

Validating Static PET Metrics Against Patlak: Foundations for Predictive Modeling in FDG-PET

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Introduction

Of the existing non-compartmental methods to quantify the glucose uptake based on FDG-PET images, Gjedde-Patlak is considered the most quantitative, while Fractional Uptake Rate (FUR) is considered semi-quantitative, where as Standardize Uptake Value (SUV) and SUV Ratio (SUVR) are considered qualitative. Patlak requires dynamic imaging and input functions (IF). However, static metrics such as SUV and SUVR are easier to obtain.

Aim

In this study, we aimed to evaluate the associations between SUV, SUVR, and FUR with Patlak Ki in a large cohort. This project evaluates how well static PET metrics — alone or combined with basic subject characteristics — can approximate Patlak Ki, compared to dynamic metrics such as FUR.

Methods

Our study is based on brain FDG-PET-imaging data (N=517). We evaluated 12 linear regression models predicting Patlak Ki using the following combinations **m0: Patlak only; m1: covariates only; m2: SUV only; m3: SUV + covariates; m4: SUVR only; m5: SUVR + covariates; m6: FUR only; m7: FUR + covariates; m8: SUV + SUVR + FUR; m9: Full model (SUV + SUVR + FUR + covariates); m10: SUV + SUVR; m11: SUV + SUVR + covariates.** Covariates: age, sex, BMI, glucose, injected dose. For each model, we computed: Classical regression metrics (R^2 , RSE, p values), 10-fold cross validated RMSE, MAE, and R^2 , and Predicted vs observed plots with confidence intervals.

Descriptives N=517

Variable	Mean	SD	Min	Max
age	57.67	15.95	19.35	90.30
height	169.17	9.77	143.00	195.00
weight	81.34	19.09	40.00	150.00
BMI	28.44	6.49	16.02	54.83
glucose	5.70	1.02	4.04	13.65
dose	239.16	54.85	147.00	412.60
sex	f: 308	(59.6%);	m: 209	(40.4%)
SUV	3.139	0.665	0.569	5.511
SUVR	1.327	0.134	0.924	2.289
FUR	0.036	0.008	0.012	0.063
Patlak Ki	0.024	0.006	0.005	0.04

Results

Classical Linear Model Performance, (10-fold CV)

Model	R^2	RSE	p-value	(RMSE)	(MAE)	(R^2)
m0	0.000	0.00575	—	0.00576	0.00446	-0.005
m1	0.538	0.00393	3.14e-83	0.00397	0.00302	0.521
m2	0.272	0.00491	1.83e-37	0.00493	0.00375	0.264
m3	0.604	0.00364	3.00e-99	0.00368	0.00270	0.590
m4	0.206	0.00513	1.14e-27	0.00516	0.00396	0.195
m5	0.568	0.00380	1.15e-89	0.00387	0.00293	0.547
m6	0.659	0.00336	1.86e-122	0.00337	0.00252	0.656
m7	0.770	0.00278	3.75e-159	0.00280	0.00205	0.763
m8	0.700	0.00316	1.51e-133	0.00319	0.00234	0.692
m9	0.780	0.00272	2.03e-161	0.00276	0.00199	0.770
m10	0.363	0.00460	4.79e-51	0.00462	0.00348	0.353
m11	0.617	0.00359	1.02e-101	0.00364	0.00267	0.600

