European Review for Medical and Pharmacological Sciences 2023; 27: 7316-7323

Bioelectrical impedance analysis in patients with posterior vitreous detachment

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Abstract. – OBJECTIVE: The purpose of the study is to assess body hydration in patients with posterior vitreous detachment (PVD) by bioelectrical impedance analysis (BIA). PVD, one of the most common eye diseases, is associated in both research and the collective image with reduced daily water intake, but this finding is not supported by strong evidence in the literature.

PATIENTS AND METHODS: Based on Spectral Domain Optical Coherence Tomography (SD-OCT) evaluation, different PVD stages are identified: absent posterior vitreous detachment, partial posterior vitreous detachment (P-PVD), or complete posterior vitreous detachment (C-PVD).

BIA is a simple, non-invasive bedside method used to assess body composition. Patients underwent BIA and completed a floaters symptoms. 30 patients were enrolled and divided into two groups according to the degree of vitreous detachment, in P-PVD (n=12) and C-PVD (n=18).
Patients underwent BIA and completed a floaters symptoms questionnaire. BIA measured the Resistance (R), Reactance (Xc), Phase Angle (PhA), Total Body Water (TBW), Extracellular Water (ECW), Fat Mass (FM), Fat-Free Mass (FFM), and Body Cell Mass Index (BCMI). Finally, patients received a test to assess adherence to the Mediterranean diet (Mediterranean Diet Test Score, MDTS) with the addition of daily water intake.

RESULTS: Relevant data were obtained from the BIA evaluation: the values of R and Xc were lower in the P-PVD group than C-PVD group (respectively 417.08±58.12 Ω *vs.* 476.94±51.29 Ω *p*=0.006 and 41.33±8.23 Ω *vs.* 50.61±7.98 Ω *p*=0.004). Instead, patients in the P-PVD group reported higher values of TBW and ECW than C-PVD group (respectively 44.13±7.57 L *vs.* 37.96±6.27 L *p*=0.021 and 21.03±4.06 L *vs.* 17.24±2.63 L *p*=0.004).

CONCLUSIONS: In the present study, we reported a significant correlation between vitreous pathology and anthropometric and BIA measurements.

Key Words:
Posterior vitreous detachment, PVD, Bioelectrical impedance analysis, BIA, Optical coherence tomography, OCT, Hydration.

Introduction

Posterior vitreous detachment (PVD) is one of the most acknowledged and potentially harmful ocular events. Although in most cases it occurs without complications, PVD may play a key role in the pathogenesis of multiple vitreoretinal interface disorders, such as a macular hole, epiretinal membrane, vitreomacular traction syndrome, retinal breaks, retinal detachments, vitreous hemorrhages, and others[1-3]. PVD is the separation between the posterior vitreous cortex (PVC) and the internal limiting membrane (ILM) of the retina, with the vitreous collapsing anteriorly towards the vitreous base[4-6]. Vitreous degeneration begins with the stage of vitreous liquefaction, which is called synchysis[7], and the weakening of adhesion between the posterior hyaloid membrane and the ILM.

When PVD occurs, the aggregation of the collagen fibrils leads to moving the vitreous toward the retrocortical, peripapillary and pre-macular space, thus causing the vitreous body to collapse (syneresis) anteriorly[6].

The prevalence of PVD increases with age and with the axial length of the eye[8-10]. Age at onset is generally in the sixth to the seventh decade, and men and women appear to be equally affected[11,12].

Recent studies1 using Optical Coherence Tomography (OCT) and ultrasonography suggest that age-related PVD may be an insidious and slowly progressive condition evolving over many years.

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PVD is the most common cause of primary symptomatic floaters. Floaters are small cobweb-shaped particles emerging from a compact collagen matrix of the posterior vitreous cortex[13].

