

Computational modeling enables individual assessment of postprandial glucose and insulin responses after bariatric surgery - Supplementary Information

Onur Poyraz^{1*}, Sini Heinonen^{2,3*}, S. T. John¹, Tuure Saarinen⁴, Anne Juuti⁴,
Pekka Marttinen^{1†}, Kirsi H. Pietiläinen^{2,5†}

¹Department of Computer Science,
Aalto University, Helsinki, Finland

²Obesity Research Unit, Research Programs Unit, Clinical and Molecular Metabolism,
University of Helsinki, Helsinki, Finland

³Department of Internal Medicine,
Helsinki University Hospital, Helsinki, Finland

⁴Department of Gastrointestinal Surgery, Abdominal Center,
Helsinki University Hospital and University of Helsinki, Helsinki, Finland

⁵HealthyWeightHub, Endocrinology, Abdominal Center,
Helsinki University Hospital and University of Helsinki, Helsinki, Finland

`onur.poyraz@aalto.fi`

`sini.heinonen@helsinki.fi`

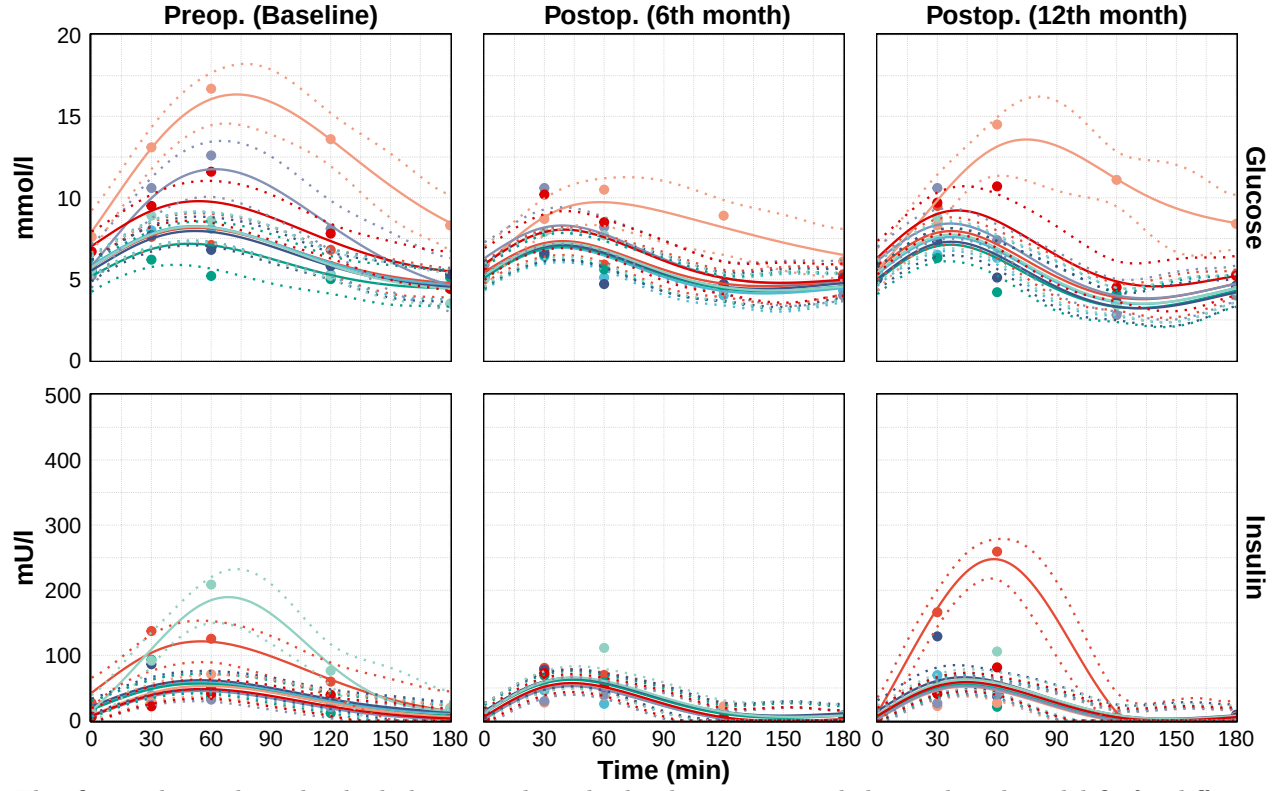
Supplementary Note - Modeling Details

