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ORIGINAL ARTICLE

Dental erosive wear assessment among adolescents and adults utilizing the basic erosive wear examination (BEWE) scoring system

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Abstract
Objectives To investigate erosive tooth wear and related variables among adolescents and adults in Israel, utilizing the new basic erosive wear examination (BEWE) scoring system, in an attempt to contribute to the ongoing review, evaluation, and further development of an international standardized index.
Material and methods A cross-sectional, descriptive, and analytic survey was conducted among 500 subjects of five age groups. Dental erosion was measured according to the new BEWE scoring system. Independent variables included gender, age, origin, education, employment status, and diet. A backward stepwise linear regression model was applied to identify significantly associated variables.
Results Fifty percent of the survey subjects demonstrated erosive tooth wear; among them, 10 % had distinct erosion of over 50 % of the dental surface. Total BEWE score differences by age groups were statistically significant; as the age increased, the mean total BEWE scores increased ($p < 0.001$). The association between acidic foods and erosion was evident among the younger population ($p = 0.038$). In a multiple regression model, age ($p < 0.001$) and diet ($p = 0.044$) achieved statistical significance as variables associated with dental erosive wear.
Conclusions Our study is one of the first to use the BEWE scoring system in an epidemiological survey among adolescents and adults. It was found that the BEWE index is straightforward, easy to conduct, and comfortably accepted by the examinees.
Clinical Relevance The present findings, together with further international research, should contribute toward continued evaluation of the BEWE system as an international standard and thereby, toward more optimal understanding, evidence-based treatment, and prevention of dental erosive wear.

Keywords Dental erosion · Dental erosive wear · BEWE · Epidemiology

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Introduction

Erosive tooth wear for many years has been a condition of secondary interest to clinical dental practitioners and dental public health experts, but perceptions are now changing. Over the last two decades, a substantial amount of research has accumulated in the fields of understanding, preventing, and treating this pathology [1–5]. Over a lifetime, teeth are exposed to a wide spectrum of physical and chemical insults, which to varying degrees contribute to the wear and tear of dental hard tissues [6, 7]. Dental erosive wear is initiated with the softening of the surface by dissolution of enamel by acids when the surrounding aqueous phase is undersaturated with remineralizing minerals. In its broader definition, dental erosion is the irreversible loss of permanent and deciduous dental hard tissue due to the chemical process of acid dissolution but not involving bacterial plaque acid and not directly associated with mechanical or traumatic factors, or with dental caries. Abrasion and attrition often exacerbate the erosive process [1, 6, 8].

The objectives of tooth erosive indices, similar to other oral health conditions, are to classify and record the severity of events in epidemiological surveys. An adequate way of defining and recording erosive tooth wear is essential in order to assess the extent of this phenomenon, both at individual and population levels [3, 4, 9]. Despite evolving awareness, no adequate diagnostic device has been available, to date, for the assessment of dental erosive wear. These defects have therefore only been clinically detected on a subjective experience-based clinical level [3, 4, 8, 9].

It is difficult to compare the results of dental erosive wear epidemiological surveys due to a wide range of examination standards and nonhomogeneous population groups. Many indices exist which vary in their manner of assessment, scale, choice of teeth, and other differing modalities, resulting in a low potential of comparability [3, 8–10]. Several dental erosive wear surveys have been conducted around the world and have revealed prevalence levels ranging from 5to 95 %. Research has found that as age increased and as the teeth are increasingly retained for life, the incidence of dental erosive wear increases [3, 11].

In the development of dental erosive wear, interactions are required which include chemical, biological, behavioral, diet, time, socioeconomic, knowledge, education, and general health factors [1, 3, 5, 12]. In conjunction with dental caries and periodontal disease, dental erosion is now recognized as a global public oral health problem [13, 14]. It is anticipated that the increasing longevity of the teeth in the 21st century will create a level of dental erosive wear more demanding on the preventive and restorative skills of the dental profession [1, 3, 4, 13, 14].

A policy and practice theme paper published in 2005 by the World Health Organization, regarding the global burden of oral diseases and risks to oral health, stated "worldwide, there is a need for more systematic population-based studies on the prevalence of dental erosion using a standard index of measurement" [14].

In 2007, a workshop entitled "Current erosion indices—flawed or valid?" was held in Basle, Switzerland, with the aim of substantiating and critically discussing research tools in this field [8]. After extensive discussion, it was agreed that there is a need for a validated, standardized, and internationally accepted index for dental erosive wear. To initiate the development of such a tool, a universal scoring system was suggested. The basic erosive wear examination (BEWE), introduced in 2008, was designed for use both within the research field of dental public health and also for dental clinicians [9]. Global researchers were encouraged to conduct national epidemiological surveys of dental erosive wear, employing this new scoring system. The authors also stated "this is to provide on one hand a clear and defined structure for scientific and clinical use, but on the other hand to be amenable for further development."

