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Generalized joint laxity and its relation with oral habits and temporomandibular disorders in adolescent girls

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SUMMARY **A group of 248 girls, aged 15–16 years, were randomly selected and examined both clinically and by questionnaire with regard to the signs and symptoms of temporomandibular disorders (TMD), generalized joint laxity (GJL), range of mandibular opening, temporomandibular joint (TMJ) hypermobility and presence of oral parafunctions. The prevalence of GJL was 43% and that of TMJ hypermobility (TMJH) was 27.3%. A significant, albeit weak, correlation was found between the two. In the presence of joint click, both active and passive opening were significantly larger. When either muscle or joint sensitivity to palpation was present, the difference between the active and passive range of mouth opening increased significantly. The presence of reported clicks was negatively associated with GJL. This association was not valid in the presence of parafunction. Some of the signs and symptoms of TMD affected the range of mouth opening. In the presence of joint clicks, the mean active and passive mandibular opening were significantly larger. In the presence of joint and muscle sensitivity to palpation, the difference between passive and active mouth opening was larger. This was possibly because of the effect of pain on the full active range of opening, which was invalid in the registration of the passive mandibular opening. GJL, when present, did not seem to jeopardize the health of the stomatognathic system as expressed in the signs and symptoms of TMD. There was a negative association between GJL and the presence of reported joint clicks and catch. When a parafunction was present in addition to GJL, this association was invalid but not reversed, as has been previously reported.**

Introduction

Benign hypermobile joint syndrome or generalized joint laxity (GJL) is a hereditary disorder leading to increased mobility (laxity) of multiple joints (Kirk, Ansell & Bywaters, 1967; Horton *et al.*, 1980; Jesse, Owen & Sagar, 1980; Finsterbush & Pogrund 1982; Beighton, Graham & Bird, 1983). The range of joint movement is influenced by many factors, including biochemical diversities in collagen and elastin structure (Westling, Holm & Wallentin, 1992). GJL can be either a separate entity or a feature in several inherited disorders of the connective tissue (Grahame *et al.*, 1981; Fridriech *et al.*, 1990; Westling *et al.*, 1992). GJL is found in 5–10% of white people, with a higher incidence in women (Beighton, Solomon & Soskolne, 1973; Jesse *et al.*, 1980; Biro, Gewnater & Baum, 1983; Boering, 1994). There is a high percentage of occurrence in East Indian, Iraqi and African populations (Beighton *et al.*, 1973; Al-Rawi *et al.*, 1985).

It has been suggested that hypermobile individuals are prone to orthopaedic disorders, such as degenerative joint disease, spontaneous dislocations, joint effusions and myalgia (Kirk *et al.*, 1967; Finsterbush & Pogrund, 1982). A significantly higher incidence of generalized osteoarthritis has been reported in women with GJL compared with patients with non-lax joints (Gedalia *et al.*, 1986). Jesse *et al.* (1980) postulated conversely that GJL is not associated with an increased incidence of musculoskeletal complaints or arthritis.

The association between degenerative diseases of the temporomandibular joint (TMJ) and GJL was first mentioned in the medical literature by Annandale (1887). Since then, several investigators have reported a correlation between GJL and internal derangement (ID) in the TMJ (Solberg, 1981; Bates, Stewart & Atkinson, 1984; Plunkett & West, 1988; Westling *et al*., 1992; Perrini *et al*., 1997). Among patients admitted for elective reconstructive surgery of the TMJ, a high percentage (54%) had lax joints (Buckingham *et al*., 1991). Dijkstra *et al*. (1992) found no significant differences between generalized joint hypermobility and TMJ osteoarthritis and postulated that GJL cannot be considered as a predisposing factor for the latter disease.

The effect of oral parafunctions on the prevalence of the signs and symptoms of temporomandibular disorders (TMD) in individuals with loose joints is another much debated subject in the literature. Westling & Mattiasson (1991) and Harkins *et al*. (1995) postulated that oral parafunction seemed to have a more detrimental effect on a person with laxed joints than it did on a normal person. In contrast, Greenwood (1987) did not support the hypotheses that TMJ disorders are factors of GJL or that TMD are more likely to occur in loose jointed individuals. Schultz (1947) introduced the concept of TMJ hypermobility (TMJH) in the dental literature and described the connection between TMJH and dysfunction of the stomatognathic system. Several studies found a significant relationship between maximal mandibular opening and GJL (Agerberg, 1974a; McCarroll *et al*., 1987), while others found no such correlation (Greenwood, 1987; Westling & Helkimo, 1992). Katzberg *et al*. (1982) investigated the relationship between the degree of condylar translation and ID. Condylar translation was assessed using tomographic radiographs, while ID was investigated by means of clinical examination and arthrography. Patients who had disc displacement with reduction were hypermobile on the symptomatic side. Boering (1994) stated that hypermobility on its own is not damaging to the joint, unless a movement disorder (in the form of clicking and/or locking) is present.

