Supplementary Table 1: Summary of studies included within the analysis in chronological order

Study Reference	Study Year	Country
Haschke F. Body composition of adolescent males. Part I. Total body water in normal adolescent males. Part II. Body composition of the male reference adolescent. Acta Paediatr Scand Suppl. 1983;307:1-23	1981-1982	Austria
Shypailo RJ, Wong WW. Fat and fat-free mass index references in children and young adults: assessments along racial and ethnic lines. Am J Clin Nutr. 2020 Sep 1;112(3):566-575	1991-1999	USA
Horlick M, Arpadi SM, Bethel J, et al. Bioelectrical impedance analysis models for prediction of total body water and fat-free mass in healthy and HIV-infected children and adolescents. Am J Clin Nutr. 2002;76(5):991-999	1993-2005	USA
Rush EC, Puniani K, Valencia ME, Davies PS, Plank LD. Estimation of body fatness from body mass index and bioelectrical impedance: comparison of New Zealand European, Maori and Pacific Island children. Eur J Clin Nutr. 2003 Nov;57(11):1394-401	2000-2001	New Zealand
Eckhardt CL, Adair LS, Caballero B, et al. Estimating body fat from anthropometry and isotopic dilution: a four-country comparison. Obes Res. 2003;11(12):1553-1562	2002	China, Philippines, Russia, South Africa
Wickramasinghe VP, Cleghorn GJ, Edmiston KA, Murphy AJ, Abbott RA, Davies PS. Validity of BMI as a measure of obesity in Australian white Caucasian and Australian Sri Lankan children. Ann Hum Biol. 2005 Jan-Feb;32(1):60-71	2003-2004	Australia
Wickramasinghe VP, Lamabadusuriya SP, Cleghorn GJ, Davies PS. Validity of currently used cutoff values of body mass index as a measure of obesity in Sri Lankan children. Ceylon Med J. 2009;54(4):114-119	2004-2005	Sri Lanka
Reichert FF, Wells JC, Ekelund U, et al. Prospective Associations Between Physical Activity Level and Body Composition in Adolescence: 1993 Pelotas (Brazil) Birth Cohort. J Phys Act Health. 2015 Jun;12(6):834-9	2006-2007	Brazil
Alvero-Cruz JR, Alvarez Carnero E, Fernández-García JC, Barrera Expósito J, Carrillo de Albornoz Gil M, Sardinha LB. Validity of body mass index and fat mass index as indicators of overweight status in Spanish adolescents: Esccola Study. Med Clin (Barc). 2010;135(1):8-14	2006	Spain
Khan AI, Hawkesworth S, Hawlader MD, et al. Body composition of Bangladeshi children: comparison and development of leg-to-leg bioelectrical impedance equation. J Health Popul Nutr. 2012 Sep;30(3):281-90	2008	Bangladesh
Danysh HE, Gilman RH, Wells JC, et al. El Niño adversely affected childhood stature and lean mass in northern Peru. Climate Change Responses. 2014;1:7	2008-2009	Peru
Mendoza Pablo PA, Valdés J, Ortiz-Hernández L. Accuracy of body mass index for age to diagnose obesity in Mexican schoolchildren. Nutr Hosp. 2015;31(6):2668-2675	2010-2011	Mexico
Ballesteros-Vásquez MN, Guerrero-Alcocer EV, Grijalva Haro MI, Ramírez-López E, Robles-Sardin AE. Effect of ingestion and excretion of fluids in determining body composition with deuterium dilution method in school children. Nutr Hosp. 2015 Sep 1;32(3):1324-8. Spanish	2011	Mexico
Devakumar D, Grijalva-Eternod CS, Roberts S, et al. Body composition in Nepalese children using isotope dilution: the production of ethnic-specific calibration equations and an exploration of methodological issues. PeerJ. 2015 Mar 3;3:e785	2011-2012	Nepal
Ben Jemaa H, Mankaï A, Khlifi S, Minaoui R, Ghozzi D, Zediri M, Kortobi B, Karmous I, Ben Hmad H, Ben Slama F, Jamoussi H, Aguenaou H, El Kari K, Aouidet A. Development and validation of impedance-based equations for the prediction of total body water and fat-free mass in children aged 8-11 years. Clin Nutr. 2019 Feb;38(1):227-233	2014-2015	Tunisia
Ten Hoor GA, Rutten GM, Van Breukelen GJP, Kok G, Ruiter RAC, Kremers SPJ, Feron FJM, Crutzen R, Schols AMJW, Plasqui G. Strength exercises during physical education classes in secondary schools improve body composition: a cluster randomized controlled trial. Int J Behav Nutr Phys Act. 2018;15:92	2014-2016	Netherlands
Desmond MA, Sobiecki JG, Jaworski , et al. Growth, body composition, and cardiovascular and nutritional risk of 5- to 10-y-old children consuming vegetarian, vegan, or omnivore diets. Am J Clin Nutr. 2021 Jun 1;113(6):1565-1577	2014-2016	Poland
Diouf A, Adom T, Aouidet A, et al. Body mass index vs deuterium dilution method for establishing childhood obesity prevalence, Ghana, Kenya, Mauritius, Morocco, Namibia, Senegal, Tunisia and United Republic of Tanzania. Bull World Health Organ. 2018;96(11):772-781	Namibia: 2014-2016 South Africa: 2017-2019	Namibia, South Africa

Supplementary Table 2: Average levels of deuterium dilution observed fat-free mass and Root Mean Square Error based on fat-free mass, by country

Country	N	Median DD fat-free Mass (kg)	RMSE in terms of fat-free Mass (kg)
North America			
Mexico	330	22.7 (19.6 - 28.4)	2.25
USA	1810	28.5 (21.3 - 38.8)	3.48
South America			
Brazil	450	38.1 (34.0 – 43.4)	3.99
Peru	56	30.9 (23.9 - 35.5)	3.06
Europe			
Austria	107	33.2 (28.5 - 40.6)	3.06
Netherlands	716	38.6 (34.0 - 43.6)	3.37
Poland	174	20.0 (17.5 - 22.8)	1.32
Russia	197	25.8 (20.0 - 33.1)	4.83
Spain	92	42.7 (37.0 - 49.2)	4.41
North Africa			
Tunisia	155	23.1 (20.2 - 27.0)	1.87
Sub-Saharan Africa			
Namibia	151	23.6 (20.6 - 28.1)	2.31
South Africa	411	17.6 (15.3 - 21.2)	1.64
South Asia			
Bangladesh	187	13.6 (12.2 - 16.2)	1.61
Nepal	100	17.6 (14.6 - 20.2)	1.42
Sri Lanka	288	21.5 (16.2 - 27.1)	3.62
East Asia			
China	95	25.6 (22.8 - 28.2)	2.74
Philippines	80	34.9 (31.3 - 40.8)	3.54
Australasia			
Australia	42	21.9 (16.7 - 27.5)	1.72
New Zealand	252	27.2 (21.7 - 37.1)	3.37

