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ORIGINAL ARTICLE

Patterns of spontaneous saliva swallowings during awake and sleep states in Parkinson's disease

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Abstract

Objective This study aimed to evaluate spontaneous swallowing frequency (SS-FR) and type of swallowing during awake and sleep states in patients with Parkinson's Disease (PD), using polygraphic recordings to identify possible associations with disease severity.

Methods A total of 27 PD patients (19 male, 8 female) and 22 age-matched healthy controls were included. All participants underwent whole-night one-hour polygraphic monitoring, and SS-FR and type of swallowing were analyzed during both wakefulness and sleep stages. Clinical characteristics, disease severity (Hoehn and Yahr staging), and motor symptoms (Unified Parkinson's Disease Rating Scale) were assessed.

Results SS-FR was significantly lower in PD patients compared to controls, both during wakefulness and especially during sleep. In PD patients, SS-FR during wakefulness was positively correlated with Hoehn and Yahr stage and motor symptom scores. The presence of dysphagia was more common in patients with markedly reduced SS-FR, indicating its potential role as a non-invasive marker for swallowing impairment. Salvo swallowing was observed in 4.5% ($n=1$) of controls and 40.7% ($n=11$) of patients with PD ($p=0.003$).

Conclusion SS-FR is significantly altered in PD, with reductions during both awake and sleep states reflecting disease severity. SS-FR measurement through polygraphic recordings may have potential as a non-invasive marker for early detection of swallowing disorders and progression in PD.

Keywords Dysphagia · Parkinson's Disease · Sialorrhea · Spontaneous swallowing · Surface EMG · Voluntary swallowing

Introduction

Clinically, swallows are categorized into two types: voluntary swallows (VS) and spontaneous swallows (SS). VS occurs when an individual intentionally initiates swallowing during wakefulness. SS refers to involuntary saliva swallowing that occurs without conscious awareness, both during wakefulness and sleep [1].

Extensive scientific literature documents various aspects of VS and associated disorders; however, research specifically focusing on SS remains limited. Moreover, SS has not been frequently studied in different disorders including PD. Evaluating SS in PD is particularly important for several reasons. First, the oral phase of voluntary swallowing is frequently impaired in PD, as demonstrated by videofluoroscopy, endoscopy, and electromyography studies [1–4]. Second, the pharyngeal phase of swallowing is also affected [5]. Under normal conditions, pharyngeal residue is cleared by spontaneous swallows; however, in neurogenic dysphagia, this mechanism may be insufficient, increasing the risk of airway compromise [5]. In addition, alterations in swallowing frequency may contribute to symptoms such as drooling, particularly in the supine position.

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PD is the second most common neurodegenerative disorder after Alzheimer's disease, characterized by bradykinesia, rigidity, tremor and postural instability [6, 7]. In addition to cardinal findings, swallowing disorder and sialorrhea are frequently seen in patients and significantly impair the quality of life [6]. In the studies in PD patients, subjective dysphagia was found in 50% of patients, and this rate was found to be between 30 and 82% in different studies [8]. The modified barium swallowing test revealed abnormalities in a high percentage of PD patients, ranging from 75% to 97% [9]. Although previous studies suggest that swallowing disorders progress with PD [4], more recent studies based on objective measurements indicate that this relationship is not always consistent [10]. There are studies showing the presence of swallowing dysfunction in patients in the early disease stage, even in patients who do not describe any complaints of swallowing disorder [8].

