ORIGINAL ARTICLE

Test–retest repeatability and software reproducibility of myocardial flow measurements using rest/adenosine stress Rubidium-82 PET/CT with and without motion correction in healthy young volunteers

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Background. Myocardial flow reserve (MFR) assessment with cardiac positron emission computed tomography (PET/CT) is well established, and quantification relies on commercial software packages. However, for reliable use, repeatability and reproducibility are important. The aim of this study was therefore to investigate and compare between scans and software packages the repeatability and reproducibility of ^{82}Rb-PET/CT estimated MFR.

Methods and Results. Forty healthy volunteers completed two ^{82}Rb-PET/CT rest and adenosine stress scans. syngo.MBF (Siemens), quantitative-gated SPECT (QGS) (Cedars-Sinai), and Corridor4DM (4DM) were used for analyses. Motion correction was available for 4DM. Fifty percent were men and age was 24 ± 4 years (mean ± SD). Repeatability of MFR varied between scans. syngo.MBF: mean difference (95% CI) 0.26 (− 0.03 to 0.54), $P = 0.07$, limits of agreement (LoA): − 1.43 to 1.95; QGS: 0.19 (− 0.08 to 0.46), $P = 0.15$, LoA: − 1.38 to 1.76; 4DM: 0.08 (− 0.17 to 0.34), $P = 0.50$, LoA: − 1.37 to 1.53; and 4DM motion corrected: 0.17 (− 0.17 to 0.51), $P = 0.32$, LoA: − 1.89 to 2.22. MFR was higher using 4DM +/− motion correction compared with syngo.MBF and QGS (all $P < 0.0001$). Concordance between syngo.MBF and QGS was high ($P = 0.83$).

Conclusions. Reproducibility of MFR varied for the different software. The highest concordance between MFRs was found between syngo.MBF and QGS. (J Nucl Cardiol 2021;28:2860–71.)

Key Words: Myocardial perfusion • Myocardial blood flow • Myocardial flow reserve • Positron emission tomography • Repeatability • Reproducibility

Abbreviations

^{82}Rb-PET/CT	Rubidium-82 positron emission tomography/computed tomography
CACS	Coronary artery calcium score
LV	Left ventricle
MBF	Myocardial blood flow
MFR	Myocardial flow reserve
SPECT	Single photon emission computerized tomography

See related editorial, pp. 2872–2875

INTRODUCTION

The use of myocardial flow reserve (MFR) assessed with cardiac positron emission computed tomography (PET/CT) is well established, and it contains important prognostic information, e.g., in patients with ischemic heart disease.[1] Cardiac PET/CT using Rubidium-82 (^{82}Rb) as a tracer for semi-quantitative myocardial perfusion imaging is widely used clinically and has important prognostic value as well.[2-6] However, the results must be interpreted under consideration of the limitations of the method. It has previously been concluded that software-specific age- and sex-matched normal values should be used as reference.[7] Furthermore, repeatability between scans seems to vary more in persons with higher risk of cardiovascular disease than in those with no risk factors.[8] Recent studies have shown that patient motion, especially in the early blood pool phase, can increase global myocardial blood flow (MBF) measures and also affect the MFR when compared with results adjusted with manually or automated motion correction.[9,10]

The studies mentioned above either described comparison of different commercially available software packages for analyses of ^{82}Rb-PET/CT scans or comparison between scans have previously been conducted using dipyridamole as a stressor.[7,8] However, no former studies have addressed this using adenosine as stressor for ^{82}Rb-PET/CT in a combined study of scan repeatability and software comparison. Additionally, no former studies have investigated the reproducibility between ^{82}Rb-PET/CT scans with and without motion correction. Therefore, we aimed to investigate repeatability of MBF at rest (MBFr) and during stress (MBFs) and the MFR between two scans and reproducibility between three commercially available software packages, with and without motion correction if available, assessed by rest/adenosine stress ^{82}Rb-PET/CT.

