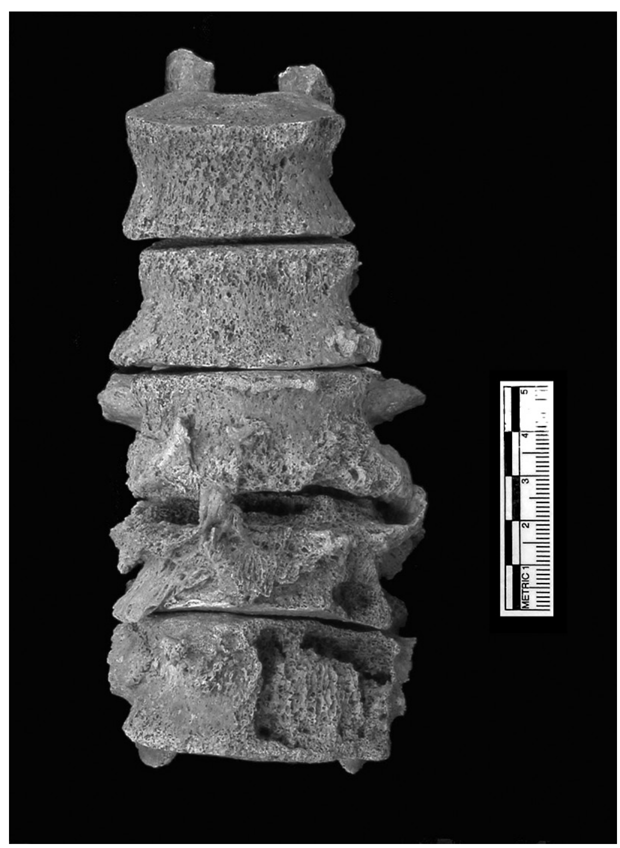

Figure 6a. Anterior view of lumbar vertebrae 1–5 in Burial 3 with destruction of the bodies in L4 and L5 and new bone formation on the margins of the joints.

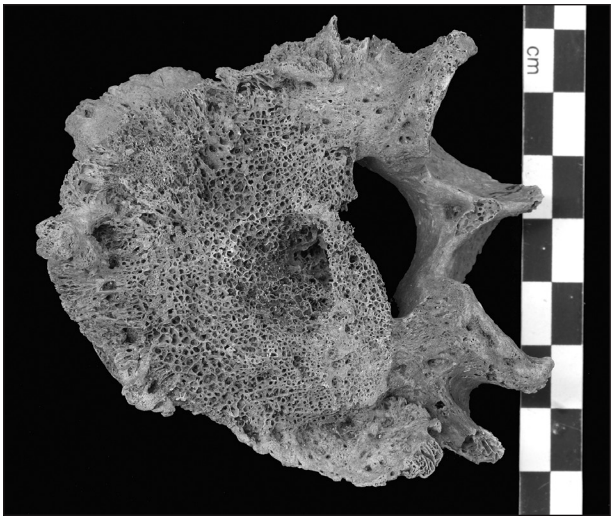

Figure 6b. Superior view of L3 showing the destruction of the subchondral bone and associated new bone formation.

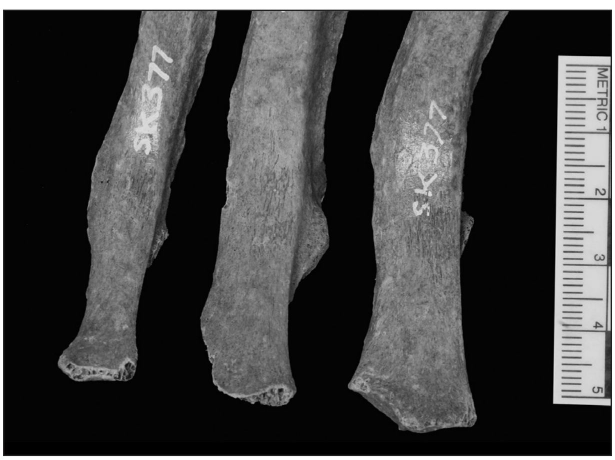

Figure 7. New bone formation of the pleural aspect of the left ribs in Burial 6.

the bone. Pacchionian depressions are associated with the accumulation of cerebrospinal fluid in granulations in the venus sinuses of the brain. These depressions are normal and usually increase with age but can become a focus for infection (Kaufman *et al*. 1997). The depressions in these four individuals appear abnormal and their cause is uncertain at this stage but may be related to infectious processes.