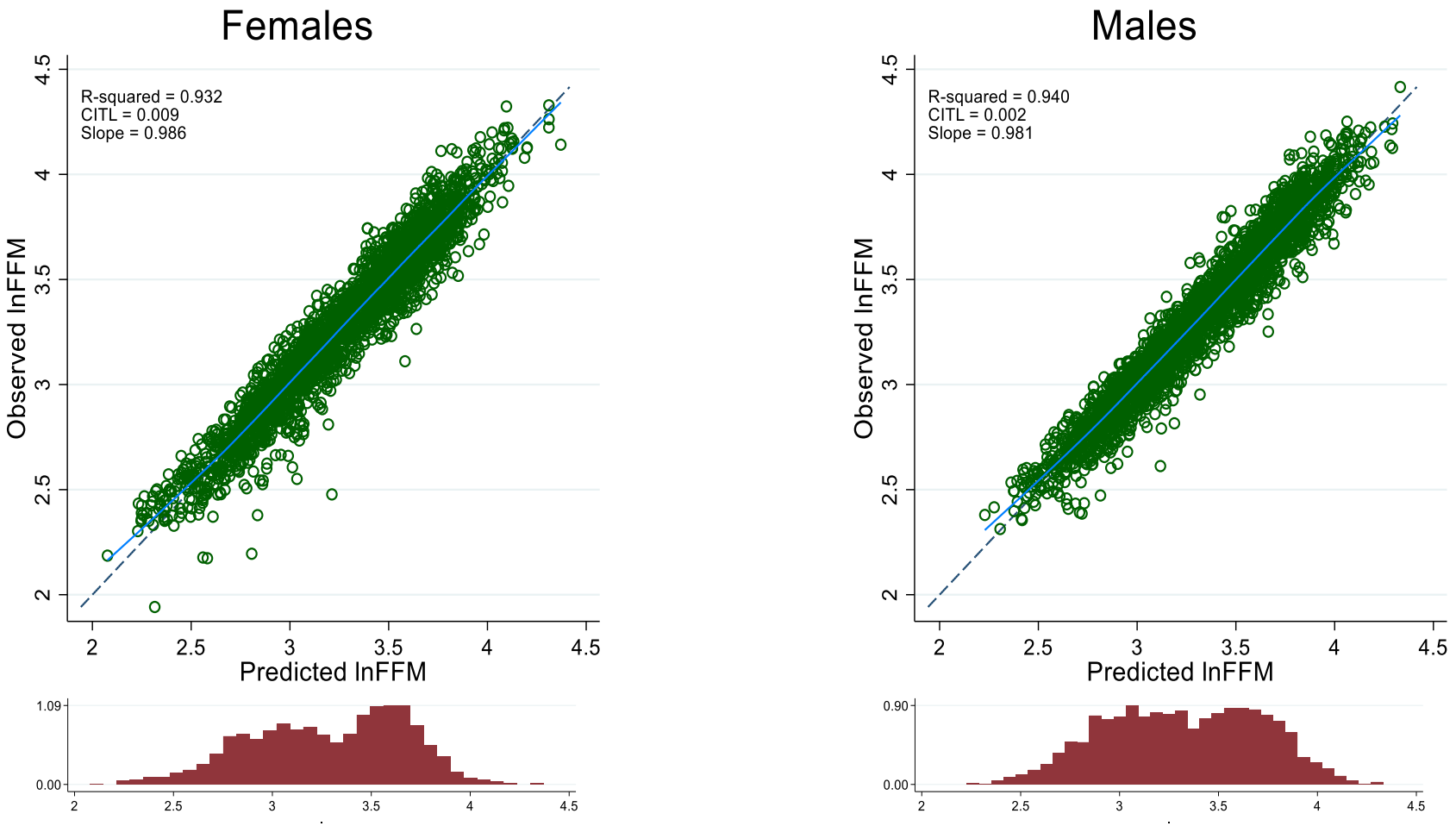
Footnote: DD= deuterium dilution, RMSE = Root Mean Square Error.

Supplementary Table 3: Country-specific external validation predictive performance statistics based on lnFFM, following re-calibration of the intercept

Country	N	Calibration-in-the-Large	RMSE (kg)
North America			
Mexico	330	0.00 (-0.01 to 0.01)	0.07
USA	1810	0.00 (0.00 to 0.00)	0.10
South America			
Brazil	450	0.00 (-0.01 to 0.01)	0.09
Peru	56	0.00 (-0.02 to 0.02)	0.08
Europe			
Austria	107	0.00 (-0.01 to 0.01)	0.06
Netherlands	716	0.00 (-0.01 to 0.01)	0.08
Poland	174	0.00 (-0.01 to 0.01)	0.05
Russia	197	0.00 (-0.01 to 0.01)	0.10
Spain	92	0.00 (-0.02 to 0.02)	0.09
North Africa			
Tunisia	155	0.00 (-0.01 to 0.01)	0.08
Sub-Saharan Africa			
Namibia	151	0.00 (-0.01 to 0.01)	0.07
South Africa	411	0.00 (-0.01 to 0.01)	0.07
South Asia			
Bangladesh	187	0.00 (-0.01 to 0.01)	0.06
Nepal	100	0.00 (-0.01 to 0.01)	0.06
Sri Lanka	288	0.00 (-0.02 to 0.02)	0.15
East Asia			
China	95	0.00 (-0.01 to 0.01)	0.07
Philippines	80	0.00 (-0.02 to 0.02)	0.08
Australasia			
Australia	42	0.00 (-0.02 to 0.02)	0.06
New Zealand	252	0.00 (-0.01 to 0.01)	0.10

