RESEARCH ARTICLE

Mean Platelet Volume in Blood vs. Platelet-Rich Plasma: Demographic Analysis and Intrasubject Variability in PRP Therapy

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Abstract

Objectives: To evaluate inter- and intraindividual differences in mean platelet volume (MPV) between blood and platelet-rich plasma (PRP), and to assess the influence of demographic factors (sex, age, body mass index (BMI)).

Methods: A retrospective analysis of 877 patients treated with PRP for musculoskeletal conditions (Nov 2021–Dec 2024). MPV values in blood and PRP were compared. Intrasubject variability was analyzed in a subgroup of 298 patients who received at least three PRP doses.

Results: MPV was significantly lower in PRP compared to blood ($p < 0.001$). Age, sex, and BMI had no significant effect on MPV. The coefficient of variation (CV) was low in both blood (2.78%) and PRP (3.87%), with the variation in PRP being significantly greater than that in blood ($p < 0.001$). Intrasubject MPV variability was low (coefficient of variation (CV): 2.78% in blood, 3.87% in PRP; $p < 0.001$), while intersubject variability was greater in PRP.

Conclusion: Centrifugation significantly reduces MPV in PRP compared to whole blood, indicating that the preparation process alters platelet characteristics. While demographic factors such as age, sex, and BMI do not appear to influence platelet size, the greater intersubject variability—compared to low intrasubject variability—suggests that centrifugation protocols play a key role in determining PRP composition. These findings support the reliability of the single-step PRP preparation method used in this study and highlight the importance of protocol standardization to ensure consistent biological quality, which may ultimately impact the therapeutic effectiveness of PRP in musculoskeletal treatments.

Level of evidence: IV

Keywords: Age, Body mass index (BMI), Mean platelet volume (MPV), Platelet-rich plasma (PRP), Sex

Introduction

In recent years, regenerative medicine has emerged as a transformative field, with platelet-rich plasma (PRP) garnering significant attention because of its crucial role in tissue repair and regenerative potential.[1-5] This is driven primarily by the high concentration of growth factors released by platelets.[6,7] However, the PRP concentration is influenced by the preparation process, particularly centrifugation protocols, which not only concentrate platelets but also impact their activation and the release of growth factors.[1,8-11] Additionally, factors such as sex, age, and body mass index (BMI) have been reported to influence PRP quality.[12-15]

While the literature has extensively examined the platelet concentration in PRP,[11,16] few studies have focused on platelet size, particularly the mean platelet volume (MPV), in the final PRP product. The MPV, a key hematological parameter, reflects the average size of platelets and serves as an indicator of platelet function and production.[17] Larger platelets are generally considered more metabolically and enzymatically active and contain higher concentrations of growth factors and proinflammatory mediators.[18-20] Additionally, MPV has been linked to platelet turnover, with increased values often indicating accelerated thrombopoiesis or increased platelet activation. In contrast, a decreased MPV may suggest platelet senescence or altered production dynamics.[17,21] In the context of PRP

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therapy, understanding MPV variations is essential, as platelet functionality influences growth factor release and, consequently, tissue regeneration potential.[1,8,9]

Inconsistent MPV values may affect PRP treatment outcomes, as efficacy depends on the quality and consistency of its bioactive content. Understanding MPV behavior during PRP preparation could help optimize protocols and support standardization for more reliable and effective therapies.

The present study aims to investigate inter- and intraindividual differences in MPV between whole blood and PRP, as well as to evaluate the influence of demographic factors on MPV.

The primary hypothesis of the study is that the MPV differs significantly between blood and PRP, with lower values in PRP due to the centrifugation process. Additionally, we hypothesize that demographic variables (age, BMI, and sex) do not significantly influence MPV values in either the blood or PRP. Finally, we explored whether intrasubject MPV variability across multiple PRP treatments remains low, supporting the reproducibility of a single-step centrifugation protocol. These hypotheses are grounded in prior findings suggesting that centrifugation alters platelet morphology, that demographic factors may influence hematological parameters, and that consistency in PRP characteristics is essential for reliable therapeutic application.[1,8,9,12-14,21]

Despite its potential significance, the clinical implications of MPV variability in PRP remain poorly understood. Since platelet size correlates with functional activity and growth factor content, variations in MPV may directly influence the biological potency of PRP formulations.