Tuberculosis? The destructive lesions of the vertebrae and new bone changes of the ribs as described above attest to a different story from the benign lesions of the limbs. Similar lesions have been reported in other Pacific Island samples (Pietrusewsky 1976; Trembly 1997; Buckley *et al.* 2008) and diagnoses of tuberculosis have been proposed (Snow 1974; Pietrusewsky 1976). However, there have been no cases of tuberculosis confirmed by aDNA analysis in any Pacific Island skeletal series.

In another report from prehistoric New Zealand, comprehensive destructive lesions of the spine were reported in an adolescent female from north Canterbury and diagnosed as metastatic lesions of a neuroblastoma of the adrenal gland (Trotter 1975, Houghton 1980). An individual from Opito Bay in eastern Coromandel was reported as having 'septic arthritis' of the knee and wrist in response to haematogenous osteomyelitis (Houghton 1977). Focal destruction of limb joints, such as these reported by Houghton (1977) may also be caused by tuberculosis.

Given that several Wairau Bar individuals have destructive lesions of the spine, the presence of abnormal lytic lesions (pacchionian depressions) in the sample and the extreme rarity of carcinoma (malignant cancer) in skeletal series (Ortner 2003), an infectious cause for the lesions in the sample is more likely than cancer. An infectious disease, such as tuberculosis may also have caused the destructive lesions in the girl from Canterbury and the male from Opito Bay.

The possible presence of the lethally infectious tuberculosis in this early group offers a tantalizing glimpse of the possible antiquity of a disease in New Zealand that is often assumed to have been introduced by Europeans. A diagnosis of tuberculosis in any of these cases cannot be confirmed without aDNA identification of the bacterium. The use of aDNA to confirm tuberculosis in a skeletal sample has been claimed to be successful in Europe and the Americas (Roberts & Buikstra 2003) and will be attempted on this sample. However, regardless of the specific infectious aetiology of the lesions of the thoracic cavity, the Wairau Bar community was coping with a previously unreported disease which caused significant bony change, probably affecting their quality of life and mortality.

Trauma. Healed fractures were observed in the hand bones of two of the *koiwi* from Group 1, burials: 2.1 and 3. Burial 3 also had a possible fracture of one of his left ribs in the mid-back region. The fracture in the hand of Burial 3 is commonly associated with punching a hard object, the so-called 'boxer's fracture' (Hershkovitz 1996) or it may have been accidental (Lovell 1997) (Figure 8). There were no healed fractures observed in the other two groups, although this is not surprising given the lack of postcranial elements. Houghton (1975) reported the presence of *os odontoideum* in Burial 28, which is where the dens of the second cervical vertebra is separate from the rest of the bone. We also observed this in B28 and agree with Houghton's interpretation of a traumatic origin for the condition, probably occurring in childhood.

One individual (B40, male) had a probable perimortem injury to the right side of the skull. The presence of a perimortem lesion is distinguished from post-mortem damage to the bone by an internal bevelling of the bone break, bone peeling, defined edges created by the object causing the hole and the colour of the edges of the break (Ortner 2003). The traumatic lesion of B40 had all of the

Figure 8. Right 5th metacarpal (on the left in the photo) of the hand showing fracture of the shaft (Burial 3). The normal left 5th metacarpal is included for comparison (on the right in the photo).

characteristics consistent with a catastrophic traumatic event and as there was no sign of remodelling, it was probably fatal (Figure 9, a & b).

Occasionally, evidence of perimortem trauma has been reported in other prehistoric Maori. For example Houghton (1977) describes a large horizontal fracture on the right side of the back of the cranium in a young woman from Opito Bay, eastern Coromandel. The injury was clearly fatal and probably caused by a blow from a *patu,* a short handled club (Davidson 1987). Fatal piercing wounds have also been described in three individuals from Palliser Bay (Sutton 1979).

DISH. Burials 2.1, 4, 5 and 6 had fusion of the sacroiliac joint (Figure 10), which is caused by a bridge of bone forming through the ligament and other joint soft tissues turning into bone (ossifying). Burial 4 also had ossification of the posterior longitudinal ligament on the left side of at least two anterior vertebral bodies (Figure 11). Numerous sites of ossification of muscle and ligament insertions in the limbs of Burial 4 were also observed. This pattern of ossification of the sacroiliac joint, the left side of the vertebral bodies, and limbs is characteristic of a condition called Diffuse Idiopathic Skeletal Hyperostosis (DISH) (Rogers *et al.* 1987). Associated with DISH is a 'metabolic syndrome', a genetically regulated condition associated with gout and diabetes in modern populations (Ortner 2003; Oxenham *et al.* 2006). DISH is usually asymptomatic but has been associated with joint and muscle pain in modern populations (Rogers *et al.* 1987).

