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Research Article

The Influence of Verbal Suggestion on Postural Stability: A Stabilometric Study in Dental Students

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Abstract

Background/Aim:

Stabilometric recordings are widely regarded as reliable references for assessing postural stability; however, they may be influenced by the measurement environment and external cognitive factors, such as verbal suggestion.

This observational study aimed to evaluate the impact of verbal suggestion on postural balance by comparing stabilometric recordings under neutral and suggestive conditions.

Material and Methods:

A controlled, randomized design was used to compare a test group (n = 126) and a control group (n = 49). Postural stability was assessed using a computerized stabilometric platform. The control group underwent three identical recordings without suggestions, while the test group performed:

1. Baseline recording (neutral condition, no suggestion).
2. Instability suggestion recording (verbal cues promoting imbalance).
3. Stability suggestion recording (verbal cues reinforcing balance).

Results:

The area of the center of pressure (CoP) displacement significantly increased under instability suggestions and decreased under stability suggestions, compared to baseline ($p < 0.05$). These findings indicate that verbal suggestion can directly influence postural control. Additionally, a habituation effect was observed, with participants demonstrating increased stability over repeated recordings.

Conclusions:

This study highlights the critical role of a neutral and controlled environment in stabilometric assessments. To ensure reproducible and unbiased results, standardized instructions should be used, and external verbal or environmental influences minimized.

Key Words: stabilometry; suggestion; center of pressure; postural control; balance assessment; clinical assessment

Introduction

Stabilometry, the analysis of postural sway, is a valuable tool for assessing balance and postural control, with applications in fields ranging from neurophysiology to sports science. Establishing normative data for stabilometric parameters is essential for identifying abnormalities and evaluating therapeutic interventions [1].

Despite extensive research on stabilometry, the potential influence of suggestion on stabilometric recordings remains largely unexplored.

Suggestion—the process by which an individual's thoughts, feelings, or behaviors are influenced by external factors—has been shown to impact various physiological and psychological processes [1]. Given that stabilometric assessments are widely used in clinical practice, where human interaction can introduce bias, it is crucial to consider how suggestion might affect these measurements [1,2].

In particular, stabilometric platforms are commonly employed in posturology-related specialties, including dentistry for occlusal analysis and the optimization of oral appliances for elite athletes. During our investigations, we observed that the recording environment might play a significant role in stabilometric measurements, raising questions about the potential impact of suggestion [2]. The literature reveals a lack of studies on how verbal instructions influence postural stability during stabilometric assessments [2]. Moreover, some authors challenge the recommendations of the Société Française de Posturologie, particularly regarding the optimal sampling frequency for recordings [3,4]. However, several studies point out that these measures can be influenced by the test environment and cognitive factors, including verbal suggestions [1,5].

Recent research shows that placebo and nocebo effects can modify postural stability, suggesting that expectations induced by verbal instructions have a measurable impact on postural control [6].

This study aims to assess the impact of verbal suggestion on stabilometric recordings and to emphasize the importance of a neutral testing environment to ensure reproducible results. To this end, we propose a clinical study involving healthy participants to investigate the potential effects of suggestion on stabilometric measurements.

Materials and Methods

Study Design and Participants

This observational study employed a controlled, randomized design to investigate the influence of verbal suggestions on postural stability. Healthy volunteers from the dental surgery department of Toulouse University (France) were recruited. Participants were screened to exclude those with a history of neuromuscular or vestibular disorders, recent musculoskeletal injuries (e.g., fractures, sprains), or any condition that could affect balance, ensuring a sample with presumptively normal postural control.

After providing informed consent, participants were randomly assigned to one of two groups:

- **Control group:** Received neutral instructions throughout the experiment.
- **Test group:** Exposed to verbal suggestions of either instability or stability during specific phases of the experiment.

Experimental Protocol

Stabilometric Assessment [7]

Postural stability was assessed using a computerized stabilometric platform equipped with Win Posturo software. The platform was calibrated before each session to ensure measurement accuracy.

Each participant underwent three consecutive stabilometric recordings, each lasting 51.2 seconds, under different instructional conditions. To standardize the experimental setup, all participants adopted the same posture:

- Eyes closed
- Arms relaxed at the sides
- Unbitted teeth
- Feet together

The study followed current stabilometry recommendations, including a sampling frequency of 40 Hz and minimum recording time [4,7,8].

