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The Departments of Clinical
Physiology, Orthodontics and
Stomatognathic Physiology,
University of Umeå, Sweden

ISOMETRIC BITE FORCE IN CHILDREN AND ITS RELATION TO BODY BUILD AND GENERAL MUSCLE FORCE

HÅKAN LINDERHOLM

BERIT LINDQVIST

MARGARETA RINGQVIST

ARNE WENNSTRÖM

Bite force, muscle strength in various muscle groups and body build (skeletal dimensions) were examined in 12 year old children, 37 boys and 42 girls. There were no statistically significant differences in bite force between boys and girls, and only small differences between the children and adults (20—30 years of age) who had been examined earlier with the same technique. In the children, maximum bite force covaried slightly with muscular force and skeletal dimension ($r = 0.24 - 0.28$, $P < 0.05$), while no statistically significant correlation was found in similarly examined adults. It is suggested that masticatory training is important for bite force while factors relating to body build seem less important.

There are several reports on bite force in children (*Dennis*, 1893; *Rowlett*, 1933; *Brawley & Sedwick*, 1940; and others). Bite force together with some anthropometric data such as height and weight (*Friel*, 1924; *Worner & Anderson*, 1944), and strength of handgrip (*Johnson & Hatfield*, 1917; *Friel*, 1924; and *Lancet*, 1927) have also been measured in children of different ages up to adult age. All these measures were found to increase with age. There is a considerable range between the values for maximum bite force reported by different investigators. This may be due to the fact that the investigations have been conducted under miscellaneous conditions on non-comparable materials and with different types of measuring apparatus.

Linderholm & Wennström (1970) investigated isometric bite force in adults, 20—30 years of age, and the correlations between bite force, general muscle force and body build. They found no significant covariation between bite force and isometric muscle force in different muscle groups or anthropometric data such as height and weight, but muscle force showed covariation

with the anthropometric data mentioned as had been shown earlier by *Linddegård* (1953), *Asmussen & Heebøll-Nielsen* (1961) and others.

It was found of interest to study in children the relationships between bite force, isometric muscle strength and anthropometric data such as height and weight using similar technique as *Linderholm & Wennström* (1970). At the same time the bite force, measured by the same method in children and adults, could be compared and data added to the sparse observations of this type.

MATERIAL AND METHODS

From five different secondary schools in Umeå, five classes were selected. The classes consisted of 100 children, 12 years of age, 49 boys and 51 girls.

Ten boys and six girls did not participate in the investigation owing to illness or absence. Moreover, two boys and three girls were excluded due to lack of the first molars. The remaining 79 children, 37 boys and 42 girls constitute the material in this investigation. Anthropometric data are given in Table I. Diet was similar for all the children. All of them had one meal at school each school day. All children had regular dental care.

Bite force measurement

The maximum voluntary isometric bite force of the first molars was measured according to the method described by *Linderholm & Wennström* (1970). The bite force was applied with the teeth in the habitual closing path of the mandible about 4 mm from intercuspal position, the bite-opening depending on the apparatus used.

Before the bite force measurements the subjects had to adapt themselves to the apparatus by performing bites of varying strength. After that they were asked first to bite powerfully, then with maximum bite force on the first molars on right respectively left side. After each maximum bite the subjects rested for 10 seconds. Three series of bite force measurements were performed on each side. The highest values obtained were taken as the maximum voluntary bite force. The value for powerful bite was the mean of three measurements. All the bite force measurements were controlled by the same experimental leader. The methodological error of a single bite force measurement was estimated from double determinations using the second and third bite force assessment in a series of measurements. The coefficient of variation was for maximum bite force 6 % and for a »strong» bite 8 %.

Measurement of hand-grip force and force of elbow flexion

Isometric muscle force during hand-grip and elbow flexion was measured as described by *Asmussen, Heebøll-Nielsen & Molbech* (1959) and *Linderholm & Wennström* (1970). Three measurements were made on the right side. The highest recorded value was taken as maximum muscle force.

The dynamometers for measurement of bite force, hand-grip and elbow flexion force were calibrated at regular intervals during the investigation.

RESULTS

The results of the bite force measurements appear in Table I. Mean values for maximum bite force were, for boys 44 kg and for girls 43 kg. There were no statistically significant differences between boys and girls with respect to bite force, anthropometric data and isometric muscle force.

The bite force produced when the subjects were asked to bite »powerfully» was on an average 57 % of the maximum bite force values for boys and 50 % for girls.