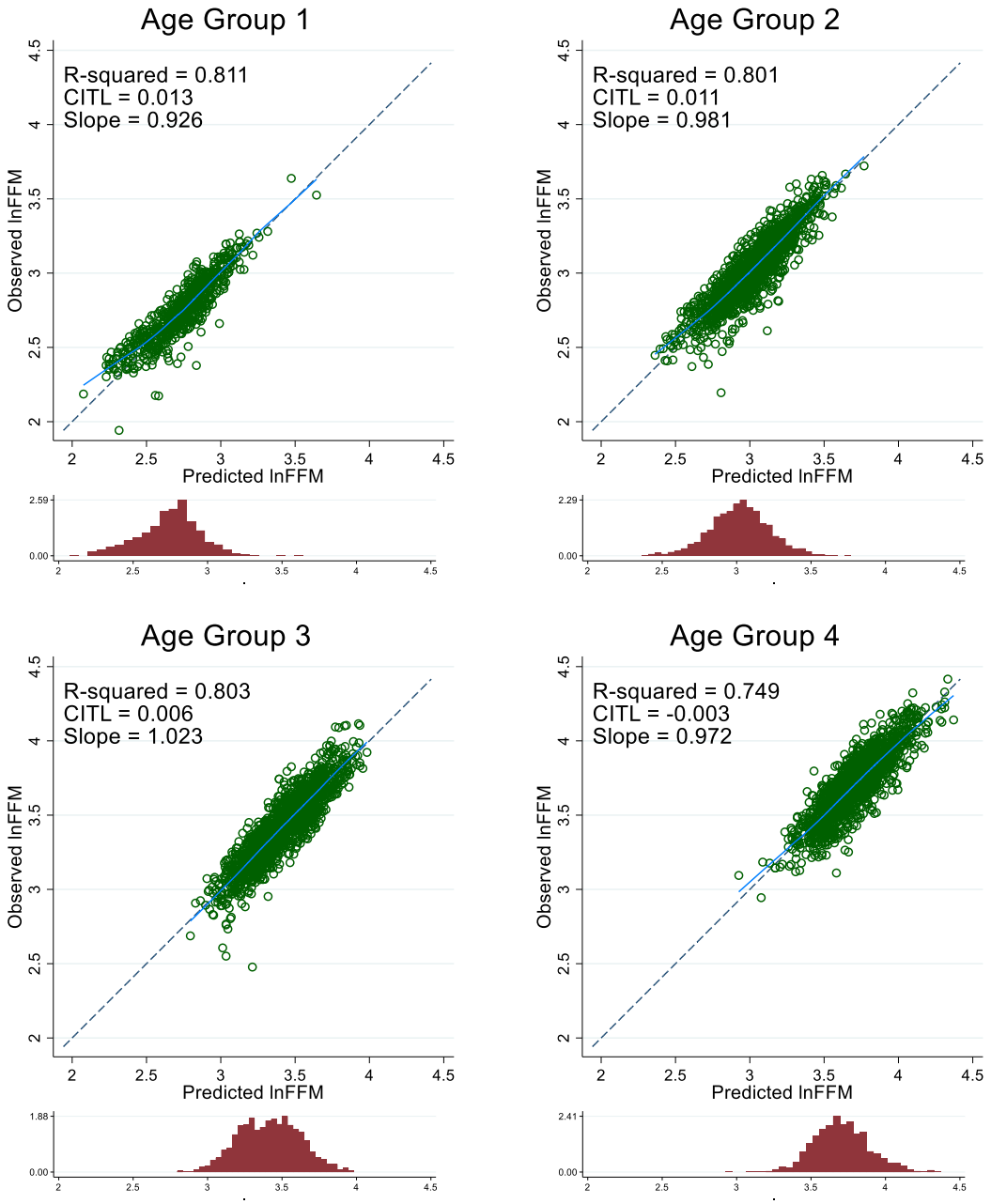
Footnote: Performance based on ln(fat-free mass). RMSE = Root Mean Square Error

Supplementary Figure 1: Calibration assessment based on lnFFM, by sex



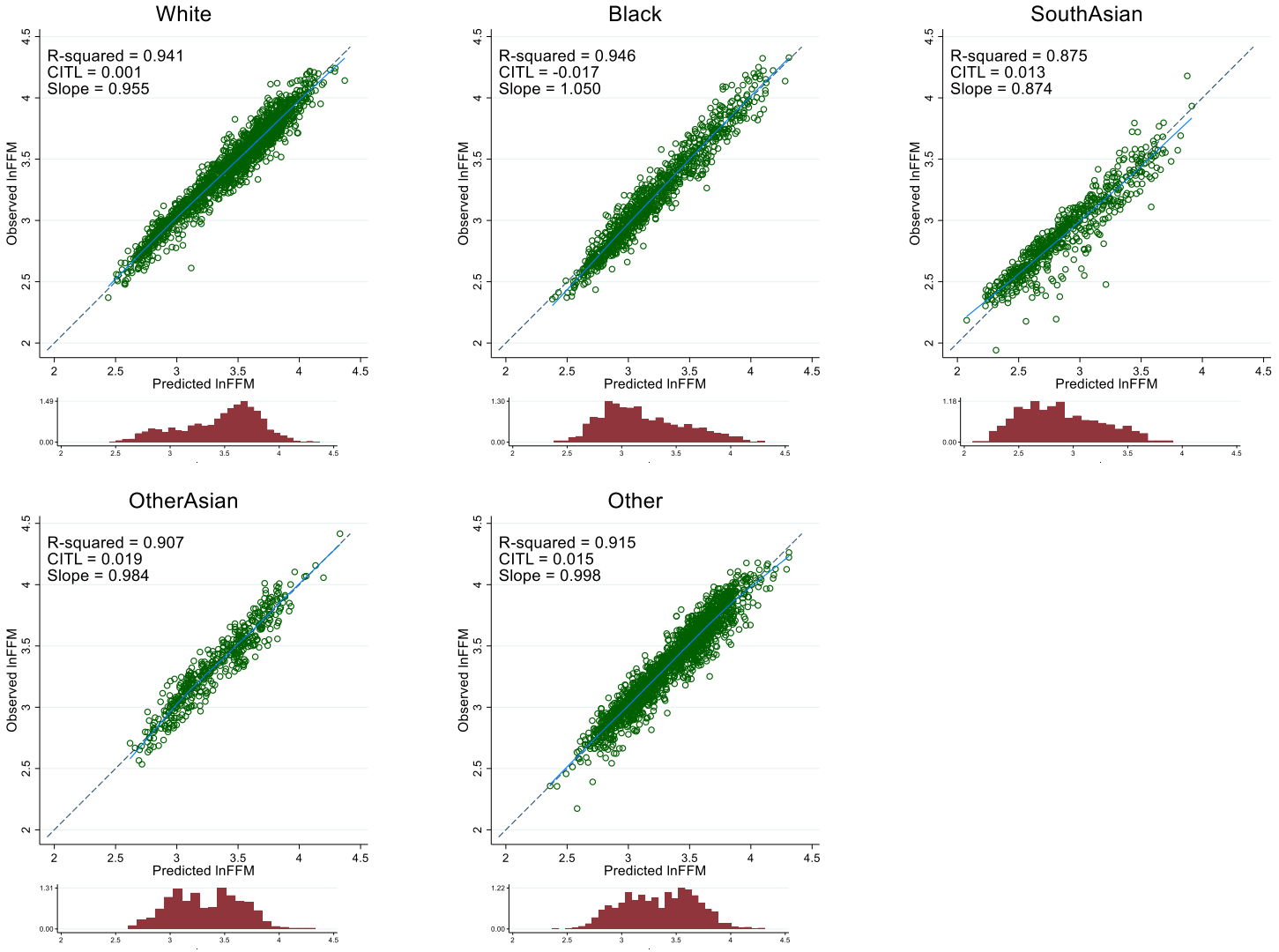
Footnote: Calibration based on ln(fat-free mass). Dashed line represents line of equality. Blue line is a loess smoother through the individual data points. Histogram is the distribution of predicted ln(fat-free mass). Slope = Calibration Slope and CITL = Calibration-in-the-Large.

