Information Value of Functional Status of the Stomatognathic System for Postural Balance Regulation

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We performed cluster analysis of stabilometry data of 129 men and 122 women at the age of 20-60 years using the following 4 methods: European stabilometry variant, Romberg test (European variant), Romberg test (American variant), and Romberg test (American Universal variant). Results of factor analysis of primary data matrix obtained during the test "eye open-teeth clenched" attest to higher clinical significance of absolute stabilometry parameters in comparison with relative ones. The results of factor analysis revealed peculiarities of functional status of the stomatognathic system as the postural sensor and its effect on postural balance. The contribution of the functional status of the stomatognathic system into the postural balance is about 2%.

Key Words: *stabilometry; factor analysis; methods of stabilometry*

Numerous studies on posturology, a science branch studying vertical body posture and the mechanisms of its maintenance, appeared during recent decades. P. M. Gagey *et al*. [8-11] and T. Fukuda [7] substantiated the major biomechanical mechanisms of posture maintenance. It was accepted that the status of the stomatognathic system affects the postural balance [2,3,12].

Much attention of specialists working in manual therapy is attracted to postural disturbances in various pathological processes. For instance, the effect of dental occlusion on functional status of the postural balance system was studied by A. M. Cuccia [4], S. Fujino *et al.* [6], A. V. Tsymbalistov *et al*. [1]. The interrelations between malocclusion, stomatognathic abnormalities, and postural disturbances and methods of their parallel correction were in the focus of studies of orthodontist M. H. Van der Linden [13] and M. Fujimoto *et al.* [5]. We found no published reports on the role of the stomatognathic system as the postural sensor and its effect on postural balance in humans. However, this problem is of great theoretical and practical importance.

Here we evaluated information value of the status of the stomatognathic system as the postural sensor and studied its effect on posture balance maintenance.

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MATERIALS AND METHODS

We performed complex examination of 251 individuals: 129 men (51.39%) and 122 women (48.61%) at the age of 20-60 years.

The exclusion criteria were toothlessness, general somatic diseases, exacerbation of chromic pathologies, myocardial infarction ≤6 months before the study, mental diseases, alcohol and drug abuse.

Stabilometry was performed on a Stabilometr computer biological feedback stabiloanalyzer according to requirements of International Society of Normal Standing Posture Studies [6].

The following stabilometric tests were used: Romberg test European variant (RTE); European stabilometry variant (EV), Romberg test American universal variant (RTAU), and Romberg test American variant (RTA). During the study, the patient stood still in his habitual posture with arms along the trunk.

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For evaluation of the effect of dental occlusion on postural balance the following tests were used: "eyes open, lower jaw relaxed" and "eyes open, teeth clenched".

The primary data matrix was subjected to factor analysis and rotation using Varimax raw, Varimax normalized, Equamax raw, Equimax normalized, Quatrimax raw, Quatrimax normalized, Biquartimax raw, Biquartimax normalized was applied for obtaining more visual results.

RESULTS

Stabilometry parameters obtained during testing "eyes open, lower jaw relaxed" were subjected to principal component factor analysis with Varimax raw rotation. The factor eigenvalues and their information values obtained during factor analysis are presented in Table 1.

Eigenvalues of other factors were below 1.0 and were not subjected to detailed analysis. On the whole, information value of the chosen eight factors was 84.001% (Table 1). Hence, the chosen 8 factors carry more than 84% information on postural stability of a patient during testing "eyes open, lower jaw relaxed".

The principal components of the first factor were mean square deviation of the common pressure center (CPC) in the saggital plane EV 0.727; amplitude of the first spectral maximum in the saggital plane EV 0.721; area of statokinesiogram 90 EV 0.867; mean square deviation of CPC in the saggital plane RTE 0.730; area of statokinesiogram 90 RTE 0.731; velocity of CPC RTAU 0.780; amplitude of the first spectral maximum in the saggital plane RTAU 0.780; area of statokinesiogram 95 RTAU 0.780; mean square deviation of CPC in the frontal plane RTA 0.820; mean square deviation of CPC in the saggital plane RTA 0.779; amplitude of the first spectral maximum in the saggital plane RTA 0.769; and area of statokinesiogram 95 RTA 0.875. They formed the positive pole of the first factor. The negative pole was formed by parameters of stabilometry stability index used in measurements: stability index for RTE -0.788, EV -0.822, RTA -0.799, RTAU -0.706. The principal components of the first factors are absolute and relative parameters of postural stability of a patient; this factors can be named as a factor of absolute and relative characteristics of postural stability.

