Growth changes of general and dental health status in Taiwanese children from mixed to early permanent dentition

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For this study, the general and dental health status of 463 Taiwanese children aged 9 to 12 years was evaluated. There were statistically significant increases in all measurements from Hellman's dental developmental stages IIIA to IVA except for the maximum mandibular protrusive, right lateral, and left lateral movements. Maximum bite forces had diminished in stage IIIB. Boys had larger maximum bite forces and hand-grip forces than did girls after stage IIIC. The proportion of subjects with TMD signs or symptoms increased to 60% by stage IVA.

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INTRODUCTION

The general morphological health status of children can be simply evaluated by standing height and body weight and the functional health status by muscle power. Maximum hand-grip strength is commonly used as an index of general health and as a screening test for the integrity of both upper motor neurons and the functioning of the motor unit.[1,2] Furthermore, it is considered the single clinical measure most representative of total body strength in humans.[3]

The dental morphological health status of children can be evaluated by dental and craniofacial characteristics and the functional health status by conditions of the masticatory system. Various techniques have been used to clinically evaluate the physiological characteristics of the muscles of mastication. One method is to measure the bite force. Bite force is exerted by the jaw elevator muscles and is regulated by the nervous, muscular, skeletal, and dental systems.[4] Maximum bite force is related to the health of the masticatory system, and it is believed that the stronger the bite force, the better the system.[5] Helkimo *et al*.[6] observed the bite force of a population between the ages of 15 and 65 years, and found that variations in bite force with dental status were obvious, and that those with complete dentition had much greater bite forces.

Although dramatic changes in dentition occur from prepuberty to puberty, relatively few studies have been conducted regarding the developmental changes in the dental and general health status during the growth of dentition. The purpose of this study was to investigate the dental and general morphological and functional health status of children from mixed to early permanent dentition.

MATERIALS AND METHODS

The subjects in this study consisted of 463 Taiwanese children (257 boys and 206 girls) aged 9-12 years, who were divided into four groups according to Hellman's dental developmental stages (IIIA, IIIB, IIIC, and IVA). The children were students of Chung-Hsiao Elementary School in Taichung City, an area where tap water is not fluoridated. The numbers of subjects in each stage are given in Table 1. After informed consent was obtained, oral examinations were conducted with the children seated on a chair of the dental unit in the school infirmary.

The oral examination included the number of teeth (TN), the number of teeth with pulp-involved caries (PC), the number of teeth with residual roots (RR), the number of teeth prematurely lost (PL), the maximum mandibular vertical opening (MO), the maximum mandibular protrusive movement (MP), and the maximum mandibular right (MR) and left (ML) lateral movements.

All maximum mandibular movements were measured with the patient sitting in an upright position using a millimeter ruler. When measuring the maximum mandibular vertical opening, one end of the ruler was placed in the median plane against the incisal

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edge of one of the mandibular central incisors and the distance to the incisal edge of the opposing maxillary incisor was measured while the subject opened the mouth as widely as possible. The maximum mandibular protrusive measurement was made in a similar way with the instruction to move the jaw out as far forward as possible. Distances between the maxillary and mandibular incisal edges were measured.

The maximum mandibular lateral movements were measured using the maxillary and mandibular midlines as guides if they coincided. If they did not, vertical marks were made with a marking pencil in the median plane on the labial surfaces of two opposing central incisors. A subject was instructed to move the jaw as far to the side as possible without specific instructions on moving it to the left or right. Distances between the maxillary and mandibular midlines were measured. Then the subject was instructed to move the jaw as far as possible to the other side. Distances between the maxillary and mandibular midlines on the other side were measured. These measurements were repeated twice, and the largest values were recorded. All recordings were made to the nearest millimeter and were performed by one of the authors.

The maximum bite force in kilograms was measured using a miniature custom bite force gauge (Occlusal Force-Meter GM10, Morita Corp., Japan). Measurements of maximum bite forces were made with the children standing in a posture such that their head was relaxed, and with the Frankfort horizontal approximately parallel to the floor. For each child, the gauge was placed between the first permanent molars on each side, and was maintained approximately parallel to the floor in frontal view. Each child was instructed to bite as hard as possible and maintain the force for a 2-s period three times in succession, resting 10 to 15 s between each bite. Care was taken to avoid lateral or protrusive deviations of the mandible during the measurements. The largest values of the right (RB) and left (LB) bite force measurements were chosen to represent the maximum bite force of the individual. Subjects were excluded from this study if they were missing teeth in the first molar region or if they experienced local pain related to dental caries or periodontal problems.

In addition to the dental status, the standing height, body weight, and maximum hand-grip strength were also measured by the school nurse. The standing height (HT) was measured with a standiometer to the nearest 0.1 cm; the body weight (WT) was measured with an electronic scale to the nearest 0.1 kg; and the right (RH) and left (LH) maximum hand-grip forces were measured with a hand dynamometer to the nearest 0.5 kg, with standardized positioning and instructions.

In addition to the above-mentioned examinations and measurements, information about food preferences (question 1) and temporomandibular disorders (TMD) (question 2) were obtained by means of a simple questionnaire:

Question 1: What kinds of food do you like?
Answer 1: Hard foods (H), soft foods (S), both hard and soft foods (HS).

Question 2: Do you have any of the following signs or symptoms? (1) Tenderness or pain around the ear or mandibular angle areas, (2) limited movements of the jaw in the morning, (3) joint sounds during mouth opening.
Answer 2: Yes (TMD+), no (TMD-).