We normalized the data in both time and value domains before the training, separately for insulin and glucose values. We used a fixed lengthscale parameters for all GPs, which is set to be $120/\sigma_{\text{time}}$, where σ_{time} is the standard deviation of the sample times. We used the Matern52 kernel for all GPs. The main difference between individual-level GPs and the population-level GPs was the prior value of the kernel variance. We used *InverseGamma*(1,1) distribution for the population level GPs, while for the individual level GPs, we used a stronger *InverseGamma*(1,0.1) distribution. This setup allowed the model to learn the shared behaviors with the population-level GPs while the individual-level GPs learned individual differences. For measurement error σ , we used *InverseGamma*(1,0.01) as a prior distribution. For $\mu^{\text{population}}$, we used $\mathcal{N}(0,1)$ as a prior distribution, and for μ_n^{patient} we used $\mathcal{N}(\mu^{\text{population}}, \sigma_n^{\text{patient}})$ as a prior distribution, where $\sigma_n^{\text{patient}} \sim \text{InverseGamma}(1,0.5)$.

*These authors contributed equally.

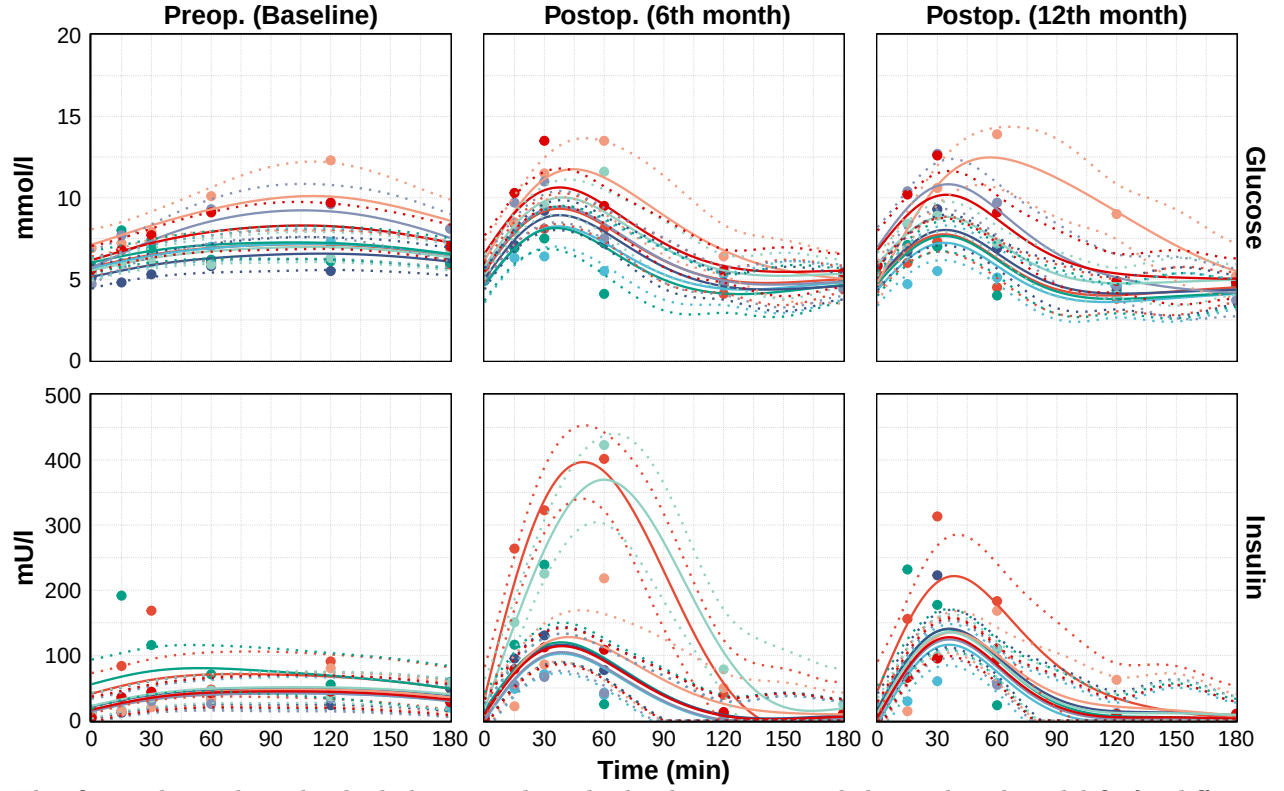
†These authors jointly supervised this work.