Swallowing dysfunction in PD is primarily attributed to impaired coordination of the oropharyngeal and esophageal musculature. This dysfunction is associated with altered basal ganglia output and disruption of brainstem swallowing centers, including central pattern generators [9, 10]. Changes in swallowing function seen in PD patients range from sialorrhea to post-feeding food residue in the mouth, inability to form a bite, slowed oral passage, repetitive pumping movements of the tongue to push the bite backwards, delay in triggering the pharyngeal swallowing reflex, delayed opening of the upper esophageal sphincter and reduction in its diameter, residue in the piriform sinuses and aspiration [8, 10, 11]. Aspiration is a serious condition that develops due to swallowing disorder in PD patients [3]. In the literature, the rate of aspiration in PD has been reported between 15% and 56% [3, 12], and asymptomatic aspiration is seen in 15–33% [13]. In a study comparing Parkinson's disease (PD) patients and normal subjects dysphagia was observed in 70–78% of PD patients compared to only 6% in the control group [4]. The causes of sialorrhea include inefficient swallowing sequence and decreased swallowing frequency, not an increase in the amount of saliva [3]. Also, contrary to popular belief, the amount of saliva is decreased in PD patients [14].

The modified barium swallowing test is commonly used to evaluate swallowing disorder in PD, with other methods such as electroglotticography, cricopharyngeal electromyography, and clinical monitoring techniques also mentioned in the literature [3].

This study aimed to evaluate spontaneous swallowing frequency and swallowing patterns in patients with PD using polygraphic recording method using an electroencephalography (EEG) device, and to compare these parameters between wakefulness and sleep.

Materials and methods

A cross-sectional observational study was planned for the research, to examine clinical and electrophysiological characteristics within the study population.

Twenty-seven patients with Parkinson's Disease (PD) and 22 healthy controls participated in the study. The study included patients with PD who were in the middle to advanced stages (Stage 3–4 and above), who did not have any other systemic disease that could cause swallowing disorders or dry mouth (Diabetes mellitus, Sjögren's disease, Scleroderma, or taking anticholinergic medications, etc.), who had not undergone esophageal and oropharyngeal surgery or received radiotherapy to the neck region, who did not have restless legs, epilepsy, and cognitive loss or encephalopathy at a level that would prevent cooperation, and who volunteered to participate. All participants provided informed consent.

All patients were diagnosed according to the UK Brain Bank Criteria [15] and registered in the PD unit of our neurology department. The clinical severity of the disease was evaluated by the UPDRS test [16] and Hoehn *and* Yahr *(*H&Y*)* disability score [7]. Salivation and drooling were clinically scored to assess the severity of drooling, following the MDS-UPDRS guidelines. Swallowing capacity was evaluated clinically [17] and electrophysiologically (dysphagia limit) [18, 19]. The dysphagia limit was assessed based on the maximum volume of water that could be swallowed in a single attempt without piecemeal deglutition, according to previously described electrophysiological methods.

For each participant, we recorded a full range of electrophysiological signals, ensuring high-quality data. A 60-minute period was designated for a thorough analysis of the polygraph data, guaranteeing meticulous attention to detail. Patients, comfortably positioned on examination tables at a 30-degree angle, prevented saliva from dripping while maintaining relaxation; this head and neck position was crucial for the controls as well.

Participants in both the patient and control groups were permitted periods of rest or sleep. The room conditions were calm, quiet and semi dark. The previously described polygraphing investigations [16] were performed with an EEG apparatus (EEG, Nicolet one EEG). Twelve channels were used: five channels recorded the EMG signals, two channels recorded the EEG (from parietooccipital electrodes on both sides), two channels recorded lateral/vertical ocular movements (OCM), one channel recorded signals from laryngeal (sensor) for vertical movements of larynx during swallowing and two channels recorded electrocardiogram (ECG) and electrodermal activity (EDA). One of the EEG channels was used to record the respiratory signal (RESP)

from a nasal cannula (sleep-sense). All EMG recordings tracked signals from the orbicularis oculi (OC), orbicularis oris (OR), submental muscle (SM) complex, masseter (MS) and sometimes anterior tibial muscle (TA).