Materials and Methods

The study was designed as a retrospective analysis of a prospective, single-center patient database cohort from November 2021 to December 2024.

PRP treatment was prescribed during routine consultations. It could involve a single PRP injection or a series of three consecutive injections, with two-week intervals between sessions. PRP counts were performed after each injection and recorded via data processing software. The study obtained approval from the Institutional Review Board (Comité Ético de Investigación Grupo Hospitalario Quironsalud-Catalunya, approval number SET-PRP-2021-01). https://www.hgc.es/ca/recerca-i-docencia/comite-d-etica-de-la-recerca-amb-medicaments-grup-hospitala

Participants

Inclusion and exclusion criteria were established to ensure that participants represented the population likely to benefit from PRP treatment while minimizing risks and variables that could impact study outcomes.

Inclusion criteria were: (1) adults aged ≥18 years receiving PRP therapy for musculoskeletal disorders; (2) availability of same-day MPV measurements for both whole blood and PRP; (3) use of a standardized PRP preparation system and centrifugation protocol; (4) absence of hematologic disorders or concurrent anti-platelet medication; and (5) normal baseline platelet counts.

The exclusion criteria included patients with severe or uncontrolled systemic diseases (e.g., cardiovascular diseases, uncontrolled diabetes mellitus), hematological disorders, active infections, or oncological pathology. Individuals with coagulation disorders, thrombocytopenia, or platelet dysfunction were excluded due to the potential impact on PRP efficacy or safety. Patients on anticoagulants, anti-platelet agents, or those with local or systemic infections at the injection site were also excluded, as were individuals who had received corticosteroids, hyaluronic acid, or other intra-articular treatments within three months prior to the study.[22,23]

PRP preparation method

PRP preparation was conducted via the Endoret© PRGF© system (BTI Biotechnology Institute, Álava, Spain). This system was selected for this study due to its widespread clinical use, standardized single-spin protocol, and consistent leukocyte- and erythrocyte-depleted platelet-rich plasma product. Its use allows for reproducible preparation and minimizes variability introduced by different PRP systems. Blood samples were drawn after a four-hour fast into eight 9 ml tubes containing a 3.8% citrate solution. A BTI System IV© centrifuge was used to spin the samples for 8 minutes at 580 g, separating red and white blood cells from the platelets and plasma. The centrifugation was performed at ambient temperature (20-22 ºC), using a swing-out rotor with no brake applied during deceleration. Acceleration was set to standard ramp speed. These conditions were consistent across all samples to ensure protocol reproducibility.

An additional 9 mL tube with EDTA and a tube containing 1 mL of the final PRP were collected for platelet counting using a quantitative, automated hematology analyzer (Shenzhen Dymind Biotechnology Co., Ltd., China). This analyzer, linked to BioSmartData software, classified PRP according to Kon *et al.*[24]

All procedures were uniformly performed by the same medical and nursing team, following an automated protocol, which ensured consistency and minimized data registration errors.

Variables

During the initial medical consultation, after PRP treatment was prescribed, demographic and anthropometric data—including age, sex, BMI, specific musculoskeletal disorders, and laterality—were collected and recorded in the patients' electronic medical records by a physician using a standardized intake form.

MPV was measured in femtoliters (fL) in both the initial peripheral blood sample and the final PRP product. All MPV values were obtained on the same day as the PRP preparation, using an automated hematology analyzer (Shenzhen Dymind Biotechnology Co., Ltd., China). Measurements were performed immediately after blood collection and again following centrifugation, prior to PRP injection.

In patients who received multiple PRP injections, MPV was measured after each procedure. Only those who received at least three consecutive injections were included in the analysis of intrasubject MPV variability. The interval between PRP injections was standardized at 14 ± 1 days, unless medically indicated otherwise.