External Auditory Exostoses (EAE). Another bony change observed is the development of bony protrusions in the

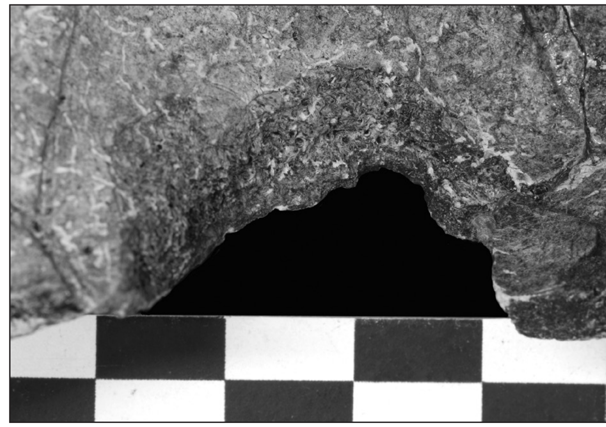

Figure 9a. Internal aspect of the parietal bone of Burial 40 showing probable perimortem injury with internal bevelling and bone peeling.

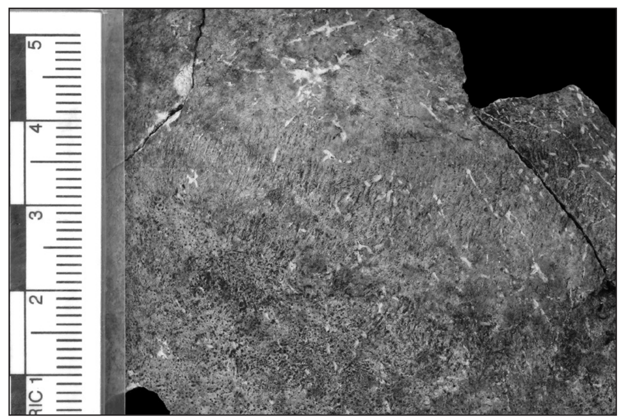

Figure 9b. External view of probable perimortem injury. Note the circular shaped defect at the apex of the injury, possibly reflecting the shape of the object used to cause the injury.

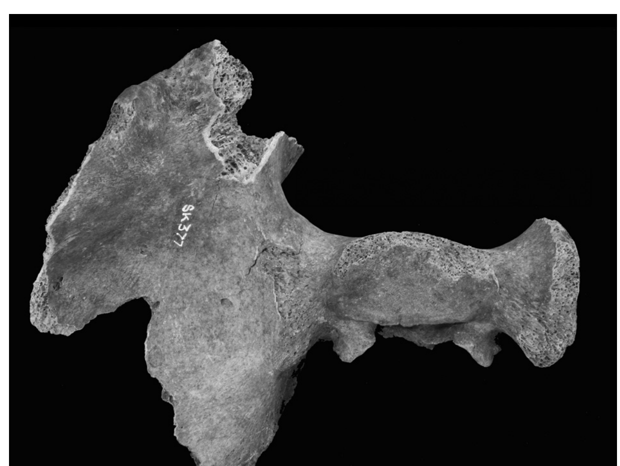

Figure 10. The left sacroiliac joint (joint between the ilium and the sacrum of the pelvis) that has fused (Burial 6).