The second factors was formed by the following parameters: 60% level of vertical spectral power RTE 0.903; frequency of the first vertical spectral maximum 0.836; frequency of the first vertical spectral maximum 0.842; 60% level of vertical spectral power RTA 0.842; 60% level of vertical spectral power RTAU 0.844; they formed the positive pole of the factor. The negative pole was formed by amplitude parameters of postural stability of the patient: amplitude of the first spectral maximum by the vertical component -0.750; amplitude of the first spectral maximum by vertical component -0.792; amplitude of the first maximum by the vertical component -0.736. On the whole, the second factor can be determined as the factor of frequency characteristics of postural stability.

The weight of the first factor more than 2-fold surpasses the weight of the second factor, which attests to higher information value of the first factor. The method of the principal components of factor analysis with Varimax rotation showed that the weight of the first 8 factors is above 1.0, therefore in further factor analysis we used only these factors.

The most significant result of factor analysis was obtained by Centroid method with Varimax raw rotation. The weight of the first factor was 7.007 and its principal components were: mean square deviation of CPC in the saggital plane EV 0.774; area of statokinesiogram 90 EV 0.742; index of stability EV -0.814;

TABLE 1. Eigenvalues of Factors and Their Information Values. Eyes Open, Lower Jaw Relaxed Testing

Factor	Eigenvalue	Information value, %	Cumulative value	Coefficient of cumulated information value, %
1	16.545	38.477	16.545	38.477
2	6.577	15.295	23.122	53.771
3	4.268	9.926	27.390	63.698
4	2.502	5.817	29.891	69.515
5	2.258	5.251	32.149	74.766
6	1.610	3.744	33.759	78.510
7	1.253	2.915	35.013	81.425
8	1.108	2.576	36.120	84.001

Note. 1: factor of absolute and relative characteristics of postural stability; 2: factor of frequency parameters of stabilometry.

TABLE 2. Eigenvalues of Factors and Their Information Values. Eyes Open, Teeth Clenched Testing

Factor	Eigenvalue	Information value, %	Cumulative value	Coefficient of cumulated information value, %
1	16.841	43.182	16.841	43.182
2	4.135	10.602	20.976	53.784
3	3.857	9.889	24.832	63.673
4	2.327	5.967	27.160	69.640
5	2.084	5.344	29.244	74.984
6	1.733	4.444	30.977	79.428
7	1.480	3.796	32.458	83.224
8	1.149	2.946	33.606	86.170

mean square deviation of CPC in the saggital plane RTA 0.889; area of statokinesiogram 95 RTA 0.761. The presented parameters are most informative for description of postural resistance of the patient. The weight of the second factor is 6.289 and it consisted of the following parameters: amplitude of the first spectral maximum by the vertical component EV 0.819; 60% level of vertical spectral power EV -0.962; frequency of the first spectral maximum by the vertical component RTE -0.806; frequency of the first spectral maximum by the vertical component RTAU -0.880; amplitude of the first spectral maximum by the vertical component RTAU 0.766; 60% level of vertical spectral power RTAU -0.869; amplitude of the first vertical spectral maximum RTA 0.787; 60% level of vertical spectral power RTA -0.900. The third factor included velocity of CPC EV 0.735; mean square deviation of CPC in the frontal plane RTE 0.810; mean square deviation of CPC in the sagittal plane RTE 0.785; velocity of CPC RTE 0.869; amplitude of the first spectral maximum by the sagittal component RTE 0.728; area of statokinesiogram 90 RTE 0.767; ratio of statokinesiogram length to its area RTE -0.712; index of stability RTE -0.861. The weight of the third factor is 6.964. Components of the second and third factors have similar weight coefficients and hence have comparable clinical value for evaluation of postural stability of the patient.

The weight of the fourth factor was 4.508 and its principal components were: mean square deviation of CPC in the frontal plane RTAU 0.761; amplitude of the first spectral maximum by the frontal component RTAU 0.819; area of statokinesiogram 95 RTAU 0.720; amplitude of the first spectral maximum by the frontal component RTA 0.762. Factor 8 included 2 stabilometry parameters: mean square deviation of CPC in the sagittal plane RTAU 0.822; index of stability RTAU -0.779. The weight of this factor was 4.402. The absolute values of factors 5, 6, and 7 were 0.998, 1.532, and 0.945, respectively. These factors had no components exceeding 0.7 in modulus and therefore they were excluded from further analysis.

Thus, at this stage of the experiment factor analysis revealed the basic weighted coefficients of the studied stabilometry parameters and their information and clinical values. These basic weighted coefficients are used as reference values in further studies.

During testing in the “eyes open, teeth clenched” mode, the most informative results were obtained with principal component factor analysis with Varimax raw rotation (Table 2).

Eigenvalues of other factors were below 1.0 and were not subjected to detailed analysis. Information value of stabilometry factors during testing in the “eyes open, teeth clenched” mode increases in comparison with “eyes open, lower jaw relaxed”. The weight of factors 1, 6, 7, and 8 increases in comparison with the data of “eyes open, teeth clenched” testing. Eigenvalues of factors 2, 3, 4, and 5 insignificantly decreased, probably due to redistribution of the weight coefficients.

