



## Bite force and state of dentition

Eva Helkimo, Gunnar E. Carlsson & Martti Helkimo

To cite this article: Eva Helkimo, Gunnar E. Carlsson & Martti Helkimo (1977) Bite force and state of dentition, Acta Odontologica Scandinavica, 35:6, 297-303, DOI: [10.3109/00016357709064128](https://doi.org/10.3109/00016357709064128)

To link to this article: <http://dx.doi.org/10.3109/00016357709064128>



Published online: 02 Jul 2009.



Submit your article to this journal [↗](#)



Article views: 224



View related articles [↗](#)



Citing articles: 18 View citing articles [↗](#)

# Bite force and state of dentition

EVA HELKIMO, GUNNAR E. CARLSSON & MARTTI HELKIMO

Department of Stomatognathic Physiology, Universities of Gothenburg and Umeå, Sweden

Helkimo, E., Carlsson, G.E. & Helkimo, M. Bite force and state of dentition. *Acta Odont. Scand.* 35, 297–303.

The maximal bite force and the strength of the finger-thumb grip of 125 Skolt Lapps, aged 15 to 65, was measured with a specially devised apparatus. The bite force was measured with the biting fork placed between the first molars and between the incisors, respectively. The finger-thumb grip was measured by letting the subject press the prongs of the fork between the thumb and forefinger of each hand as hard as possible. The range of inter-individual variation of the maximal bite force and finger-thumb grip was great. The mean values were higher for the males than for the females. In the males the maximal bite force thus measured in the molar region was 39 kg (382 N) and 18 kg (176 N) in the incisor region. The corresponding values for the females were 22 kg (216 N) and 11 kg (108 N). The finger-thumb grip strength for males was, on the average, 10 kg (98 N); that of the females, 7 kg (69 N). The average difference in bite force between the men and the women was larger in the group with natural teeth than in the one with complete dentures. The values found for the bite force decreased with increasing age, especially for the females. Most of this reduction with increasing age was probably due to the age-dependent deterioration of the dentition. In both sexes the bite force was notably smaller among the denture wearers than among the dentate persons. The number of natural teeth varied closely with the bite force, *i.e.* the greater number of natural teeth the greater the bite force.

*Key-words:* Masticatory muscles; mastication; physiology

*Eva Helkimo, Department of Stomatognathic Physiology, Faculty of Odontology, University of Gothenburg, Fack, S-400 33 Gothenburg 33, Sweden*

Interest in the strength of the masticatory musculature dates back to the 17th century. In the 20th century the force exerted during biting and chewing has been studied with various types of so called gnathodynamometers and since the 1950-ies electronic equipment has been used, in recent years including telemetric techniques (*De Boever, 1975*). Parameters such as sex, age, state of the dentition, training, bruxism, general muscular strength and various anthropometric dimensions have proved to be correlated with bite force, but the correlations are not strong or obvious (for surveys see

*Carlsson, 1974; Bates, Stafford & Harrison, 1975, 1976*). Correlation between bite force and such factors as chewing efficiency, general state of health and nutritional status does not seem to have been the subject of systematic investigation. Bite force in patients with symptoms of dysfunction of the masticatory system is lower than in healthy persons (*Molin, 1972*), and increases as the symptoms disappear (*Helkimo, Carlsson & Carmeli, 1975*). The present investigation of maximal bite force was performed on a group of Lapps in the north of Finland. The individuals selected were also subjected to a

---

Received for publication August 25, 1976

number of other medical and odontological examinations included in a large international research project (*Lewin & Hedegård, 1971*), which will permit comparative analyses of many variables.

The aim of the present investigation was to devise a simple method for measuring bite force for use in field studies, and secondly, to elucidate the relation between bite force and sex, age, the state of the dentition, the functional state of the masticatory system and general muscle strength as judged from the strength of the finger-thumb grip.