In polygraphic recording (on-line) the paper speed was 30 mm (mm) / second (sec). During all channels were filtered at an appropriate frequency response (high cut off was 35–1600 Hz [Hz]) and all sensitivities were 100 microV / cm centimeter (cm). However, because the data were recorded to the external memory, the values could be changed in the off-line analysis. SS data were included according to the following criteria [20]; (1) The OR, MS and SM muscles had to fire altogether and sequentially in a burst that lasted 1–3 s; the SM-EMG was often highest in amplitude during this activity. (2) All three muscles mentioned above had to be recorded in parallel with a synchronous, laryngeal sensor deflexion indicating vertical movements of the larynx during swallowing. (3) During the recording one of the investigators ensured the upward and downward movements of the thyroid cartilage and swallowing movement, in spite of the laryngeal sensor recording. (4) In all three muscles, the response amplitudes for deglutition muscles had to be at least four times higher than baseline. (5) The swallowing activity should be in apnea period of respiration from the nasal sensor recording. All SSs were also counted separately during waking and sleep states (Fig. 1). Although both wakefulness and sleep states were recorded within the same session, simultaneous and standardized duration recording across these states was not feasible due to the spontaneous and variable nature of sleep onset and maintenance under laboratory conditions.

Statistical analysis

Data was analyzed using IBM SPSS Statistics (version 26.0). Descriptive statistics were computed for all demographic and clinical variables. Continuous variables are presented as mean ± standard deviation (SD) for normally distributed variables and median [interquartile range (IQR)] for non-normally distributed variables, while categorical variables are expressed as frequencies (percentages). The normality of data distributions was assessed using the Shapiro-Wilk test. For normally distributed data, comparisons between groups were performed using independent t-tests. For non-normally distributed data, the Mann-Whitney U test was used to compare differences between groups (Fig. 2).

To compare the swallowing characteristics between PD patients and control subjects and subgroup analyses within PD patients, the presence or absence of sialorrhea and salvo swallowing, independent t-tests were used for normally distributed variables, while the Mann-Whitney U test was used for non-normally distributed variables. In addition, to assess the impact of dysphagia on swallowing behavior, PD patients were divided into those with and without dysphagia. Statistical differences in total swallowing counts between these subgroups were assessed using the Mann-Whitney U test. A p-value of less than 0.05 was considered statistically significant for all tests. All statistical tests were two-tailed.