METHODS

Study Population

From September 2016 to March 2017, 40 young healthy volunteers were scanned with rest and adenosine stress myocardial perfusion ^{82}Rb-PET/CT. We included participants using advertisements approved by the Scientific Ethics Committee [protocol number H-15009293] in the age span from 20 to 40 years, primarily recruited from surrounding universities. Volunteers were recruited according to these inclusion criteria: age > 18 years, no current participation in studies testing drugs, no use of tobacco or euphoric substances (except alcohol) within three months, no regular consumption of medicine, and no known medical condition. Participants were excluded based on the following criteria: allergy or intolerance to theophylline or adenosine, any prior medical history of asthma, and pregnancy or inability to follow the protocol. All volunteers provided informed oral and written consent, and the protocol was approved by the Scientific Ethics Committee of the Capital Region of Denmark and the Danish Data Protection Agency [protocol number H-15009293]. Half of the scans assessed in the current study were used as control scans in another study so that only one extra scan per participant was necessary to test for repeatability. The trial was performed in accordance with the principles of the Declaration of Helsinki.

PET Imaging Quantitative and Semi-Quantitative Analyses

Volunteers completed two PET scans with at least 24 hours in between. Participants underwent serial rest–stress imaging on a Biograph mCT 128-slice scanner (Siemens Healthcare) using list-mode 3D acquisition after ^{82}Rb infusion (Bracco Diagnostics). Patients were instructed to abstain from caffeine for 24 hours before imaging. Low-dose CT (0.4 mSv; 120 kVp; effective tube current, 26 mA [11-mAs quality reference]; 3.3 seconds) was performed for AC, during normal breathing. Doses of ^{82}Rb for rest and stress imaging were (mean ± SD) 1,091 ± 159 MBq and 1,085 ± 162 MBq, supplied from a CardioGen-^{82}Sr/^{82}Rb generator manufactured for Bracco Diagnostics Inc., Princeton, NJ. were administered intravenously at 50 mL/min. Acquisition started with the tracer infusion and continued for 7 minutes. Stress was induced with adenosine infused at 140 cg/kg/min for 6 minutes, with acquisition starting 2.5 minutes later. Alignment between non-attenuation-corrected PET and CT images was verified and corrected manually by an experienced technologist for any patient body motion. In cases of significant patient motion between PET and CT, an additional low-dose CT scan was acquired at the end of the study for stress AC. Both rest and stress dynamic images were reconstructed into 18 time frames (1 · 10 seconds, 8 · 5 seconds, 3 · 10 seconds, 2 · 20 seconds and 4 · 60 seconds; total, 7 minutes) using the vendor standard-ordered subsets

expectation maximization 3D reconstruction (2 iterations, 21 subsets) with 6.5-mm gaussian postprocessing filter.

Coronary artery calcium score (CACS) images from a non-contrast breath-hold CT were acquired in all volunteers at their first scan.[11]

Quantification of myocardial blood flow from dynamic rest and stress images was conducted as previous described by Armstrong et al.[12] The quantification of MBF was conducted with quantitative-gated nuclear imaging based on a single compartment ^{82}Rb tracer kinetics model as suggested by Lortie et al.[13] using three different software packages: syngo.MBF (Siemens Medical Solutions, Version VB15, Illinois, USA), quantitative-gated SPECT (QGS) v. 2015.5 (Cedars-Sinai Cardiac Suite, Los Angeles, USA) and Corridor4DM v. 2015.0.0.44 (INVIA, LLC, Ann Abor, USA), (Figure 1). MFR was defined as MBF at adenosine-induced maximal hyperemia divided by resting MBF. To correct the MBFr for baseline work, we divided MBFr with the rate pressure product (RPP), which is the systolic blood pressure, times the heart rate (HR), and multiplied by 10,000.[14] MFR above 2.5 was considered normal.[15]

In syngo.MBF, the automatic data processing algorithm was unable to generate an accurate LV contour in two of 155 MBF measures available. In those cases, it was necessary to correct the LV contours manually. Using QGS, this was the case in which 92 of 155 MBF measures and with 4DM adjustments were made in four of 155 MBF measures. Further, Corridor4DM allows evaluation and manually correction for motion frame-by-frame where the dynamic tracer activity does not align properly to the displayed LV contours. Comparison of test–retest was defined as repeatability whereas comparison between software was defined as reproducibility, as suggested in previous studies.[16-18]

Statistical Analyses

Statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). Continuous variables were summarized with means with standard deviations. Analyses of differences between scans and between software packages were conducted with paired t-tests and the Bland–Altman method with 95% confidence intervals and limits of agreement. Coefficient of variation (COV) between scans was calculated as SD of differences/mean of the 2 measurements.[19] Differences between men and women were analyzed with the two-sample t-test. P values were considered statistically significant when < 0.05. False discovery rate-correction was used to adjust for multiple testing.