The final PRP product was classified using a PRP-coding system.[24] Briefly, this coding system consists of a 6-digit number (XX-XX-XX) that provides information about platelet concentration in whole blood, platelet concentration in PRP, the presence of red and white blood cells in the final PRP product, the use of platelet activation, and the addition of calcium chloride during activation. According to the authors, the digits are determined using a truncation method—that is, the digit representing platelet concentration corresponds to the hundreds place of the measured value. For example, a baseline whole blood platelet concentration of 285 $\times 10^3/\mu L$ would correspond to the digit "2" in the classification system. Similarly, a PRP preparation with a final platelet concentration of 450 $\times 10^3/\mu L$ would be assigned the digit "4." If this preparation contains no red blood cells ("0") or white blood cells ("0"), and platelet activation is performed ("1") using calcium chloride ("1"), the resulting 6-digit classification code would be 24-00-11. Each pair of digits represents, in order: platelet concentration in whole blood, platelet concentration in PRP, red blood cell content, white blood cell content, platelet activation, and calcium chloride use.

Statistical analysis

Descriptive statistics were utilized to summarize demographic, anthropometric, and injury-related characteristics. Qualitative variables are presented as counts and percentages, whereas quantitative variables are expressed as the means ±standard deviations (SDs). The Shapiro–Wilk test was used to assess the normality of the data.

Group comparisons were conducted using unpaired t tests for normally distributed variables with equal variances (per Levene's test); otherwise, the Wilcoxon rank-sum test was applied. Correlations were assessed using Pearson's or Spearman's coefficients based on normality and categorized by standard thresholds. Intrasubject MPV variability was evaluated via the coefficient of variation. PRP codes representing over 2% of the sample were classified following Kon et al.[24] Statistical analyses were performed using SPSS® v15 (SPSS Inc., Chicago, IL, USA), with significance set at $p < 0.05$.

As this was a retrospective study, no a priori sample size calculation was performed; however, the final cohort (n = 877) is large and representative, supporting robust analysis. Moreover, the observed effect in MPV sizes exceeded the minimal detectable change, indicating adequate statistical power.

Results

Between November 2021 and December 2024, a total of 3,087 PRP treatments were recorded. Only the first treatment of each subject was included; duplicates, patients with missing data, or tests performed on "nonpatients" were removed, leaving a total of 877 treatments that were ultimately included in the analysis [Figure 1]. A subgroup of 298 patients from the total sample of 877, each of whom received at least three consecutive PRP treatments, was analyzed to assess intrasubject variability in MPV.