Supplementary Figure 2: Calibration assessment based on lnFFM by age group



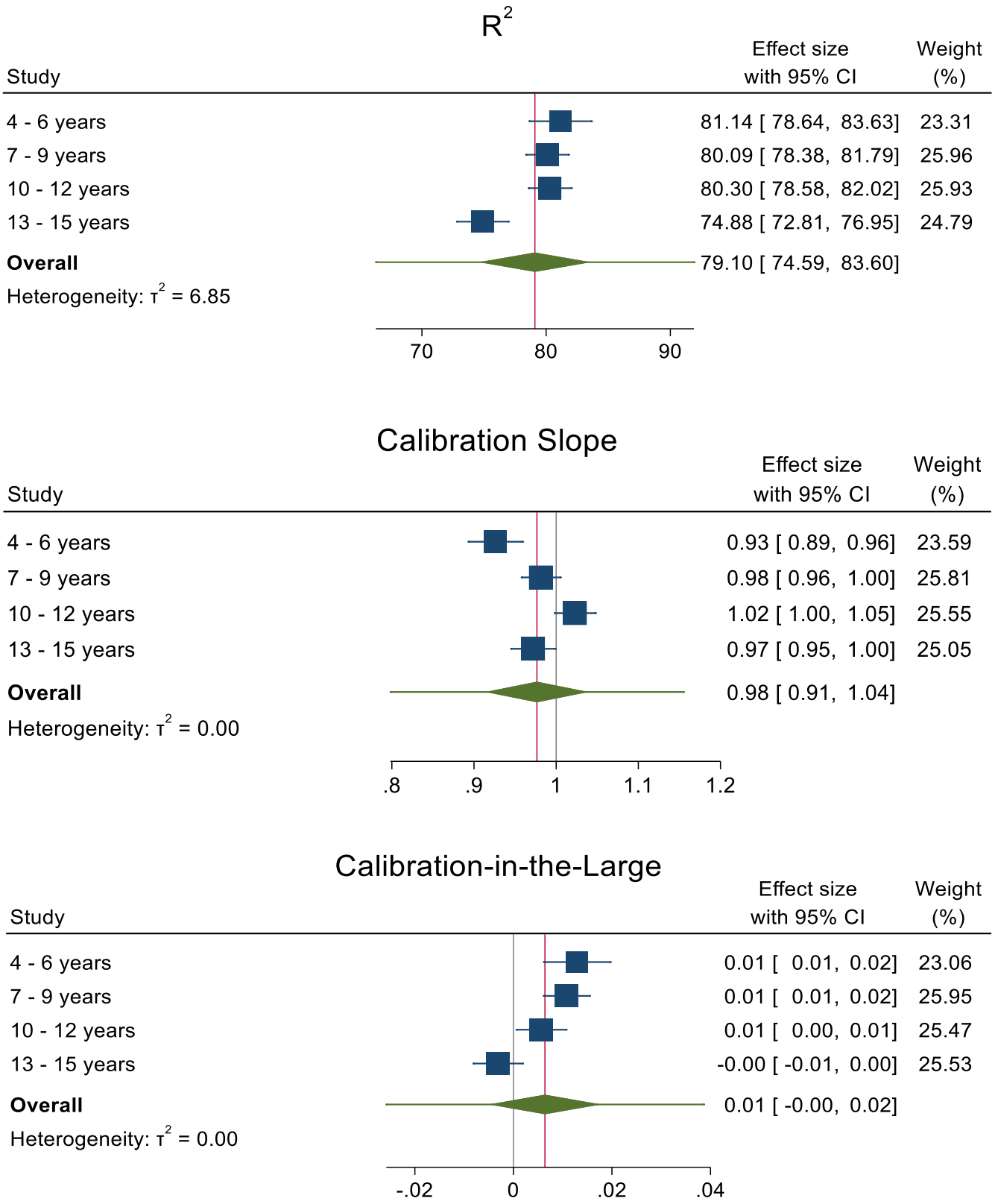
Footnote: Calibration based on ln(fat-free mass). Dashed line represents line of equality. Blue line is a loess smoother through the individual data points. Histogram is the distribution of predicted ln(fat-free mass). Slope = Calibration Slope and CITL = Calibration-in-the-Large. Age group 1 = 4-6 years, Age group 2 = 7-9 years, Age group 3 = 10-12 years and Age group 4 = 13-15 years.