RESULTS

Study Population and Hemodynamic Parameters

Forty healthy young volunteers were included in our study. Of those, 39 (98%) underwent two PET scans. Adenosine stress test was successful in all scans except from three (4%). Characteristics of the study population are summarized in Table 1. Fifty percent of the participants were men, mean (± SD) age was 24 ± 4 years, and mean body mass index was 23 ± 3 kg/m^2. CACS was 0 in all volunteers and the timespan between two scans was 17 ± 14 days. Overall, heart rate and blood pressures as well as mean arterial pressure and RPP were lower at the second scan compared with the first. However, no significant difference was found in any of the hemodynamic parameters on the response from rest to stress between the two scans. Mean serum-caffeine level and plasma-glucose level were also similar between scans. Furthermore, dose of ^{82}Rb did not differ significantly between scans (Table 1). Left ventricular ejection fraction was normal across software and increased as expected with adenosine stress and the summed difference score was zero. Results on ejection fraction and LV volumes in this cohort have been published previously.[20]

Repeatability of MBF and MFR Between Scans

Mean values of MFR and MBF at rest and stress for both scans and by software package are shown in Table 2 and Figure 2a to c. Results from 4DM are shown both without and with motion correction. Repeatability between scans was high for all flow parameters regardless of software package (Table 2). COV of MFR was 23% for syngo.MBF and QGS and 20% and 27% for 4DM without and with motion correction, respectively. Figure 3a to d shows Bland–Altman plots comparing MFR from the two scans using the three different software packages and using 4DM with motion correction. Bland–Altman plots comparing rest and stress MBF from the two scans are shown in Supplementary Figures A1 to A2.

Reproducibility of MBF and MFR Between Software Packages and for 4DM with and Without Motion Correction

Comparisons of MBF and MFR between software packages as well as for 4DM without and with motion correction are shown in Table 3. Furthermore, Bland–Altman plots for all comparisons are shown in Supplementary Figures A3 to A5. When comparing MBF at

Figure 1. Software overview. Top: syngo.MBF, middle: QRS, bottom: 4DM.

Table 1. Characteristics of study population and adenosine-induced hemodynamic changes

Characteristics			
Participants completed both scans (%)			39 (98)
Successful rest and stress scans (%)			76 (96)
Age—year			24 ± 4
Male sex—no. (%)			20 (50)
Body-mass index—kg/m^2			23 ± 3
Time between scans—days			17 ± 14
	Scan 1 (n = 40)	**Scan 2 (n = 39)**	**P value**
Plasma-glucose level—mmol/l	5.0 ± 0.7	5.0 ± 0.7	0.80
Serum-caffeine level mg/l	0.4 ± 0.6	0.6 ± 1.4	0.45
^{82}Rb rest—Mbq	1,068 ± 142	1,116 ± 174	0.12
^{82}Rb stress—Mbq	1,067 ± 147	1,105 ± 178	0.25
Heart rate—bpm			
Rest	63 ± 13	58 ± 11	< 0.01
Stress	88 ± 19	86 ± 17	0.04
Change	24 ± 16	27 ± 13	0.88
Diastolic blood pressure—mmHg			
Rest	61 ± 8	57 ± 8	< 0.01
Stress	60 ± 9	56 ± 9	0.02
Change	-2 ± 8	-1 ± 7	0.60
Systolic blood pressure—mmHg			
Rest	107 ± 12	105 ± 11	0.26
Stress	108 ± 12	101 ± 11	< 0.01
Change	1 ± 10	-3 ± 12	0.06
Mean arterial pressure—mmHg			
Rest	77 ± 8	73 ± 7	< 0.01
Stress	76 ± 9	71 ± 8	< 0.01
Change	-1 ± 7	-2 ± 6	0.62
Rate pressure product—×10^3 mmHg/min			
Rest	6.7 ± 1.6	5.9 ± 1.6	< 0.01
Stress	9.5 ± 2.3	8.5 ± 2.5	< 0.001
Change	2.7 ± 1.9	2.6 ± 1.4	0.23

Data are mean and standard deviation if not indicated otherwise. Two-sided P values were determined by paired t-test

rest and during stress between QGS and syngo.MBF, we found significant differences between software packages both at rest and stress. However, no significant difference was found with regard to MFR between QGS and syngo.MBF. Both 4DM without and with motion correction differed significantly from both syngo.MBF and QGS at rest and stress as well as in MFR.