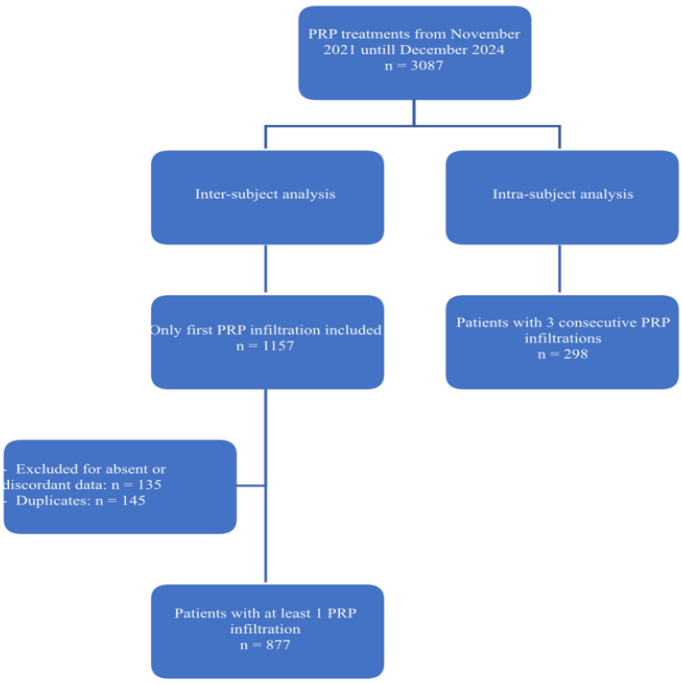

Figure 1. Flowchart of patient selection and inclusion in the inter-subject and intra-subject analyses
From a total of 3,087 platelet-rich plasma (PRP) treatments administered between November 2021 and December 2024, 1,157 cases were initially identified for inter-subject analysis (first infiltration only). After excluding 135 cases due to missing or discordant data and 145 duplicates, 877 unique patients were included in the final inter-subject analysis. Separately, 298 patients who received at least three consecutive PRP treatments were included in the intra-subject analysis to evaluate MPV variability over time.

The demographic, anthropometric, and injury characteristics of the subjects are detailed in [Table 1]. The most common pathologies are described in [Table 2].

The most common PRP codes according to Kon et al. (those accounting for more than 2% of the total) were selected [Figure 2].[24]

Table 1. Anthropometric and demographic characteristics of the study population (n = 877).

	N	Mean ± SD
Age		58.37 ± 15.79
BMI		26.75 ± 4.58
Male (%)	426	48.6%
Female (%)	451	51.4%
Bilateral (%)	487	55.6%
Right (%)	217	24.7%
Left (%)	173	19.7%

Values are presented as mean ± standard deviation for continuous variables (age, BMI) and as absolute numbers and percentages for categorical variables (sex and laterality of the affected region).

Table 2. Most common musculoskeletal pathologies treated with PRP in the study population (n = 877).

	N	%
Knee Osteoarthritis – Grade I	283	32.3%
Knee Osteoarthritis – Grade II	269	30.7%
Knee Osteoarthritis – Grade III	141	16.1%
Knee Osteoarthritis – Grade IV	14	1.6%
Shoulder Bursitis	20	2.3%
Ankle Osteoarthritis	15	1.7%
Patellar Condromalacia	18	2.1%
Meniscal Injury	10	1.1%
Others	107	12.2%

The most frequent clinical diagnoses among patients receiving PRP treatment. Frequencies are expressed as absolute numbers and percentages.

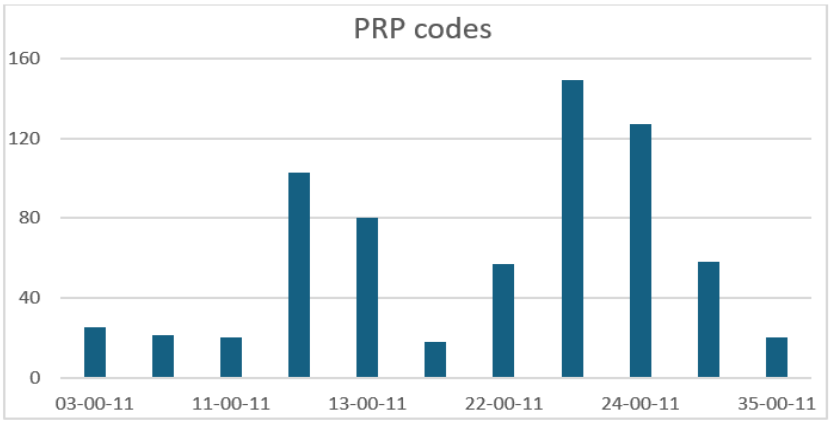

Figure 2. Distribution of the most frequent PRP classification codes (n = 877)
The chart displays the distribution of platelet-rich plasma (PRP) codes according to the classification system proposed by Kon et al., which encodes six variables: platelet concentration in whole blood and PRP, presence of red and white blood cells, platelet activation, and use of calcium chloride. Only codes representing more than 2% of the total sample are shown. The most frequently observed codes were 24-00-11, 22-00-11, and 13-00-11, all corresponding to leukocyte- and erythrocyte-depleted PRP with platelet activation and the use of calcium chloride.

