European Journal of Orthodontics 27 (2005) 601–606
doi:10.1093/ejo/cji043
Advance Access publication 11 July 2005

Prevalence and distribution by gender of occlusal characteristics in a sample of Italian secondary school students: a cross-sectional study

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SUMMARY The aim of this study was to describe the prevalence and distribution, by gender, of occlusal traits in a sample of Italian students aged 11–14 years (mean 13 ± 1 years). Using standardized and validated recording criteria, a single operator measured the overjet, overbite, open bite, anterior and posterior crossbites, crowding, coincidence of the upper and lower midlines, and diastema, in 810 secondary school students (53.6 per cent males). Chi-square, *t*-test statistics, and odds ratios (ORs) with 95 per cent confidence intervals (CI) were used to investigate the relationship between gender and malocclusion characteristic. Logistic regression was used to further analyse the independent association between gender and each outcome measure.

Ninety-three per cent of the subjects showed at least one occlusal trait, with one or two anomalies recorded in 63 per cent of children. The prevalence of occlusal traits ranged from 1.1 (negative overjet) to 54 per cent (upper and lower midlines not coincident). Males were more likely than females to show both an increased overbite and an increased overjet, although the latter result was not confirmed by logistic regression ($P = 0.05$). Multivariate analysis showed a negative association between overbite and misalignment of the lower incisors and lack of coincidence of the upper and lower midlines, whereas subjects with an increased overbite were more likely to have an increased overjet (all $P < 0.01$). Further studies are required in order to further clarify these findings and to provide accurate estimates of the orthodontic treatment need in Italian adolescents.

Introduction

Although debate persists on the definition of an 'ideal occlusion', an 'acceptable occlusion' is universally indicated as the goal of orthodontic treatment (Svedström-Oristo *et al.*, 2000).

To quantify orthodontic need, as well as to provide an insight into the concept of an acceptable occlusion, a number of epidemiological studies on dentofacial anomalies and orthodontic treatment need have been performed in various countries during the last two decades. Different ethnic groups have been investigated, including Amerindian (de Muniz, 1986; Thilander *et al*., 2001), Caucasian (Kerosuo, 1990; Tschill *et al*., 1997), non-Hispanic black (Isiekwe, 1983; Kerosuo *et al*., 1988; Brunelle *et al*., 1996; Otuyemi *et al*., 1999), and non-Hispanic white (Brunelle *et al*., 1996).

At present, however, there are no generally accepted criteria to define normality or abnormality as regards occlusal status. It is not surprising, therefore, that studies have used several different indices for the same aim, including the Index of Orthodontic Treatment Need (IOTN; Burden and Holmes, 1994), the Dental Aesthetic Index (DAI; Otuyemi *et al*., 1999) and the Treatment Priority Index (TPI; Uğur *et al.*, 1998). By contrast, other authors have preferred disaggregated measures of the major occlusal characteristics, with the epidemiological registration of malocclusion developed by Björk *et al*. (1964) facilitating comparisons of the prevalence of malocclusion (Isiekwe, 1983; de Muniz, 1986; Kerosuo, 1990; Brunelle *et al*., 1996; Tschill *et al*., 1997).

Despite the amount of literature on the subject, which has been summarized by Thilander *et al*. (2001), there are few studies investigating the distribution of these occlusal traits in Italians (Anelli and Montaruli, 1998; Sticco *et al*., 1989). Of these, only one reported on children in the late mixed dentition (Sticco *et al.*, 1989). While both used a method based on Angle's classification (Angle, 1907), a description of occlusal characteristics of Italians using single trait recording has not been performed. Indeed, the latter methodology is ideal for international comparisons as well as planning prevention strategies (Brunelle *et al.*, 1996).

The main aim of the present survey was, therefore, to document the prevalence of individual traits of malocclusion, including anterior alignment, irregularity score for mandibular incisors, midline diastema, posterior and anterior crossbites, overjet, overbite, open bite and the coincidence of the upper and lower midlines, in a sample of Italian children aged 11–14 years. Furthermore, the association between gender and the above traits was evaluated.