High reproducibility was found for resting MBF between 4DM and 4DM with motion correction. For stress MBF and MFR, reproducibility was lower between 4DM and 4DM with motion correction.

MBF and MFR in Men and Women

Table 4 illustrates resting and stress MBF and MFR in men and women for the two scans using all three software packages. Values of 4DM are shown both without and with motion correction. Rest and stress MBF were significantly higher in women than in men (P < 0.05) at both scans and within all software packages with one exception: MBFr was borderline significant for scan 2 using 4DM without motion correction; men vs. women: 0.65 ± 0.27 vs. 0.72 ± 0.17 (P = 0.05). MFR, on the other hand, did not differ significantly between sexes (Table 4).

Table 2. Summary of myocardial blood flow parameters by scan, software, and repeatability measures: Scan 2 vs. Scan 1

	Scan 1 (*n* = 40)	Scan 2 (*n* = 37)	Mean difference (95% confidence interval)	*P* value	Adjusted *P* value	Limits of agreement
syngo.MBF						
MBF rest	0.88 ± 0.30	0.84 ± 0.25	− 0.04 (− 0.10 to 0.03)	0.25	0.37	(− 0.42; 0.35)
MBF stress	3.09 ± 0.88	3.22 ± 0.70	0.05 (− 0.18 to 0.28)	0.67	0.76	(− 1.29; 1.38)
MFR	3.65 ± 0.93	3.94 ± 0.80	0.20 (− 0.07 to 0.47)	0.13	0.20	(− 1.35; 1.76)
QGS						
MBF rest	0.85 ± 0.25	0.82 ± 0.22	− 0.04 (− 0.10 to 0.19)	0.18	0.28	(− 0.40; 0.31)
MBF stress	2.97 ± 0.74	3.05 ± 0.54	− 0.03 (− 0.20 to 0.15)	0.76	0.83	(− 1.01; 0.96)
MFR	3.69 ± 0.90	3.88 ± 0.82	0.17 (− 0.10 to 0.44)	0.21	0.32	(− 1.37; 1.71)
4DM						
MBF rest	0.67 ± 0.22	0.69 ± 0.22	0.02 (− 0.05 to 0.08)	0.63	0.72	(− 0.36; 0.39)
MBF stress	2.60 ± 0.80	2.72 ± 0.67	0.03 (− 0.18 to 0.23)	0.81	0.86	(− 1.16; 1.21)
MFR	3.94 ± 1.01	4.11 ± 0.83	0.08 (− 0.17 to 0.34)	0.50	0.62	(− 1.37; 1.53)
4DM with motion correction						
MBF rest	0.71 ± 0.24	0.66 ± 0.21	− 0.05 (− 0.10 to 0.01)	0.09	0.14	(− 0.39; 0.29)
MBF stress	2.66 ± 0.88	2.64 ± 0.79	− 0.04 (− 0.25 to 0.18)	0.72	0.80	(− 1.35; 1.27)
MFR	3.88 ± 1.08	4.09 ± 1.05	0.17 (− 0.17 to 0.51)	0.32	0.45	(− 1.89; 2.22)

Data are mean and standard deviation. Repeatability measures are calculated from the Bland Altman method and paired *t*-test. Adjusted *P* values are calculated with false discovery rate-correction

DISCUSSION

In the current study, we investigated the repeatability between scans and reproducibility between software (syngo.MBF, QGS, and 4DM +/− motion correction) of MBF and MFR assessed by [82]Rb-PET/CT. We scanned 40 healthy young volunteers. Overall repeatability between scans was high for both MBFr and MBFs as well as for MFR. No significant differences were found between scans for any parameters. A significant difference was found between MFR values when using 4DM without vs. with motion correction. However, the small statistically significant difference was considered without clinical relevance. The highest concordance between software packages was found between syngo.MBF and QGS. MFR did not differ significantly between syngo.MBF and QGS whereas statistically significant difference was found when comparing syngo.MBF or QGS with 4DM without and with motion correction. Overall our findings on reproducibility between software packages were as expected from previous studies, revealing significant differences between software package measures.[7,21] In a study by Nesterov et al.[22] comparing ten different software packages, the authors found consistent results when

measuring global and regional MBF values when using the same kinetic model described by Lortie et al.[13] as we used in this study. 4DM and syngo.MBF were both included in the mentioned study, but no direct comparison of these two software tools was reported. However, comparing one or the other with the rest of the available tools pooled together showed consistent results. The study by Nesterov et al. underlines the importance of using the same kinetic model conducting the data.[22]