The objectives of this study were to:

1. establish the prevalence of GJL and TMJH in female adolescents;
2. evaluate the association between TMJH and GJL;
3. investigate the contribution of TMJH and GJL to the signs and symptoms of TMD;
4. find a relationship between the presence of TMJH and GJL and the prevalence of oral habits; and
5. examine the impact of certain oral parafunctions on the prevalence of the signs and symptoms of TMD in laxed individuals.

Subjects and methods

A group of 248 girls, aged 15–16 years, who were randomly selected from a junior high school in central Israel, participated in this study. All of the participants and their parents were informed of the nature of the investigation, and their acceptance was obtained.

Prior to the clinical examination, all of the girls completed a questionnaire (Gavish *et al*., 2000). One experienced examiner determined beforehand that all of the questions were correctly understood and answered. A second experienced examiner carried out the clinical examinations and was purposely unaware of the questionnaire results.

Information relating to the following symptoms of TMD, self-estimated general flexibility and oral habits was obtained from the questionnaire.

Symptoms (their presence assessed by 'yes' or 'no' in the questionnaire)

1. Joint noises: feeling of joint noises (clicking, popping or grading) during jaw movement.
2. Joint catching: presence of joint catching (a sudden momentary sticking of the jaw that prevents full opening but is self-releasing).
3. Joint lock: limitation in opening and feeling that the jaw is caught without the ability to release.
4. Joint pain: pain in the joint area at rest and/or in function.
5. Joint tension: feeling of increased tension within the joint, forcing a tension-releasing movement.

Self-estimated general flexibility: as expressed during sport exercises and dancing

Oral habits:

1. Gum chewing—average time of chewing per day (h).
2. Nail biting: at present.

3. Biting foreign objects (e.g. pencils): daily frequency.
4. Eating of seeds: daily frequency.
5. Crushing of ice and popsicles: daily frequency.
6. Continuous leaning on the arm: leaning of the head on the palm of the hand or arm, daily frequency.
7. Daytime bruxing, clenching or grinding awareness.
8. Night-time bruxing, clenching or grinding knowledge.
9. 'Jaw play': habit of performing small non-functional mandibular movements without tooth contact.

Participants were also requested to specify the reasons for their gum chewing habit on a scale of 1–6 (Table 1).

Clinical examination included:

1. Range of mouth opening (RMO): measurement of the intrinsic distance in active (voluntary) maximal mouth opening (AMO) and in passive (assisted) maximal mouth opening (PMO) by applying finger pressure to extend the opening to its maximal capacity. The difference between PMO and AMO was calculated (PAD).
2. Presence of joint clicking/crepitation in opening, closing or lateral movement felt by palpation over the TMJ area.
3. Joint sensitivity: sensitivity to palpation of the lateral aspect of the joint of approximately 1·5 kg (3 lb) (present or absent).
4. Muscle sensitivity to palpation: at least one site of tenderness on manual palpation of approximately 2 kg (4 lb) on the superficial and deep masseter, anterior portion of the temporalis and its tendon (mild, moderate or severe).

Assessment of GJL

Using the criteria in the mobility index and the Carter–Wilkinson Scale (Carter & Wilkinson, 1964), as modified by Beighton *et al.* (1973) to include:

1. Passive dorsiflexion of the fifth metacarpo–phalangeal joint (MPJ) beyond 90° (1 point for each fifth MPJ).
2. Passive apposition of the thumb to the flexor aspect of the forearm (1 point for each thumb).
3. Hyperextension of the elbows beyond 10° (1 point for each elbow).
4. Hyperextension of the knees beyond 10° (1 point for each knee).
5. Forward flexion of the trunk, knees straight, palms touching the floor (1 point).