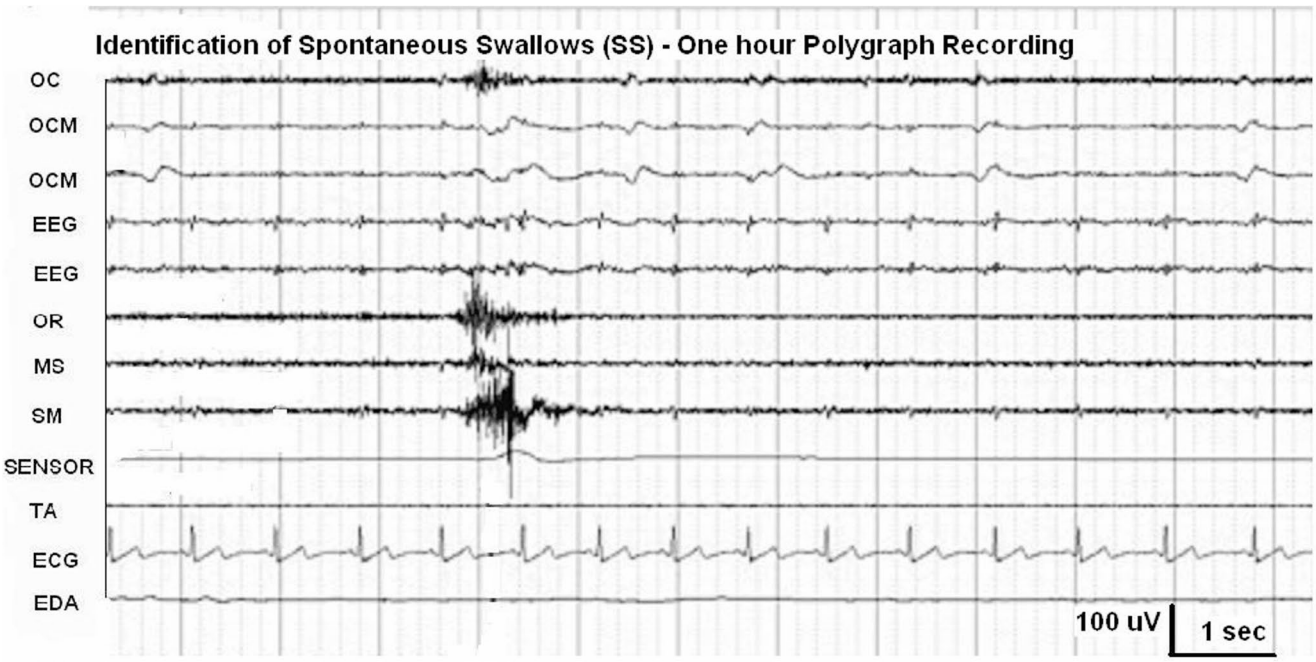

Fig. 1 Identification of spontaneous swallows in a healthy control subject

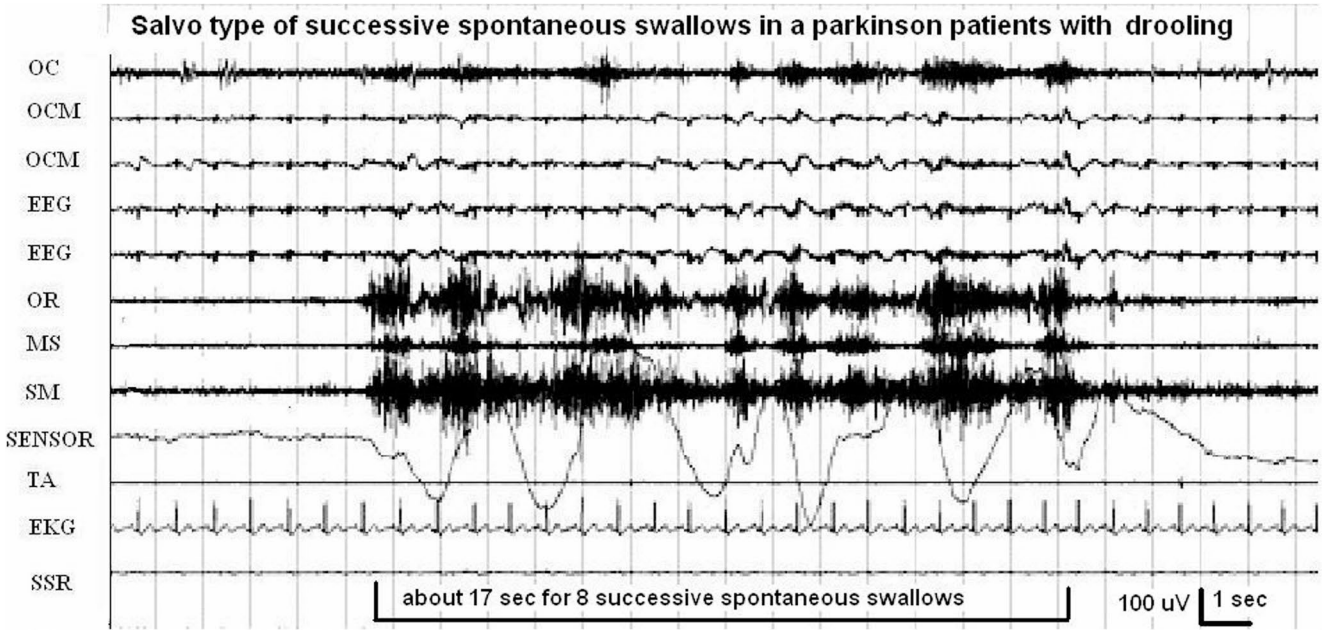

Fig. 2 A salvo type of swallowing in a patient with PD

Results

The study cohort consisted of 27 individuals diagnosed with PD, with demographic and clinical characteristics summarized in Table 1. The mean age was 68.8±9.7 years, and 29.6% (n=8) of participants were female. The mean disease duration, Hoehn & Yahr stage and UPDRS total score were 7.2±3.6 years, 3.4±0.5, indicating moderate disease severity, and 73.8±17.3, respectively. Clinical symptoms associated with swallowing were common: 66.7% of patients experienced sialorrhea, and 59.3% had clinically identified dysphagia.