So far, epidemiological data regarding dental erosive wear in the Israeli population are lacking. The aim of the present cross-sectional, analytic epidemiological survey was to investigate dental erosive wear among adolescent and adult population, in order to assess dental erosion status and potential risk levels of different age groups. The study utilized the new BEWE scoring system, in an attempt to contribute to the ongoing review, evaluation, and further development of an international standardized index.

Study population

Adolescents and adults in Israel residing in "Kibbutz" villages were chosen to participate in the survey due to their accessibility and the fact that these communities reflect a wide range of social strata, including agricultural, industrial, academic, public, and private sectors. The study sample comprised 500 subjects stratified by age and gender. Inclusion criteria included being willing and able to supply written informed consent, being in the defined age group, having at least 20 natural teeth, and not being pregnant.

Material and methods

The study was approved by the local IRB (Helsinki) committee. Data were collected during 2011 by one experienced epidemiologist (Y.V.) who was trained by one of the authors (A.L.). Using the BEWE scoring system, guidance included the study of criteria for the identification of erosive lesions as compared with attrition and abrasion lesions, with regard to sound, restored, and decayed tooth surfaces. Diagnosis of early forms of erosion is difficult, as it is accompanied by few signs and fewer, if any, symptoms. There is no device available in routine dental practice for the specific detection of dental erosion and progression. Therefore, clinical appearance is the most important feature of dental professionals to diagnose this condition.

The early signs of erosive tooth wear appear as a smooth silky-shining glazed surface with the absence of perikymata. Initial lesions are located coronal from the enamel-cemento junction with an intact border of enamel along the gingival margin. In the more advanced stages, changes in the original morphology occur. On smooth surfaces, the convex areas flatten or concavities become present; the width of which clearly exceeds its depth. Progression of occlusal erosion leads to rounding of the cusps, grooves on the cusps, and incisal edges and restorations rising above the level of the adjacent tooth surfaces [15].

Calibration was conducted by comparing diagnoses with the second author (H.D.S.C.) among the 15 examinees, until the level of agreement had reached 90 %. Examinations were

conducted in dental clinics, employing a dental chair and an operating light. Teeth were air-dried, and a plane dental mirror was used.

Dental erosive wear (dependent variable) was measured according to the BEWE [8]. According to this scoring system, all teeth are examined, and thereafter, the most severely affected surfaces (buccal/facial, occlusal, and lingual/palatal) in each of six sextants (teeth 14–17, 13–23, 24–27, 34–37, 33–43, 44–47) are recorded.

The graded levels for appearance or severity of dental erosion are the following:

0 No erosive tooth wear
1 Initial loss of enamel surface texture
2 Distinct defect, hard tissue loss (enamel and dentine) less than 50 % of the surface area
3 Hard tissue loss equal or more than 50 % of the surface area.

The sum of the scores of the sextants, ranging from 0 to 18, is then calculated and can be transferred into risk levels. Bartlett and coworkers suggested the following:

No erosive tooth wear ("None")–a cutoff value of total score less than or equal to 2.
"Low" erosive tooth wear–a cutoff value of total score between 3 and 8.
"Medium" erosive tooth wear–a cutoff value of total score between 9 and 13.
"High" erosive tooth wear–a cutoff value of total score of 14 and above.

Independent variables included the following: gender (male, female), age (five different age groups: 15–18 years, 25–28 years, 35–38 years, 45–48 years, and 55–60 years, 100 subjects in each group), origin (place of birth), education (elementary, high school, and above high school), and employment (elementary, professional, and managers).

Additionally, each of the participants filled in a questionnaire which included the following items: recent dental hypersensitivity to cold, hot, or different taste stimuli; lifetime parotid gland inflammation; lifetime exposure to radiation due to head and neck tumors; frequency of reflux; vomiting; exposure to acidic vapors at the workplace; and frequency of consumption of sedatives, sleeping, antiallergy, or other drugs.

Diet data were derived from questions regarding the daily frequent consumption of acidic foods and beverages (for example, orange, apple, fresh vegetables, lemon drink, cola, and energy drink). The questionnaire, previously employed by Lussi, had been translated from German to Hebrew and then translated back for validation.