Based on OCT evaluation, different PVD stages were identified: absent posterior vitreous detachment, partial posterior vitreous detachment (P-PVD) and complete posterior vitreous detachment (C-PVD)[14,15]. Vitreous detachment is associated both in the research and in the collective imagination with a reduction in water supply[16], but this data is not supported by strong evidence in the literature.

Bioelectrical impedance analysis (BIA) is a simple and non-invasive method used at the patient's bedside to assess body composition by measuring the opposition to the flow of an electric current through body tissues (electrical impedance), which can be used to estimate total body water (TBW)[17,18].

The basic principle of the BIA technique is that the transit time of low intensity (800 mA) and very high frequency (50 KHz) electric current through the body depends on body composition characteristics.

Applications of BIA are useful to assess differences in body composition caused by clinical and nutritional status[19,20]. Several studies[21,22] have been conducted to determine how balanced fluctuations in hydration affect the validity of this kind of analysis for assessing body composition.

Measurements are performed under the assumption that total body resistance depends on the body water content, indeed Allison et al[23] indicated that the total body resistance increased with dehydration.

The study aims to evaluate the state of body hydration using BIA in a population of adult subjects suffering from complete and/or partial vitreous detachment.

Patients and Methods

The study protocol followed the international ethical standard of the Helsinki Declaration and was approved by the University Hospital PTV Independent Ethics Committee (217/18, Clinical Experimentation Register of PTV). Informed consent was obtained from all participants.

In the present study, we consecutively recruited 30 patients with floaters symptoms admitted at the Ophthalmology Department of the Tor Vergata Polyclinic in Rome and evaluated them at the Clinical Nutrition Department of the same structure, in the period between January 2019 and January 2020.

We defined symptomatic vitreous floaters as those that cause visual discomfort and are observed in daily life.

The exclusion criteria were the absence of other eye diseases (such as diabetic retinopathy, glaucoma, myopia >6 diopters), nephropathies, chronic kidney failure (CKD), arterial hypertension, use of topical eye drugs, vitamins and supplements or systemic drugs such as diuretics, presence of swollen lymph nodes, thyroid diseases, diabetes mellitus. Pacemaker wearers were also excluded.

The patients underwent a complete ophthalmologic examination including slit-lamp evaluation of the anterior and posterior segment, fundus examination, Spectral-Domain OCT (SD-OCT, Spectralis Heidelberg, Germany), Ocular Ultrasonography (VuPad, Sonomed Escalon, Sonomed Inc, NY, USA).

A vitreous floaters symptom questionnaire, described by Kim et al[24], was used for the subjective floaters' assessment. Two degrees, mild and severe, were used to categorize the intensity of the reported discomfort. The discomfort was graded mild if it was minimal in daily life (score ≤9), and severe if vitreous floater-related disturbance caused patients to feel as though their eyesight was deteriorating (score >9).

The anthropometric analysis included: stature, weight, body mass index (BMI), waist and hip circumference measurements as described by De Lorenzo et al[25]. The patient was fasting, placed supine, and evaluated with BIA, mono frequency instrument Akern 101 (Florence, Italy), according to the manufacturer's recommendations[25]. Two pairs of electrodes were placed on the right wrist and right ankle[26,27]. BIA calculated the Resistance (R), Reactance (Xc), Phase Angle (PhA), Total Body Water (TBW) in Liters and Percentage, Extracellular Water (ECW) in Liters and Percentage, Fat Mass (FM) in Kg, and Percentage, Fat-Free Mass (FFM) in Kg and Percentage and Body Cell Mass Index (BCMI). Finally, patients received a test to assess adherence to the Mediterranean diet (Mediterranean Diet Test Score, MDTS) with the addition of daily water intake[28].

Subsequently, patients enrolled in the study were divided into two groups according to the degree of vitreous detachment based on OCT scanning. Patients with at least one eye with complete PVD were classified into the C-PVD group, and patients with at least one eye with partial PVD and no complete PVD were classified into the P-PVD group.