Supplementary Figure 1: Pre-operative (Preop.) and post-operative (Postop.) individual responses to the oral glucose tolerance test (OGTT).



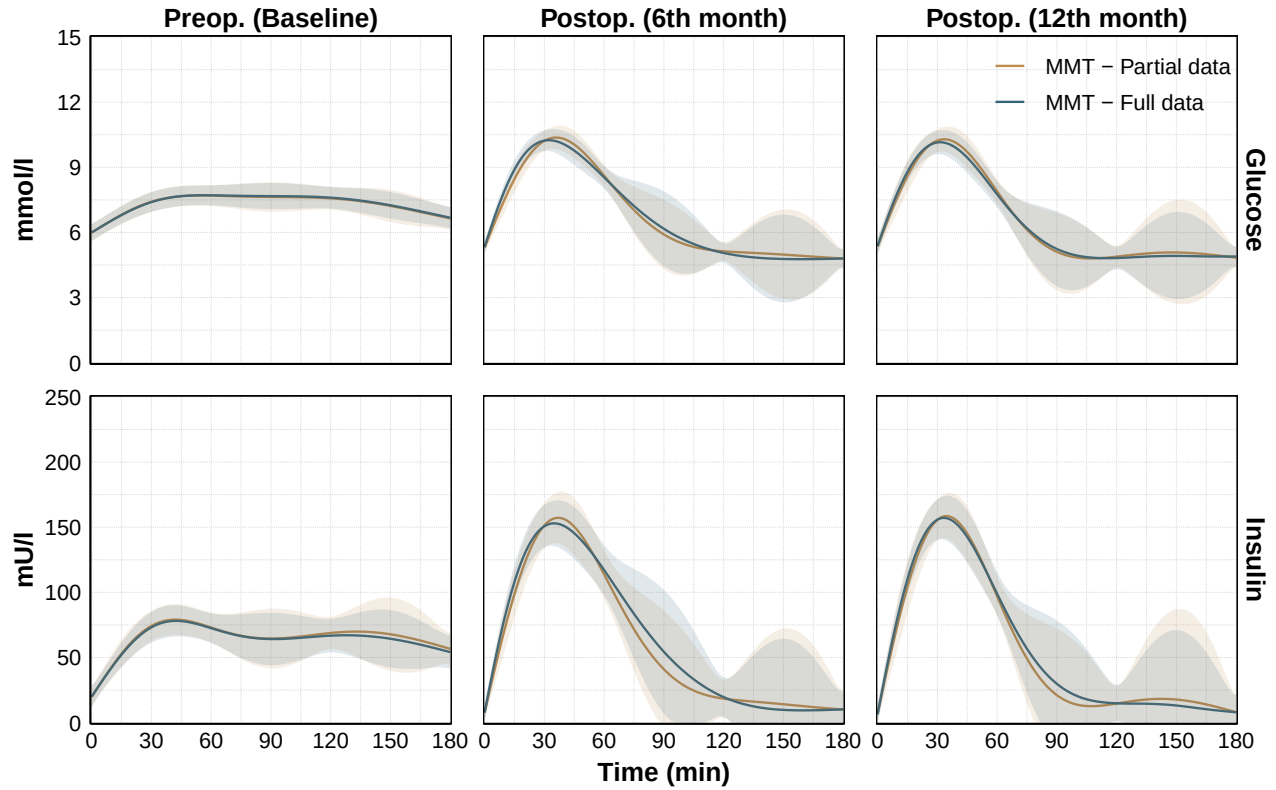
This figure shows the individual glucose and insulin level responses and the predicted model fit for different participants undergoing the oral glucose tolerance test (OGTT). The 95% confidence intervals (CI) for each individual are shown as dotted lines in corresponding colors, derived from $n=1000$ simulation samples.