The obtained results of factor analysis showed that information value of the first 8 factors increased to 86.17%. This suggests that functional state of the stomatognathic system makes a great contribution into postural stability of the patient, which agrees with the data of other investigators [13]. The observed regularity suggests that the contribution of the functional status of the stomatognathic system into postural stability is about 2%.

During “eyes open, teeth clenched” testing, the results of factor analysis were characterized by greater differences by factors 1 and 2.

The principal components of the first factor forming its positive pole were: amplitude of the first spectral maximum by the sagittal component EV 0.770; area of statokinesiogram 90 EV 0.871; mean square deviation of CPC in the sagittal plane RTE 0.740;

area of statokinesiogram 90 RTE 0.743; mean square deviation of CPC in the sagittal plane RTAU 0.779; velocity of CPC RTAU 0.767; amplitude of the first spectral maximum by the sagittal component RTAU 0.710; area of statokinesiogram 95 RTAU 0.765; mean square deviation of CPC in the sagittal plane RTA 0.843; velocity of CPC RTA 0.723; amplitude of the first spectral maximum by the sagittal component RTA 0.762; area of statokinesiogram 95 RTA 0.769. The negative pole of the first factor was formed by stability index EV -0.720, stability index RTE -0.788, stability index RTAU -0.834, and stability index RTA -0.890. Other factors contained no parameters exceeding 0.7 by modulus. Qualitative analysis showed that factor 1 includes greater number of stabilometric parameters with weight coefficient >0.7 by modulus. The positive pole was primarily formed by the absolute stabilometry parameters and the negative pole by the relative ones. Increased weight of velocity of CPC during "eyes open, teeth clenched" testing probably attests to an interrelationship between this stabilometry analysis and functional status of the stomatognathic system. Components of the factor with weight coefficients below 0.7 by modulus were excluded from the analysis.

Further factorization of the matrix of "eyes open, teeth clenched" testing data was performed on the basis of the result of principal component factor analysis. Therefore, the primary data matrix was factorized at the following parameters: maximum number of factors was set at 9 and minimum at 0.0, parameter "minimum changes" was set at 0.01, and maximum number of repetitions was 50.

The most significant parameters in factor 1 were: mean square deviation of CPC in the sagittal plane EV 0.907; index of stability EV -0.835. The weight of the first factor is 4.75. Factor 2 included parameters: mean square deviation of CPC in the frontal plane RTE 0.703; velocity of CPC RTE 0.888; amplitude of the first spectral maximum by the frontal component RTE 0.831, area of statokinesiogram 90 RTE 0.762. The weight of this factor attained the maximum value (6.09). The components of the third factor with maximum values were: mean position of CPC in the frontal plane EV 0.884; mean position of CPC in the frontal plane RTE 0.868; mean position of CPC in the frontal plane RTAU 0.927; mean position of CPC in the frontal plane RTA 0.882. The weight of the third factor is 3.966. Of components of factor 4, area of statokinesiogram 95 RTA had maximum value, 0.749. The weight coefficient of this factor was 4.66. In factor 6, the components with maximum weight were mean square deviation of CPC in the frontal plane RTAU 0.743; amplitude of the first spectral maximum by the frontal component RTAU 0.816; area of statokinesiogram 95 RTAU 0.778. The weight coefficient of factor 6 was 5.31. Factors 5, 7, and 8 contained no components with weight coefficients above 0.7 by modulus, The absolute values of these factors were also minimum: 2.17, 2.11, and 1.52 for factors 5, 7, and 8, respectively.

Results of factor analysis of primary data matrix obtained during "eye open-teeth closed" testing attest to maximum clinical significance of absolute stabilometry parameters in comparison with relative ones. Thus, absolute stabilometric parameters are most informative criteria in clinical analysis of postural stability of the patient. In should be noted that information value of absolute stabilometry parameters increased under conditions of "teeth clenched" testing, while weight coefficients of CPC velocity surpassed 0.7. Factor analysis showed that European variants of stabilometry have greater information value, which is confirmed by higher weight coefficients of the corresponding parameters. The results of factor analysis revealed peculiarities of functional status of the stomatognathic system as the postural sensor and its effect on postural balance. Comparison of factor loads during "lower jaw relaxed" and "teeth clenched" tests suggests that information value of the studied stabilometry parameters increased by ~2% during "teeth clenched" testing, which can be explained by the contribution of the functional status of the stomatognathic system into the postural balance. This also suggests that stabilometry for differential diagnostics of postural balance should be performed under conditions of physiological rest of the lower jaw at central occlusion or central jaw alignment. The effect of the functional status of the stomatognathic system on the postural balance can be both positive and negative. This is probably determined by the peculiarities of the functional status of the stomathognathic system and requires further investigations.

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