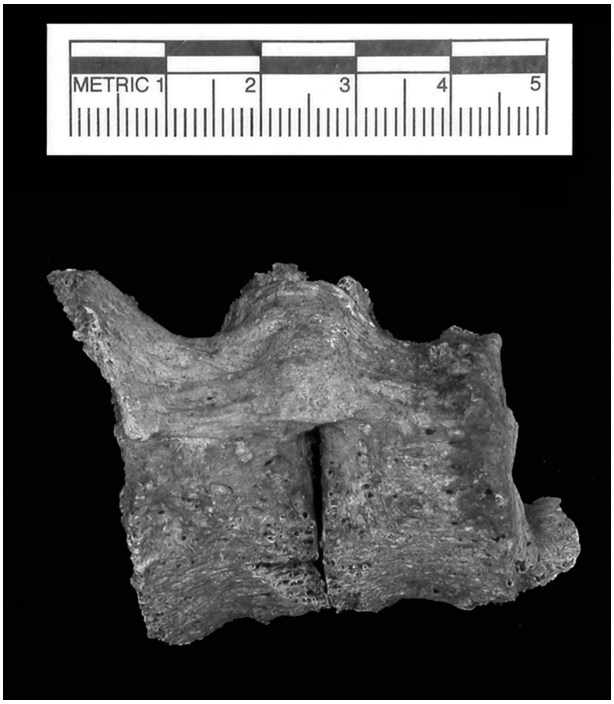

Figure 11. Two thoracic vertebral bodies with ossification of the posterior longitudinal ligament (Burial 4).

auditory canals of Burials 2.1 and 4, often associated with coastal and island populations who engage in swimming and diving in cold waters on a regular basis (Okumura *et al.* 2007). It is interesting that EAE were not observed in any from Groups 2 and 3, which may suggest the males from Group 1 engaged in more aquatic activities than others in the sample. This difference is unlikely to be due to a lack of the appropriate cranial material in Groups 2 and 3, as the temporal is one of the bones more frequently present in the collection. These changes have been reported in a number of Pacific Island skeletal series (Houghton 1996) including the Wairau Bar (Katayama 1988). Katayama (1988) reported a prevalence of EAE of 42.3% (n=11/26) in the Wairau Bar sample, with males more affected than females (50% versus 35.7%). Katayama (1988: 65) does not provide the criteria he used to identify these lesions except to say that they 'denote all discrete bony auditory lesions, small or large' nor does he provide photos of examples of the lesion. It is therefore assumed that his relatively high assessment of the frequency of the condition reflects a lower size threshold than ours for identification of the lesions.

Oral Pathology

It is generally assumed that the nature and pattern of dental disease varies because of differences in the effects of diet, but there are numerous other factors involved including oral bacteria, salivary pH, tooth form and occlusion, the use of teeth as a 'third hand' and even dental hygiene (although this is unlikely to have been practised at Wairau Bar) (Milner & Larsen 1991; Hillson 1996).

The first step in the analysis of the Wairau Bar dentitions was to record a census of the teeth and associated supporting bone present. This provided the sample size and identified one of the disease indicators, the loss of teeth during life (antemortem loss). To identify other aspects of dental disease, a series of indicators was recorded, including the amount of wear on the occlusal surfaces of the teeth, the condition of the supporting bone (periodontal health), any evidence of inflammation and/or infection, and any evidence of dental decay in the form of caries. Wear on the occlusal surfaces was recorded using the standards in Buikstra & Ubelaker (1994). Periodontal disease was identified by the location and severity of porosity and resorption around the teeth. Inflammation or infection (often incorrectly identified as abscessing (Dias & Tayles 1997)) was identified by the presence of discrete cavities in the bone, either on the crest surrounding the tooth (periodontal in origin) or around the apex of the tooth root, which indicates the lesion is a result of infection of the tooth. Caries is identified by the presence of a discrete hole in the enamel of the tooth. The teeth were examined using a dental explorer under good light, using the naked eye or with slight magnification. Prevalence of each condition is reported using both individuals and teeth as the units of analysis.

Twenty-seven individuals had sufficient teeth and/or supporting bone to have an assessment made of their oral health. Only ten had most or all of their teeth present, with jaws either damaged so the bone and teeth were partly missing, or the teeth having fallen from their sockets post mortem. There were more females (16 individuals) than men (n=9) in this subsample, and two had no estimate of sex. More than half were young adults (between 20 and 34 years), and one third were relatively 'old' adults.