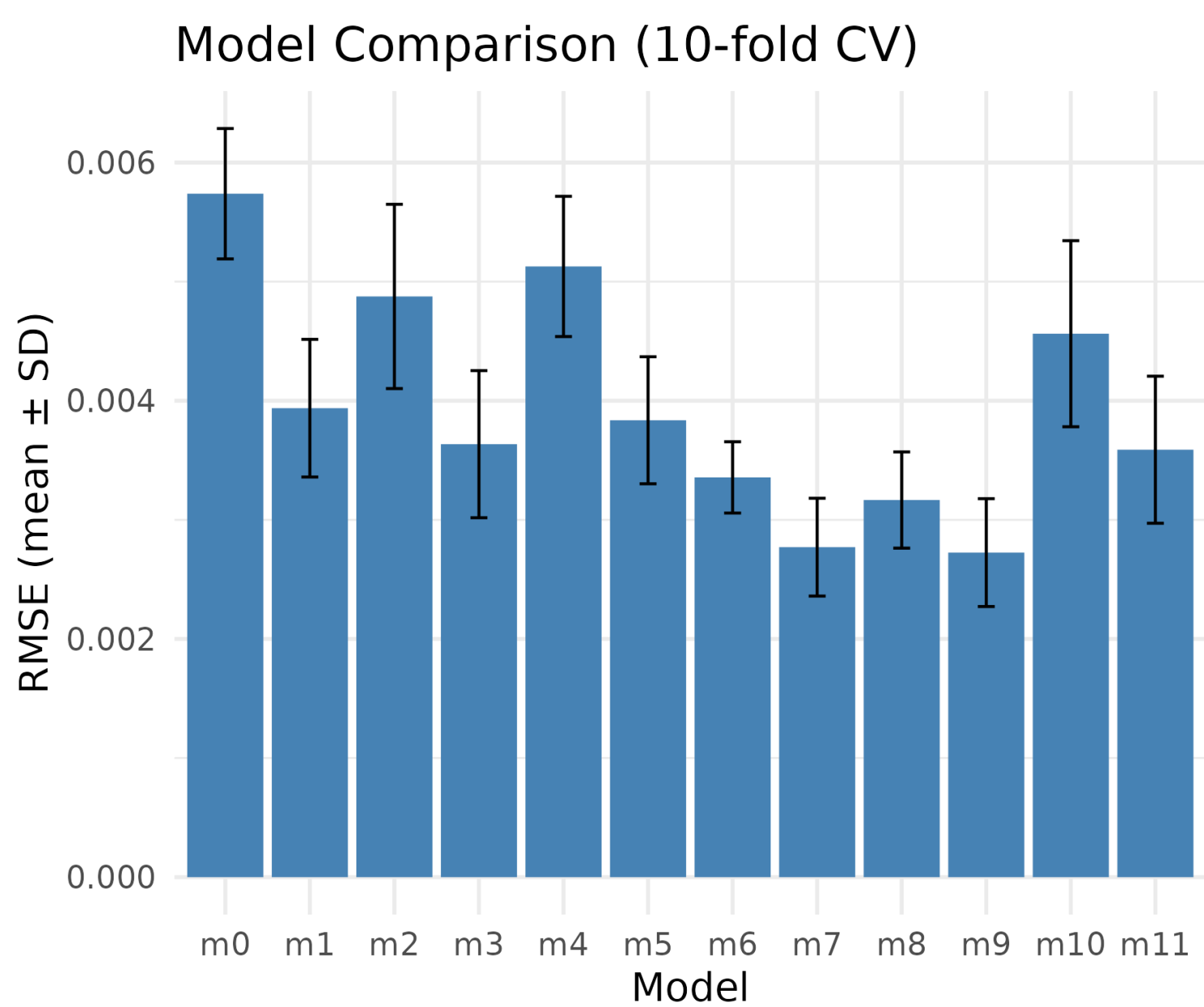


Figure 1. Model Comparison (10-fold Cross Validation). Bar plot showing mean RMSE for each model with ± 1 SD error bars.

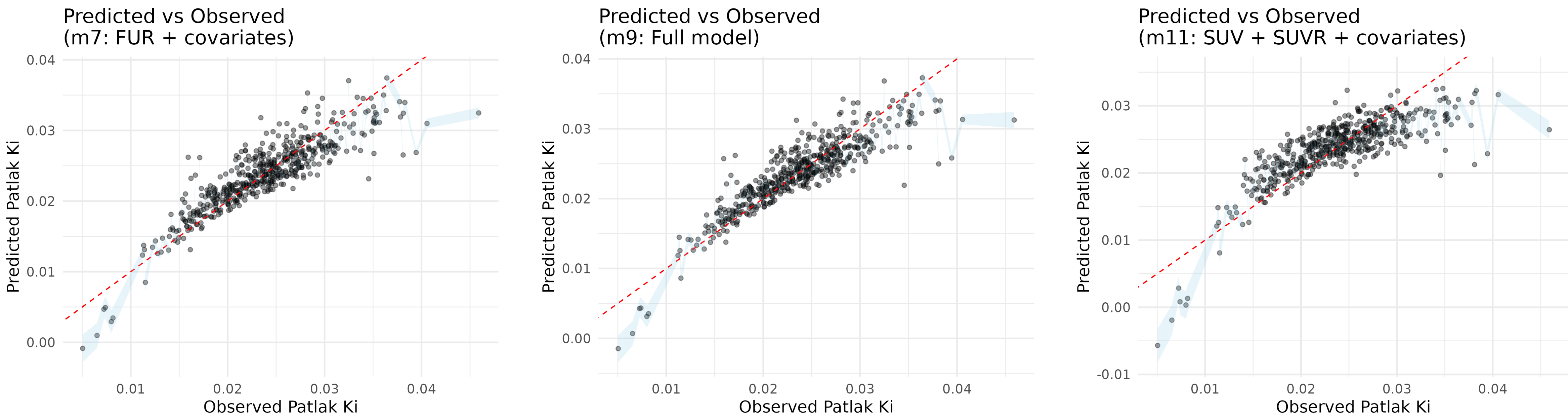


Figure 2. Predicted vs Observed Patlak Ki (example Models m7, m9, and m11). Scatter plot comparing observed Patlak Ki to model predictions. The dashed red line represents perfect prediction ($y = x$). The shaded ribbon shows the model's confidence interval. Tighter clustering and narrower ribbons indicate better predictive accuracy and lower uncertainty.

Conclusions

As a single PET metric, dynamic FUR (m7 [FUR + covariates]) remains the strongest predictor of Patlak Ki. Static PET metrics combined with basic subject characteristics (m11 [SUV + SUVR + covariates]) perform surprisingly well and may offer a practical alternative when dynamic imaging is not available. The full model (m9 [SUV + SUVR + FUR + covariates]) provides the most accurate and stable predictions.

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