Statistical Analysis

The Kolmogorov-Smirnov test was used to test the normality of data. Categorical variables are presented as frequency (%). Continuous data are presented as average±standard deviation for continuous variables and as percentage frequency for categorical variables. To assess the difference between the groups, a *t*-test was performed for independent samples and the significance was set at $p<0.05$. To assess the frequency difference in the severity of vitreous symptoms among the groups, a Chi-Square test was carried out and statistical significance was set at $p<0.05$. All data were initially entered into an Excel database (Microsoft, Redmond, WA, USA), and analysis was performed using the SPSS software (23.00, IBM Corp., Armonk, NY, USA).

Results

The mean age of the all-enrolled patients was 62.73±11.86 years. Of the 30 patients with PVD analyzed, 21 (70%) were female, while 9 (40%) were male.

All patients were affected by C-PVD and/or P-PVD and complied with the previous exclusion criteria listed above.

Group 1 consisted of 12 patients with P-PVD in at least one eye, and Group 2 comprised 18 patients with C-PVD in at least one eye. Table I shows the percentages of complete and partial PVD in each group and each eye.

The values overall detected through BIA have a PhA value of 5.91±0.93°, the percentage value of TBW was 55.90±7.60%, FM was 27.79±9.88%, and the BCMI was 10.42±1.65 Kg/m^2.

Table II shows the parameters examined for each group as average±standard deviation values and the comparison between the two groups. There were no statistically significant differences between the two groups in age and anthropometric parameters ($p>0.05$). Regarding BIA parameters, the P-PVD group, compared to the C-PVD group, showed statistically lower values of R and Xc (Figure 1 A-B) and significantly higher values of TBW, ECW (Figure 1 C-D), and FFM ($p<0.05$). For the remaining values found in the BIA analysis, including PhA, and MDTS, there were no significant differences.

Table III and Figure 2 show a comparison between the P-PVD group and the C-PVD group concerning the severity of PVD symptoms. In the P-PVD group, mild and severe symptoms were found with the same frequency, while in the C-PVD group, there was a greater occurrence of severe symptoms, but not statistically significant ($p=0.765$).

Finally, Figure 3 shows different daily water intake frequencies between groups.

Most patients in the P-PVD group consumed between 1-1.5 liters of water per day (41.7%), while in the C-PVD group, less than 1 liter of water per day (38.9%).

Discussion

PVD is a very common pathology, and age is the main risk factor. PVD is present in 75% of people over the age of 65[4,8].

The vitreous humor is composed of 99% water, as well as hyaluronic acid (0.5%) and type II collagen, a hybrid of types V/XI, and type IX collagen (0.5%)[29].

The aging of the eye is accompanied by the dehydration of the vitreal gel, leading to the formation of a liquid pocket in the center of the vitreous in a process commonly referred to as liquefaction. PVD is caused by a series of events: the vitreoretinal adhesion weakens with age; after the age of 40, the volume of the vitreous gel decreases linearly with aging, while the volume of the eye cavity remains roughly constant[13,30]. The vitreous gel is in tension, thus exerting tensile forces on the ILM[31], and there are tensile forces exerted on the vitreoretinal interface by eye rotation and saccadic movements.

Table I. Percentages of complete and partial PVD in each group and each eye.

	P-PVD (n: 12)		C-PVD (n: 18)	
Degree of Detachment	**RE**	**LE**	**RE**	**LE**
None	83.0%	16.7%	0.0%	0.0%
Partial	17.0%	83.3%	50.0%	44.4%
Complete	0.0%	0.0%	50.0%	55.6%

PVD: posterior vitreous detachment; RE: Right Eye; LE: Left Eye.

Table II. Descriptive statistics of the total sample and assessment of the difference between the groups; a *t*-test was performed for independent samples, and statistical significance was set at a value of $p<0.05$, SD: Standard Deviation.