Regarding swallowing characteristics (Table 1). The total swallowing count across all states (awake and sleep) was 48.3±45.1. One-hour polygraphic recordings showed that the duration of awake monitoring was 46.7±19.3 min, during which the mean number of swallows was 44.9±45.8. A significant decrease was observed in both monitoring duration (11.4±17.7 min) and mean swallow count (3.4±5.9) during sleep.

Table 2 presents a comparison of Parkinson's disease patients with a control group of similar age. In the awake stage, PD patients showed a similar mean number of swallows (44.9±45.9) compared to controls across age groups (29.7±21.2 for all controls combined), although with greater variability. However, in the slow-wave sleep stage, PD patients—particularly those with dysphagia—demonstrated a marked reduction in swallowing activity (2.8±4.2 in dysphagic PD vs. 16.9±19.2 in controls). This difference was statistically significant, as indicated by differing superscripts. PD patients exhibited a significantly higher mean swallow count (48.3±45.1) compared to healthy controls (37.6±24.6); however, this difference was attributable to increased awake swallowing and negligible sleep-related swallowing in the PD group. Cough ωασ μορε cομμον ιν τhe Ραρκινσον'σ γρουπ τηαν ιν τhe cοντρολ γρουπ (π=0.047).

Further subgroup analysis of PD patients based on the presence or absence of dysphagia revealed distinct differences in polygraphic swallowing characteristics during both awake and sleep stages (Table 2). While the awake stage duration did not significantly differ between patients with dysphagia (42.1±22.0 min) and those without (53.3±12.6 min), the total number of swallows during wakefulness was relatively similar (44.2±55.1 vs. 45.9±30.2). However, significant differences emerged during the sleep stage. Patients with dysphagia exhibited a higher sleep-stage duration (14.7±20.4 min) compared to those without dysphagia (6.7±12.0 min), yet the number of swallows during this stage was paradoxically lower in the dysphagic group (2.8±4.2 vs. 4.3±8.0). Despite observed sleep-related discrepancies in swallowing frequency between the two groups, overall swallow counts remained comparable (dysphagia: 47.0±53.6; control: 50.2±31.2), indicating that awake compensatory mechanisms might counteract sleep deficits.

Subgroup analyses of the PD cohort are provided in Table 3. Patients exhibiting salvo swallowing (defined as rapid sequences of consecutive swallows) had significantly higher total swallowing counts [42.0, IQR: 35.5–91.5] compared to those without salvo swallowing [25.0, IQR:

Table 1 Demographical and clinical features of the patients With PD

Variable	*n*	Value
Demographics		
Age (years)	*27*	68.8 ± 9.7
Sex	*27*	
Male		19 (70.4%)
Female		8 (29.6%)
Clinical Features		
Disease duration (years)*	*23*	7.2 ± 3.6
Hoehn & Yahr stage (HY)	*27*	3.4 ± 0.5
UPDRS total score	*27*	73.8 ± 17.3
Sialorrhea	*27*	
With sialorrhea		18 (66.7%)
Without sialorrhea		9 (33.3%)
Dysphagia	*27*	
With dysphagia		16 (59.3%)
Without dysphagia		11 (40.7%)
Recorded Frequency of Swallowing Types		
Double/triple swallowing	*25*	5.4 ± 6.0
Cough	*13*	4.5 ± 3.2
Salvo swallowing	*11*	6.0 ± 9.8
Total swallowing	*27*	48.3 ± 45.1
Polygraphic Recording		
Awake duration (min)	*27*	46.7 ± 19.3
Swallowing while awake (frequency)	*27*	44.9 ± 45.8
Sleep duration (min)	*27*	11.4 ± 17.7
Swallowing during sleep (frequency)	*27*	3.4 ± 5.9