The scoring range was 0–9, with the higher scores denoting greater joint laxity. Individuals who carried out four or more of the above manoeuvres were con-

Table 1. The range of mouth opening (AMO and PMO) and mobility index versus joint clicks (reported and examined)

	Range of mouth opening & mobility index								
	AMO			PMO			GJL score		
Joint clicks	Mean	s.d.	*P*	Mean	s.d.	*P*	Mean	s.d.	*P*
Joint noises (reported)									
With	52·8	5·8	0·008	54·7	5·7	0·02	2·9	2·0	0·07
Without	50·7	6·4		52·9	6·3		3·4	2·4	
Joint click (examined)									
With	52·5	5·8	0·07	54·8	5·7	0·026	3·1	2·2	0·52
Without	51·0	6·4		53·0	6·3		3·3	2·3	

The result of ANOVA for the independent variables AMO, PMO and mobility index versus reported joint noises and joint clicks in examination.
The mean and s.d. of the range of mouth opening and the mobility index are calculated for each subgroup.

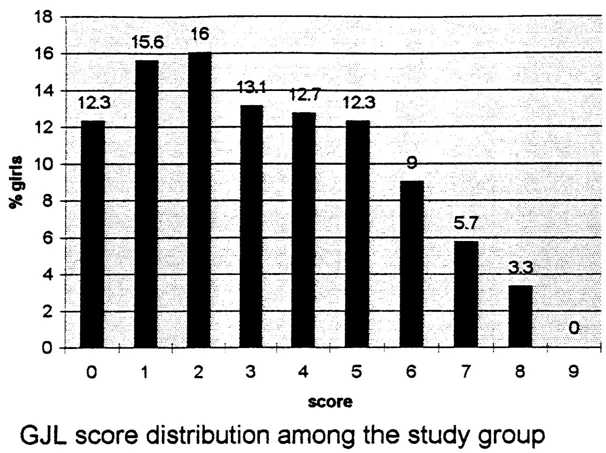

Fig. 1. Generalized joint laxity (GJL).

sidered to be hypermobile (Harinstein *et al.*, 1988; Plunkett & West, 1988; Buckingham *et al.*, 1991; Westling & Mattiasson, 1991; Perrini *et al.*, 1997).

Statistical analysis

The BMDP statistical software* (Dixon, 1990) was used to analyse the data.

One-way analysis of variance (ANOVA) was used to find significant differences between groups when the variable being analysed was a continuous one.

A linear correlation was used to examine the relationship between maximal mouth opening (AMO and PMO) and GJL.

Results

GJL

A GJL score of 3·2 (s.d. 2·2) was found, in accordance with the Beighton Scale. The highest score (8) was found in eight girls (3·3%). None of the girls scored 9. Of the participants, 43% had scored 4 or more (hypermobile group) (Fig. 1). It was found that 18·9% of the girls estimated their general flexibility as high, based on their performance in sport and dancing.

Pearson's chi-square test revealed a statistically significant association between the hypermobile group (scored 4 or more) and the self-estimated flexibility as reported by the girls in the questionnaire ($P < 0{\cdot}005$).

RMO and the assessment of TMJH

AMO ranged between 35 and 70 mm (mean AMO was 51·6 mm s.d. 6·2). Four girls opened their mouths less than 40 mm (1·6%) and 60 girls (24·5%) had an AMO greater than 55 mm.

PMO ranged between 37 and 71 mm (mean 53·7 mm, s.d. 6·1). Only two girls had a PMO of less than 40 mm; 67 of the girls (27·3%) had a PMO greater than 57 mm (Fig. 2). The cut-off point was 57 mm. PMO was used to determine TMJH. In the population examined, 27·3% of the girls had hypermobile TMJs. PAD ranged from 0 to 12 mm (mean 2·1 mm, s.d. 1·9). Only one girl had a PAD of 12 mm, but 80 (33%) had a PAD of more than 2 mm.