Supplementary Figure 3: Calibration assessment based on lnFFM by ethnic group



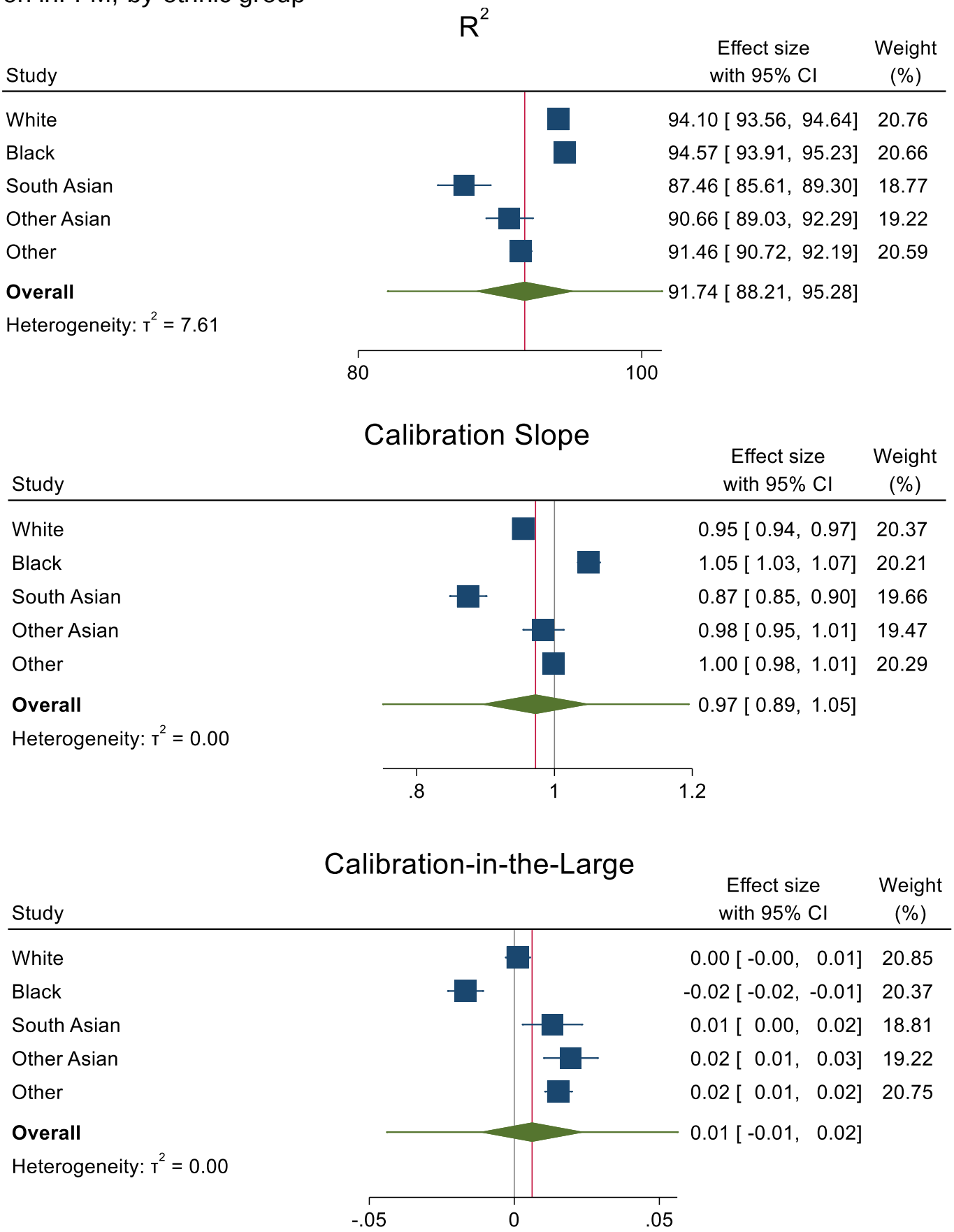
Footnote: Calibration based on ln(fat-free mass). Dashed line represents line of equality. Blue line is a loess smoother through the individual data points. Histog ram is the distribution of predicted ln(fat-free mass). Slope = Calibration Slope and CITL = Calibration-in-the-Large.

Supplementary Figure 4: External validation predictive performance statistics based on lnFFM, by age group



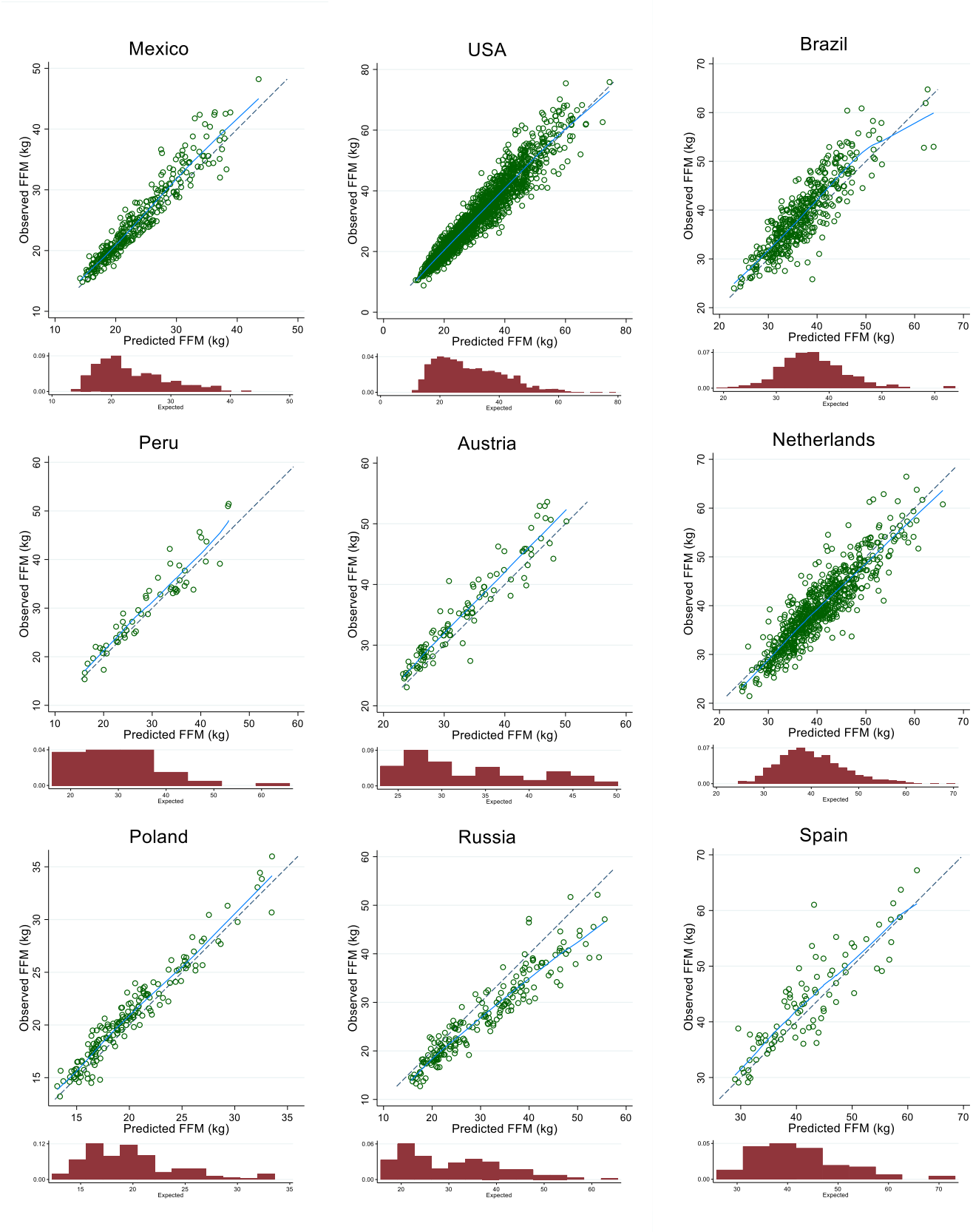
Footnote: Performance based on ln(fat-free mass). Age group-specific estimates obtained from individual participant data from relevant three-year age groups and then pooled across groups using random-effects meta-analysis to obtain 'Overall' estimates. Overall estimates from random-effect REML model with Hartung-Knapp standard errors. Green line around the 'overall' diamond indicates the 95% prediction interval. Age group 1 = 4-6 years, Age group 2 = 7-9 years, Age group 3 = 10-12 years and Age group 4 = 13-15 years.