#### MATERIAL AND METHOD

The maximal bite force was recorded in 125 Skolt Lapps (68 females and 57 males), aged 15 to 65 (Table I). The mean age was 32.6 years. The distribution was not even, 41% being between the ages of 15 and 24, and only 24% above 44 years. The state of the dentition and the function of the masticatory system were examined according to methods described elsewhere (*Helkimo, 1974a, b*).

The bite force was measured with a specially designed apparatus provided with strain gauge attached to metal beams united into forks, on which the patient was requested to bite (Fig. 1). The force applied to the forks was recorded by a writer (Speedomax Recorder, Leeds & Northrup). One of the forks could record pressures to 25 kg, the other to 100 kg. (In this paper force values are given in kg – the recommended unit Newton 1 N = 0.102 kg). The biting surfaces of the forks were coated with self-curing acrylic resin, 2 mm thick, and a covering of thin rubber before use. The thickness was 6.9 mm for the 100 kg fork and 7.4 mm for the 25 kg fork when unloaded; 4.6 and 4.5 mm respectively, when fully loaded. The apparatus has been described previously (*Carlsson, Helkimo & Helkimo, 1971; Helkimo, Carlsson & Carmeli, 1975*).

The equipment was calibrated with known

Table I. Age and sex distribution of the material

Age (years)	Men	Women	Total
15–24	27	24	51
25–34	5	17	22
35–44	9	13	22
45–54	8	8	16
55–65	8	6	14
Total	57	68	125

loads and a linear relation between the load and the deflexion on the writer was obtained.

The apparatus was used for measuring the maximal bite force in the area of the first molars and the incisors. When the molars were missing, the recordings were made in the area of the premolars or the canines.

The fact that not all candidates could be examined owing to the state of the teeth and hands explains the differences between the numbers of persons examined with the various tests. Notation was always made of the pair of teeth used for measuring the bite force. The biting fork was placed and held in the actual area of the mouth by the investigator and the test persons were requested to bite as hard as they could on the fork. The same apparatus was used for measuring the maximal strength of finger-thumb grip of each hand. The candidates were asked to press the prongs of the fork between their thumb and forefinger on each hand as hard as possible (Fig. 2). The fork was held by the investigator while the test person was pressing. The series of registrations of bite and finger force were repeated after a pause of 2 minutes. For test persons with good teeth the 100 kg fork was used. For those with dentures the 25 kg fork was used. With 26 candidates both forks were used to permit methodological analyses. The highest measured value of the registrations for bite and finger force was used for the analyses.

#### Statistical methods

For calculating the mean value ( $\bar{x}$ ), standard deviation (S.D.), standard error of the mean

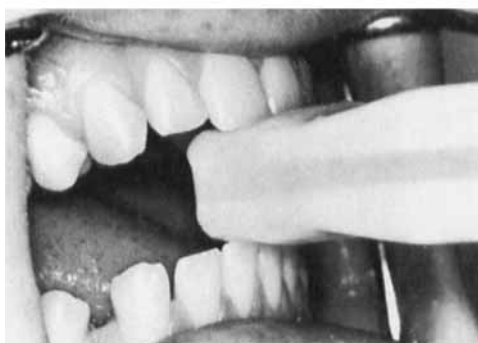
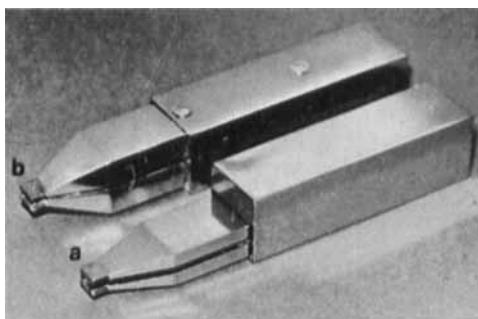


Fig. 1. A. Biting forks for maximal recording of 25 kg (a) and 100 kg (b).  
B. Biting with 25 kg fork on incisors.

(S.E.) and the coefficient of correlation ( $r$ ) conventional methods were used. For the statistical analyses of repeated recordings the Student's  $t$ -test was used. In comparisons between groups, sexes, ages and dental state the Mann-Whitney  $U$ -test was used (Siegel, 1956).