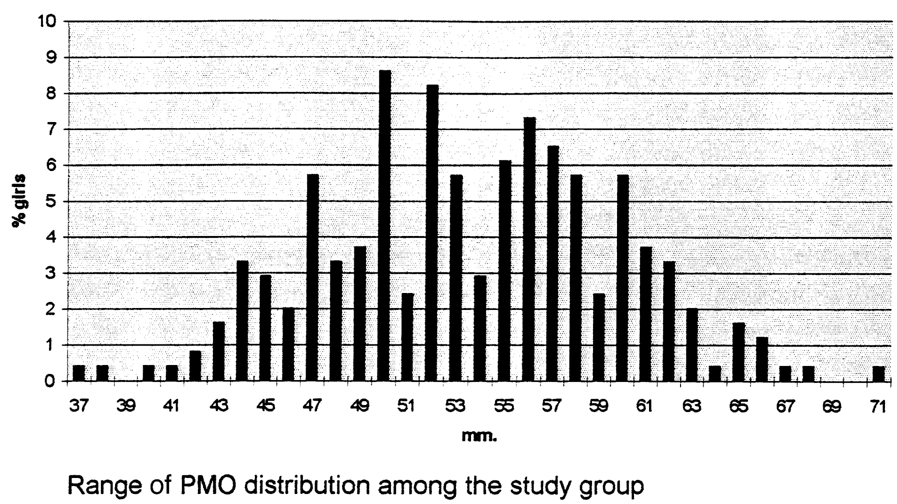

Fig. 2. Passive mouth opening (PMO).

* BMDP Inc., Los Angeles, CA, U.S.A.

Table 2. Difference between active and passive mouth opening (PAD) versus joint and muscle sensitivity to palpation

Sensitivity to palpation	PAD Mean	s.d.	*P*
Joint sensitivity			
With	2·5	2·3	0·01
Without	1·9	1·6	
Muscle sensitivity			
With	2·5	2·5	0·04
Without	1·9	1·6	

The result of ANOVA for the independent variable PAD versus joint and muscle sensitivity to palpation.
The mean and s.d. of the range of PAD are calculated for each subgroup.

Association between maximal mouth opening and GJL

There was a linear correlation between maximal mouth opening and the GJL score: AMO/GJL score $r = 0{\cdot}17$ and $P = 0{\cdot}008$; and the PMO/GJL score, $r = 0{\cdot}157$ and $P = 0{\cdot}014$. However, no statistically significant association, by means of the Pearson chi-square test, was found between TMJH (PMO greater than 57 mm) and the hypermobile group (GJL score of 4 or more on a scale of 9).

Maximal mouth opening and signs and symptoms of TMD

In ANOVA, the mean AMO in the girls who reported joint noises was greater than in the group that did not (52·8 mm, s.d. 5·8 versus 50·7 mm, s.d. 6·4). The difference was statistically significant ($P < 0{\cdot}01$). The same tendency was found with PMO (54·7 mm, s.d. 5·7 versus 52·9 mm, s.d. 6·3). When the clicks were analysed by means of clinical examination and the degree of active and passive mouth opening, similar results were obtained (Table 1). Another positive association between PAD and sensitivity to palpation of the joints and muscles was also found. In the presence of sensitivity of either the TMJ or the masticatory muscles, the PAD was significantly greater than in the absence of these signs (Table 2). No other associations between the RMO and the signs and symptoms of TMD were found.

TMJH and the signs and symptoms of TMD

No statistically significant association was found using the two-way Pearson chi-square test between TMJH and the signs and symptoms of TMD.

GJL and TMD

No significant findings with regard to the GJL score and the signs and symptoms of TMD when using the ANOVA test were found; however, a negative association ($P = 0{\cdot}07$) between reported clicks and GJL score was evident. The mean score of GJL among those girls who reported the presence of clicks and those who did not was 2·9 (s.d. 2·0) versus 3·4 (s.d. 2·4), respectively.

Using the Pearson chi-square test, a significant negative association was found between GJL and the reporting of clicks and catch. A lower percentage of girls with GJL reported the presence of clicks and catch ($P < 0{\cdot}05$). No other associations between GJL and the signs and symptoms of TMD were found.

TMJH and oral habits

Pearson's chi-square test revealed a positive association between TMJH and the oral habits of 'jaw play' ($P < 0{\cdot}05$) and crushing ice ($P < 0{\cdot}005$).

TMJH, oral habits and the signs and symptoms of TMD

Pearson's three-way chi-square test found no statistically significant association between TMJH, the signs and symptoms of TMD and the oral habits of intensive gum chewing (more than 3 h/day), 'jaw play' and continuous leaning on the arm.

GJL, oral habits and the signs and symptoms of TMD

Pearson's three-way chi-square test found no statistically significant association between the hypermobile group, oral habits and the signs and symptoms of TMD.

Discussion

The Carter–Wilkinson Scale, as modified by Beighton *et al.* (1973), is widely used as a joint mobility index. There is no agreement concerning the quantitative definition of GJL. The cut-off point of a score of 4 out of 9 (Beighton *et al.*, 1973) was chosen in accordance with most other studies (Harinstein *et al.*, 1988; Plunkett & West, 1988; Buckingham *et al.*, 1991; Westling &

Mattiasson, 1991; Perrini *et al*., 1997). This enabled comparison with previous results.

