# Tooth size discrepancies among Jordanian schoolchildren

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SUMMARY The aims of this study were to determine the tooth size discrepancies (TSD) in a representative sample of Jordanian schoolchildren and to compare TSD between genders. Dental casts of 367 (174 males and 193 females; mean age 15.5 years) Jordanian schoolchildren were selected. Anterior and overall Bolton ratios were determined using a digital calliper. Differences between genders were analyzed using a *t*-test.

The results showed that there were no significant differences in the TSD between males and females. The percentages of subjects with more than 2 standard deviations for the anterior and overall ratios were 23.7 and 9.5, respectively.

## Introduction

Andrews (1972) studied the dental casts of 120 nonorthodontic individuals with normal occlusion and concluded that there are six essential 'keys' required to achieve this normal occlusion. McLaughlin *et al.* (2001) stated that tooth size should be considered the 'seventh key' and that without coordination between the sizes of the upper and lower teeth, it would not be possible to obtain a good occlusion during the final stages of orthodontic treatment. This lack of co-ordination is called 'tooth size discrepancies' (TSD).

Proffit (2007) defined TSD as a disproportion among the size of individual teeth. Without a correct match of the mesiodistal widths of the maxillary and mandibular teeth, it is difficult to obtain an ideal overjet and overbite and a good occlusion during the final stages of orthodontic treatment (Neff 1957; Bolton, 1958, 1962; Crosby and Alexander 1989).

Bolton (1958) developed a method for evaluation of maxillary to mandibular tooth-width proportions based on 55 subjects with excellent occlusions. He developed two ratios for estimating the TSD by measuring the summed mesiodistal widths of the mandibular to maxillary teeth. The analysis distinguishes between the 'overall ratio' of 91.3 per cent, which involves all permanent teeth except the second and third molars, and the 'anterior ratio' of 77.2 per cent, which encompasses only the six anterior teeth of each jaw. Bolton (1962) also suggested that a ratio greater than 1 standard deviation (SD) from the reported mean values indicated a need for diagnostic consideration. Other authors have defined a significant discrepancy as a value more than 2 SD from Bolton's mean (Crosby and Alexander, 1989; Freeman *et al.*, 1996).

A review of literature reveals that the incidence of TSD has been found to vary between different racial and population groups (Lavelle, 1972; Santoro *et al.*, 2000; Smith *et al.*, 2000; Bernabé *et al.*, 2004). Therefore, different

norms and standards have been developed for different ethnic and racial groups. The incidence of TSD has been established for white Americans (Crosby and Alexander, 1989; Smith et al., 2000), black Americans (Smith et al., 2000), Chinese (Nie and Lin, 1999; Ta et al., 2001), Spanish (Paredes et al., 2006) South Americans (Santoro et al., 2000; Araujo and Souki, 2003; Bernabé et al., 2004), Turkish (Uysal et al., 2005; Akyalcin et al., 2006), and Saudi (Alkofide and Hashim, 2002; Al-Tamimi and Hashim, 2005) populations. Most of these investigations derived their sample from an orthodontic population (Sperry et al., 1977; Crosby and Alexander 1989; Freeman et al., 1996; Nie and Lin, 1999; Santoro et al., 2000; Smith et al., 2000; Araujo and Souki, 2003; Al-Tamimi and Hashim, 2005; Uysal et al., 2005). In a few studies, the samples comprised a normal population chosen from schoolchildren (Ta et al., 2001). In addition the literature review demonstrated wide variation in the sample size with a range of 55-710.

Most research on TSD investigated the effect of sexual dimorphism. They did not, however, demonstrate a common trend, with most of the studies finding no differences in the prevalence of TSD between males and females (Nie and Lin, 1999; Alkofide and Hashim, 2002; Araujo and Souki, 2003; Al-Tamimi and Hashim, 2005; Uysal *et al.*, 2005; Akyalcin *et al.*, 2006; Paredes *et al.*, 2006). On the other hand, Lavelle (1972) and Smith *et al.*, (2000) found significant differences in tooth size ratios for both genders. In a recent review (Othman and Harradine, 2006) of studies investigating TSD, no differences were found in the mean Bolton ratios between genders. In a few studies, however, the mean Bolton ratios for males were larger but the difference was small (Othman and Harradine, 2006).

There appears to be no published data on the prevalence of TSD in a representative sample of the Jordanian population. Therefore, the aims of the present study were to determine TSD in a representative Jordanian sample and to compare TSD between genders.

## Subject and methods

Ethical approval for the study was obtained from the Ministry of Health of Jordan and the Deanship of Scientific Research of the University of Jordan. Written consents were obtained from the parents of all students who underwent examination and/or impression taking.

## Sample

A total of 1439 Jordanian students in the 10th grade (mean age: 15.5 years) were screened in 12 schools from the six regional directories in Amman, which is the largest city and capital of Jordan with a population over 2 million. The schools were randomly selected from a list of all schools in

Amman. For each directory, the total number of selected subjects was approximately equal to 0.1 per cent of the total number of the population living in the same directory.