Sigmastat software (Jandel Scientific, vers. 2.0) was used for all statistics analyses. The mean values and standard deviations were calculated for all measurements. Differences between sides were tested with Wilcoxon's matched-pairs signed-rank test; differences between genders were tested with Student's *t*-test. Groups were compared for significant differences by means of one-way ANOVA, followed by Tukey's test. For all comparison, p values < 0.05 were considered statistically significant.

RESULTS

Mean values and standard deviations for all measurements for boys and girls in each dental age and the results of Student's *t*-test are given in Table 2 (dental health status) and Table 3 (general health status). Developmental changes of all measurements are shown in Figures 1 to 4. There were no statistically significant differences in any measurements except hand-grip force between the right and left sides in either gender. There were statistically significant differences in measurements RR (IIIB stage), ML (IIIB stage), LB (IVA stage), RB (IIIC stage), and hand-grip forces (IVA stage) between boys and girls. Boys had statistically significantly larger values for these measurements than did girls. There were statistically significant changes from stages IIIA to IVA in all measurements except ML, MR, and MP. Measurements PC, RR, and PL decreased, while the other measurements increased during the observation period from stages IIIA to IVA.

Results of the questionnaire are shown in Figures 5 and 6. Because there was no statistically significant difference between boys and girls, the data from boy and girl subjects were pooled. About 10% of subjects preferred hard foods through the four dental developmental stages. The distributions of subjects who liked soft foods and both soft and hard foods were almost the same in stages IIIA and IIIB; however, the subjects who preferred soft foods decreased to 37%, while the subjects who liked both soft and hard foods increased to 55% in stages IIIC and IVA. There were almost identical distributions of subjects with TMD+ and with TMD- from stages IIIA to IIIC, however, in stage IVA, about three-fifths of subjects had TMD signs or symptoms.

DISCUSSION

There were few differences in measurements of general health status between boys and girls until stage IIIC. In stage IVA, however, differences in body weight and hand-grip forces between boys and girls became large; boys had larger values than girls for these measurements. With regard to general muscle strength, girls are as strong and as large as boys until puberty. The increase in muscle mass during puberty, influenced by androgenic steroids, creates the differences between male and female muscle strength. Muscle mass comprises 45%-50% of fat-free body weight and is closely related to age and body weight. Therefore, in this study the sex differences in stage IV may have been related to the increased muscle mass during growth for boys.

Much effort has been made to characterize the physiological mandibular function in terms of mandibular movement, bite force, and electromyograms. Restricted mandibular mobility is commonly accepted as one of the main signs of mandibular dysfunction, and so it is an important variable in evaluating the functional state of the masticatory system. According to Agerberg,[7] the lower limit of normal mandibular opening movement is 40 mm; that of horizontal movements of the mandible is 5 mm. Previous investigations[7-12] have shown that the range of mandibular movement varies considerably from one individual to another. Statistically significant differences in jaw mobility are present between men and women[7,10] as well as between young and old people. The opening capacity of the mandible has been noted to increase until 12 to 15 years of age.[13-15] In addition to results of measurements of mandibular movements which coincide with these previous reports, it was found that the maximum mandibular vertical opening increased by about 5 mm and maximum mandibular protrusive movement tended to decrease from stages IIIA to IVA in this study. Further longitudinal research is necessary to confirm these developmental changes and clarify the causes.

Clinicians have long been interested in the potential influence of bite force on the development of the masticatory complex. Maximum bite force assessed unilaterally may be used as a simple indicator of mandibular elevator muscle strength as a whole.[16] Since reduced strength is an important factor in overload and hyperactivity of masticatory muscles and a common feature of patients with craniomandibular disorders,[17,18] assessment of bite force is relevant for diagnosis and treatment planning. Routine recordings of bite force for clinical purposes can provide normal values and knowledge of factors responsible for their variability.[19] Measurement of maximum bite force is dependent on the effort of the subject, which is influenced by motivation, pain, and fear, among other factors. These factors add to the normal biological intra-individual variation and to technical imperfections. Previous investigators have shown that the bite force increases with age up to adolescence,[20] and that differences between the sexes are first seen at puberty.[21] The observed increase in bite force in this study during growth is in agreement with the report by Brawley and Sedwick,[20] who found that the average rate of increase in bite force of the first permanent molars in children was approximately 2.3 kg/year from 7 to 16 years. The lack of a difference in bite forces of both sides of the mouth for both sexes in this study could have been due to bilateral articulation of the mandible in which the force exerted on one side also influences that on the other side. It is interesting to find that the maximum bite force decreased in stage IIIB. Although the subjects had about 23 teeth in stage IIIB, the deciduous molars were due to exfoliate before long. The maximum bite force was measured in the first molar area; however, it seems that the transition of buccal teeth may have influenced the functioning of the masticatory system. Gender differences in bite forces were similar to those of hand-grip forces; the differences were clearer after stage IIIC. Therefore, it is suggested that gender differences in both the general and dental functional health statuses might appear before gender differences in the morphological health status.

Individuals with poor masticatory function change the types of food they choose to eat, with malnutrition a possible consequence.[22] This study demonstrated an alteration in food choice with increasing numbers of teeth. More than one-half of subjects liked to eat both soft and hard foods after stage IIIC. Meanwhile, subjects who had TMD signs or symptoms increased with increasing numbers of teeth. Taking all factors into consideration, it seems that the stages from IIIC to IVA (from emergence of the permanent second molar to occlusion with the antagonist tooth) is the key time for clinicians to pay attention to the developmental changes of the patient in order to prevent subsequent morphological and functional problems.

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