Supplementary Figure 5: External validation predictive performance statistics based on lnFFM, by ethnic group



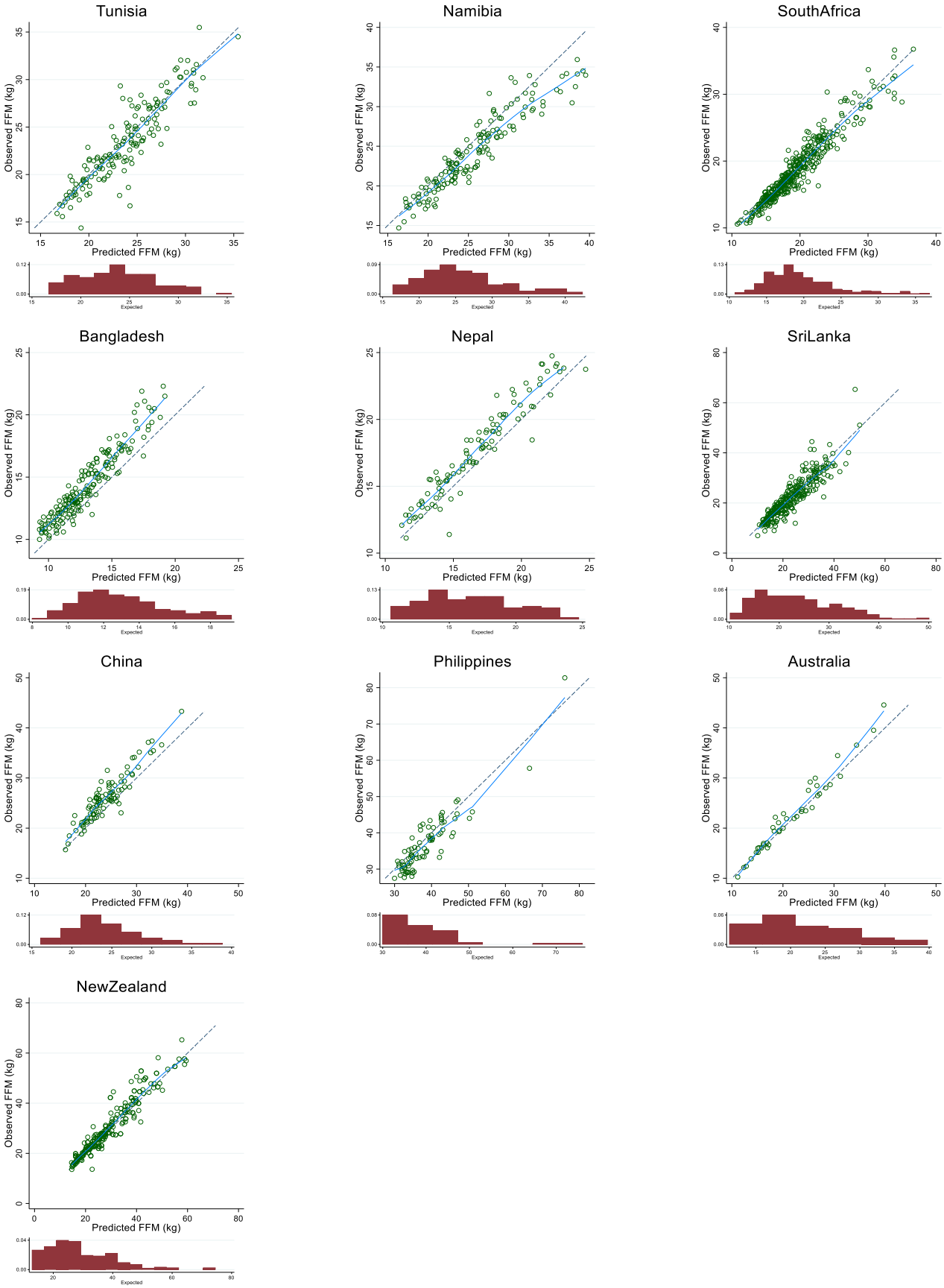
Footnote: Performance based on ln(fat-free mass). Ethnic-specific estimates obtained from individual participant data from relevant ethnic groups and then pooled across groups using random-effects meta-analysis to obtain 'Overall' estimates. Overall estimates from random-effect REML model with Hartung-Knapp standard errors. Green line around the 'overall' diamond indicates the 95% prediction interval

Supplementary Figure 6a: Calibration assessment of the model in the Americas and European countries on the fat-free mass scale