Adolescent girls were chosen for the present study group because of the reported higher prevalence in females with joint mobility (Beighton *et al*., 1973; Jesse *et al*., 1980; Biro *et al*., 1983; Boering, 1994) and TMD (Grosfeld, Jackowska & Czarnecka, 1985).

In the present study, the GJL of 43% exceeded the findings of previous studies. Westling & Mattiasson (1991), in a similar population of 96 randomly selected 17-year-old girls, found a prevalence of 28%. Other investigations, carried out on different healthy populations, found a prevalence of between 13·2 and 19% (Plunkett & West, 1988; Perrini *et al*., 1997). In other studies (Harinstein *et al*., 1988; Westling, 1989; Westling, Carlsson & Helkimo, 1990), the prevalence for TDM patients was higher (30–52·5%), in some cases up to 54·0% (Buckingham *et al*., 1991). All of these studies used the same criteria as the present one. Studies using other criteria found a lower prevalence (Carter & Wilkinson, 1964; Jesse *et al*., 1980; Gedalia *et al*., 1993).

The high prevalence of GJL found in this study could be the result of genetic predisposition. A high percentage of GJL occurs in selected ethnic groups of East Indian, Iraqi and African populations (Beighton *et al*., 1973; Al-Rawi *et al*., 1985). It should be remembered that joint mobility diminishes with age, rapidly throughout childhood and at a decreasing rate in adulthood. At any age, females are consistently more hypermobile than males (Beighton *et al*., 1973). Taking this into account makes comparison among a mixed population difficult. It should also be kept in mind that the Israeli population is not ethnically homogeneous, and thus a large sample is needed in order to establish the prevalence of GJL.

A positive association was found between the self-estimated flexibility (hypermobility) and the objective findings of the clinical examination (GLJ), suggesting the reliability of questionnaires when determining the prevalence of the phenomenon.

Range of mouth opening is a variable that can be measured with reliability (Dworkin, LeResche & DeRouen, 1988; Dworkin *et al*., 1990) and used as an indirect assessment of TMJ mobility (Stegenga *et al*., 1993). A more direct measurement is determined by assessing the condylar translation and its position in relation to the peak of the articular eminence, either clinically or radiographically (Stegenga *et al*., 1993). Clinically, TMJ translatory mobility may be assessed by palpation during a full range of mandibular movements, but this is more complicated and is less reliable (Stegenga *et al*., 1993). A radiographic measurement does not fit an epidemiological study. In the present study, TMJH was assessed using the criterion of a PMO greater than 57 mm. This cut-off point was chosen according to the highest normal range of movement measured intrinsically in young persons (Agerberg, 1974b) and in accordance with Plunkett & West (1988).

The mean active intrinsical opening was 51.6 mm, which is in accordance with the accepted range of the normal maximal opening (Okeson, 1993). A similar mean range of maximal mouth opening was found in studies conducted on female adolescent populations (Greenwood, 1987; McCarroll *et al*., 1987; Plunkett & West, 1988). In another study, Westling & Helkimo (1992) found that the active range of opening exceeded 50 mm in 74% of girls and in 87% of boys. The range of active mandibular opening in three groups of Israeli adolescents (10–13 years, 13–16 years and 16–18 years) has been studied by Gazit *et al*. (1984). They found that there was an increase of mean opening towards the oldest age group (50 mm for females and 55 mm for males). Szentpétery (1993) reported that mouth opening was widest between the ages of 11–20 years (55·6 mm) and gradually decreased with age (48 mm by the age of 71 + years).

The correlation between general joint mobility and RMO was as expected: positive, albeit weak ($r = 0{\cdot}17$). Plunkett & West (1988) studied this correlation and found it to be positive in a general population of men and women aged 18–35 years. Another study found that there was no significant relationship between maximal mouth opening and GJL (Westling & Helkimo, 1992). The angular rotation of the mandible at maximum opening, however, was significantly larger in hypermobile individuals. Moreover, PMO was strongly correlated with mandibular length. These factors, which could influence the PMO, in addition to the laxity of the ligaments, may explain the weak correlation found in the present study.