The pattern of oral health (Table 6) is that teeth were worn down rapidly, probably from the inclusion of fibrous foods or the inadequate cleaning of grit from shellfish or vegetable foods. The oldest people had their teeth worn to an extreme where only the roots remained (Figure 12). This is particularly shown in the larger group of older women, where the range of wear in both anterior and posterior teeth reaches the upper limit of the grading scale. The apparently anomalous lower limit to the range of wear in this group is a reflection of early loss of opposing teeth. The rapidity of wear is well-illustrated in those who died as young adults, where first molars, which erupt at around the age of six years, were considerably worn before the third molars (wisdom teeth) completed eruption in late adolescence or early adulthood (Figure 13). The so-called 'fern-root plane' is not present in the Wairau Bar teeth. This is where the buccal (cheek) aspects of the molar teeth were so worn as to dislocate the tooth from its socket, possibly as a consequence of the chewing of bracken fern

Table 6. *Dental conditions of the Wairau Bar koiwi by sex and age.*

	Wear* (mean/range)		Periodontal disease		Inflammation/ infection		Antemortem loss		Caries	
Males	Anterior	Posterior	Teeth	Indiv.	Teeth	Indiv.	Teeth	Indiv.	Teeth	Indiv.
Young	3.10/2–6	12.44/4–21	121/123	6/6	2/153	1/6	2/156	1/6	6/124	1/6
Mid	6.05/5–7	26.25/19–35	35/35	2/2	9/36	2/2	3/49	1/2	0/38	0/2
Old	4.00/4	20.00/20	17/17	2/2	5/5	2/2	21/49	3/3	0/2	0/1
Total males			173/175	10/10	16/196	5/10	26/254	5/11	6/164	1/9
Females										
Young	2.91/1–5	11.98/0–22	80/93	8/8	4/139	2/7	0/200	0/8	0/122	0/8
Mid	6.07/5–7	24.10/16–36	47/47	2/2	8/55	2/2	2/62	1/2	3/39	2/2
Old	6.97/3–8	27.60/12–40	66/66	6/6	26/78	5/6	26/144	5/6	10/74	2/6
Total females			193/206	16/16	38/272	9/15	28/406	6/16	13/235	4/16
Unknown sex										
Young	2.60/1–4	9.75/0–20	5/6	1/1	0/2	0/1	0/52	0/2	1/35	1/2

* wear scale anterior 0–8, posterior 0–40.

Figure 12. Mandible showing severe tooth wear in an old female where only the roots remain (Burial 8).

Figure 13. Left mandible showing the rapidity of tooth wear in a young adult (Burial 6). The 1st molars, which erupt at around the age of six years, were considerably worn before late adolescence, or early adulthood, when the 3rd molars erupt.

(Taylor 1963, Simpson 1981). Nonetheless, the wear on the young adults at Wairau Bar is considerable and by old age the teeth were worn down to the roots.

Such rapid wear had the potential to ultimately wear away the occlusal surface, and expose the so-called 'pulp cavity', to bacteria so that it became infected resulting in abscess or death of the nerve, and usually loss of the tooth. Along with the rapid tooth wear, most of the people in the group suffered from periodontal disease, again from a very early age. This involves the build-up of calcified dental plaque (calculus) around the tooth and consequent damage to the gingiva (gums) and ultimately to the bone supporting the teeth (Hillson 1996). Poor periodontal health would have progressed with age and led to reduction in the amount of bone supporting the teeth, inflammation, infection or abscessing or loss of the tooth (Figure 14). Four individuals, all young males (B2.1, 6, 19, 36) had crowded teeth (Figure 15), creating an environment where periodontal disease was able to flourish. The data in Table 6 show that inflammation and/or infection, either from dental wear or periodontal disease, began from an early age in both sexes, with the consequence that the oldest people in the group had all lost a number of teeth during life.

This rather unhealthy picture is somewhat counterbalanced by the low proportion of individuals with dental caries (decay of the teeth) which is concentrated in a few individuals, particularly two older women (B8, B30). Most of these were small interproximal crown caries, although one tooth crown had been destroyed. Only one man had caries, a young individual from Group 1 (B6) with interproximal caries. This higher caries rate in women is com-

Figure 14. Loss of bone and teeth, and abscessing in an old female (Burial 8).

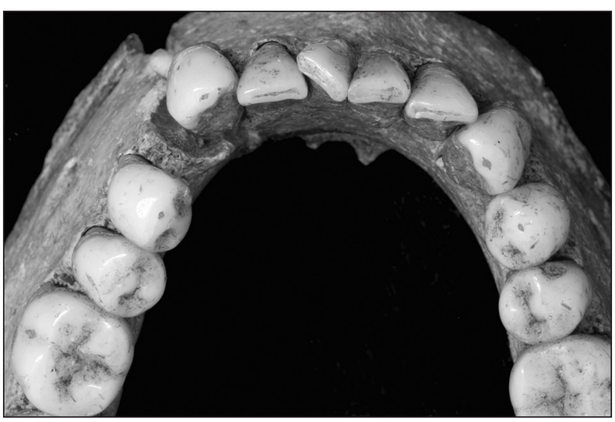

Figure 15. Crowded incisors (Burial 2.1).

mon in prehistoric and historic populations worldwide, possibly as a consequence of hormonal effects on the oral environment in women (Lukacs 2008). A number of individuals (3 males, 4 females) had chips broken from their teeth during life, no doubt a consequence of biting hard objects such as small stones accidently mixed in with food or from using teeth to bite on seeds or nuts, or using teeth as 'tools'.