Examinations were carried out by two examiners (IO and ZB) on school premises under natural lighting. Alginate impressions were taken for subjects who fulfilled the following criteria:

- 1. Jordanian ancestors at least from one previous generation
- 2. all permanent teeth erupted (except third molars)
- 3. no interproximal caries and/or restorations
- 4. no missing or supernumerary teeth
- 5. no abnormally sized or shaped teeth

Table 1 The mean, standard deviation (SD), and statistical comparisons of the mesiodistal tooth measurements for males and females (mm).

		Males ( $n = 174$ )		Females $(n = 193)$		
		Mean	SD	Mean	SD	Significance
Maxillary	Central incisor	8.82	0.60	8.68	0.49	*
	Lateral incisor	6.83	0.55	6.73	0.58	NS
	Canine	8.10	0.50	7.69	0.39	*
	First premolar	7.10	0.42	6.93	0.61	*
	Second premolar	6.67	0.47	6.60	0.39	NS
	First molar	10.34	0.57	10.49	0.48	*
Mandibular	Central incisor	5.50	0.39	5.43	0.40	NS
	Lateral incisor	6.10	0.42	5.97	0.35	*
	Canine	7.16	0.48	6.66	0.37	*
	First premolar	7.20	0.44	7.00	0.40	*
	Second premolar	7.23	0.53	7.04	0.45	*
	First molar	11.23	0.61	10.88	0.53	*

\**P* < 0.05.

NS, not significant.

Table 2 The mean and standard deviation (SD) for the anterior and overall tooth size discrepancy for males and females.

	Males ( <i>n</i> = 174)		Females $(n = 193)$			Total ( <i>n</i> =367)	
	Mean (%)	SD	Mean (%)	SD	P value	Mean (%)	SD
Anterior ratio	79.0	0.83	78.2	0.63	NS	78.6	0.73
Overall ratio	92.8	1.41	91.7	1.36	NS	92.2	1.83

 Table 3
 The mean and standard deviation (SD) in anterior and overall tooth size discrepancy for the present sample and Bolton's study.

	Anterior ratio			Overall ratio		
	Mean	SD	Range	Mean	SD	Range
Bolton (1958) ( $n = 55$ ) Present study ( $n = 367$ )	77.2 78.6	1.65 0.73	74.5–80.4 73.3–84.1	91.3 92.2	1.91 1.83	87.5–95.8 85.0–93.5

- 6. minimal or no tooth wear
- 7. no previous orthodontic treatment

Impressions were poured on the same day with hard dental stone, using standard procedures for material mixing, impression disinfection, and taking into consideration correct storage of impressions until they were poured. The dental casts were not soaped or waxed.

Dental casts of 395 subjects were obtained. A small number of them were discarded because they were of inadequate quality, leaving 367 study models (193 females and 174 males) which represented 0.1 per cent of the target population.

### Measurements

The measurements were carried out using a digital calliper (Orteam, Milano, Italy) with an accuracy of 0.01 mm. The mesiodistal widths of the teeth were measured by the same two examiners according to the method described by Hunter and Priest (1960).

## Error of the method

Prior to the study, intra- and interexaminer error were assessed by randomly selecting the study models of 20 subjects and remeasuring them after an interval of 2 weeks. Systematic bias was determined using a paired *t*-test (Stirrups, 1993) and estimation of random error was carried out using the index of reliability by correlating repeat measurements (Houston, 1983). Error analysis showed no significant intra- or interexaminer differences when systemic bias was tested (P > 0.05). Intra- interexaminer correlations of repeat measurements were found to be greater than 0.95, indicating no random error.

## Statistical analyses

Statistical analysis was carried out using the Statistical Package for Social Sciences (Release 12.0.1 for Windows 2003. SPSS Inc., Chicago, Illinois, USA). An independent sample *t*-test was used to measure differences between genders and a paired sample *t*-test to compare measurements of contralateral teeth. Significance was set at the 5 per cent level (P < 0.05).

## Results

#### Tooth measurements

The mean, SD, and statistical comparisons of the mesiodistal tooth measurements for males and females are shown in Table 1. There were significant differences between genders for all teeth measured (P < 0.05) except for the mandibular right central incisor, maxillary right and left second premolars, and maxillary right and left lateral incisors.

There were no significant differences between measurements of contralateral teeth (P > 0.05) except for the mandibular first molars, maxillary and mandibular second premolars, and the maxillary lateral incisors.

#### TSD and gender

Anterior and overall ratios for TSD for males and females are presented in Table 2. There were no statistically significant differences between males and females for the anterior and overall ratios. Although the TSD ratios were larger for males, the differences were not significant.

## TSD and the clinical significance

The frequency of TSD 1, 2, and more than 2 SD from Bolton's mean for anterior and overall ratios are shown in Table 4. The percentage of subjects with significant deviations (>2 SD) from the anterior and overall mean ratios was 23.7 and 9.5 per cent, respectively.