Numeric variables are expressed as mean ± standard deviation. Categorical variables (sex, sialorrhea, dysphagia) are presented as frequency (percentage). Polygraphic recordings measured the swallowing function while participants were awake and asleep. "Salvo swallowing" refers to sequences of consecutive swallows without pause. UPDRS = Unified Parkinson's Disease Rating Scale; HY = Hoehn and Yahr stage

*Four patients had no follow up information

19.5–36.0], with a p-value of 0.009, indicating statistical significance. Salvo swallowing was observed in 4.5% ($n = 1$) of controls and 40.7% ($n = 11$) of patients with PD ($p = 0.003$).

Table 3 Comparison of total swallowing count across subgroups in Parkinson's Disease

Group	*n*	Median [IQR]	*p* value
Sialorrhea			
With sialorrhea	*18*	38.5 [25.0–87.0]	0.095
Without sialorrhea	*9*	25.0 [20.8–35.5]	
Salvo Swallowing			
With salvo swallowing	*11*	42.0 [35.5–91.5]	**0.009**
Without salvo swallowing	*16*	25.0 [19.5–36.0]	

Data are expressed as median and interquartile range (IQR). Mann–Whitney U test was used for between-group comparisons. A p value < 0.05 was considered statistically significant and is shown in bold. "Salvo swallowing" refers to rapid sequences of consecutive swallows. "Sialorrhea" indicates the presence of drooling/hypersalivation

Discussion

This study provides a detailed analysis of swallowing behavior in patients with PD, highlighting significant alterations across both awake and sleep states. Our research indicates that while awake swallowing frequency is largely unaffected, swallowing during sleep is significantly reduced, especially among individuals with dysphagia. Subgroup analyses further reveal that specific clinical features, such as the presence of salvo swallowing, are associated with increased swallowing activity, whereas sialorrhea does not significantly affect overall frequency. These findings suggest the complexity of swallowing dysfunction in PD and emphasize the need for state-specific assessments in clinical evaluation.

SS–FR requires accurate identification of individual SS against a background activity from other activities of the upper aerodigestive tract and it can be assessed using various techniques [21] including submental muscle EMG as a measure of SS-FR [22, 23]. In our study, we also performed multiple swallowing muscle recordings from perioral, SM and mandibular muscles and included a laryngeal sensor

Table 2 Summary of the results of polygraphic recording in normal subjects and Parkinson's Disease (PD) Patients

	Normal subjects			PD subjects		
	≤40 Years ($n = 9$)	>40 Years ($n = 13$)	Total ($n = 22$)	With dysphagia ($n = 16$)	Without dysphagia ($n = 11$)	Total ($n = 27$)
Age	30.6 ± 5.8[a]	57.3 ± 7.0[b]	46.4 ± 14.9[a]	69.8 ± 10.8[c]	68.4 ± 10.5[c]	68.8 ± 9.7[c]
Awake Stage						
Duration (min)	41.8 ± 20.6	48.0 ± 18.6	45.5 ± 19.2	42.1 ± 22.0	53.3 ± 12.6	46.7 ± 19.3
No of Swallow	29.8 ± 20.1	29.6 ± 22.8	29.7 ± 21.2	44.2 ± 55.1	45.9 ± 30.2	44.9 ± 45.9
Slow Sleep Stage						
Duration (min)	34.2 ± 15.6[a]	29.0 ± 16.2[a]	31.6 ± 15.3[a]	14.7 ± 20.4[b]	6.7 ± 12.0[c]	11.4 ± 17.7[b]
No of Swallow	23.2 ± 25.6[a]	10.6 ± 8.7[b]	16.9 ± 19.2[a]	2.8 ± 4.2[c]	4.3 ± 8.0[c]	3.4 ± 5.9[c]
Total Swallow	45.3 ± 24.2	32.2 ± 24.3	37.6 ± 24.6	47.0 ± 53.6	50.2 ± 31.2	48.3 ± 45.1