Subjects and methods

The research was carried out as part of the Regional Dental Examination Survey promoted by the Puglia Regional Health Service and the University of Chieti, Italy. The examinations were conducted over 6 months between 3 December 2001 and 7 June 2002 in the city of Foggia.

Non-Caucasians and subjects over 14 years of age were not included in the analysis. In order to reduce potential confounding factors, other exclusion criteria were: a history of orthodontic therapy, missing or fractured incisors, and restoration of upper central incisors (115 subjects were thus excluded). The final sample (Figure 1) consisted of 810 students aged 11–14 years (mean 13 ± 1 years) attending public high schools in the city. Of these students, 434 were male (53.6 per cent). Informed consent was obtained for each participant and confirmed by one parent.

A single orthodontic specialist (FC) performed all dental examinations in order to avoid inter-operator bias. Examiner reliability was checked through intra-examiner replicate examinations for 80 subjects.

The occlusal characteristics were measured and recorded according to the criteria adopted in the US National Health and Nutrition Examination Survey (NHANES III, Brunelle *et al*., 1996). The overall occlusal status was assessed by means of disaggregated measurements of the major occlusal characteristics, including: anterior and posterior crossbites, coincidence of the upper and lower dental midlines (so called 'midline misalignment'), crowding, diastema, overjet, and overbite/open bite. A detailed description of the criteria adopted for each malocclusion trait is given in Table 1, and illustrated in Figure 2.

Univariate analyses were used to describe the study sample and the prevalence of occlusal traits. All variables were treated as categorical and the results presented as percentages and 95 per cent confidence intervals (CI). Overbite, overjet, and 'overall number of malocclusion traits' were also treated as continuous variables, and means and standard deviations (SD) were calculated. Bivariate chi-square, *t*-test statistics, and odds ratios (ORs), with 95 per cent CI, were used to document the relationship between gender and each occlusal characteristic, while binomial logistic regression was used to examine the independent association between gender and each outcome measure as well as that between increased overbite and the other variables. Statistical significance was defined as a two-sided P-value < 0.05. All analyses were performed using STATA statistical software, version 8.0 (Stata Corporation, College Station, Texas, USA).

Results

The intra-examiner repeatability study showed a high level of agreement (kappa statistic 0.87).

The prevalence of each occlusal trait is reported in Table 2. Ninety-three per cent of the subjects were affected by at least one occlusal trait, but none by all traits. One or two anomalies were recorded in 514 children (63 per cent), while a single occlusal trait was present in 21.8 per cent of students (n = 188). The mean number of anomalies in the sample was two (standard error = 0.04). Non-coincidence of the centrelines was the most frequent anomaly (54 per cent), followed by anterior misalignment and an overbite greater than 3 mm (both around 41 per cent). An overjet of more

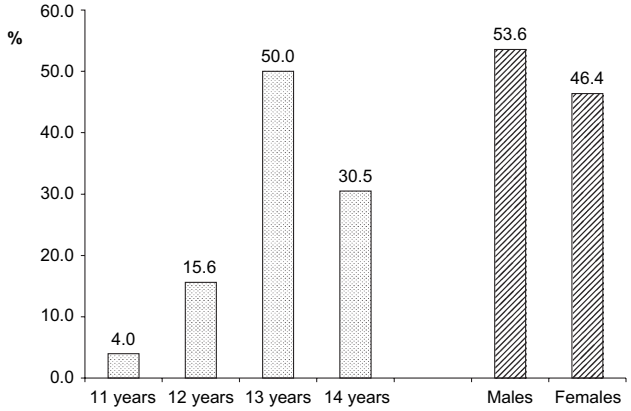

Figure 1 Age and gender distribution of the sample of 810 Italian high school students.

Table 1 Method of registration of single occlusal characteristics.