Parameters	Overall (n: 30) Mean±SD	P-PVD Group (n: 12) Mean±SD	C-PVD Group (n: 18) Media±SD	P-PVD *vs.* C-PVD *p*-value
Age (years)	62.73±11.86	65.08 ± 11.07	61.17±12.41	0.385
Weight (kg)	72.99±12.61	75.28±11.83	71.47±13.21	0.428
Height (cm)	162.42±8.39	165.58±7.01	160.31±8.75	0.092
WC (cm)	90.63±13.6	92.83±15.89	89.17±12.09	0.479
WHR	0.88±0.08	0.90±0.10	0.87±0.08	0.366
BMI (kg/m^2)	27.81±5.37	27.55±4.79	27.99±5.85	0.831
R (Ω)	453±60.93	417.08±58.12	476.94±51.29	**0.006**
Xc (Ω)	46.9±9.19	41.33±8.23	50.61±7.98	**0.004**
PhA (°)	5.91±0.93	5.68±0.92	6.07±0.93	0.262
TBW (%)	55.90±7.60	58.91±6.78	53.90±7.63	0.076
TBW (L)	40.43±7.37	44.13±7.57	37.96±6.27	**0.021**
ECW (%)	46.47±4.37	47.68±4.41	45.67±4.27	0.225
ECW (L)	18.76±3.72	21.03±4.06	17.24±2.63	**0.004**
ICW (%)	53.53±4.38	52.32±4.44	54.33±4.27	0.223
ICW (L)	21.58±4.59	22.88±4.78	20.72±4.39	0.213
FFM (%)	72.11±9.98	75.17±8.31	70.07±10.68	0.175
FFM (Kg)	52.16±9.04	56.32±8.99	49.39±8.17	**0.037**
FM (%)	27.79±9.88	24.83±8.31	29.76±10.56	0.185
FM (Kg)	20.83±10.01	18.96±8.21	22.07±11.1	0.414
BCMI (kg/m^2)	10.42±1.65	10.58±1.73	10.32±1.63	0.671
MDTS	6.70±1.56	6.33±1.30	6.94±1.70	0.300

WC: waist circumference, WHR: waist/hip ratio, BMI: Body Mass Index, R: Resistance, Xc: Reactance, FM: Fat Mass, PhA: Phase Angle, TBW: Total Body Water in Liters (L) and Percentage (%), ECW: Extracellular Water in Liters (L) and Percentage (%), FFM: Fat-Free Mass in Kg and Percentage (%), FM: Fat Mass in Kg and Percentage (%), BCMI: Body cell mass index, MDTS: Mediterranean Diet Test Score.