## TSD in Jordanian schoolchildren

Table 5 compares the anterior and overall tooth size ratios for Jordanians with other populations. The anterior and overall ratios for the TSD among Jordanian schoolchildren were 92.2 and 78.6 per cent, respectively (Table 3).

## Discussion

In the present investigation, the sample was randomly selected from 10th grade schoolchildren. The age of the sample was relatively young in order to minimize the influence of tooth wear. Furthermore, the sample represented 0.1 per cent of the all the 10th grade subjects in the Amman governance. The sample size is one of the largest among studies that have investigated TSD (Table 5).

The results demonstrated a significant difference in mesiodistal tooth width between males and females for most teeth. This is in agreement with results of a previous study on the Jordanian population which found statistically significant differences between males and females for mesiodistal crown diameters (Hattab *et al.*, 1996). Other investigators have found the same sexual dimorphism in tooth size measurements (Ballard, 1944: Lavelle, 1972).

A review of literature of studies that have measured TSD shows that significant differences exist among the various ethnic groups (Table 5). Therefore, tooth size ratios have been established for different ethnic and racial groups. In the present investigation, the anterior and overall tooth size ratios for the Jordanian schoolchildren were established. The tooth size ratios reported here for Jordanians were close to the mean anterior and overall Bolton ratios. In addition, the findings of the present study are in agreement with the results of tooth size ratios reported for an Arab population in Saudi Arabia (Alkofide and Hashim, 2002; Al-Tamimi and Hashim, 2005).

The results of the present investigation showed that there were no statistically significant differences between males and females for the anterior and overall ratios. Although, the TSD ratios for males were larger, the differences were small. This finding is in agreement with most studies on TSD (Nie and Lin, 1999; Alkofide and Hashim, 2002; Araujo and Souki, 2003; Al-Tamimi and Hashim, 2005; Akyalcin *et al.*, 2006; Paredes *et al.*, 2006). Although those studies demonstrated a tendency for larger Bolton ratios in males, the differences were not statistically significant. Other research, however, has shown a statistically significant difference in tooth size ratios for both genders (Lavelle, 1972; Smith *et al.*, 2000).

The majority of investigations on TSD have chosen values outside 2 SD as an indication of a clinically significant TSD. In the present study, the percentages of subjects with clinically significant TSD of the anterior and overall ratio were 23.7 and 9.5 per cent, respectively. Similar results for the anterior and overall ratio have been reported by Araujo and Souki (2003), Crosby and Alexander (1989), and Bernabé *et al.* (2004). Higher percentages for the anterior ratio, however, were found by Freeman *et al.*, (1996) and Santoro *et al.* (2000). Both studies were derived from orthodontic populations which may explain the higher percentage of anterior tooth size deviations. On the

**Table 4**The number and percentage distribution of anterior andoverall tooth size discrepancies from Bolton's mean.

	Anterior ra	atio	Overall ratio		
	Number	Percentage	Number	Percentage	
Bolton $\pm 1$ SD	157	42.7	224	61	
Bolton $\pm 2$ SD	123	33.6	108	29.5	
>2 SD	87	23.7	35	9.5	
Total	367	100	367	100	

other hand, the results of the present investigation demonstrated a higher discrepancy in the anterior than the overall ratio. This trend is comparable to the majority of research on TSD.

## Conclusions

In the present investigation, the anterior and overall tooth size ratios for Jordanian schoolchildren were established. The findings showed the following:

- 1. There were no significant differences in TSD between males and females.
- 2. The percentage of subjects with a deviation of more than 2 SD for the anterior and overall ratios was 23.7 and 9.5 respectively.

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 Table 5
 Anterior and overall tooth size ratios in different populations.

Population	Author	Sample size	Anterior ratio (%)	Overall ratio (%)
White Americans	Bolton (1958)	55	77.2	91.3
	Crosby and Alexander (1989)	109	77.5	91.4
	Smith <i>et al.</i> (2000)	180	79.6	92.3
Black Americans	Smith et al. $(2000)$	60	79.3	93.1
Spanish	Smith <i>et al.</i> (2000)	60	80.5	93.4
~F	Paredes et al. (2006)	100	78.32	91.97
Dominican	Santoro et al. (2000)	54	78.1	91.3
Peruvian	Bernabé <i>et al.</i> (2004)	200	78.09	90.79-91.33
Brazilian	Araujo and Souki (2003)	300	78.18	_
Chinese	Ta et al. (2001)	110	77.5	90.9
	Nie and Lin (1999)	300	81.52	93.27
Saudi Arabian	Al-Tamimi and Hashim (2005)	65	77.4	91.4
Turkish	Uvsal <i>et al.</i> (2005)	710	78.26	89.88
	Akvalcin et al. (2006)	152	78.15	91.34
Jordanian	Present study	367	78.6	92.2

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