Overjet was defined as the horizontal overlap of the incisors, being positive if the upper incisor was ahead of the lower incisor, and negative if the lower incisor was in front of the upper incisor. It was assessed by means of a periodontal probe from the labial surface of the most anterior lower central incisor to the labial surface of the most anterior upper central incisor, parallel to the occlusal plane.
Overbite was considered as the vertical overlap of the incisors when the posterior teeth were in contact: classified as positive if the incisors overlapped vertically, and negative (defined as open bite) if they were vertically separated. It was measured on the upper right central incisor by means of a periodontal probe. If the right upper central incisor was missing, or fractured, it was substituted by the left upper central incisor. If an open bite was present, a single measurement was performed, between the edge of the lower central incisor and that of the upper central incisor.
Diastema was recorded as 'present' when the space between the maxillary central incisors was greater than 2 mm. If one of these teeth was missing or crowded, no assessment was made. Subjects with restorations on the mesial surfaces of these teeth were also excluded.
Crossbite: the presence of buccally or lingually displaced/occluding teeth in the anterior (canines/incisors) or posterior teeth (premolars and molars), was defined as, anterior or posterior crossbite, respectively. If the anterior crossbite involved the central incisors, already defined as a negative overjet, the latter definition was used.
Crowding: the scoring method was based on the Irregularity Index (Little, 1975) used to assess dental alignment of the lower incisors. An irregularity score between 0 and 3 mm was considered as anterior misalignment, whereas a score greater than 3 mm was recorded as crowding. Perfect alignment from the mesial aspect of the left canine to the mesial aspect of the right canine was given a score of zero.
Midline misalignment was defined as non-coincident upper and lower midlines when the posterior teeth were in a maximum intercuspal relationship. If a diastema, missing or mesial restoration of the central incisors was present, midline misalignment was not recorded.

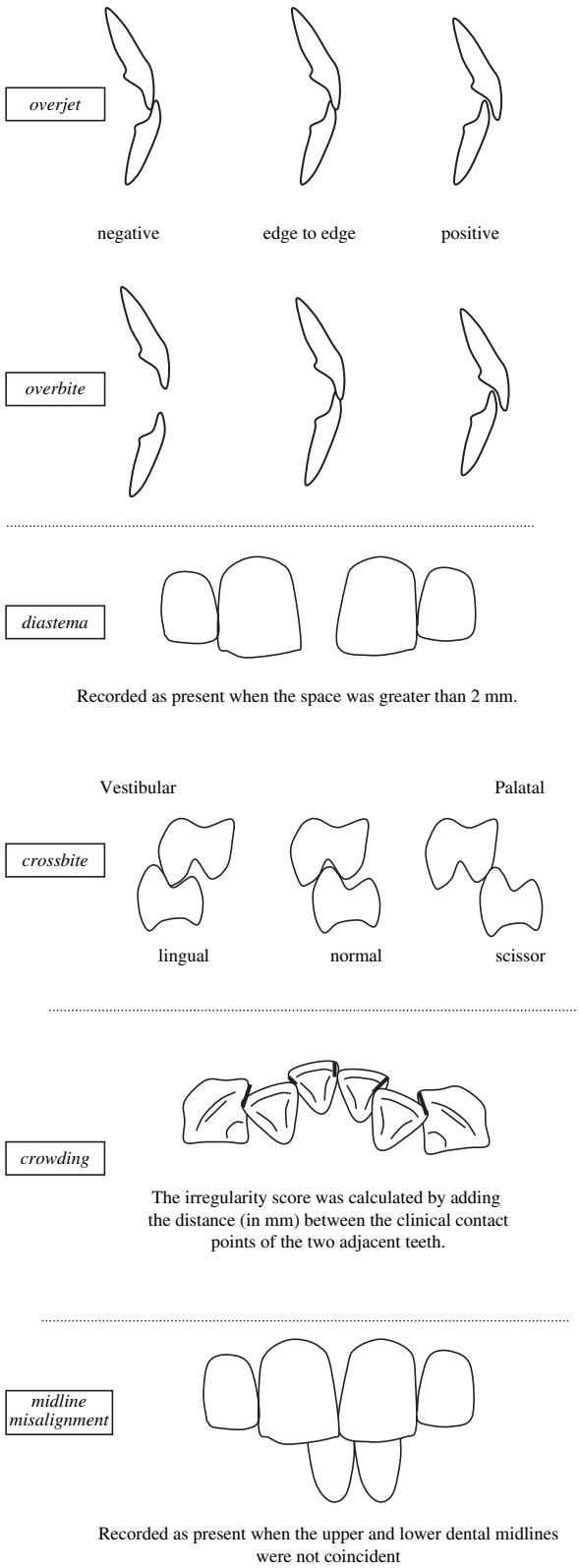

Figure 2 Characteristics of occlusion investigated in the study.