## RESULTS

### *Reproducibility of the method*

There was no statistically significant differences between the first and the repeated recordings with respect to the bite force and finger force. The correlations between the first and the second recordings were statistically significant ( $p < 0.001$ ) (Table II).



Fig. 2. Measurement of finger-thumb grip with 25 kg fork.

Comparison between recordings made with the two forks in the same individuals showed no significant differences (Table III).

The correlations between the results obtained with the two forks were lower than those for repeated registrations with the same fork, but still significant. For finger-thumb grip there was no difference between the means of the recordings with the two forks. The correlations between the two forks were of the same magnitude as for double determinations with the same fork (Table II and III). Of the 26 persons tested with both the 25 and the 100 kg fork the bite force between the molars was greater than 25 kg in more than 50% of the registrations, thus no comparisons between the forks were made of the bite force between the molars.

### *Recording of maximal force*

The inter-individual range of variation of the recordings of the maximal bite force and of the finger-thumb grip strength was great. For example, the range was 10 to 73 kg for maximal bite force between natural molars, 1 to 44 kg between incisors and 4 to 21 kg for the finger-thumb grip. No significant difference was found for the mean values of bite force between teeth on the right side and the left. The tables therefore give only the recordings for the right side and those between the incisors. The values noted at the incisors were significantly lower than those at the molars.

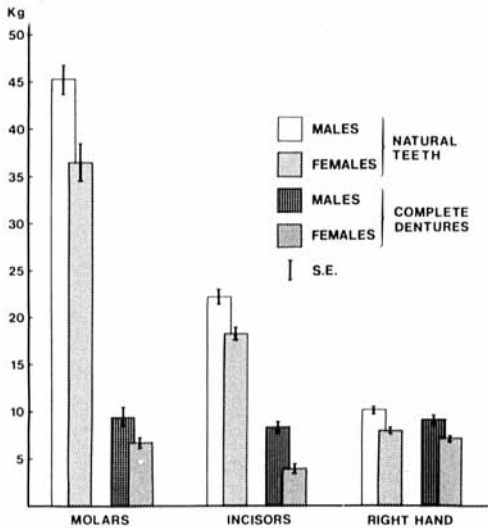


Fig. 3. Maximal bite force and finger-thumb grip according to sex and dental status (means and standard errors).

The value found for finger-thumb grip was significantly higher for the right hand ( $p < 0.05$ ).

A comparison of the means of the bite force and finger-thumb grip strength showed that the values were higher throughout for the males. In comparison with the entire material the differences were significant (Table IV). The same tendency was found among complete denture wearers but the differences were not significant for the bite force in the molar region (Fig. 3). The bite force decreased with increasing age, especially in the females (Fig. 4). The finger-thumb grip strength, however, varied only slightly with age.

The variation of the bite force with dental state is obvious from Figs. 3 and 5. The bite force was substantially lower for complete denture wearers than for persons with natural teeth. Young persons with natural teeth had a maximal value of bite force which was 4 to 5 times higher than that of the denture wearers.

The bite force was smaller when the fork was placed in a more anterior part of the mouth. The average values for the whole material were 30 kg for the molars, 19 for the

premolars, 15 for the canines and 14 for the incisors. These differences were small in denture wearers (Fig. 5).

## DISCUSSION

Maximal bite force depends not only on muscle strength, but also on other factors, such as dental and periodontal lesions and the measuring apparatus used (Jenkins, 1966). Psychological factors have been shown to be capable of influencing the recordings (Marklund & Wennström, 1972). This influence can, however, be reduced by the use of submaximal levels and of psychophysical methods (Wennström, 1971a,b; Wennström, 1972; Marklund & Molin, 1972; Molin, 1972; Helkimo et al., 1975).