Data are presented as mean ± standard deviation. The cutoff age for normal subjects' age groups was 40 years. Superscripts indicate statistically significant differences between groups at $p < 0.05$. Groups sharing the same superscript do not differ significantly. a, b, c denotes groupings based on t-tests: [a] = differs from [b] and/or [c], etc. During polygraph monitoring, swallowing data was collected in both awake and slow-wave sleep. PD: Parkinson's disease. Dysphagia status was determined clinically. "Total Swallow" represents the combined count of swallows in both sleep and awake states

of up/down movement of larynx. In normal awake healthy adult subjects; SS –FR was found about once per minute or less [24]. In sleep stage, the SS-FR significantly decreases in comparison to awakeness [20], as we observed in our normal subjects in the present study.

Although young healthy people have slightly higher number of total SS than older age group this comparison did not reach to significant level due to large variations of SS rate among normal controls. Additionally, the older cohort of control participants exhibited noticeably reduced slow-wave sleep duration during the monitoring period. Reduced sleep duration in older participants may have skewed statistical results, as mean SS-FR values remained elevated compared to younger, healthy controls. Therefore, differences in recording duration between wakefulness and sleep should be considered when interpreting the observed differences in SS-FR, as they may partly reflect methodological constraints rather than purely physiological alterations.

The SS is in fact difficult to rate, due to their non-rhythmic appearance and irregularity during registration, both in awake and slow sleep. Arrhythmical SS appearance may be due to the artificial trial conditions. It may be necessary a small device measuring SS for 24-hours. It has been suggested that at least for healthy adults, a sample window as short as 5 min may provide a valid indication of SS frequency [21]. According to our experience short recording time might be inadequate as one could not observe any SS in 5 min at the onset of registration in normal participants and in patients with PD. It was possible to show some qualitative features of SS individually with our method. For instance, “double SS” in both groups and “salvo type consecutive SS” in PD patients could be clearly recorded. There are many studies in literature that have obtained results that are correlated with our study [25–27]. Double swallow was recorded in all normal controls regardless of age and even in patients with PD, however, the salvo type swallows with 4 or more consecutive swallows without any interval could be recorded only in PD patients.

Among all patients with PD, most of them had dysphagia with drooling. This finding can be interpreted as sialorrhea and drooling of saliva are significantly related to clinical oropharyngeal dysphagia. It has been already reported that dysphagia is a significant factor in the multifactorial model of drooling [22].

Recent studies seem to confirm that tongue bradykinesia is associated with both oropharyngeal dysphagia and drooling [28]. In accordance with these studies the sialorrhea and drooling are significantly accompanied by the oropharyngeal dysphagia in our PD patients. However, these findings could not be a sole reason as all patients were lying in a supine position with their head and neck resting at a 30-degree angle from the table. This position can easily prevent the accumulated saliva from flowing outside from the oral cavity and the salivary accumulation can be flowed into the pharynx. In this evaluation, the salivary accumulation in mouth and anterior or posterior dripping could not be accurately measured, but the assessment of drooling in PD is currently based on the subjective response of patients to questions but objective instruments are lacking or unsatisfactory [22, 28].