DISCUSSION

Houghton (1975: 238) described the people from Wairau bar as;

> …a tall, muscular people of Polynesian origin, living a vigorous physical life. Their diet was nutritionally adequate, and apparently softer and less abrasive than that of most other prehistoric New Zealand populations. Those surviving to adult life suffered few childhood illnesses, but their life-span was still, by modern standards, short, and comparable to that of similar populations elsewhere in prehistory.

Our re-evaluation of health and disease has produced new evidence about their quality of life; new evidence of childhood stress, but without consequences for the attainment of a tall adult height, about the possible presence of specific infectious diseases, and about the dental evidence of diet. Our estimates of age at death and sex differ in some respects from those of Houghton (1975) and we suggest a longer life expectancy than he proposed. Our assessment of sex shows an imbalance in favour of females, along with age at death estimates showing more died young and old than mid-aged. We do not support the idea that life was necessarily 'short' but as age estimates are based largely on dental wear the risk of circularity means definitive assessment is not valid, as Houghton (1975: 231–232) rightly points out. We did not make age estimates in specific years because of this uncertainty, which applies to all age estimates from skeletal remains, regardless of era or origin.

Our evidence of childhood stress disclosed by dentition shows that growth disruption was common during early childhood and that both sexes were affected, although the frequency of defects differs between the sexes, implying either a different response or a different aetiology. In either case, there are hints of differential stresses suffered by boys and girls. As Harris lines require the presence of postcranial bones the assessment is restricted to males in Group 1 but the prevalence is consistent with the dental evidence for childhood stress in this subsample. The third non-specific stress indicator, anaemia, suggests there may have been restricted access to protein rich foods for some children, resulting in iron-deficiency anaemia in both sexes. Despite this evidence of stress during childhood, adult height was unaffected, with the males being among the tallest in the Polynesian skeletal series and the single female within the Polynesian range. This argues for relief from early stresses, whether dietary or illness, allowing for adequate catch-up growth during the adolescent growth spurt.

Evidence from degenerative joint disease is limited by the low representation of postcranial bones, particularly for females, but it suggests a vigorous active life with greater use of the upper limbs.

Beyond joint degeneration, there is also evidence of other types of pathology in the form of infectious disease taking a toll on the Wairau Bar people. The possible occurrence of attacks of gout lends support to a genetic rather than a purely lifestyle source of this disease in modern Maori. The possible presence of the lethal infectious disease of tuberculosis in this early group may offer an insight into the antiquity of a disease in New Zealand often assumed to have been introduced by Europeans.

The dental health of the people buried at the Wairau Bar suggests a diet that was not so abrasive as that found in later prehistory (Houghton 1978) or elsewhere in New Zealand, such as in Palliser Bay, but it would have caused them discomfort and, with older age, pain and difficulty with mastication as teeth were lost. It could have contributed to deteriorating systemic health.

Diet and health in early New Zealand prehistoric people

Possible causes of childhood stressors include an inadequate diet during growth and/or infectious or metabolic disease, including parasitic infestation. Recent studies have suggested a multi-factorial cause for iron-deficiency anaemia in past populations, with an emphasis more on parasitic infestations rather than diet, particularly among coastal or island dwellers exploiting marine resources (Walker 1986; Buckley 2000; Buckley 2006).

The 'Archaic' period in New Zealand prehistory is characterised by coastal settlements based on exploitation of megafauna such as fur seals (Anderson 1989, Smith 2005) and in the eastern South Island, moa (Anderson 1989, Walter *et al.* 2006). After the rapid anthropogenic extinction of megafauna (Holdaway & Jacomb 2000), populations dwindled for a time in the south as the emphasis moved to horticultural subsistence in the north (Walter *et al.* 2006). At Wairau Bar there is evidence of heavy exploitation of megafauna, including moa and seals (Anderson 1989). There is no direct evidence of horticulture at Wairau Bar but it is likely that it contributed to the diet (Walter 2004: 138) because Polynesian cultigens were grown in the northern South Island (Barber 2004: 177–185). Access to meat protein and therefore iron should not have been restricted for these people, arguing against a purely ecological cause of the anaemia and other stress observed in the population.