Recent results by Lee and colleagues have suggested that the use both manual and automated motion correction limit flow result errors in patients referred for clinical implicated [82]Rb-PET/CT. Furthermore, they showed that motion correction was primarily an issue during stress imaging.[9,10] Motion of the heart during adenosine stress may be greater in young and healthy individuals. However, we did not find clinically significant differences in global flow results between 4DM without and with motion correction and scan to scan repeatability did not improve with motion correction either. This may suggest that the use of motion correction could be focused to scans with abnormal flow results.

Our findings on test–retest repeatability between scans were in accordance with previous results. In a
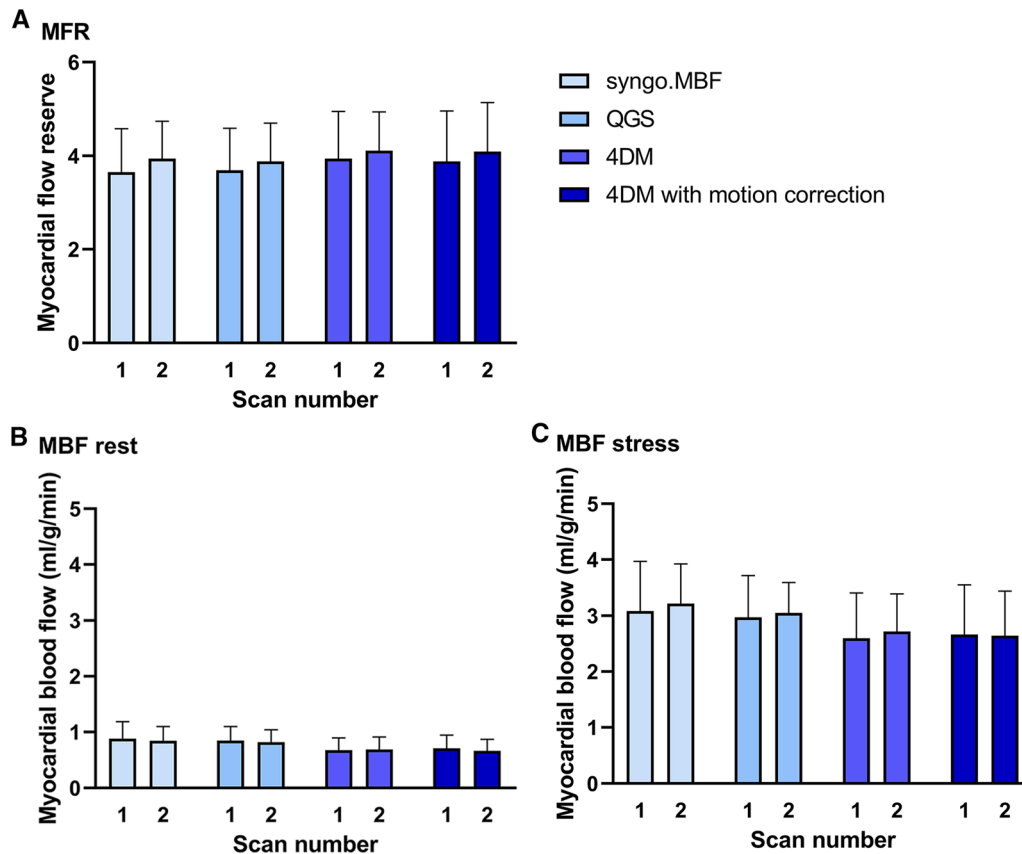
Figure 2. Mean (±SD) MFR (**A**), MBF rest (**B**) and MBF stress (**C**) by scan number and software package. No significant difference between scans for the individual software packages ($P > 0.05$).

study by Kitkungvan et al. the authors found a day to day COV in MFR of 21%, which was similar to our findings.[19] An important factor that may affect the scan to scan repeatability is the caffeine level in the blood. Patients in our study were instructed to restrain from caffeine for at least 24 hours prior to scan and additionally serum-caffeine level was measured right before scan. Serum-caffeine was low in both scans. In a recently study, our research group showed that 100 mg of caffeine prior to scan corresponding to a serum-caffeine level of 2mg/l did not significantly change MBFs and MFR compared to no caffeine.[23] Therefore, we do not consider the very low serum-caffeine levels in this study population modifying on our results.