There was a statistically significant difference in the MPV between the blood sample (9.8 fL) and the PRP sample (7.4 fL), with the latter being significantly lower ($p < 0.001$) [Table 3 and Figure 3].

Neither age, BMI, nor sex had any influence on the mean platelet volume in the blood sample or the PRP sample [Table 4].

Table 3. Mean platelet volume (MPV) in whole blood and PRP samples (n = 877).

	N	Mean (fL)	Dev	Median (fL)	P value*
MPV_Bl	877	9.87	0.84	9.8	< 0.001
MPV_PRP	876	7.43	0.59	7.4	

MPV values are expressed in femtoliters (fL) as mean ± standard deviation and as median. A statistically significant reduction in MPV was observed between the initial blood samples (MPV_Bl) and the final PRP product (MPV_PRP). Statistical comparison was performed using a paired test, with p < 0.001 indicating a significant difference. P value corresponds to Pearson correlation.fL = femtoliters.

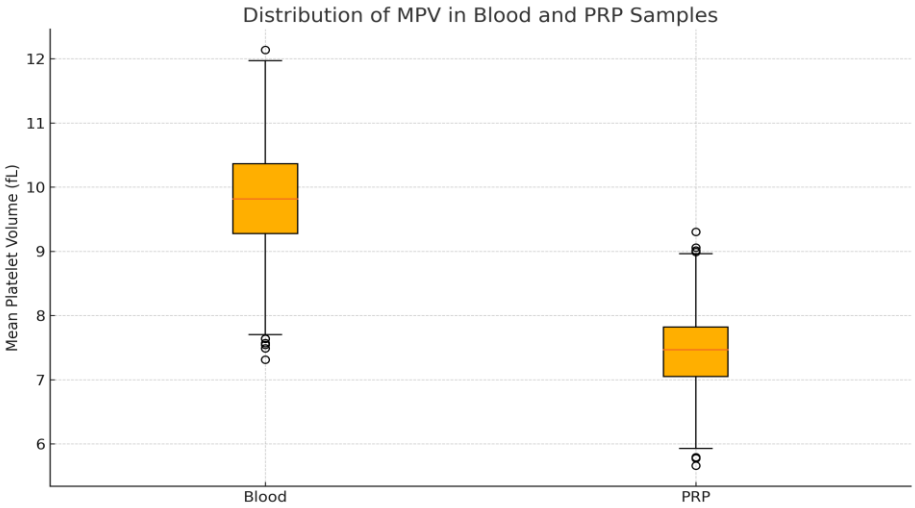

Figure 3. Boxplot showing the distribution of Mean Platelet Volume (MPV) in Blood and Platelet-Rich Plasma (PRP) samples. The red lines indicate median values

Table 4. Influence of age, BMI, and sex on mean platelet volume (MPV) in whole blood and PRP samples.

Variable	MPV Bl	P value	MPV PRP	P value
Age	-0.012*	0.705	-0.019*	0.597
BMI	-0.012*	0.758	-0.009*	0.812
Sex				
Male	9.84 ± 0.81 fL	0.341	7.41 ± 0.60 fL	0.178
Female	9.90 ± 0.87 fL		7.45 ± 0.58 fL	

MPV values are reported separately for blood (MPV Bl) and PRP (MPV PRP). For age and BMI, correlations with MPV were assessed using Pearson's correlation coefficient (*), with associated p-values shown. For sex, MPV is presented as mean ± standard deviation in femtoliters (fL), and group comparisons were tested using independent samples t-tests. No statistically significant associations were found between MPV and age, BMI, or sex in either the blood or PRP samples. FL = femtoliters.

To assess intrasubject variability in MPV, only patients who received at least three consecutive PRP treatments were included (n = 298). The CV was calculated as the standard deviation across three treatments, expressed as a percentage of their mean [Table 5]. The CV was low for both blood (2.78%) and PRP (3.87%). However, the difference between them was statistically significant ($p < 0.001$), indicating that although variability remained low overall, PRP samples exhibited slightly greater intrasubject variation compared to whole blood.