Control Group

Participants in the control group were given neutral instructions for all three recordings (such as “the recording is starting in 3 seconds”, “now the second”. nothing during the the recordings). They were simply asked to stand still on the platform with their feet together, serving as a baseline measure of postural stability without any external cognitive influence.

Test Group

Participants in the test group received verbal suggestions designed to induce either instability or stability. These suggestions were delivered verbally and corresponded to information provided in a participant information sheet, which described a scientifically neutral concept: the reverse photo-proprioceptive reflex. This fictional phenomenon suggested that light stimulation of a tooth could influence balance.

The test group underwent three stabilometric recordings:

• **Recording 1 (Neutral Instructions):** Identical to the control group, participants were simply asked to stand still on the platform.

• **Recording 2 (Instability Suggestions):** Participants were given verbal cues designed to induce a sensation of imbalance, such as:

o “As indicated by the inverse photo-proprioceptive reflex, with the stimulation of this canine, you will begin to perceive small movements…”

o “As if you were a tree branch caught in a gust of wind.”

o “As if you were a blade of grass pushed by the wind.”

o “The more you move, the more unstable you are, and the more unstable you are, the more you move.”

o “Completely unstable, completely mobile.”

• **Recording 3 (Stability Suggestions):** Participants were given verbal cues intended to reinforce a sense of stability, such as:

o “You will be surprised to feel that the stimulation of this canine is going to restabilize you.”

o “As if you were an oak stake firmly anchored in the ground.”

o “Very stable, very immobile.”

o “Completely stable, completely immobile.”

Blinding and Randomization

To minimize bias, participants were blinded to the study’s true hypothesis. They were informed that the study aimed to examine the effects of light dental stimulation on postural stability, without reference to verbal suggestion as a key factor. Randomization ensured an even distribution of participants with potentially different balance capabilities between the control and test groups.

Data Analysis

The stabilometric platform recorded multiple postural parameters, but the primary outcome measure was the area of displacement of the center of pressure (CoP), representing the projection of the center of gravity onto the platform. A larger CoP area indicates greater postural instability.

Statistical Analysis

• Descriptive statistics (mean, standard deviation, variance) were calculated for each group and condition.

• A one-way ANOVA and a Student's t-test was conducted (after testing the normal distribution of the subjects) to compare mean CoP areas between:

o The control and test groups

o The instability and stability conditions within the test group

• The alpha level was set at 0.05 to determine statistical significance.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the local ethics committee prior to participant recruitment (n° 2023TOU33047). All participants provided written informed consent after receiving a detailed explanation of the study's objectives, procedures, potential risks, and benefits.

Results

Descriptive Statistics

A total of 175 participants aged 18 to 45 years, were included in this study out of the 480 students of the dental surgery department. They were divided into two groups:

• **Test group (n = 126):** Exposed to verbal suggestions of stability and instability during stabilometric recordings.

• **Control group (n = 49):** Received neutral instructions throughout the experiment.

Demographic Characteristics

• **Gender distribution:** In the test group, 24% of participants were male and 76% were female, while in the control group, the male-to-female ratio was 30%/70%.

• **Age:** The mean age of participants was 22.4 years (range: 19–45 years).

• **Handedness:** 86% of participants were right-handed, while 14% were left-handed, a proportion consistent with general population estimates.

Surface Area of Statokinesigram (Center of Pressure Displacement)

The surface area of the center of pressure (CoP) displacement for both groups across the three recordings is presented in Table 1.

	Group	Observation	Mini	Maxi	Mean	SD	ANOVA
Recording 1	Test	126	61.6	1226.4	274.18	165.56	0.8004
	Control	49	61	1647.7	272.58	233.17	
Recording 2	Test	126	60.8	5922.8	454.38	789.14	**0.0480***
	Control	49	73.1	1344.4	226.86	194.2	
Recording 3	Test	126	50.7	832	217.01	125.68	0.2191
	Control	49	50.5	2003.2	255.91	292.18	

Table 1: Descriptive Statistics of the Surface Area (mm²) of the Statokinesigram for Both Groups

(*Statistically significant differences between groups are indicated with an asterisk*)

• In the **control group,** CoP displacement remained relatively stable across all three recordings, indicating no significant variation in postural stability over time.