Linear product moment correlation coefficients show positive and statistically highly significant correlations between height, weight and width of the wrist on the one side and maximum hand-grip and elbow flexion force on the other for the boy and the girl group as well as for the whole group of

Table I.

Mean ($\bar{x}$) and standard deviation (S.D.) of some anthropometric data, maximum voluntary isometric muscle force of some muscle groups, maximum isometric bite force and »powerful» bite for 37 boys and 42 girls 12 years of age. (The differences between the means of boys and girls are not statistically significant, $P>0.05$)

	Boys		Girls		Differences $\bar{x}_1 - \bar{x}_2$
	$\bar{x}_1$	S.D.	$\bar{x}_2$	S.D.	
Height, cm	151	5.72	153	6.37	—2.5
Weight, kg	42.0	6.79	43.8	8.22	—1.8
Wrist width, right, cm	4.98	0.31	4.74	0.30	0.24
Hand-grip force, right, kg	27.2	6.71	24.2	4.69	3.0
Elbow flexion force, right, kg	16.9	3.49	15.0	2.68	1.9
Max. bite force, right 1. molars, kg	43.4	11.4	40.8	10.4	2.6
Max. bite force, left 1. molars, kg	43.7	11.5	43.0	10.1	0.6
»Powerful» bite, right 1. molars, kg	24.3	8.7	20.2	10.4	4.1
»Powerful» bite, left 1. molars, kg	25.2	9.6	21.6	8.5	3.6

Table II.

Linear correlation coefficients for product moment correlation between some anthropometric data, and measures of maximum voluntary force and maximum bite force taken from 37 boys and 42 girls (n = 79)

	1	2	3	4	5	6	7
Height	1	—					
Weight	2	.72***	—				
Wrist width	3	.44***	.48***	—			
Hand-grip force, right	4	.62***	.50***	.64***	—		
Elbow flexion force, right	5	.55***	.62***	.56***	.75***	—	
Max. bite force, right 1. molars	6	.02	.20	.28*	.24*	.27*	—
Max. bite force, left 1. molars	7	.18	.28*	.27*	.27*	.25*	.78***

Symbols:

* = $0.05 > P > 0.01$

** = $0.01 > P > 0.001$

*** = $0.001 > P$

boys and girls (Table II). The measurements of maximum isometric muscle force in different muscle groups were also positively correlated to each other. The covariation between maximum isometric bite force and the mentioned variables was, however, considerably slighter. Statistically probably significant positive correlation coefficients were obtained between bite force on the one side and elbow flexion force, hand-grip force, wrist width, and body weight on the other side in the total material of boys and girls. A statistically highly significant positive correlation coefficient was also seen between maximum bite force on right and left side ($r = 0.78$, see Table II) and between powerful bite force and maximum bite force ($r = 0.55$).

DISCUSSION

In the boys and girls the maximum isometric bite force for the first molars was only slightly less than in the adults examined with the same technique by *Linderholm & Wennström* (1970). These adults, 20–30 years of age, had a maximum bite force for the first molars of 49 kg for males and of 43 kg for females. The difference between children, 12 years old, and these adults is smaller than the corresponding difference obtained from results reported by *Worner* (1939) and *Worner & Anderson* (1944). The values for

isometric muscle force were considerably lower in the child group of the present investigation than in the adults examined by *Linderholm & Wennström* (1970). Thus the bite force of 12 year old children may approach adult values while the elbow flexion and hand-grip force are lower.

The bite force seems to covariate slightly with body build and muscle force in children. *Linderholm & Wennström* (1970) found no similar correlations in adults. The slight covariation in children between the maximum bite force and the other anthropometric characteristics studied indicates, however, that they are not closely associated. Masticatory training is probably more important for the maximum bite force (*Brekhus, Armstrong & Simon*, 1941).

The force of a powerful bite in children was somewhat smaller in relation to maximum bite force than in adults and showed a somewhat larger coefficient of variation (cf. *Linderholm & Wennström*, 1970). The correlation coefficient for the relationship between powerful and maximum bite force was smaller in children (0.55) than in adults (0.63) (*Linderholm & Wennström*, 1970) and therefore such submaximal measures of bite force seem to be less applicable in children than in adults for the evaluation of bite force.

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Addresses:

H. Linderholm,
Dept. of Clinical Physiology,

B. Lindqvist,
Dept. of Orthodontics,
M. Ringqvist, A. Wennström,
Dept. of Stomatognathic
Physiology, School of Dentistry,

University of Umeå,
S-901 87 Umeå,
Sweden