The mean value of the PAD found by Westling & Helkimo (1992) was 1·2 mm. Adolescents with reciprocal clicking presented, on average, with a larger difference, although this was not statistically significant (mean 1·4 mm). All those with a difference greater than 5 mm had reciprocal clicks. Higher values of PAD (2·7–3·1 mm) were found in clinical studies conducted on adults (McCarroll *et al.*, 1987; Pullinger *et al.*, 1987; Hesse, Naeije & Hansson, 1990). In our study population, the mean PAD was 2·1 mm. No significant differences of the degree of PAD were found between girls with joint clicks and those without.

The presence of a joint click does not seem to interfere with mandibular opening capacities (active and passive). On the contrary, girls who had clicks exhibited a significantly larger RMO (Table 1). The clinical contribution of this finding is limited because clinicians cannot diagnose the presence of a click by RMO, nor can they be certain that the RMO exceeds the normal opening capacity of the patient because of the click.

In the presence of muscle or joint sensitivity to palpation, the PAD was significantly larger (Table 2). This may suggest the inhibitory effect of pain on the full active range of opening that is invalid in the registration of PMO. The significant, albeit weak, correlation found between maximal mouth opening and general joint mobility should be considered when examining a hypermobile patient complaining of restricted mouth opening. A clinical finding of 45 mm AMO in such a patient, the normal range being 65 mm, is restricted, although it is within the normal range of opening. Such a perception of reduced opening is more important than the actual measurement (Szentpétery, 1993).

Because there is a correlation between generalized joint mobility and RMO, and a significantly greater opening capacity for girls with clicks (compared with those without clicks), the correlation between GJL and clicks was examined. According to the statistical analyses, there was no relationship.

Controversy exists in the literature with regard to the relationship between GJL and TMD. Some researchers report such an association between both entities (Solberg, 1981; Bates *et al.*, 1984; Gedalia *et al.*, 1986; Harinstein *et al.*, 1988; Plunkett & West, 1988; Westling, 1989; Westling *et al.*, 1990; Buckingham *et al.*, 1991), whereas others have found no evidence to support this relationship (Greenwood, 1987; Dijkstra *et al.*, 1992). In the present study, such an association was not established, suggesting that other aetiologic factors contribute to the prevalence of TMD, one being the presence of oral habits (Gavish *et al.*, 2000).

The effect of certain oral parafunctions on the health of the masticatory system in girls with TMJH and/or GJL was examined in the present study. The habits of 'jaw play' and crushing ice and popsicles were highly prevalent in girls with TMJH. The speculative influence of these habits on the TMJ ligament length should be investigated. Oral parafunction in the presence of GJL did not jeopardize the health of the masticatory system. Moreover, the presence of GJL is not a contributing factor for an increase in complaints of the presence of joint clicks and catch, according to our results. In fact, the opposite was found. It is possible that this could explain the reason for a negative association between the signs and symptoms of TMD and GJL in the presence of certain habits. The latter is reported to have a detrimental effect on some aspects associated with the health of the stomatognathic system (Gavish *et al.*, 2000).

Conclusions

From the present study, it was evident that the some of the signs and symptoms of TMD affected the RMO. In the presence of joint clicks, the mean active and passive mandibular openings were significantly larger. In the presence of joint and muscle sensitivity to palpation, the PAD was larger, possibly because of the effect of pain on the full active range of opening, which was invalid in the registration of the passive mandibular opening.

GJL, when present, did not seem to jeopardize the health of the stomatognathic system as expressed in the signs and symptoms of TMD. On the contrary, there was a negative association between GJL and the presence of reported joint clicks and catch. When a parafunction was present in addition to GJL, this association was invalid but not reversed, as was previously reported.

References

Agerberg, G. (1974a) Maximal mandibular movements in teenagers. *Acta Morphologica Neelandic-Scandinavica*, **12,** 79.

AGERBERG, G. (1974b) Maximal mandibular movement in young men and women. *Swedish Dental Journal*, **67,** 81.

AL-RAWI, Z.S., AL-AZAWI, A.J. & AL-CHALABI, T. (1985) Joint mobility among university students in Iraq. *British Journal of Rheumatology*, **24,** 326.

ANNANDALE, T. (1887) Displacement of the inter-articular cartilage of the lower jaw, and its treatment by operation. *The Lancet*, **1,** 411.

BATES, R.E., STEWART, C.M. & ATKINSON, W.B. (1984) The relationship between internal derangements of the TMJ and systemic joint laxity. *Journal of the American Dental Association*, **109,** 446.