• In contrast, the **test group,** which received different verbal suggestions, exhibited notable variations in CoP displacement:

o Neutral Instructions (Recording 1): Baseline CoP values were comparable to those of the control group.

o Instability Suggestions (Recording 2): A statistically significant increase in CoP displacement (p = 0.008) was observed, suggesting that verbal cues promoting instability induced greater postural sway.

o Stability Suggestions (Recording 3): CoP displacement decreased significantly (p < 0.0001) compared to Recording 2, indicating improved postural stability in response to stability-enhancing suggestions.

These findings highlight the influence of verbal suggestion on postural stability.

Statistical Significance Analysis

To evaluate the **significance of changes in CoP displacement** between recordings, p-values were calculated for both groups (Table 2) after verification of their normal distribution.

Comparison	Test Group	Control Group
Recording 1 vs 2	**0.008**	**0.042**
Recording 1 vs 3	**<0.0001**	**0.001**
Recording 2 vs 3	**0.001**	0.447

Table 2: Statistical Significance (p-values) Between Recordings

• In the test group, significant differences were observed:

o Between Recording 1 (neutral) and Recording 2 (instability): p = 0.008

o Between Recording 1 (neutral) and Recording 3 (stability): p < 0.0001

o Between Recording 2 (instability) and Recording 3 (stability): p = 0.001

• In the **control group,** although some small variations in CoP displacement were observed, they were not systematically significant, except between Recording 1 and 2 (p=0.042) and Recording 1 and 3 (p = 0.001), suggesting a potential habituation effect rather than an influence of verbal suggestion.

Analysis of Variance (ANOVA)

A one-way ANOVA was conducted to compare CoP displacement across conditions. The results indicated:

• A significant difference in CoP displacement during the instability suggestion condition (p = 0.048), confirming that verbal cues inducing instability significantly affect postural stability.

• No significant differences were found in baseline (neutral) or stability suggestion conditions, suggesting that the body naturally returns to stable postural control when verbal instability cues are removed and when verbal stability cues are added.

Impact of Hypnosis Susceptibility on CoP Displacement

To explore the role of individual susceptibility to hypnosis, the test group was further stratified into two subgroups:

• **Normo-receptive** participants (n = 111): Participants with typical responsiveness to hypnosis.

• **Hyper-receptive** participants (n = 15): Participants identified as highly susceptible to hypnosis.

The impact of **hypnotizability on CoP displacement** was analyzed for each recording (Table 3):

Group	Recording 1	Recording 2	Recording 3	p-value (Rec 1)	p-value (Rec 2)	p-value (Rec 3)
Normo-Receptive (n=111)	270.57 (SD: 135.99)	292.92 (SD: 264.45)	210.01 (SD: 113.93)	0.0657	**<0.0001**	0.0889
Hyper-Receptive (n=15)	354.34 (SD: 304.63)	1649.19 (SD: 1809.57)	268.85 (SD: 189.16)			

Table 3: Impact of Hypnosis Susceptibility on CoP Displacement

• During the instability condition (Recording 2), hyper-receptive participants exhibited a significantly greater increase in CoP displacement compared to normo-receptive participants ($p < 0.0001$).

• For the neutral condition (Recording 1) and the stabilization condition (Recording 3), no significant differences were found between the two groups, indicating that heightened susceptibility to hypnosis primarily affects responses to instability-inducing verbal cues.

Summary of Key Findings

• **Verbal suggestion significantly influences postural stability.** Instability suggestions lead to increased postural sway, while stability suggestions reduce sway, improving balance.

• **The effect of verbal suggestion is statistically significant.** ANOVA confirmed significant changes in CoP displacement under instability conditions ($p = 0.048$).

• **Hypnosis susceptibility amplifies the effect of verbal suggestion.** Hyper-receptive participants showed a much stronger response to instability cues ($p < 0.0001$).

These results support the hypothesis that cognitive processes and verbal suggestions play a crucial role in postural control, opening new perspectives on the psychological regulation of balance.