SPSS 17.0 software (IBM Company, Chicago, IL, USA) was employed. A sample size of at least 405 participants, equally distributed in five age groups ($n = 81$), was originally calculated according to the "Winpepi" program [16] and provided 90 % statistical power to identify a difference of 10 % in the proportion of participants with erosion between strata. The calculation assumed that 30 % of the population had symptoms of erosion; α equals 0.05, and β equals 0.10. The final study sample included 500 subjects (above the required number of 405).

Prevalence was assessed according to percentage of distribution. Independent t test, one way analysis of variance (ANOVA), and Chi-squared test were applied to test the univariate associations between the dependent and independent variables. A backward stepwise linear regression model was applied to identify the significantly associated variables. Statistical significance was chosen at $p < 0.05$.

Results

Study population comprised 245 male subjects (49 %) and 255 female subjects (52 %). Distribution of study population by independent variables revealed that the majority (441, 88 %) of the 500 participants were born in Israel. Excluding the younger age group (aged 15–18 years), 96 % of the participants had a level of education of high school and higher, 92 % were employed as semi-skilled, skilled, professionals, and managers, and 8 % were unemployed or unskilled.

Half of the survey participants demonstrated erosive tooth wear. According to the distribution of the worst BEWE scores, 252 (50 %) of the survey participants had no erosive wear (BEWE 0), 81 (16 %) scored BEWE 1 (initial loss of enamel surface texture) as their worst score, 118 (24 %) scored BEWE 2 (distinct defect, hard tissue loss (enamel and dentine) less than 50 % of the surface area) as their worst score, and 49 participants (10 %) had distinct erosion of over 50 % of the dental surface (BEWE 3).

The distribution of dental erosion among the survey participants by the worst BEWE scores of different sextants revealed that in the upper anterior sextant, 19.8 % of the participants demonstrated hard tissue loss (13.4 % scored BEWE 2 as their worst score, and 6.4 % scored BEWE 3 as their worst score), as compared with maximum of 5 % for the other sextants.

The mean total BEWE score of the six sextants (potentially ranging from 0 to 18) of the present study population was 1.84 ± 2.53 with a range from min = 0 to max = 12. Mean total BEWE score differences by gender were not statistically significant; male subjects = 1.94 ± 2.68; female subjects = 1.75 ± 2.38.

Mean total BEWE score and percentage of people with BEWE score 1 or more (at least initial loss of enamel surface texture) by age groups are presented in Table 1. As the age increased, the mean total BEWE scores increased from 1.07 ± 1.82 at 15–18 years to 2.34 ± 2.73 at 55–60 years ($p < 0.001$). Concurrently, as the age increased, the percentage of people

Table 1 Mean total BEWE score (all sextants) and percent of BEWE score (1 and more) differences by age groups

Age category	BEWE (Mean+SD)	BEWE (% of score of 1+)
15–18 years	1.07±1.82	36.6
25–28 years	1.38±2.19	42.0
35–38 years	2.22±2.79	55.8
45–48 years	2.21±2.74	53.1
55–60 years	2.34±2.73	61.9
P	<0.001	0.002

with BEWE scores of 1 and more increased from 36.6 % at 15–18 years to 61.9 % at 55–60 years ($p = 0.002$).

Among the current study population, the mean daily consumption of acidic foods and beverages was 9.63 ± 5.65 items (min = 0, max = 38). We operationally classified diet categories, according to quartiles, as follows:

- Low–first quartile of study subjects consuming 1 to 5 acidic items per day.
- Medium–second quartile of study subjects consuming 6 to 8 acidic items per day.
- High–third quartile of study subjects consuming 9 to 12 acidic items per day.
- Very high–fourth quartile of study subjects consuming 13 to 38 acidic items per day.

Presence or absence of erosion (BEWE scores 0 vs 1 and more) and mean diet daily consumption by age groups are presented in Table 2. Statistical significance was demonstrated for the 25–28 years age group, as those who scored BEWE 0 consumed an average of 9 acidic food items per day as compared with those who scored BEWE 1 or more who consumed an average of 11 acidic foods per day ($p < 0.038$).

With regard to the other items of the questionnaire, 128 participants (26 %) reported recent dental hypersensitivity to cold, hot, or different taste stimuli; 6 participants (1 %) reported lifetime parotid gland inflammation; 31 participants (6 %) reported weekly reflux; 9 participants (2 %) reported weekly vomiting; 15 participants (3 %) reported exposure to acidic vapors at the workplace; and 116 participants (23 %) reported consuming sedatives, sleeping, antiallergy, or other drugs. Association of these independent variables with dental erosion (BEWE-dependent variable) revealed no statistically significant results.