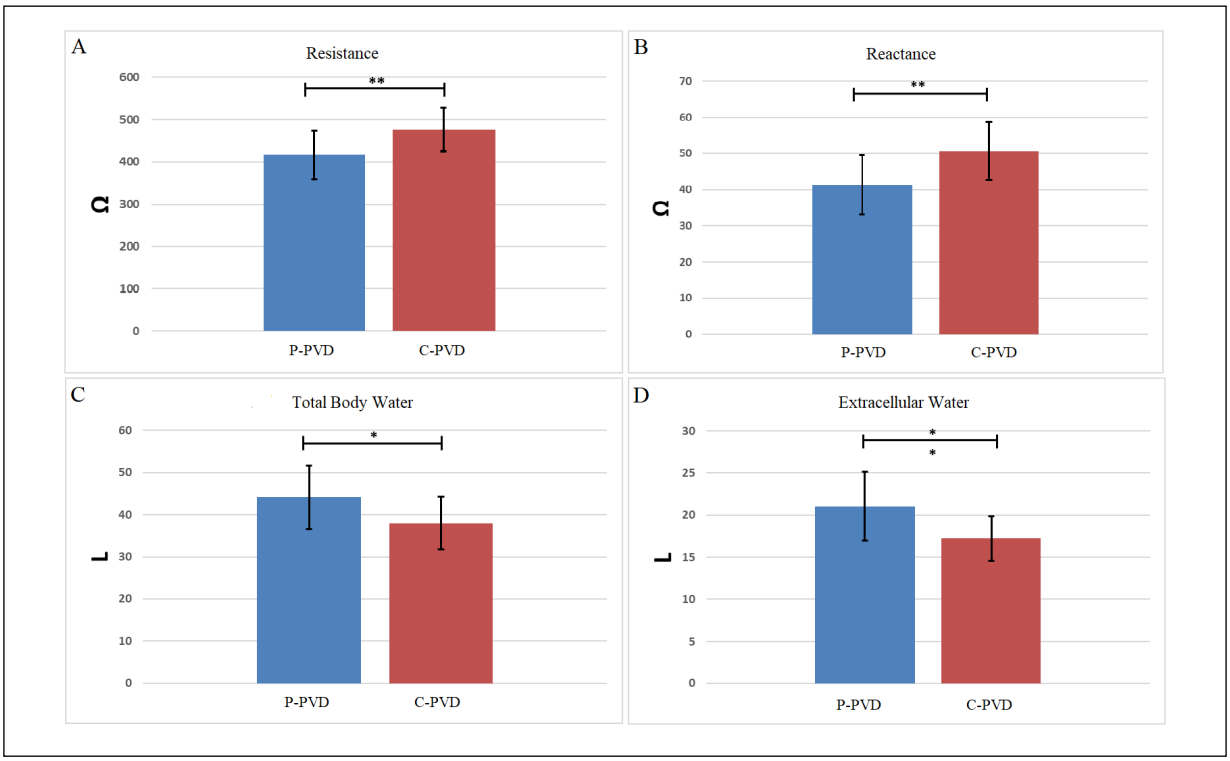

Figure 1. The difference in BIA parameters between the P-PVD group and the C-PVD group. **A**, Comparison between Body Resistance P-PVD and C-PVD. **B**, Comparison between Body Reactance P-PVD and C-PVD. **C**, Comparison between total body water P-PVD and C-PVD. **D**, Comparison between Extracellular Body Water P-PVD and C-PVD.

Posterior eye water dynamics and details are unclear, but an important role in water distribution in the vitreal cavity is played by aquaporin AQ4. The absence of AQP4 in the KO mice[32] induces lower water outflow from the vitreous body to the retina (postiridial flow).

Although the role of AQP4 in humans remains unknown, as a matter of fact, vitreal water dynamics seem to be crucial for vitreal and retinal integrity and some light must be shed on possible correlations between daily water intake and vitreal status.

In all patients, the average PhA, a marker of the health status and cell permeability, was in the normal range (5.91±0.93°), whereas mild dehydration (TBW=55.90%) was present with the expansion of the extracellular compartment, a percentage of fat mass (27.79%) above normal values and a normal BCMI (10.42 km/m^2) (Table II).

The main results were obtained from the BIA evaluation, which showed higher values of resistance and reactance in the C-PVD group than in the P-PVD. Patients in the P-PVD group reported 5 percentage points more TBW, corresponding to about 6 liters, and the ECW component, which includes eye fluids, was about 2 percentage points higher, corresponding to about 3 liters.

Patients with C-PVD showed significant dehydration, which was greater than patients with P-PVD, and especially a reduction of water in the extracellular compartment, which includes hydration of the eye.

Table III. Analysis between P-PVD Group and C-PVD Group in the severity of PVD symptoms.

		PVD	
		P-PVD	C-PVD
Vitreous symptoms	Mild	50.0%	37.5%
	Severe	50.0%	62.5%
		100%	100%

Vitreous symptoms were scored in ≤9 Mild and >9 Severe. To assess the difference between the groups, a Chi-square test was performed with p=0.765.

In agreement with the literature[16], these data suggest that body hydration could be a protective factor for vitreous detachment and may be associated with slowing down the evolution from an incomplete to a complete form of vitreous detachment.