Table 2 Distribution of occlusal traits in the sample of Italian adolescents (n = 810; 434 males).

Variable	Percentage	95 per cent confidence interval
Anterior misalignment	41.5	38.1–44.9
Midline misalignment	53.8	50.4–57.3
Crowding	20.2	17.5–23.2
Diastema	5.6	4.1–7.4
Overbite > 3 mm	41.0	37.6–44.5
Overbite > 5 mm	9.6	7.7–11.9
Open bite	1.7	0.9–2.9
Overjet > 3 mm	19.1	16.5–22.0
Overjet > 5 mm	6.5	4.9–8.5
Negative overjet	1.1	0.4–2.1
Anterior crossbite	5.4	4.0–7.2
Posterior crossbite	12.2	10.0–14.7
At least one malocclusion trait	93.0	91.0–94.6
Only one malocclusion trait	21.8	19.2–24.7
One or two malocclusion traits	63.0	60.8–65.1

Variable (as continuous)	Mean	Standard deviation	95 per cent confidence interval
Overbite (mm)	3.17	1.78	3.05–3.29
Overjet (mm)	2.62	1.98	2.48–2.75
Number of malocclusions	2.01	1.01	1.94–2.08

than 3 mm and crowding were present in approximately the same percentage of subjects (20 per cent). All other occlusal traits had a lower prevalence: posterior crossbite (12 per cent), diastema (6 per cent), anterior crossbite (5 per cent), open bite (2 per cent) and negative overjet (1 per cent). Severe traits, such as an overbite or overjet greater than 5 mm, were present in 10 and 6 per cent of children, respectively. Overall, the mean overbite was 3.2 mm (SD 1.8) and overjet 2.6 mm (SD 2.0).

The distribution, by gender, of the occlusal traits is shown in Table 3, together with the results of the multivariate analysis. Adjusted ORs were significant only for overbite; males being more likely than females to have both an overbite greater than 3 mm (OR = 1.38; CI = 1.02–1.87) or greater than 5 mm (OR = 1.77; CI = 1.06–2.94). A suggestion of a positive association between male gender and an overjet of more than 3 mm was also found, but the adjusted P-value was of borderline significance (P = 0.052).

The results of the additional multivariate analysis examining the independent correlation between increased overbite and the other occlusal traits are reported in Table 4. In addition to the above-mentioned association with male gender, an overbite of more than 3 mm was significantly more frequent in those who also had an increased overjet (OR = 2.52; CI = 1.72–3.69). By contrast, children with anterior or midline misalignment were less likely to have an increased overbite (OR = 0.46; CI = 0.33–0.64 and OR = 0.61; CI = 0.45–0.83, respectively).

Table 3 Occlusal traits in the sample of Italian adolescents by gender.

Variable	% males	OR	95% CI	*P**	OR adjusted†	95% CI	*P*†
Anterior misalignment	53.9	1.02	0.77–1.35	0.890	1.15	0.84–1.59	0.372
Midline misalignment	50.5	0.76	0.58–1.01	0.065	0.77	0.57–1.03	0.092
Crowding	51.8	0.92	0.65–1.29	0.615	0.91	0.63–1.33	0.630
Diastema	55.6	1.09	0.59–1.99	0.785	1.01	0.54–1.89	0.966
Overbite > 3 mm	59.6	1.52	1.14–2.01	0.004	1.38	1.02–1.87	0.038
Overbite > 5 mm	66.7	1.83	1.12–3.00	0.016	1.77	1.06–2.94	0.028
Open bite	28.6	0.34	0.11–1.09	0.071	0.37	0.11–1.21	0.100
Overjet > 3 mm	61.9	1.53	1.07–2.18	0.021	1.45	1.00–2.11	0.052
Overjet > 5 mm	66.0	1.74	0.97–3.14	0.063	1.70	0.92–3.12	0.089
Anterior crossbite	47.7	0.78	0.42–1.43	0.424	0.99	0.52–1.19	0.976
Posterior crossbite	50.5	0.87	0.57–1.32	0.513	0.86	0.55–1.33	0.493

OR, odds ratio of being male, where OR > 1 indicates a higher likelihood of being male; CI, confidence interval.
*Chi-square statistics.
†Binomial logistic regression analysis: model size = 810; 53.6 per cent males.