Supplementary Figure 2: Pre-operative (Preop.) and post-operative (Postop.) individual responses to the mixed meal test (MMT).



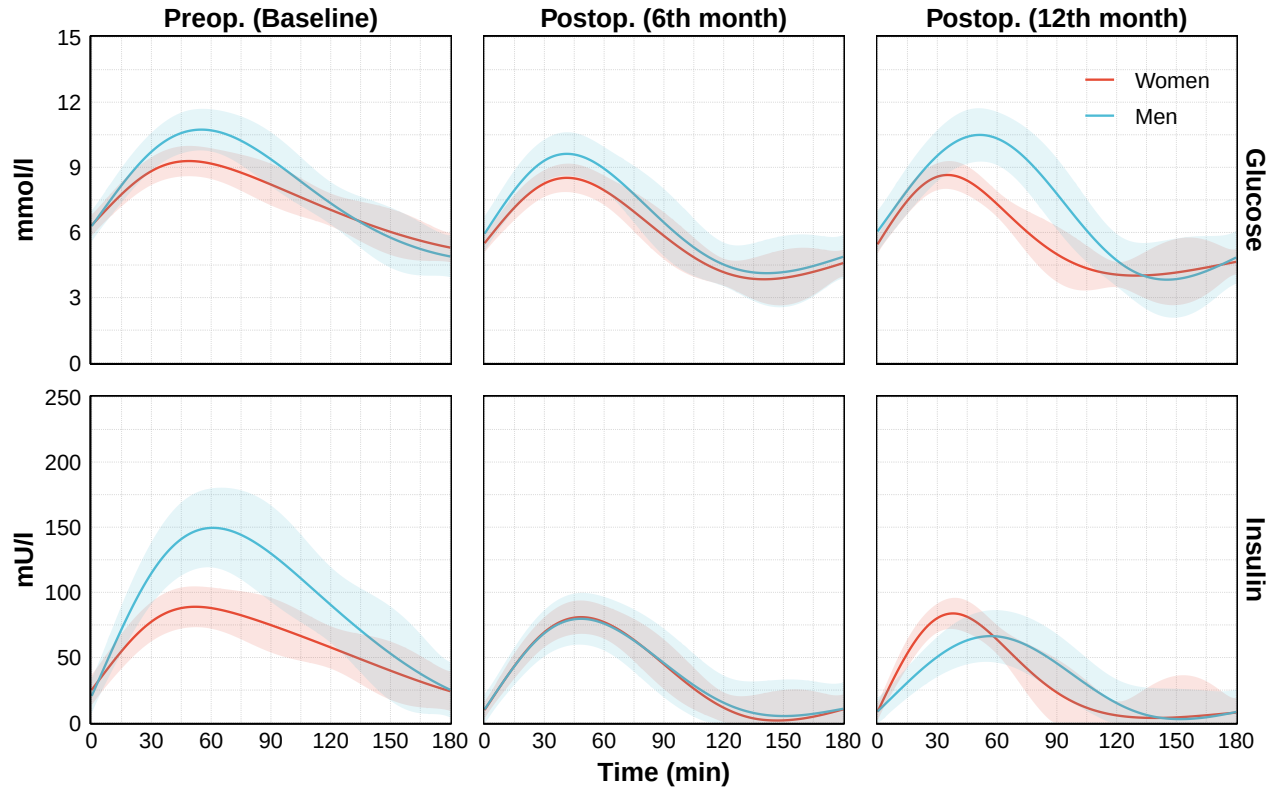
This figure shows the individual glucose and insulin level responses and the predicted model fit for different participants undergoing the mixed meal test (MMT). The 95% confidence intervals (CI) for each individual are shown as dotted lines in corresponding colors, derived from $n=1000$ simulation samples.