A backward stepwise linear regression model for mean tooth erosion total score including unstandardized B coefficients is presented in Table 3. Two variables age and diet were found to be significantly associated with tooth erosion. As age and consumption of acidic foods increased, the risk for dental erosion increased (age B = 0.034, $p < 0.001$ and diet B = 0.040, $p < 0.044$). This model was adjusted for all other demographic, socioeconomic, and health status variables.

Table 2 BEWE scores (0 vs 1+) and diet (mean daily consumption) by age groups

Age (category)	BEWE (score)	Diet (mean daily consumption)	*p*
15–18 years	0	8.93±6.40	0.068
	1+	11.78±9.03	
25–28 years	0	8.78±4.14	*0.038*
	1+	10.85±5.69	
35–38 years	0	9.23±5.56	0.773
	1+	8.93±5.00	
45–48 years	0	9.80±5.21	0.711
	1+	9.41±5.16	
55–60 years	0	9.62±4.22	0.669
	1+	10.06±5.35	

Discussion

The present cross-sectional study analyzed dental erosive wear data collected among the five age groups and is among the few studies to use the BEWE scoring system in an epidemiological survey among adolescents and adults. Recent studies [17, 18], which investigated dental erosion prevalence among preschool children and adolescents, have also utilized the BEWE index.

Half of the present survey participants (248, 49.6 %) demonstrated dental erosion. Among 167 (33.4 %) of this population, distinct erosive defects (BEWE scores 2 and 3) were recorded. In the upper anterior sextant, about 20 % of the participants demonstrated a distinct erosive defect (BEWE scores 2 and 3 as their worst score) as compared with 2–5 % in the other sextants.

Our results revealed a substantial distinct erosive defect with hard tissues loss (BEWE scores 2 and 3) among a third of the population. About one fifth of the population experienced distinctive erosive wear located in the upper anterior sextant.

Prevalence studies of dental erosion among children have indicated an increase with age [2, 19, 20]. There is some evidence that erosive wear in the primary dentition is predictive of erosive wear in the permanent dentition [3]. In the present study, a clear and positive association was found

Table 3 Backward stepwise linear regression model for independent variables[a] effect on total BEWE score

	B	SE	95 % CI	*p*
Age	0.034	0.008	0.019–0.049	*0.001*
Diet	0.040	0.020	0.001–0.078	*0.044*

[a] Gender, origin, education, employment, dental hypersensitivity, different taste stimuli, parotid gland inflammation, exposure to radiation, reflux, vomiting, exposure to acidic vapors, and consumption of drugs had not reached statistical significance ($p \geq 0.05$)

between age (from teenagers to 60-year-old adults) and erosion in both univariate and multivariate analysis ($p < 0.001$).

In the literature, an association is demonstrated between the consumption of acidic foods and dental erosion [1–3, 5, 7, 19]. In this study, the mean daily total consumption of acidic foods and beverages was 9.63 ± 5.65 items. When examining dental erosion levels and mean daily diet consumption by age groups, statistical significance was revealed for the 25–28 years age group, whereas those who demonstrated no dental erosion consumed an average, less acidic food items per day as compared with those who demonstrated dental erosion ($p = 0.038$). No similar significant associations were detected for the other age groups. It may be postulated that the 25–28 year age group is of specific importance in the development of risk for dental erosive wear. Lifestyles and dietary habits change over time, including the amount and frequency of consuming acidic foods and drinks. Recently, "energy" beverages, herbal teas, and other "health" drinks have become increasingly popular. Associations between popular diets and dental erosive wear need to be further explored in continued research.

In the multiple regression analysis, diet and age maintained a statistical significant association with dental erosive wear (age, $p < 0.001$ and diet, $p < 0.044$). In our present survey, demographic, socioeconomic, lifestyle, work style, and health and ill variables were not been found to be significantly associated with tooth erosion.

Some of these items have been assumed as causative factors for erosion (e.g., chronic vomiting) and others as predisposing factors (e.g., medication) or as result of erosion (hypersensitivity). However, these associations were not revealed in the present study and indicate further exploration. Generally, dental diseases are recognized as strongly related with socioeconomic variables [21–23]. In a recent study, among children [18], conflicting results were demonstrated with regard to socioeconomic and health variables. Further research is indicated, and these potential factors should not be ignored or discarded.