Table 4 Binomial logistic regression model predicting overbite (more than 3 mm) for the overall sample (n = 810).

Variable	OR	95% CI	*P*
Anterior non-alignment	0.46	0.33–0.64	<0.001
Midline non-alignment	0.61	0.45–0.83	0.002
Overjet	2.52	1.72–3.69	<0.001
Male	1.44	1.06–1.95	0.018

OR, odds ratio referred to the risk of having an overbite, OR > 1 indicates a higher likelihood; CI, confidence interval.

Discussion

The large expansion of orthodontic practices in Italy highlights the importance of having data for planning orthodontic treatment need. This survey provides the first estimate of Italian occlusal characteristics in children in the late mixed dentition since that reported by Sticco *et al*. (1989). More importantly, the present investigation is the first in Italy to adopt a single traits recording method based on the criteria defined by Proffit (1986), which follows the logic of the epidemiological registration of malocclusion developed by Björk *et al*. (1964).

Many studies have described the distribution of occlusal traits in diverse populations, reporting large differences in prevalence that may depend on ethnicity, registration methods, and sample composition (Tang and Wei, 1993; Thilander *et al*., 2001). Therefore, the influence of the above factors must be taken into account when comparing findings from different surveys. From a methodological viewpoint, comparison should first be made with the NHANES III study, where the same recording method was used (Brunelle *et al*., 1996). Those authors reported similar rates of malocclusion for US adolescents, with the exception of lower anterior misalignment, the prevalence of which was approximately half that in the Italian sample. The prevalence of overjet and overbite greater than 3 mm was also different from that recorded in the current study (19 and 41 per cent, respectively, in the Italian sample versus 31 per cent in the US sample). However, the percentage of children with an overjet and overbite greater than 5 mm was almost the same in the Italian and US populations. In contrast, Brunelle *et al*. (1996) reported a significant positive association between male gender and misalignment or diastema, whereas the latter occlusal traits did not appear to be related to gender in the present study.

The previous Italian epidemiological studies (Sticco *et al*., 1989; Anelli and Montaruli, 1998) also reported a high prevalence of malocclusion (79–84 and 73–75 per cent, respectively), although lower than that found in the present study (93 per cent). Sticco *et al*. (1989) observed rates of overjet, overbite, open bite, crowding, anterior and posterior crossbite that were similar to those found in the present sample.

Likewise, the proportion of Caucasians with a severe overjet, severe overbite, open bite and all types of crossbite found by de Muniz (1986), who studied 968 Caucasians and 586 Amerindians, is in agreement with that found in the present study. However, the prevalence of anterior mandibular crowding and a midline shift was different, as these characteristics were observed in a large number of Italian adolescents (20 and 53 per cent, respectively), but in a smaller proportion of subjects (4 and 8 per cent) in the study undertaken by de Muniz (1986). Another Caucasian sample (Tschill *et al*., 1997) showed that crowding was seen relatively frequently (24 per cent), as was a lateral crossbite (16 per cent) and open bite (37.4 per cent), whereas an increased overjet (more than 6 mm) was present in fewer subjects (6 per cent). While the above occlusal traits were present with almost identical prevalence in the present study, an open bite was found in only 1.7 per cent of subjects. However, it should be taken into account that the sample investigated by Tschill *et al*. (1997) comprised subjects in the primary dentition.

Similar to the findings for Caucasians, adolescents from Latin America and Colombia showed substantial agreement with the present findings. Silva and Kang (2001) reported that 93 per cent of Latin American adolescents were affected by some type of malocclusion and Thilander *et al*. (2001) observed similarly high rates for Colombians (88 per cent).