The apparatus used in the present investigation has also been employed in other studies (Helkimo et al., 1975; Lundgren et al., 1975), and in principle and type it resembles that described by Linderholm & Wennström (1970) which has been used in various Swedish studies in recent years. Therefore, comparisons between maximal values measured with the two apparatuses should be possible, though with due caution. It is then obvious that the Skolt population does not correspond to the popular concept that people living in the periphery of civilization can exert extremely great bite forces, with Eskimos often mentioned as an example (Jenkins, 1966). The explanation is probably first of all differences in the state of the dentition that in general was poor in the Lapp population (Lewin, Hedegård & Kirveskari, 1971).

The correlations found between values recorded on repeated occasions were strong to very strong, which shows that the method is reliable. Laboratory studies with varying loads showed a high degree of accuracy and precision of the apparatus.

However, the differences that occurred showed that the recordings of the bite force were not quite reproducible. This may be due

Table II. Correlation coefficients,  $r_{1,11}$  for the association between repeated registrations of maximal bite and the strength of the finger-thumb grip;  $n$  denotes the number of subjects recorded with the two forks used (25 and 100 kg, resp. 1 kg = 9.8 N)

Fork		Bite force			Finger-thumb grip	
		right side	incisors	left side	right hand	left hand
25 kg	$n$	60	65	58	66	66
	$r_{1,11}$	0.92	0.95	0.94	0.84	0.79
100 kg	$n$	54	52	54	56	54
	$r_{1,11}$	0.84	0.83	0.88	0.83	0.94

Table III. Means,  $\bar{x}$ , and standard deviations,  $S.D.$ , for maximal bite force and finger-thumb grip registration with two bite forks in 26 persons who were tested twice.  $r_{25,100}$  denotes the correlation coefficient for the association between the registrations with the two forks

	25 kg fork		100 kg fork		$r_{25,100}$
	$\bar{x}$	$S.D.$	$\bar{x}$	$S.D.$	
Bite force (incisors)	14.2	3.1	15.7	2.0	0.64
Finger force (right hand)	7.5	5.1	7.5	2.0	0.89

Table IV. Means,  $\bar{x}$ , and standard deviations,  $S.D.$ , of maximal bite force and finger-thumb grip measurements in kg for males and females with natural teeth

	Bite force						Finger-thumb grip		
	Right molars			Incisors			Right hand		
	$n$	$\bar{x}$	$S.D.$	$n$	$\bar{x}$	$S.D.$	$n$	$\bar{x}$	$S.D.$
Male	28	45.3	16.0	44	19.3	7.3	42	9.5	2.4
Female	16	36.4	16.2	34	15.7	5.6	34	7.3	2.6

to biologic and psychologic factors. The correlations between the determinations with the two forks used in the present investigation were not so close as between repeated determinations with one and the same fork, which shows that the construction of the recording apparatus is important in the measurement of the bite force. In this respect the recording of the finger-thumb grip did not seem to be so critical; Table III. Though the two forks used in the present investigation were similar the sensation when biting the 25 kg fork obviously differed from that of biting the 100 kg fork. Among other things, the 25 kg fork was more delicate and «softer» to bite in than the 100 kg fork. With maximal

loading the decrease in distance between the two prongs was 2.3 mm for the 100 kg fork and 2.9 mm for the 25 kg fork. Thus extreme caution must be exercised when comparing the results reported by different authors unless the same apparatus is used. The small difference between the two forks in recording the bite force has probably not influenced the main results of the present study.

Closer analysis revealed that various factors can influence the recording of the maximal bite force. Differences occur between the sexes, between different age groups, between denture wearers and persons with natural teeth, between different parts of the dental arch, between persons with and

without clinical symptoms of dysfunction. In these respects the results in the present investigation agree with those on record. The reduction in bite force with increasing age is evidently due to an age-dependent factor, *viz* deterioration of the dentition, which is very rapid after the age of 20 years in Skolt Lapps (Lewin *et al.*, 1971; Hansson, 1973; Helkimo, 1974a). As for gross muscular strength, it probably varied but little between the age groups in the present investigation (Hettinger, 1964). The finger-thumb grip strength also varied but little with age. The substantially lower bite force found in complete denture wearers than in others confirms earlier results and strengthens the impression that loss of all natural teeth implies an oral handicap that can be only partly compensated by removable prostheses (Wennström, 1972; Wennström, Marklund & Eriksson, 1972; Haraldson, Karlsson & Carlsson, 1977).