Discussion

This study investigated the relationship between verbal suggestion and postural control using a stabilometric platform to objectively measure the effects of verbal cues promoting either stability or instability. These findings highlight the strong influence of verbal suggestion on postural stability, demonstrating that psychological cues alone can alter postural control.

Sample Selection

Participants were recruited from dental surgery students, as this was the most practical way to obtain a sufficient sample size. The test group primarily consisted of third-year dental students, who were the most accessible and available. Only six students from this cohort declined participation. Additionally, volunteers from the second, fourth, fifth, and sixth years, as well as interns, were included.

While our sample is highly representative of the student population at the Toulouse Faculty of Dental Surgery, it is less so of the general population, particularly in terms of age and gender distribution. In the test group, the male-to-female ratio was 24% to 76%, a proportion similar to that reported by Bracco et al. [10] in their study on jaw relations and postural stability. Most stabilometry studies tend to focus on specific populations, such as young, healthy individuals - like in the studies of Amaricai et al. [11] and Tardieu et al. [12], as well as those replicated by Visser et al. [13] and Doyle et al. [14] - or older patients with balance disorders [15].

Regarding handedness, our sample included 86% right-handed and 14% left-handed participants, a proportion consistent with general population estimates (8–15% left-handed individuals) [16] and similar to the distribution reported by Henderson et al. among UK dental students [9]. Importantly, no participant was included in both the test and control groups.

The participants were in good health, which helps to avoid adding complexity to the interpretation of the results. However, other types of population could be used. As Older adults with Alzheimer's disease [23] or in the study of Jouira et al. [24] were they investigated the effect of verbal encouragement (VE) on static and dynamic balance in individuals with intellectual disabilities (IDs). Verbal encouragement significantly reduced center of pressure mean velocity values for mild IDs in firm bipedal closed Eyes conditions. The mild IDs group exhibited improved Y Balance Test scores and enhanced Expanded Time Up and Go Test performances for both groups under verbal encouragement. Incorporating verbal encouragement as a motivational strategy in balance training interventions can positively impact static and dynamic balance in individuals with mild IDs, especially in challenging conditions like unipedal stances on firm surfaces [24].

Stabilometric Settings

The recommended minimum recording frequency for stabilometry is 5 Hz, as per standard guidelines (1985); however, this threshold has been criticized by several authors. A higher sampling rate of 40 Hz is now recommended for greater precision [4,7,8]. In our study, we adhered to this higher standard to ensure optimal data reliability.

The Powerful Influence of Suggestion on Balance

Our results clearly demonstrate the significant impact of verbal suggestion on balance control. Participants exposed to verbal cues suggesting instability exhibited a statistically significant increase in their sway area compared to their baseline measurements. This finding suggests that verbal cues, even in the absence of physical manipulation, can create a perception of instability that translates into measurable alterations in postural stability. These results highlight the strong interplay between cognitive processes and physiological responses, reinforcing the notion that seemingly automatic bodily functions can be influenced by psychological factors.

Habituation: A Methodological Consideration and a Potential Area of Inquiry

Our study also revealed a significant habituation effect, with participants in both the control and test groups exhibiting a reduction in sway area over repeated recordings. This finding underscores the importance of accounting for habituation in studies employing stabilometric platforms while also opening new avenues for further research.

For the test group, it remains to be determined what proportion of the reduction in sway area is attributable to suggestion versus habituation. The literature confirms this habituation phenomenon [8, 19]. Ruhe et al. suggest that averaging 3–5 recordings is necessary for reliable data [19]. Their study recommends conducting at least three recordings of 30 seconds each under identical conditions, with the third measurement considered the most stable. Our results align with these findings.

While habituation likely plays a role, future studies should investigate whether the observed decrease in sway area is also influenced by the type of suggestion provided (stability vs. instability), further illuminating the interaction between psychological factors and postural control.