Supplementary Figure 3: Comparison of model fits with full and partial data on the mixed meal test (MMT).



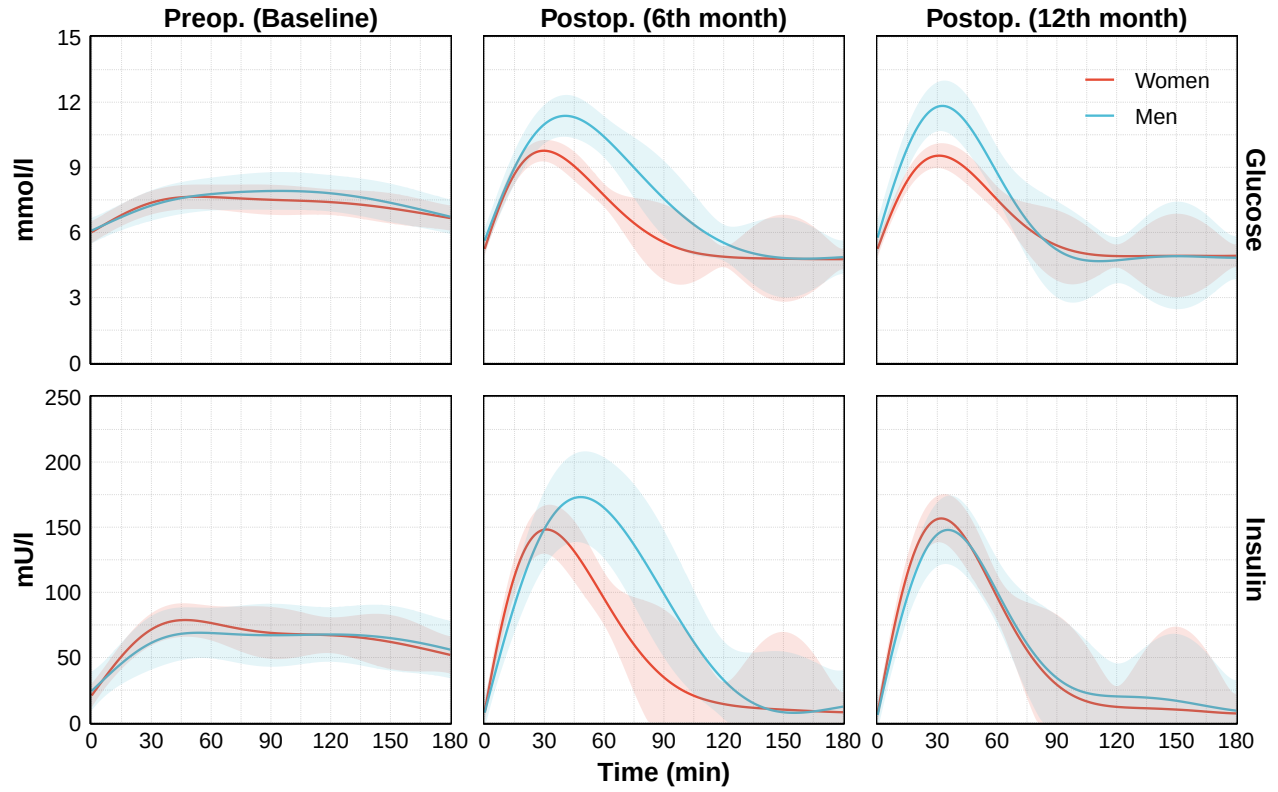
The mixed meal test (MMT) includes additional sampling times (15, 240, and 360 minutes) compared to the oral glucose tolerance test (OGTT). To ensure a fair comparison, this figure shows the difference between model fits when trained on the full MMT data versus a partial dataset using only the timepoints available in the OGTT. Shaded areas represent 95% confidence intervals (CI) derived from n=1000 simulation samples.

Supplementary Figure 4: Oral glucose tolerance test (OGTT) responses by sex.