BEIGHTON, P.H., SOLOMON, L. & SOSKOLNE, C.L. (1973) Articular mobility in an African population. *Annals of the Rheumatic Diseases*, **32,** 413.

BEIGHTON, P.H., GRAHAME, R. & BIRD, H. (1983) *Hypermobility of Joints*. Springer-Verlag, Berlin.

BIRO, F., GEWNATER, H. & BAUM, J. (1983) The hypermobility syndrome. *Pediatrics*, **72,** 701.

BOERING, G. (1994) *Temporomandibular Joint Osteoarthrosis*, pp. 280–300. Drukkerij Van Denderen, Groningen.

BUCKINGHAM, R.B., BRAUN, T., HARINSTEIN, D. A., ORAL, K., BAUMAN, D., BARTINSKI, W. *et al*. (1991) Temporomandibular joint dysfunction syndrome: a close association with systemic joint laxity (the hypermobile syndrome). *Oral Surgery, Oral Medicine, Oral Pathology*, **72,** 514.

CARTER, C. & WILKINSON, J. (1964) Persistent joint laxity and congenital dislocation of the hip. *Journal of Bone and Joint Surgery*, **46(b),** 40.

DIJKSTRA, P.U., LAMBERT, G.M., DE BONT, L.G.M., STEGENGA, B. & BOERING, G. (1992) Temporomandibular joint, osteoarthrosis and generalized joint hypermobility. *Journal of Craniomandibular Practice*, **10,** 221.

DIXON, W.J. (1990) *BMDP Statistical Software*. University of California Press, Berkeley, CA.

DWORKIN, S.F., LERESCHE, L. & DEROUEN, T. (1988) Reliability of clinical measurement in temporomandibular disorders. *Clinical Journal of Pain*, **4,** 89.

DWORKIN, S.F., LERESCHE, L., DEROUEN, T. & VON KORFF, M. (1990) Assessing clinical signs of temporomandibular disorders: reliability of clinical examiners. *Journal of Prosthetic Dentistry*, **63,** 574.

FINSTERBUSH, A. & POGRUND, H. (1982) The hypermobility syndrome: musculoskeletal complaints in 100 consecutive cases of joint hypermobility. *Clinical Orthopaedics and Related Research*, **168,** 124.

FRIDRIECH, K.L., FRIDRIECH, H.H., KEMPF, K.K. & MOLINE, D.O. (1990) Dental implications in Ehlers–Danlos syndrome. *Oral Surgery, Oral Medicine, Oral Pathology*, **69,** 431.

GAVISH, A., HALACHMI, M., WINOCUR, E. & GAZIT, E. (2000) Oral habits and their association with signs and symptoms of temporomandibular disorders in adolescent girls. *Journal of Oral Rehabilitation*, **27,** 22.

GAZIT, E., LIEBERMAN, M., EINI, R., HIRSCH, N. & SERFATY, V. (1984) Prevalence of mandibular dysfunction in 10–18 year old Israeli schoolchildren. *Journal of Oral Rehabilitation*, **11,** 307.

GEDALIA, A., PERESON, D., BREWER, E. & GIANNINI, E. (1986) Hypermobility of the joints in juvenile episodic arthritis/arthralgia. *Journal of Pediatrics*, **107,** 317.

GEDALIA, A., PRESS, J., KLEIN, M. & BUSKILA, D. (1993) Joint hypermobility and fibromyalgia in schoolchildren. *Annals of the Rheumatic Diseases*, **52,** 494.

GRAHAME, R., EDWARDS, J.C., PITCHER, D., GABEL, A. & HARVEY, W. (1981) A clinical and echocardiographic study of patients with the hypermobile syndrome. *Annals of the Rheumatic Diseases*, **40,** 541.

GREENWOOD, L.F. (1987) Is temporomandibular joint dysfunction associated with generalized joint hypermobility? *Journal of Prosthetic Dentistry*, **58,** 701.

GROSFELD, O., JACKOWSKA, M. & CZARNECKA, B. (1985) Results of epidemiolgical examinations of the temporomandibular joint in adolescents and young adults. *Journal of Oral Rehabilitation*, **12,** 95.

HARINSTEIN, D., BUCKINGHAM, R.B., BRAUN, T. *et al*. (1988) Systemic joint laxity (the hypermobility joint syndrome) is associated with temporomandibular joint dysfunction. *Arthritis and Rheumatism*, **31,** 1259.