We hypothesize that a reduction in body hydration may lead to vitreous shrinkage and promote PVD.

In support of this, there is an increase in the number of rhegmatogenous retinal detachment cases[33] due to post-PVD retinal breaks in summer and spring.

Patients showed, on average, a BMI of 27.8 Kg/m^2, indicative of an overweight state. The average waist-to-hip ratio (WHR) was 0.88, a limit value for men and higher for women, associated with a substantial increase in the risk of metabolic and cardiovascular complications[34].

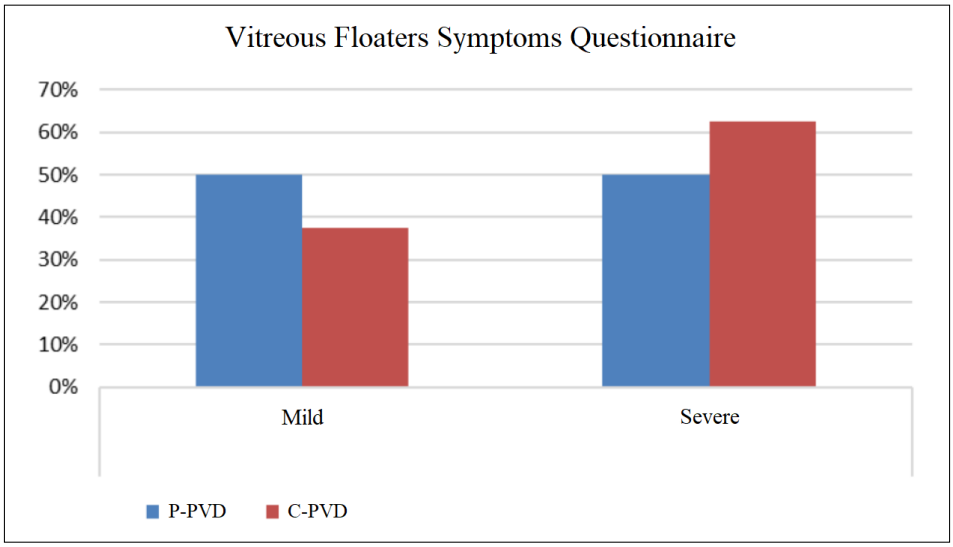

Figure 2. Comparison of symptom severity for posterior vitreous detachment between two groups. Mild, if the patient notices vitreous floaters in daily life, however, moderate discomfort (floaters symptoms questionnaire score ≤9). Severe, if the patient feels severe discomfort, and it seems like vision is worsened due to vitreous floaters (floaters symptoms questionnaire score >9).