Table 5. Intrasubject coefficient of variation (CV) in mean platelet volume (MPV) across three PRP treatments (n = 298).

Bl		PRP		p value*
Mean ± SD (fL)	CV (fL)	Mean ± SD (fL)	CV (fL)	
9.87 ± 0.84	2.78 ± 2.04	7.43 ± 0.59	3.87 ± 2.89	< 0.001

MPV values in femtoliters (fL) are presented as mean ± standard deviation and CV for both whole blood (Bl) and PRP samples. The CV was calculated for each subject as the standard deviation across three measurements divided by the mean, expressed as a percentage. The comparison of MPV variation between blood and PRP was performed using the Wilcoxon test for paired nonparametric data (*). A statistically significant difference was found, with higher CV in PRP (3.87%) compared to blood (2.78%) ($P < 0.001$).fL = femtoliters.

Discussion

The statistically significant difference in MPV between blood and PRP is a crucial finding of this study (9.8 to 7.4 fL). Despite both distributions being nonnormal, the results establish that the platelet volume is significantly lower in PRP than in blood ($p < 0.001$). The normal range of MPV in healthy patients is considered to be between 7.2 and 11.7 fL.[21] Centrifugation, a critical step in PRP preparation, directly affects the platelet concentration, activation, and growth factor release.[1,2,8-11] Previous studies, such as those by Södeström et al, have demonstrated that suboptimal centrifugation protocols can lead to premature platelet activation, potentially diminishing the therapeutic efficacy of PRP.[25] Larger platelets contain a greater number of alpha granules, which store key growth factors such as platelet-derived growth factor (PDGF) and transforming growth factor-beta (TGF-β), which are essential for tissue repair and regeneration.[1,2,10] Previous studies have suggested that platelet size is correlated with activation potential and growth factor release, factors that may influence the therapeutic efficacy of PRP.[10,20]

The final MPV result in PRP achieved with the current protocol falls within normal limits (one-step centrifugation process at 580 g). Even so, we must consider the potential risk of decreased MPV and platelet functionality with other protocols that may include more centrifuge steps or higher centrifuge speeds. These findings underscore the importance of optimizing centrifugation protocols to preserve platelet integrity and functionality.

The clinical effectiveness of orthobiologic therapy remains debated due to the variability in PRP characteristics.[26-32] The wide range of commercial devices and the different protocols used for PRP preparation are the two main factors considered in the literature that may contribute to these variations.[14,33,34] This variability in platelet concentration protocols is determined by whether the centrifugation involves one-step or two-step processes, the type and operation of the collecting tube, the centrifuge speed, and other production processes.[8-11,35] As a result, these variations lead to PRP preparations with diverse volumes, platelet counts, and concentrations of residual white and red blood cells, contributing to the multifaceted landscape of PRPs.[8, 36-38] Additionally, different application protocols, including the number of injections, time between injections, long-lasting placebo effects of injectables, concomitant treatment with anti-inflammatory drugs, or specific injection locations for similar disorders, may explain differences in clinical outcomes. The PRP preparation method used in this study involves a one-step centrifugation process at 580 g and activation with calcium chloride. The results of the present study show that the most frequent codes correspond to platelet concentrations approximately doubling the platelet concentrations in the final PRP product compared with those in the blood, without red blood cells or white blood cells and, as the results show, preserving the MPV within the normal range limits (12-00-11, 24-00-11 and 36-00,11). Understanding the relationship between centrifugation parameters and platelet biology is critical for optimizing PRP protocols.

This study provides novel insight into the behavior of MPV in PRP compared to whole blood, based on a large cohort of patients undergoing a standardized, leukocyte- and erythrocyte-depleted PRP protocol. Previous studies have reported inconsistent changes in MPV after centrifugation. For instance, Li et al.[25] demonstrated that excessive centrifugation speeds can induce premature platelet activation. Although the final MPV values in PRP remained within the normal physiological range, the observed reduction compared to whole blood may still have biological implications. Since MPV is associated with platelet activation potential and growth factor content, a lower MPV could indicate a shift toward less reactive or less bioactive platelets.[1,2,8-11,20] While the clinical impact of this reduction is not yet fully understood, even modest decreases could potentially influence the therapeutic efficacy of PRP, particularly in applications where maximal growth factor release is desired. These findings underscore the importance of standardizing PRP preparation protocols to preserve platelet functionality and optimize therapeutic potential.