Questions of the role of diet versus infection in childhood stressors among the Wairau Bar people, as with any study of this nature, cannot be resolved from the macroscopic observations alone. The dietary isotope analyses being conducted on all individuals as part of this project will be important for understanding the diet of the population as a whole. From the perspective of health the isotope data will have the potential to clarify the role of diet in childhood disease at the Wairau Bar. Analyses of the isotopes in teeth can provide a direct picture of the types of foods being consumed during childhood and inform on social differences in access to foods (Kinaston *et al.* 2009, Müldner & Richards 2005; Valentin *et al.* 2006).

The pattern of significant tooth wear and poor periodontal health suggests that the diet of the Wairau Bar people was fibrous and/or gritty. The lack of evidence of the fern-root plane in the Wairau Bar dentitions is consistent with Simpson's (1981) finding that this characteristic wear was not common in regions either side of Cook Strait. A relative lack of dental decay is characteristic of prehistoric populations, where the diet contained few cariogenic foods such as sugary carbohydrates, although tooth decay is not caused only by dietary composition. Frequency of exposure to naturally-occurring fluoride is one of many other possible factors (Fejerskov 2004). Greater dental wear in Palliser Bay adults than in the Wairau Bar individuals, has been used to support an argument of a change in diet (Sutton 1979), but our assessment of the Wairau Bar material suggests that the diet was more abrasive than previously thought.

Differential health in the Burial groups of Wairau Bar?

Differences in the preservation of bones led Duff (1977: 36), initially, to interpret the site as having been occupied for some centuries with Groups 2 and 3 having been buried much later than Group 1. He later reconsidered and discarded the possibility that the poorer burials in the southern *uruupa* were from later in the 'moa-hunter' period than Group 1 (Duff 1977: 61). Anderson (1989) suggested on the basis of stratigraphy that Group 1 might be earlier than the rest of the burials, indeed even the earliest in New Zealand (Anderson 1991). The brevity of activity at the site suggested by Higham *et al.* (1999) argues against much time depth to the burials. An alternative explanation for the differences in the groups, also advanced by Duff (1977: 61) was that the relative wealth of the Group 1 graves represented a status difference with this area being 'the exclusive resting place of men of superior rank' and the other Groups in a 'common burial ground'. Whether these differences reflect status or a chronological difference awaits further evidence.

Regardless of site chronology our data show a difference in health between the groups. Childhood stress as evidenced by anaemia differentially affects Group 3 although the evidence from dental defects suggests a sex difference in type of stress rather than a Group difference. Despite this, oral health data suggests a difference in diet between the Groups with the males from Group 1 consuming a diet which led to early onset of periodontal disease while those from Group 3 were eating foods causing more rapid wear of their anterior teeth. Taken together, the dental conditions suggest dietary differences between Groups 1 and 3 for the males at least. Other differences between the groups are the prevalence of external auditory exostoses only in Group 1, perhaps suggesting a more aquatic lifestyle, and the presence of abnormal pacchionian depressions only in Group 3, suggesting that the infectious disease (possibly tuberculosis) evident on the postcranial skeletons of Group 1 could well have extended beyond this Group. At the risk of labouring the point, it is important to remember that detailed analysis of health is limited by the differential representation of skeletons among the groups, meaning that the differences identified here cannot be read as conclusive.

CONCLUSIONS

The Wairau Bar *koiwi* represent one of the few examples of an early group within the colonisation era of a Pacific Island or indeed more widely on a global scale. The bones reveal evidence of the rigours faced by an early prehistoric community, with poor oral health and degenerative joint disease attesting to the vigorous lifestyle needed to survive in this temperate part of Polynesia. While these macroscopic findings might paint a gloomy picture of the quality of life of this early Maori community it must be remembered that all of these parameters of health and disease attest to the Wairau Bar people as survivors of the stress during childhood and living active, mostly healthy lives. In the context of other studies on human skeletal remains from New Zealand, these new data have changed the picture of how the Wairau Bar people fit into perceived changes in population health from early to later periods of New Zealand prehistory (Sutton 1979, Houghton 1996).

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