The BEWE index was recently evaluated and compared with other dental erosive indices [10, 17]. The authors concluded that "the reliability of the BEWE scoring system proved acceptable for scoring the severity of dental erosion wear and for recording such lesions in prevalence studies" and that "the BEWE had sufficient sensitivity and specificity."

As indicated, the BEWE is a partial scoring system recording the most severely affected surface in each sextant, after examination and scoring of all teeth [9]. The designation of worst scores for each sextant has been previously successfully employed in other epidemiological indices, such as the CPI index for periodontal disease [24], which is the leading periodontal health status index for collecting epidemiological data worldwide, allowing international comparisons. Further research might investigate a potential advantage of scoring each tooth and then deriving a total average for dental erosion assessment.

Research has shown that erosive tooth wear is located on all tooth surfaces but most commonly on the occlusal and facial surfaces of maxillary and mandibular teeth and on the palatal surfaces of the maxillary anterior teeth [1, 3]. The BEWE does not allow tooth surface specification. A system permitting location of erosive wear on different dental surfaces might increase knowledge and understanding.

We found that the BEWE index is straightforward, simple, easy to conduct, and comfortably accepted by the examinees. A similar conclusion was reached in a recent study [17]. Although developed as a tool for general clinical practice, we think that the BEWE index can be considered useful, practical, and effective on an epidemiological research level.

The mean total BEWE score of the six sextants of the present study population was 1.84 ± 2.53. In 2008, Bartlett, Ganss, and Lussi [9] stated "BEWE is a partial scoring system recording the most severely affected surface in a sextant, and the cumulative score guides the management of the condition for the practitioner," and added, "The cutoff values (of the risk levels of tooth erosion) are based on experience and studies of one of the authors (AL) and have to be reconsidered." An ongoing evaluation of the classification of dental erosive wear severity in different populations was stressed. As the World Health Organization supports the formulation of goals, targets, and standards of oral health (e.g., level of DMFT index for dental caries) tailored for different countries, regions, and population groups, the same approach can be adapted for erosive tooth wear. Due to the fact that in our study the total BEWE score was low, we might arbitrarily suggest, for the present population, a tailored modified classification of dental erosive wear severity risk categories as follows:

- No erosive tooth wear ("None")–total score of 0 ($N = 251$, 50.1 % of study participants).
- "Low" erosive tooth wear–total score of 1–3 ($N = 143$, 28.6 % of study participants).
- "Medium" erosive tooth wear–total score of 4–6 ($N = 74$, 14.8 % of study participants).
- "High" erosive tooth wear–total score of 7 and above ($N = 32$, 6.4 % of study participants). The amenability to modification and adaption is an advantage of the BEWE method.

It should be emphasized that this suggestion does not imply that 21.2 % of the present population has medium-high risk levels for dental wear and that this group relatively (to the others) demonstrated the highest risk.

The limitations of the present study should be highlighted and considered. The study sample in our study is not nationally representative and could be considered as a "convenience" sample, although it should be noted that the

population mirrored a wide range of social strata and sectors of the Israeli population. Our study was cross-sectional and not longitudinal; hence, causal determinacy of the two variables (age and diet), despite coherence with current theory, should therefore be considered with caution.

We chose five age groups, with emphasis on adults, as these have seldom been highlighted in previous research. Despite the fact that much of the previous research has been based on children, it is generally accepted that tooth wear is age related and, therefore, a physiological process. The aging dentate population will inevitably have some degree of tooth wear. In certain cases abrasion, attrition and/or erosion results in unacceptable or pathological levels of tooth surface loss. Our results confirmed the increase of dental erosive wear with age, from adolescence to 60-year-old adults. We aimed to pinpoint those age groups where dental erosive wear might be more vulnerable. This objective was reached, by showing that acidic diet had the strongest effect on dental erosive wear among the 21–25 years age group.

The questions have to be asked: what is being measured by the BEWE index, in particular, in an adult population? Does the BEWE index only measure tooth surface loss as a result of acid dissolution and exclude any other category of lifetime dental wear? The answer remains ambivalent. Although the utilization of the BEWE scoring system included clear guidance and specific criteria for the identification of erosive lesions as compared with attrition and abrasion lesions, with consideration of sound, restored, and decayed tooth surfaces, more studies are needed in order to validate these criteria. International comparisons remain difficult to achieve.

The present findings together with further international, longitudinal, and large scale epidemiological research, should contribute toward continued evaluation of the BEWE system as an international standard and development of a more optimal, evidence-based global data bank on dental erosion. This is the basic requisite for promoting the understanding, treatment, and prevention of dental erosive wear.

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Conflict of interest The authors declare that they have no conflict of interest.

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