Some considerations should be made when using a single-acquisition protocol for [82]Rb infusion, as in this study and as it is routine in [82]Rb-PET/CT. In a study by Tout et al., the authors found detector block saturation to be observed in 15% of cases when using an administered activity of 1480 MBq.[24] Therefore, the authors recommended use of activity of 1110 MBq. This corresponds to the activity used in the current study. Therefore,

detector block saturation was not considered a major factor in our study. Also, we found no significant difference in mean [82]Rb dose between scans.

Differences in the software algorithms can result in differences in the estimated myocardial flow reserve measurements. For example, the image-derived arterial input function may be contaminated by spillover signal from the myocardium into the LV cavity due to the limited image spatial resolution. Spillover into the arterial input region may be greater with one method and result in larger values for the arterial input and lower flow calculations. This effect would be minimized with the flow reserve calculations. Further, Vasquez et al.[25] have shown that selection of a customized arterial site for each individual improved quantification of myocardial perfusion and coronary flow reserve with less variability compared with utilizing a single, pre-selected, fixed anatomic site.

Previous studies have found conflicting results on sex-specific MBF. One study found no difference between resting and stress MBF in men and women[14], while others have found higher resting perfusion in
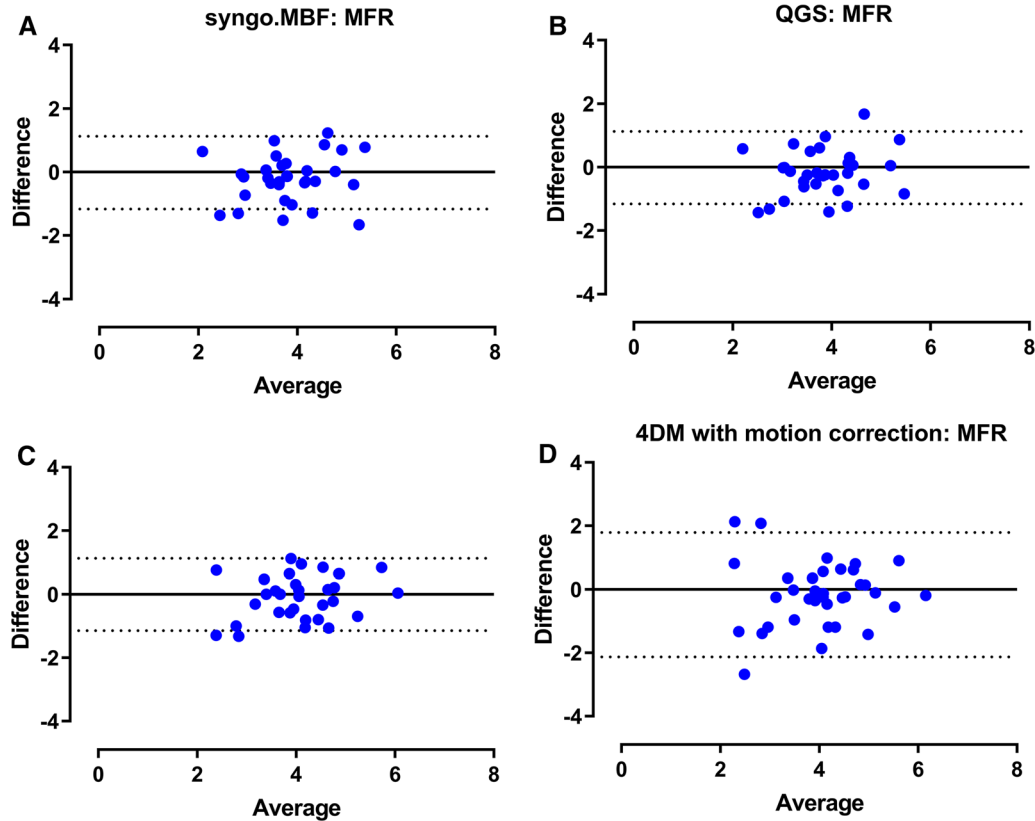
Figure 3. Bland–Altman plots of MFR: (**A**) comparison of scan 1 and 2 using syngo.MBF; (**B**) comparison of scan 1 and 2 using QGS; (**C**) comparison of scan 1 and 2 using 4DM; (**D**) comparison of scan 1 and 2 using 4DM with motion correction.