## REFERENCES

- Bates, J.F., Stafford, G.D. & Harrison, A. 1975, 1976. Masticatory function – a review of the literature. Part II and III. *J. Oral Rehab.* 2, 349–361; 3, 57–67
- De Boever, J. 1975. Radiotelmétrische en elektromyografische studie van de functionele occlusale krachten. Thesis University of Gent
- Carlsson, G.E. 1974. Bite force and chewing efficiency. In: *Frontiers of oral physiol.* (Ed.: Y. Kawamura) Karger, Basel 1, 265–292
- Carlsson, G.E., Helkimo, E. & Helkimo, M. 1971. Bite force in a Lapp population in northern Finland. *Proceedings 2nd International Symposium on Circumpolar Health, Oulu, Finland*
- Hansson, H. 1973. Frequency of oral disease in the Skolt population. *Fifth International Symposium on the Biology of Circumpolar People.* Reykjavik, Island
- Haraldson, T., Karlsson, U. & Carlsson, G.E. 1977. Bite force and oral function in complete denture wearers. *J. Oral Rehab.*, in press
- Helkimo, M. 1974a. Studies on function and dysfunction in the masticatory system. I. An epidemiological investigation of symptoms of dysfunction in Lapps in the north of Finland. *Proc. Finn. Dent. Soc.*, 70, 37–49
- Helkimo, M. 1974b. Studies on function and dysfunction of the masticatory system. II. Index for anamnestic and clinical dysfunction and occlusal state. *Swed. Dent. J.* 67, 101–121
- Helkimo, E., Carlsson, G.E. & Carmeli, Y. 1975. Bite force in patients with functional disturbances of the masticatory system. *J. Oral Rehab.* 2, 397–406
- Hettinger, H. 1964. *Isometrisches Muskeltraining.* George Thieme Verlag, Stuttgart
- Jenkins, G.N. 1966. *Physiology of the mouth.* Blackwell Scientific Publications, Oxford
- Lewin, T. & Hedegård, B. 1971. The internordic IBP/HA studies of the Skolt Lapps in Northern Finland 1966 to 1969. *Suom. Hammaslääk. Toim.* 67, Suppl. 1, 9–12.
- Lewin, T., Hedegård, B. & Kirveskari, P. 1971. Odontological conditions among the Lapps in Northern Fenno-Scandia. *Suom. Hammaslääk. Toim.* 67, Suppl. 1, 99–104
- Linderholm, H. & Wennström, A. 1970. Isometric bite force and its relation to general muscle force and body build. *Acta Odont. Scand.* 28, 679–689
- Lundgren, D., Nyman, S., Heijl, L. & Carlsson, G.E. 1975. Functional analysis of fixed bridges on abutment teeth with reduced periodontal support. *J. Oral Rehab.* 2, 105–116
- Marklund, G. & Molin, C. 1972. Horizontal isometric muscle forces of the mandible. *Acta Odont. Scand.* 30, 97–115
- Marklund, G. & Wennström, A. 1972. A pilot study concerning the relation between manifest anxiety and bite force. *Swed. Dent. J.* 65, 107–110
- Molin, C. 1972. Vertical isometric muscle forces of the mandible. *Acta Odont. Scand.* 30, 485–499
- Siegel, S. 1956. *Nonparametric statistics: For the behavioral sciences.* McGraw-Hill Book Company, New York
- Wennström, A. 1971a,b. Psychophysical investigation of bite force. Part I and II. *Swed. Dent. J.* 64, 807–819 and 821–827
- Wennström, A. 1972. Psychophysical investigation of bite force. Part IV. *Swed. Dent. J.* 65, 185–190
- Wennström, A., Marklund, G. & Eriksson, P.-O. 1972. A clinical investigation of bite force and chewing habits in patients with total maxillary denture and partial mandibular denture. *Swed. Dent. J.* 65, 279–284