One of the outstanding findings of this study was the salvo type of consecutive swallows (more than 4 swallows) in patients with PD. This phenomenon might be misinterpreted as resulting from accumulated saliva in oral cavity could be dropped down (i.e. posterior dripping) and accumulated in the pharynx and therefore consecutive swallows occur, probable due to patient’s head position. We can propose that this is not related with the only head and body position, but also is probably related with the triggering nature of SS that was changed in PD. We may explain this finding with two pieces of evidence. First, before any salvo type swallowing, patients may wait several minutes without any SS. Secondly, in patients without sialorrhea, even complaint of dry mouth, we still recorded the salvo type swallowing clearly. We may propose that the triggering of SS is also disordered and mostly delayed to triggering of SS at the pharyngeal phase. Delayed triggering of VS at the oral phase was clearly demonstrated [5, 29]. In PD patients, an impaired tongue movement for swallowing action (tongue akinesia) result in defective tongue popping which causes also a delay in the swallowing reflex [2–4, 10]. The increase of SS-FR in PD patients in awake state should not be surprised; the alteration in SS-FR can be related a disturbance of automatic movement pattern for clearing of accumulated saliva in oral phase in PD patients, likewise the other semi-automatic movements. It might be that the differentiation of SS recordings between wakefulness and sleep states is important in understanding underlying physiological mechanisms. Another important reason should be the insufficient sensory input in the oropharyngeal mucosae which may not activate properly the brain stem swallowing center, i.e., nucleus tractus solitarius. There are some anatomical evidences for the second proposal that the pharyngeal sensory nerves are directly affected by pathological processes in PD patients [10]. These abnormalities may decrease pharyngeal sensation thereby impairing the SS-FR by delaying the triggering input of SS at the pharyngeal phase.

Patients with PD had more coughing than normal subjects. No SS was observed around coughing events in normal subjects while the SSs were observed in many times around the cough recordings. Higher incidence of coughing may mean that the swallowing material could be transmitted into the upper airway during deglutition [30]. Dysphagia plus frequent coughing has been occurred in all stage of PD [31]. However it was proposed, that many individuals with PD, presents as

"silent aspirations" with little awareness of their dysphagia symptoms and little or no cough response to aspiration [12]. Although we could not clearly indicate and demonstrate the silent aspiration; probably many aspirations around the cough could be demonstrated both clear aspiration and/or silent aspiration without awareness of patients probably due to affected sensory nerves of pharyngeal mucosae [10].

This study has several limitations that should be considered when interpreting the findings. First, the relatively small sample size may have reduced statistical power and limits the generalizability of the results. Second, the cross-sectional design precludes any causal inference between SS-FR and disease-related variables. Although patients were categorized according to the presence of dysphagia, swallowing capacity was not objectively quantified using dysphagia limit measurements (e.g., volume in mL), and therefore quantitative data on dysphagia limits could not be included in the analysis or tables. The lack of such quantitative assessment may have reduced sensitivity in detecting subtle impairments and limited direct comparability with previous studies. In addition, the shorter duration of sleep recordings compared with wakefulness may have influenced the observed swallowing frequencies, potentially leading to an underestimation of sleep-related swallowing activity. While polygraphic recordings provided objective data, certain environmental and physiological factors affecting SS-FR—particularly during sleep—may not have been fully controlled. Simultaneous and duration-matched recording of wakefulness and sleep was not feasible within the study design. Finally, autonomic involvement was not assessed using standardized scales, which may have constrained the interpretation of its relationship with swallowing parameters. Future studies with larger, longitudinal cohorts are needed to further validate and extend these findings.

A major strength of this study is its use of objective, 1-hour polygraphic recordings to assess spontaneous swallowing frequency in both sleep and wake states—an approach rarely used in PD research. The inclusion of age- and sex-matched healthy controls allowed meaningful comparisons. Additionally, the comprehensive evaluation of clinical and motor parameters enabled the exploration of potential associations between SS-FR and disease characteristics, suggesting that SS-FR may serve as a practical, non-invasive marker for early swallowing dysfunction in PD.

Conclusion

The findings indicate that swallowing behaviors in PD patients may undergo notable alterations, particularly evident while they are asleep. The reduced number of sleep swallows in PD, compared to healthy individuals, highlights a disruption of involuntary swallowing mechanisms. Furthermore, the existence of dysphagia and particular ways of swallowing, such as salvo swallowing, seem to be linked to fluctuations in the total count of swallows. These insights may have implications for both clinical assessment and the management of swallowing dysfunction in PD.

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Declarations

Ethical statement Data from PD patients and a control group treated at Ministry of Health Atatürk Training and Research Hospital from August 2011 to August 2012 were collected. The study was approved by the Ethics Committee of Dokuz Eylül University (Decision protocol no: 2011/29-12)

Conflicts of interest The authors have no conflicts of interest to disclose.

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