Hypnotizability and Suggestion Susceptibility

Our investigation into the relationship between hypnotizability and susceptibility to suggestion yielded clear findings. Participants identified as "highly receptive" to hypnosis exhibited a more pronounced response to verbal suggestions, particularly those emphasizing instability. Hypnotizability was assessed subjectively by an experienced investigator during hypnosis training sessions. While more standardized methods, such as the Stanford Hypnotic Susceptibility Scale (SHSS:C) or the Elkins Hypnotizability Scale (EHS), could have been used, these tools are time-consuming (approximately 30 minutes for EHS and 45–60 minutes for SHSS:C per participant) [17,18].

This observation raises interesting questions about the underlying mechanisms governing responses to external cues. It is possible that individuals with higher hypnotizability have a more permeable boundary between conscious and subconscious processing, making them more susceptible to suggestion-induced alterations in both cognitive and physiological domains. Further research, including neurophysiological investigations, could help elucidate the mechanisms underlying this phenomenon.

Limitations

Although this study provides valuable insights into the interplay between suggestion and balance, it has several limitations or methodological biases. The relatively short recording duration may not fully capture the temporal dynamics of suggestion-induced effects on postural control. Additionally, the lack of multiple testing sessions limits our ability to assess inter-session variability. Future studies could address these limitations by incorporating longer recording times and repeated measurements over extended periods. A novel unconstrained protocol, proposed by Haworth et al., named volitional Limits of Stability (vLOS), shows high test-retest-reliability. They tested if verbal encouragement impacts this protocol and they show that Significant, large increases in sway area with verbal encouragement indicate that top-down mechanisms should be considered in theories of postural control. As well, clinical utilization of novel vLOS should be careful with word selection and delivery of protocol instructions [22]

Beyond the laboratory setting, our findings have potential clinical applications. A better understanding of the interaction between psychological factors and postural control could contribute to the development of novel therapeutic approaches for balance-related disorders, such as vestibular dysfunctions and neurodegenerative diseases [20,21]. Additionally, the methodology employed in this study could be extended to investigate the influence of other sensory inputs, cognitive processes, or emotional states on postural stability.

While exploring personalized interventions was beyond the scope of this study, our findings suggest that verbal suggestions promoting stability could potentially enhance postural control. This opens the door to the use of suggestion as a complementary approach in balance training, particularly for individuals with postural impairments [20]. However, further research is needed to determine the feasibility, efficacy, and optimal application of suggestion-based interventions in clinical settings.

Conclusion:

This study investigated the influence of verbal suggestion on postural stability, recording the postural sway of dental students on a stabilometric platform under either neutral or suggestive conditions. Our results demonstrate that the 126 students in the test group exhibited significant variations in their stabilometric recordings depending on the nature of the verbal suggestion, while the control group showed consistent postural recordings across all three measurements. These findings provide strong evidence that psychological factors, particularly verbal suggestion, can modulate postural control, irrespective of individual hypnotic susceptibility.

These results reinforce the idea that stabilometric recordings should not be considered as mere biomechanical measurements, but that they are sensitive to psychological and environmental influences. They underscore the importance of controlling environmental and verbal conditions when conducting stabilometric assessments. The presence of verbal suggestion - whether intentional or inadvertent - can introduce a significant bias in postural measurements. Therefore, to enhance the reliability and reproducibility of stabilometric recordings, we recommend that future studies and clinical assessments adhere to standardized testing conditions, including:

- A neutral, white, passage-free room to minimize external visual or spatial cues.
- A quiet environment where only essential instructions are provided to the participant.
- Standardized verbal instructions, free of suggestive language that could influence postural control.
- Calibrated visual anchoring with eyes open, ensuring uniform testing conditions across participants.

To further explore the robustness and generalizability of these findings, future studies could:

- Repeat the experiment over time to assess the stability and persistence of suggestion-induced postural changes.
- Introduce a randomized order of suggestions to eliminate potential sequence effects.
- Investigate neurophysiological correlates of suggestion-induced postural modulation, using neuroimaging or electrophysiological techniques.

Finally, by demonstrating the strong interplay between cognitive factors and postural control, this study highlights the need to carefully consider environmental and psychological influences in stabilometric assessments. The findings open new perspectives on the role of cognition in motor function and suggest that verbal suggestion could be a relevant factor in balance training or rehabilitation protocols. Further research is needed to explore the long-term effects of suggestion on postural stability and its potential applications in clinical practice.

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