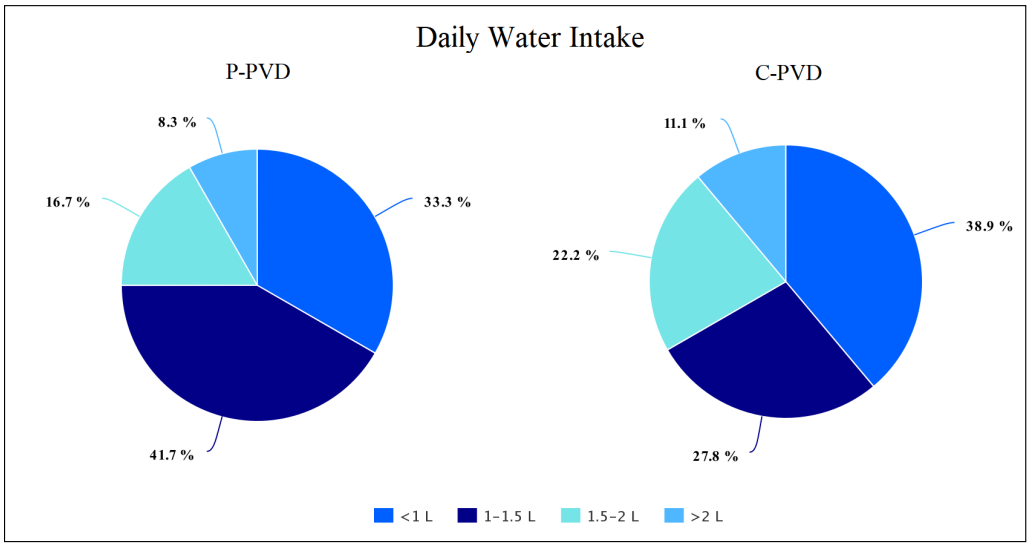

Figure 3. Daily water intake in the P-PVD group and C-PVD group.

The comparison of anthropometric data showed no statistically significant differences between P-PVD and C-PVD groups, with BMI, waist circumference, and waist-hip ratio overlapping in the two groups.

Patients with C-PVD had higher percentages of FM and lower FFM than the P-PVD group and this could suggest a connection between adipose tissue dysfunction and vitreous detachment: one explanation for this is that obesity is associated with inadequate hydration[35].

To date, among different ocular and systemic diseases, obesity has been linked with age-related cataracts, glaucoma, age-related maculopathy, diabetic retinopathy, and obstructive sleep apnea syndrome[36,37].

Patients reported symptoms of visual floaters documented by the test administered to them, which were mild and frequent in the P-PVD group and slightly more severe in the C-PVD group (Table III), although very often the severity of the pathology is not closely related to the severity of the symptoms and may sometimes be asymptomatic[24].

The Mediterranean diet adherence test results were similar in both groups and slightly better for the C-PVD group but not statistically significant. Both groups' scores were low, indicating that patients did not follow a proper food intake.

The daily water intake test did not give any important differences between the two groups, with the P-PVD group drinking 1-1.5 liters of water per day and the C-PVD drinking less than 1 liter per day (Figure 3). In both groups, the daily water intake was deficient, especially low in the C-PVD group, and this could have an impact on the vitreous pathology.

Subjects with P-PVD were asymptomatic or complained of perceived myodesopsies, whereas those with complete detachment reported photopsia and flashes in addition to floaters.

The smallness of the sample probably prevented the detection of other complications such as hemorrhages and retinal ruptures, which have been extensively described by Seider et al[38] and impose caution in the interpretation of our results. Accuracy and reliability vary widely among BIA instruments. Although single-frequency devices demonstrate the largest differences compared to the Dual-energy X-ray absorptiometry, with the inaccuracy increasing in conjunction with higher levels of BMI, several studies[39] have demonstrated the validity of single-frequency devices, concluding that BIA can be used to assess whole and segmental body composition in large groups.

However, to date, even with the limitations mentioned, bioimpedance analysis, for the first time, has been evaluated in correlation with posterior vitreous detachment.

In the present study, we reported a significant correlation between vitreous pathology and anthropometric and BIA measurements. The investigation was aimed exclusively at patients with

a diagnosis of complete and/or partial PVD who had no other ocular pathology.

Despite aging is an important risk factor for PVD, other factors, such as poor eating habits and body dehydration, affect the pathophysiology of vitreous diseases[11].

Conclusions

This study reports a correlation between dehydration and PVD through BIA analysis. The collaboration between ophthalmologists and nutritionists becomes essential to support the patient with correct eating habits and lifestyle to prevent or slow down the progression of vitreal and ocular pathology in general. Water, an essential nutrient, may deserve more attention in scientific research and therapeutic strategies.

Informed Consent
Informed consent was obtained from all subjects involved in the study.

Ethics Approval
The study protocol, following the Helsinki Declaration, was approved by the University Hospital PTV Independent Ethics Committee (217/18, Clinical Experimentation Register of PTV).

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

Availability of Data and Materials
The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' Contributions
All authors had equal contributions.

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