Because ethnic differences in malocclusion patterns have been repeatedly documented (Brunelle *et al*., 1996; Thilander *et al*., 2001), the observed differences between Italian and African samples were expected. Kerouso *et al*. (1988) found that twice the number of Tanzanians had an increased overjet and overbite, as compared with the individuals in the present study. Likewise, in Nigeria, the frequency of an increased overjet was 14 per cent and for an open bite and diastema 10 and 24 per cent, respectively (Otuyemi *et al*., 1999). In contrast, the rates for Caucasians were much lower, especially for the presence of diastemas.

The distribution of malocclusion in an Italian sample can be assumed to be similar to that reported in other areas with comparable populations (Caucasians and Latin Americans). This might suggest that information from prevention strategies adopted in these countries could be successfully integrated in the development of an effective national programme aimed at increasing the level of oral hygiene and reducing other malocclusion risk factors.

In the present sample, fewer children had only one occlusal trait ($n = 188$) compared with those who had more than one characteristic ($n = 616$; 76 per cent). This indicates that traits tend to be present in association with each other, and suggests that further analyses may be required in order to investigate which traits are correlated. Controlling for the other occlusal traits and gender, the multivariate analysis showed that students with an increased overbite had a significantly higher likelihood of having an increased overjet. In contrast, an inverse correlation was present between overbite and anterior or midline misalignment. Although these findings might be relevant when planning a strategy for orthodontic treatment, they must be confirmed in a larger sample.

The main strengths of the present study include the clinical registration based on a standardized and repeatable methodology (Brunelle *et al*., 1996), the high intra-observer calibration, the exclusion of children who had previously had any type of orthodontic treatment (as malocclusion is no longer possible to determine), and the homogeneity of the ethnicity and age of the sample. However, some of these strengths are also limitations that have to be considered in interpreting the results. First, as the sample comprised students aged 11–14 years, it provides no information on the rest of the Italian population. Second, due to funding and time limitations it was not possible to perform an orthodontic need assessment as well as stratification by dental development. An in-depth estimate of orthodontic need is important for effective organization and planning of orthodontic services. However, it requires the use of an index, which should be based upon the number and severity of occlusal traits, as well as an evaluation of the subjective need. The latter has problems of comparability and of translation into practical recommendations, as it may depend on the socio-economic and cultural context. It was thus considered a priority to provide objective measures on single occlusal traits, and the use of an index of orthodontic need was left for future analyses. With regards to dental status, it is known that malocclusion is a manifestation of morphological variations that are related to the development of the dentition and this, in turn, varies in males and females (Thilander *et al*., 2001). Therefore, grouping by chronological age, rather than by dental age, might have reduced the likelihood of detecting gender differences in malocclusion prevalence in the present sample.

Another potential limitation arises from the fact that children with a history of orthodontic therapy or with fractured incisors were excluded from the analysis. Certainly, by 14 years of age some children with significant malocclusions will have received treatment. Also, subjects with an increased overjet are more likely to fracture their incisors and thus to have been excluded (Hamdan and Rajab, 2003). These issues might have yielded an underestimation of the overall occlusal trait prevalence and especially of the number of children with an increased overjet. Similarly, the chances of obtaining significant results in the investigation of the relationship between gender and overjet could have been reduced (in fact, the relationship between gender and overjet was no longer significant in the multivariate analysis; $P = 0.052$). Unfortunately, no data were collected on the excluded children, so it is difficult to comment on. However, it might be supposed that, in the presence of a bias due to the above selection criteria, the prevalence of malocclusion would significantly decrease with age, as more children receive treatment. Although stratification by age revealed a small decrease in the prevalence of 'one or two occlusal characteristics' (from 67.5 per cent at 12 years to 60.3 per cent at 14 years), this difference was not statistically significant (data not shown). Finally, the number of excluded children was relatively small (12.4 per cent of the total), and the proportion of those with at least one occlusal characteristic was found to be one of the highest in the literature. It is therefore unlikely that any bias that occurred led to significant effects.

Conclusion

As in other populations, malocclusion traits were very common in this sample of Italians in the late mixed and permanent dentition. The occlusal anomalies tended to be present in association with each other, not individually, and the prevalence of an increased overbite and overjet (as well as the mean value of these characteristics) was higher in

males than in females. In order to clarify which factors are related to malocclusion, as well as which is the effective orthodontic treatment need in Italian adolescents, further studies are required.

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