women compared with men.[26,27] A recent study, investigating middle-aged normal individuals with [82]Rb-PET/CT, found higher resting and dipyridamole stress MBF in women compared with men measured with different software packages but no difference in MFR.[7] These results were similar to our resting and adenosine stress results in young and healthy individuals. Furthermore, we could confirm that MFR, on the other hand, did not differ between sexes in young individuals.

STUDY LIMITATIONS

Some limitations of the current study should be mentioned. In this study we included healthy young volunteers with flow parameters within the normal range. Results may have differed in patients with heart failure or comorbidities or in older individuals in general. However, we find repeatability and reproducibility data in normal subjects important prior to comparison within older individuals and within patients with cardiovascular disease. In three participants, adenosine stress was unsuccessful in one of the scans. This

was not due to caffeine intake. Technical causes such as subcutaneous infusion, by mistake too low concentration of adenosine or too low infusion rate may be the explanation.

NEW KNOWLEDGE GAINED

To the best of our knowledge, this study is the first to compare MBF and MFR using [82]Rb-PET/CT with adenosine stress both between two different scans and between different software packages in one study including motion correction performed in healthy young individuals of both sexes equally represented. Our results indicate that the flow parameters are reliable, but that the same software package should be used when interpreting and comparing the data. As previously shown with dipyridamole as stressor in middle-aged individuals, MFR was not sex specific in our young volunteers. However, normal ranges of rest and stress MBF differed between young and healthy men and women, as previously shown in an older normal

Table 3. Reproducibility of myocardial blood flow parameters between software packages and for 4DM with and without motion correction

	Mean difference (95% confidence interval)	P value	Adjusted P value	Limits of agreement
QGS vs. syngo.MBF				
MBF rest	− 0.03 (− 0.06 to − 0.01)	< 0.01	0.03	(− 0.22; 0.15)
MBF stress	− 0.15 (− 0.22 to − 0.09)	< 0.0001	< 0.001	(− 0.71; 0.41)
MFR	− 0.01 (− 0.12 to 0.10)	0.83	0.86	(− 0.93; 0.91)
4DM vs. syngo.MBF				
MBF rest	− 0.21 (− 0.19 to − 0.16)	< 0.0001	< 0.001	(− 0.44; 0.07)
MBF stress	− 0.50 (− 0.59 to − 0.41)	< 0.0001	< 0.001	(− 1.26; 0.27)
MFR	0.24 (0.13 to 0.34)	< 0.0001	< 0.001	(− 0.63; 1.10)
4DM with motion correction vs. syngo.MBF				
MBF rest	− 0.18 (− 0.20 to − 0.16)	< 0.0001	< 0.001	(− 0.36; − 0.01)
MBF stress	− 0.43 (− 0.51 to − 0.36)	< 0.0001	< 0.001	(− 1.04; 1.17)
MFR	0.29 (0.20 to 0.38)	< 0.0001	< 0.001	(− 0.49; 1.08)
4DM vs. QGS				
MBF rest	− 0.15 (− 0.18 to − 0.13)	< 0.0001	< 0.001	(− 0.35; 0.04)
MBF stress	− 0.35 (− 0.42 to − 0.27)	< 0.0001	< 0.001	(− 0.98; 0.29)
MFR	0.25 (0.16 to 0.33)	< 0.0001	< 0.001	(− 0.48; 0.98)
4DM with motion correction vs. QGS				
MBF rest	− 0.15 (− 0.17 to − 0.13)	< 0.0001	< 0.001	(− 0.35; 0.05)
MBF stress	− 0.28 (− 0.34 to − 0.23)	< 0.0001	< 0.001	(− 0.77; 0.20)
MFR	0.30 (0.20 to 0.40)	v0.0001	< 0.001	(− 0.52; 1.12)
4DM with motion correction vs. 4DM				
MBF rest	− 0.001 (− 0.02 to 0.02)	0.96	0.96	(− 0.21; 0.21)
MBF stress	− 0.06 (− 0.13 to 0.001)	0.05	0.08	(− 0.60; 0.47)
MFR	− 0.06 (− 0.11 to − 0.01)	0.02	0.04	(− 0.47; 0.35)

Reproducibility measures are calculated from the Bland Altman method and paired t-test. Adjusted P values are calculated with false discovery rate-correction

population; hence, those values should not be compared across sexes.