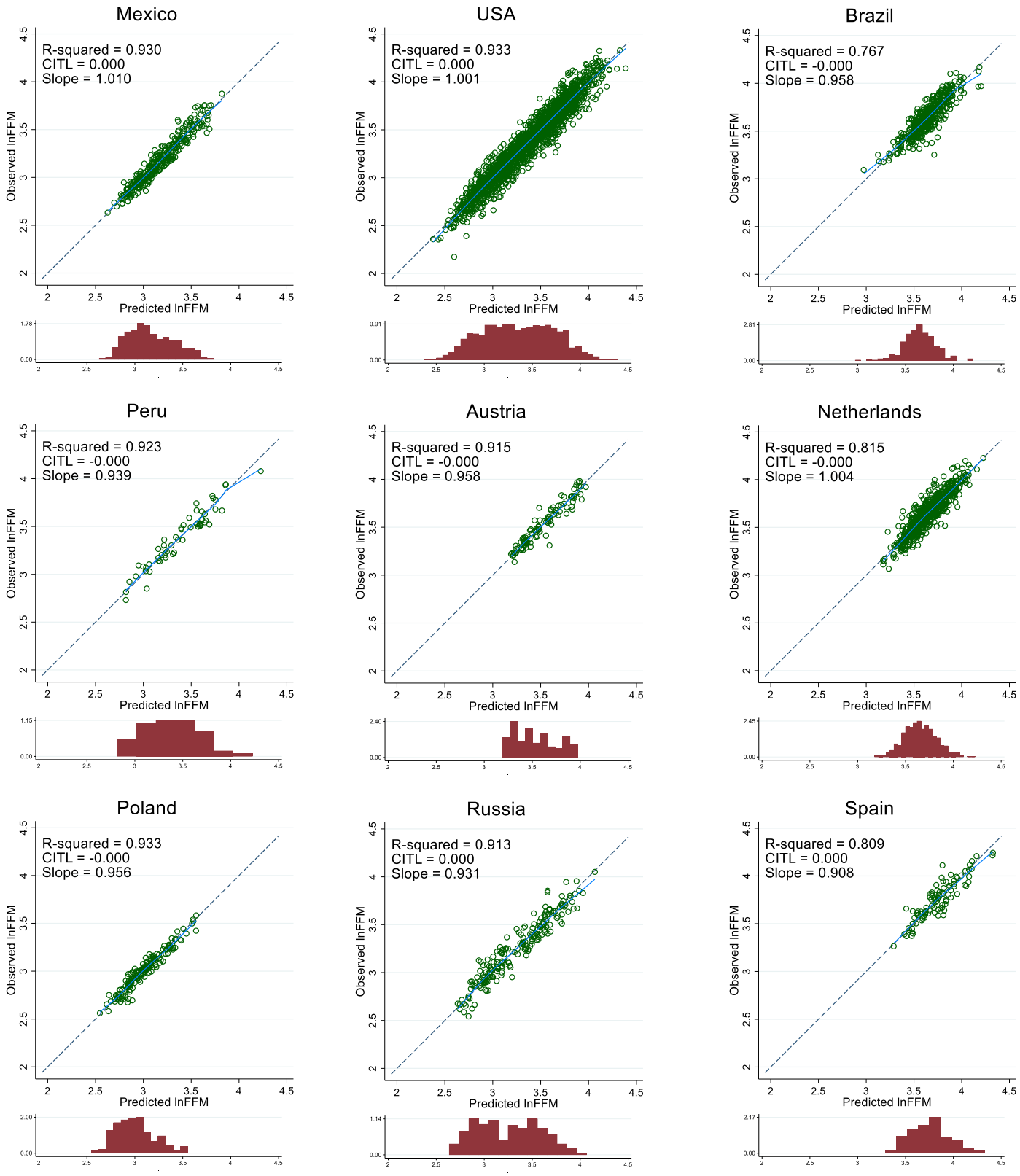
Footnote: Calibration based on fat-free mass (kilograms). Dashed line represents line of equality. Blue line is a loess smoother through the individual data points. Histogram is the distribution of predicted fat-free mass in kilograms.

Supplementary Figure 6b: Calibration assessment of the model in the African, Asian and Australasian countries on the fat-free mass scale



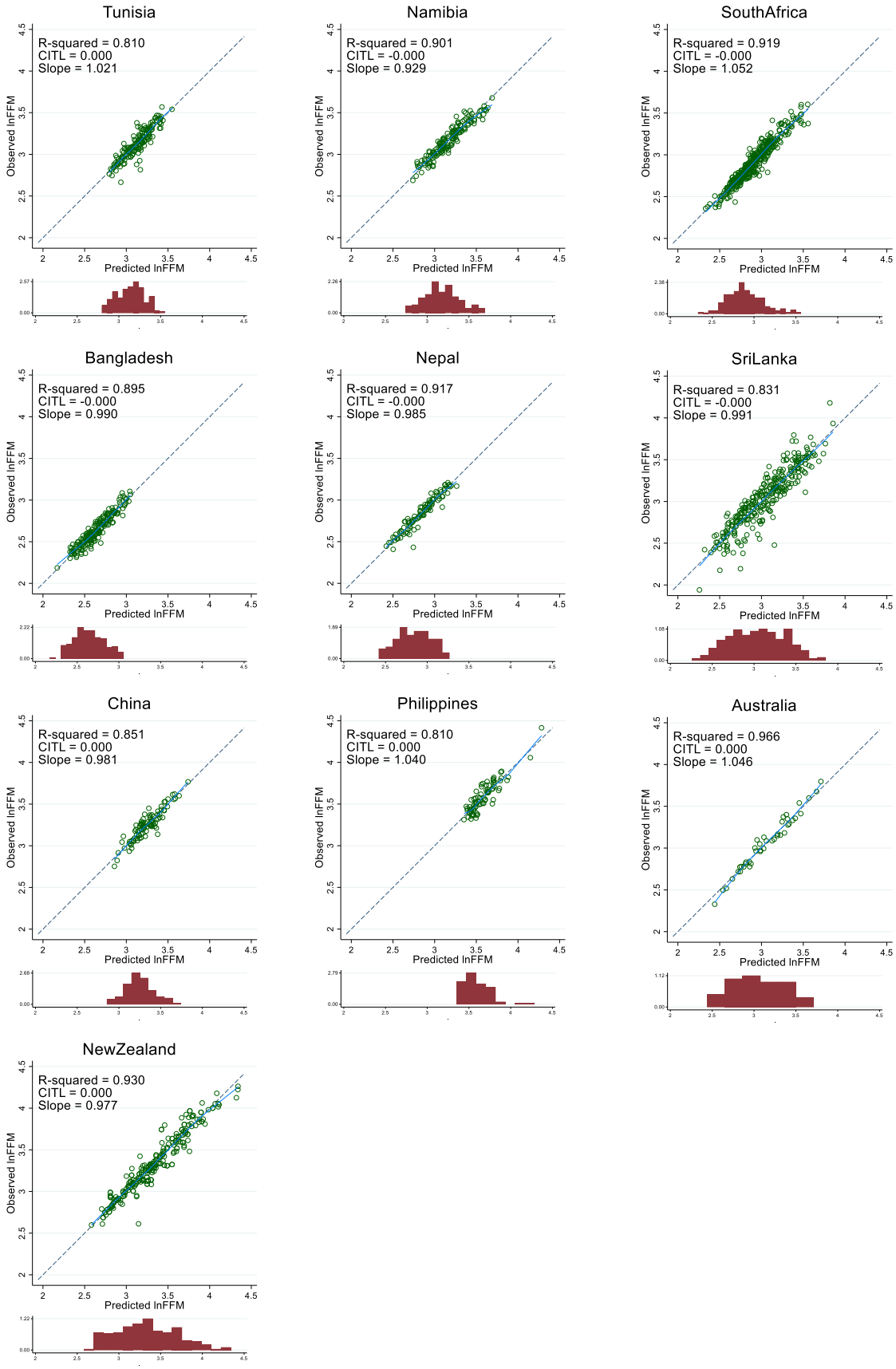
Footnote: Calibration based on fat-free mass (kilograms). Dashed line represents line of equality. Blue line is a loess smoother through the individual data points. Histogram is the distribution of predicted fat-free mass in kilograms.