HARKINS, S., CUEVA, L.A., ANTONIOTTI, T. & ROCABADO, M. (1995) Systemic ligament hypermobility and parafunction in temporomandibular disorders. In: *Orofacial Pain and Temporomandibular Disorders* (eds J. R. Fricton & R. Dubner), pp. 363–374. Raven Press Ltd, New York.

HESSE, J.R., NAEIJE, M. & HANSSON, T.L. (1990) Craniomandibular stiffness toward maximum mouth opening in healthy subjects: a clinical and experimental investigation. *Journal of Craniomandibular Disorders: Facial & Oral Pain*, **4,** 257.

HORTON, W.A., COLLI, D.L., DESMET, A.A., KENNEDY, J.A. & SCHIMKE, R.N. (1980) Familial joint instability syndrome. *American Journal of Medical Genetics*, **6,** 221.

JESSE, E.F., OWEN, D.S. JR. & SAGAR, K.B. (1980) The benign hypermobile joint syndrome. *Arthritis and Rheumatism*, **23,** 1053.

KATZBERG, R.W., KEITH, D.A., GURALNICK, W.C. & TEN EICK, W.R. (1982) Correlation of condylar mobility and arthrotomography in patients with internal derangements of the temporomandibular joint. *Oral Surgery, Oral Medicine, Oral Pathology*, **54,** 622.

KIRK, J.A., ANSELL, B.M. & BYWATERS, E.G.L. (1967) The hypermobility syndrome: musculoskeletal complains associated with generalized joint hypermobility. *Annals of the Rheumatic Diseases*, **26,** 419.

MCCARROLL, R.S., HESSE, J.R., NAEIJE, M., YOON, C.K. & HANSSON, T.L. (1987) Mandibular border position and their relationship with peripheral joint mobility. *Journal of Oral Rehabilitation*, **14,** 125.

OKESON, J.P. (1993) *Management of Temporomandibular Disorders and Occlusion*, 3rd edn, pp. 91–108. Mosby Year Book, St Louis, MO.

PERRINI, F., TALLENS, R.H., KATZBERG, R.W., RIBEIRO, R.F., KYRKANIDES, S. & MOSS, M.E. (1997) Generalized joint laxity and temporomandibular disorders. *Journal of Orofacial Pain*, **11,** 215.

Plunkett, G.A. & West, V.C. (1988) Systemic joint laxity and mandibular range of movement. *Journal of Craniomandibular Practice*, **6,** 320.

Pullinger, A.G., Liu, S.-P., Low, G. & Tay, D. (1987) Differences between sexes in maximum jaw opening when corrected to body size. *Journal of Oral Rehabilitation*, **14,** 291.

Schultz, L.W. (1947) Report on ten years of experience in treating hypermobility of the temporomandibular joint. *Journal of Oral Surgery*, **5,** 202.

Solberg, W.K. (1981) The troubled temporomandibular joint: new opportunities and challenges in research and clinical management. *Oro-bio (UCLA)*, **2,** 2.

Stegenga, B., DeBont, L.G.M., DeLeeuw, R. & Boering, G. (1993) Assessment of mandibular function impairment associated with temporomandibular joint osteoarthrosis and internal derangement. *Journal of Orofacial Pain*, **7,** 183.

Szentpétery, A. (1993) Clinical utility of mandibular movement ranges. *Journal of Orofacial Pain*, **7,** 163.

Westling, L. (1989) Craniomandibular disorders and general joint mobility. *Acta Odontologica Scandinavica*, **47,** 293.

Westling, L. & Mattiasson, A. (1991) Background factors in craniomandibular disorders: reported symptoms in adolescents with special reference to joint hypermobility and oral parafunctions. *Scandinavian Journal of Dental Research*, **99,** 48.

Westling, L. & Helkimo, E. (1992) Maximum jaw opening in adolescents in relation to general joint mobility. *Journal of Oral Rehabilitation*, **19,** 485.

Westling, L., Carlsson, G.F. & Helkimo, M. (1990) Background factors in craniomandibular disorders with special reference to general joint hypermobility, parafunction and trauma. *Journal of Craniomandibular Disorders and Facial Oral Pain*, **4,** 89.

Westling, L., Holm, S. & Wallentin, I. (1992) Temporomandibular joint dysfunction: connective tissue variations in skin biopsy and mitral valve function. *Oral Surgery, Oral Medicine, Oral Pathology*, **74,** 709.

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