CONCLUSION

All software packages identified the participants with flow values in the high end of the normal range, as expected for healthy volunteers. Varying repeatability of MFR was found between scans for the different software packages and 4DM seemed to have the highest inter-scan repeatability. Concordance between MFR measures was high between syngo.MBF and QGS whereas higher MFR measures was conducted from 4DM in comparison with the two other software packages. High reproducibility of MFR was found between 4DM without and with motion correction and using motion correction for 4DM did not change the significant difference between 4DM measures and measures with syngo.MBF and QGS. Our results suggest that MBF analyzed with syngo.MBF and QGS may be mutually comparable but that 4DM may be preferred for analyses due to possibly higher scan to scan repeatability.

SUPPLEMENTARY DATA

Bland–Altman plots comparing rest and stress MBF between scans are shown in supplementary figures A1 to A2. MBFr, MBFs, and MFR comparing the different software packages and comparing 4DM without and with motion correction are shown in supplementary

Table 4. Myocardial blood flow parameters in men and women

Men (n = 20) vs. women (n = 20)		Scan 1 (n = 40)	P value men vs. women	Adjusted P value men vs. women	Scan 2 (n = 37)	P value men vs. women	Adjusted P value men vs. women
syngo.MBF							
MBF rest	M	0.79 ± 0.27	0.01	0.03	0.77 ± 0.28	< 0.01	0.03
	F	1.00 ± 0.31			0.91 ± 0.20		
MBF stress	M	2.70 ± 0.83	< 0.01	0.02	2.97 ± 0.75	0.02	0.04
	F	3.54 ± 0.72			3.43 ± 0.60		
MFR	M	3.59 ± 0.97	0.82	0.86	4.03 ± 0.97	0.45	0.57
	F	3.71 ± 0.90			3.86 ±0.65		
QGS							
MBF rest	M	0.76 ± 0.23	< 0.01	0.02	0.77 ± 0.27	0.03	0.06
	F	0.96 ± 0.23			0.86 ±0.16		
MBF stress	M	2.66 ± 0.70	< 0.01	0.02	2.84 ± 0.54	0.02	0.04
	F	3.35 ± 0.62			3.22 ± 0.48		
MFR	M	3.77 ± 1.03	0.57	0.68	3.94 ± 1.06	0.58	0.68
	F	3.60 ± 0.74			3.83 ± 0.60		
4DM							
MBF rest	M	0.60 ± 0.21	0.02	0.03	0.65 ± 0.27	0.05	0.09
	F	0.76 ± 0.22			0.72 ± 0.17		
MBF stress	M	2.24 ± 0.76	< 0.01	0.02	2.45 ± 0.67	0.01	0.03
	F	3.02 ± 0.65			2.94 ± 0.60		
MFR	M	3.80 ± 1.02	0.33	0.45	4.04 ± 0.92	0.86	0.87
	F	4.10 ± 1.00			4.18 ± 0.77		
4DM with motion correction							
MBF rest	M	0.61 ± 0.22	< 0.01	0.02	0.61 ± 0.24	< 0.01	0.03
	F	0.81 ± 0.22			0.71 ± 0.17		
MBF stress	M	2.22 ± 0.84	< 0.01	< 0.01	2.28 ± 0.81	< 0.01	0.02
	F	3.15 ± 0.66			3.01 ± 0.60		
MFR	M	3.71 ± 1.16	0.32	0.45	3.86 ± 1.21	0.45	0.57
	F	4.07 ± 0.98			4.32 ± 0.84		

Data are mean and standard deviation. Differences are calculated with a two-sample *t*-test. Adjusted *P* values are calculated with false discovery rate-correction

figures A3 to A5.

Disclosures

All authors declare that they have no conflict of interest.

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