Supplementary Figure 7a: Calibration assessment of the model based on lnFFM in the Americas and European countries, after re-calibration of the intercept



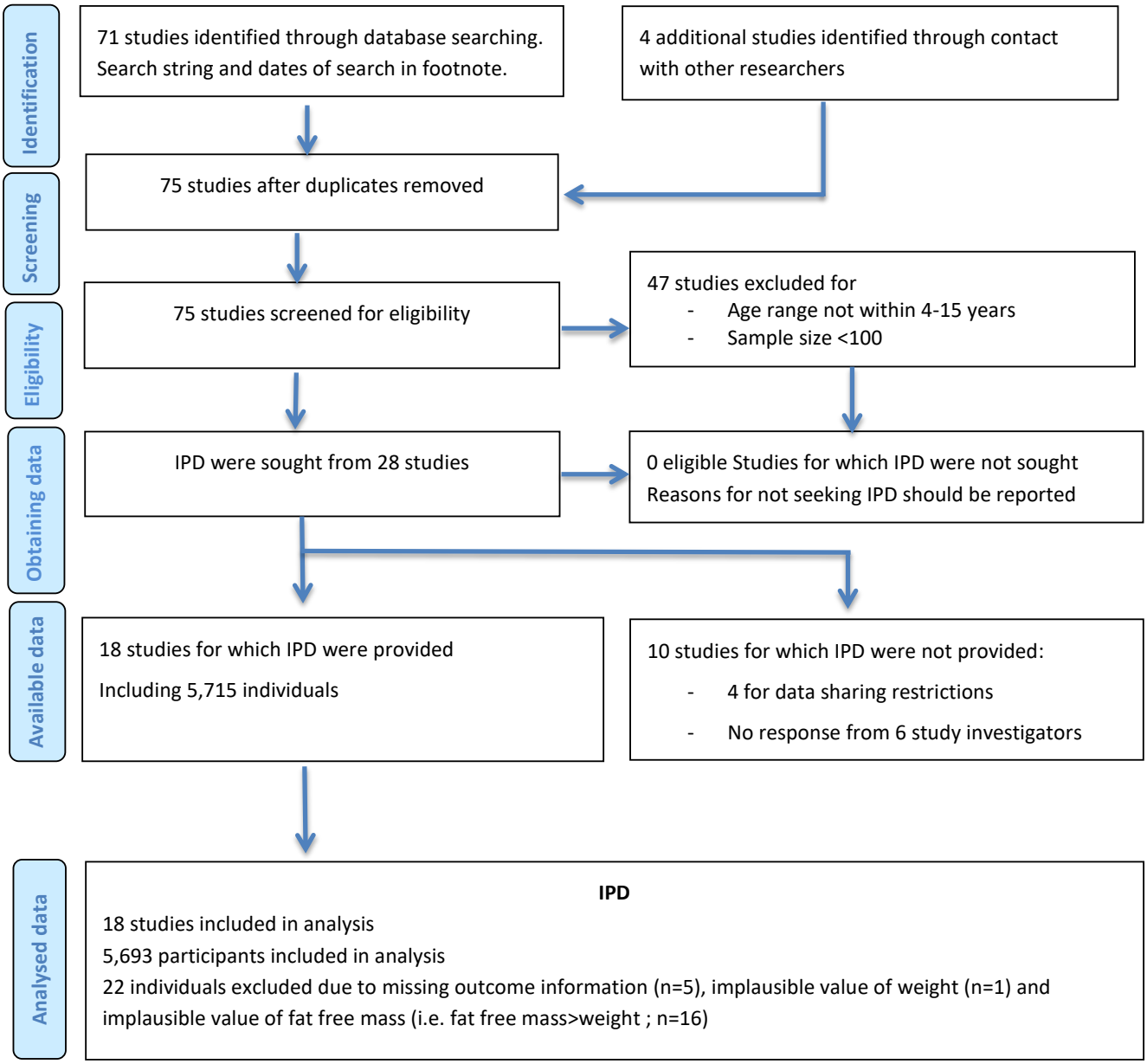
Footnote: Calibration based on ln(fat-free mass) after country-specific re-calibration of the intercept term. Dashed line represents line of equality. Blue line is a loess smoother through the individual data points. Histogram is the distribution of predicted ln(fat-free mass).

Supplementary Figure 7b: Calibration assessment of the model based on lnFFM in the African, Asian and Australasian countries, after re-calibration of the intercept



Footnote: Calibration based on ln(fat-free mass) after country-specific re-calibration of the intercept term. Dashed line represents line of equality. Blue line is a loess smoother through the individual data points. Histogram is the distribution of predicted ln(fat-free mass).

PRISMA IPD Flow Diagram



FOOTNOTE: Search date: May 2020, exact search string: “deuterium dilution”, “study”, “children OR adolescents”

The PRISMA IPD flow diagram