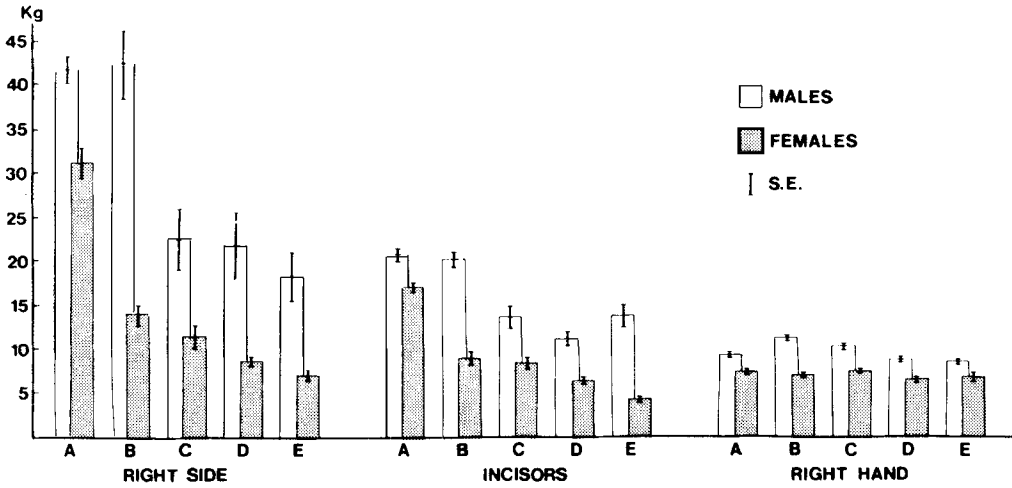


Fig. 4. Maximal bite force and finger-thumb grip of male and female in 5 different age groups (means and standard errors). A: 15-24 years, B: 25-34 years, C: 35-44 years, D: 45-54 years, E: 55-65 years.

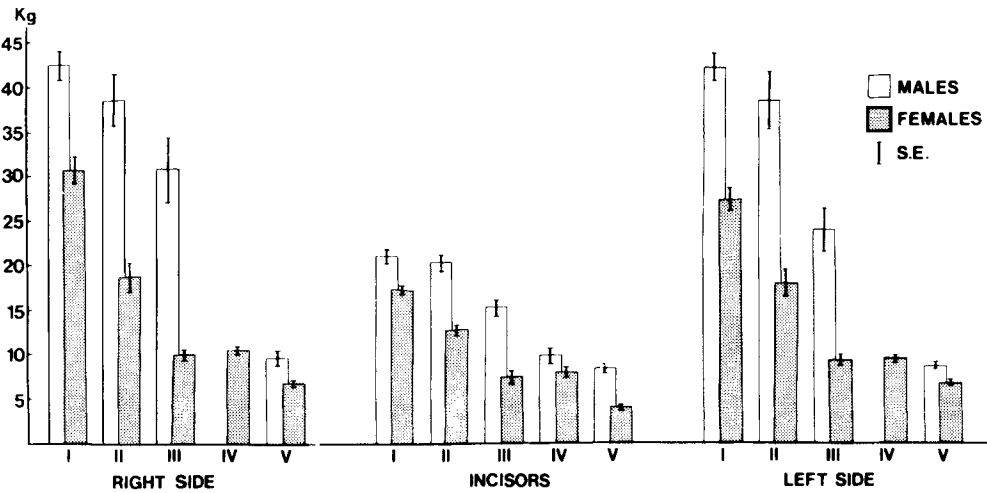


Fig. 5. Maximal bite force of male and female according to age and dental status (means and standard errors). I: dentate 15-25 years, II: dentate 26-39 years, III: dentate  $\geq$  40 years, IV: complete upper denture and residual natural teeth in lower jaw, V: complete upper and lower dentures.