This study also evaluated the influence of demographic variables (age, BMI, sex) on the MPV in both the blood and PRP. Although previous studies from García-Bordes et al. suggested that older age, higher BMI, and sex-related differences might affect platelet characteristics, the results revealed no statistically significant impact of these factors on the final MPV in the PRP.[12] This finding supports the consistency of PRP preparations across diverse patient populations and reduces concerns about demographic variability influencing therapeutic outcomes.

The intersubject variability in MPV was significant, with a higher coefficient of variation in PRP (3.87%) than in blood (2.78%) ($p < 0.001$). This finding indicates that the PRP

preparation process introduces greater variability, potentially linked to the mechanical forces applied during centrifugation. In contrast, intrasubject variability in patients receiving multiple PRP doses remained low, with variations of less than 5%. The preparation protocol employed in the present study (a single centrifuge spin for 8 minutes at 580 × g) presented great stability at repeated doses, suggesting its reliability, which is a positive finding for clinical applications.

This study has several limitations that should be considered when interpreting the findings. First, the retrospective design restricts the ability to control for confounding variables, potentially introducing bias in data collection and analysis, particularly in terms of which patients received repeated PRP doses. Second, the absence of a control group (e.g., patients treated with a different PRP system, or no PRP at all) prevents direct conclusions regarding the clinical superiority or therapeutic relevance of the observed MPV patterns. Third, the study was conducted at a single center using a single PRP preparation system (Endoret® PRGF®) and a single hematology analyzer (Shenzhen Dymind analyzer), which may limit the generalizability of our findings. While this system ensured consistency in the study and should be considered a point of strength, the findings may not be directly applicable to other preparation systems or protocols, particularly those that include leukocyte-rich formulations, double-spin methods, or alternative activation strategies. These limitations should be considered when interpreting the results and designing future research.

Although this study did not directly assess clinical outcomes, the consistency of MPV within individuals and the overall reduction in PRP samples underscore the need to better understand the functional consequences of these changes. Future studies should examine whether MPV variations correlate with actual differences in healing rates, pain reduction, or functional outcomes in musculoskeletal disorders. Additionally, randomized controlled trials comparing PRP systems with different centrifugation protocols could help establish whether platelet volume metrics such as MPV serve as reliable proxies for PRP quality and clinical effectiveness.

This study has notable strengths, including a large sample size and a lack of comparable studies in the literature. This size is large enough to support the conclusions obtained compared with those of previous studies. The data included in the analysis were also collected consistently by the same medical and nursing team, following the same automated protocol, minimizing errors related to data recording.

These findings highlight the importance of refining laboratory procedures to reduce platelet damage and variability, thereby enhancing the consistency of the MPV in PRP. Additionally, the absence of demographic influences on the MPV further validates the broader applicability of PRP therapy across diverse patient populations.

Conclusion

In summary, this study provides valuable data on PRP characteristics, including differences in platelet volume between whole blood and PRP, the apparent lack of influence from demographic variables, and the low variability observed across repeated doses within individuals. Although this study did not analyze the clinical efficacy of PRP based on the MPV, the findings suggest that centrifugation protocols may influence platelet morphology and, potentially, PRP composition. These results may contribute to the ongoing discussion regarding the standardization of PRP preparation methods. However, due to the retrospective, single-center nature of the study and the exclusive use of one PRP system, caution is warranted when generalizing these findings. Further prospective, multicenter research is needed to assess whether MPV variations translate into clinically meaningful differences in PRP efficacy.

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Declaration of Informed Consent: There is no information (names, initials, hospital identification numbers, or photographs) in the submitted manuscript that can be used to identify patients.

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