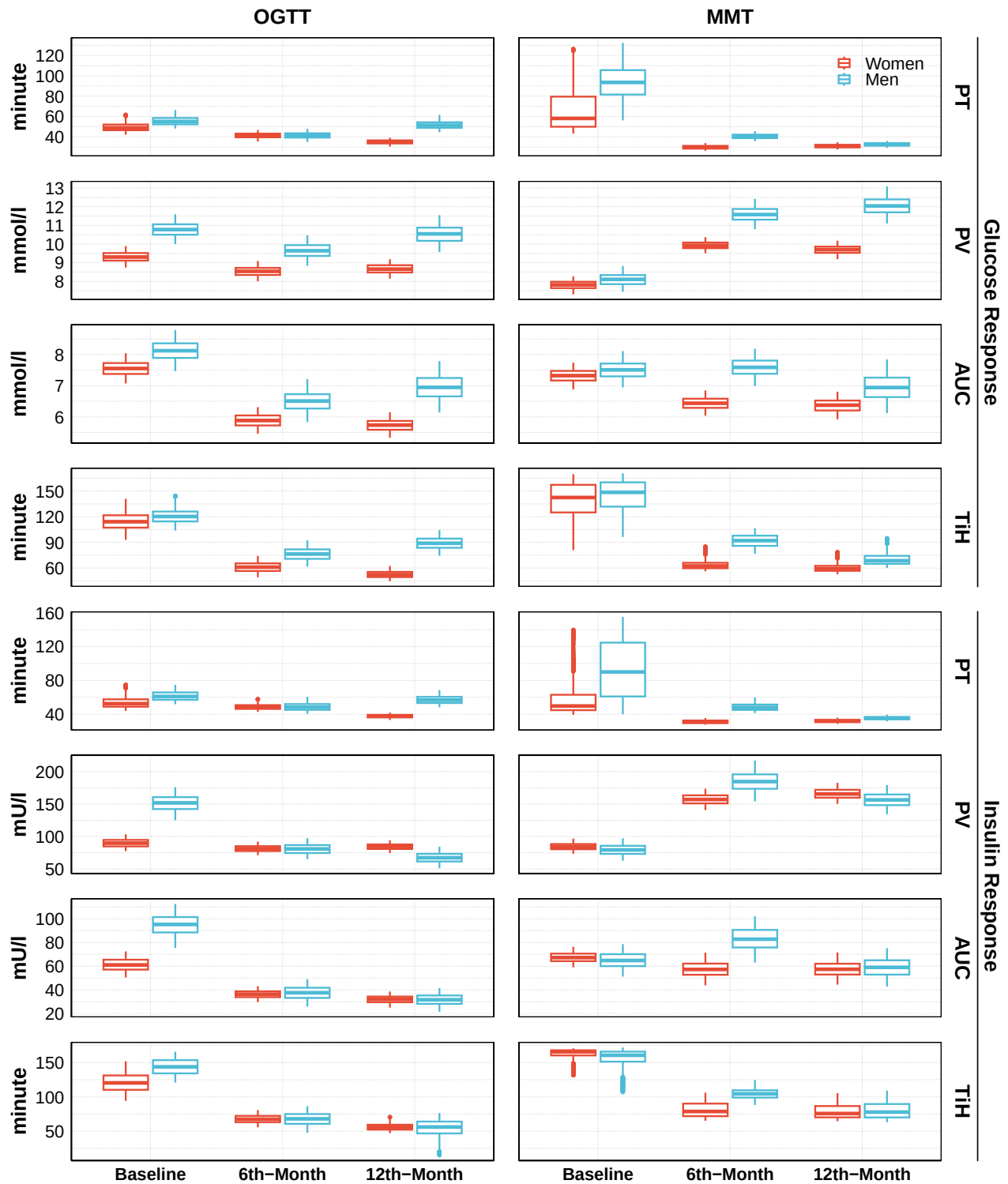
A comparison of the model-predicted average glucose and insulin responses between women and men participants during the oral glucose tolerance test (OGTT). Shaded areas represent 95% confidence intervals (CI) derived from $n=1000$ simulation samples.

Supplementary Figure 5: Mixed meal test (MMT) responses by sex.



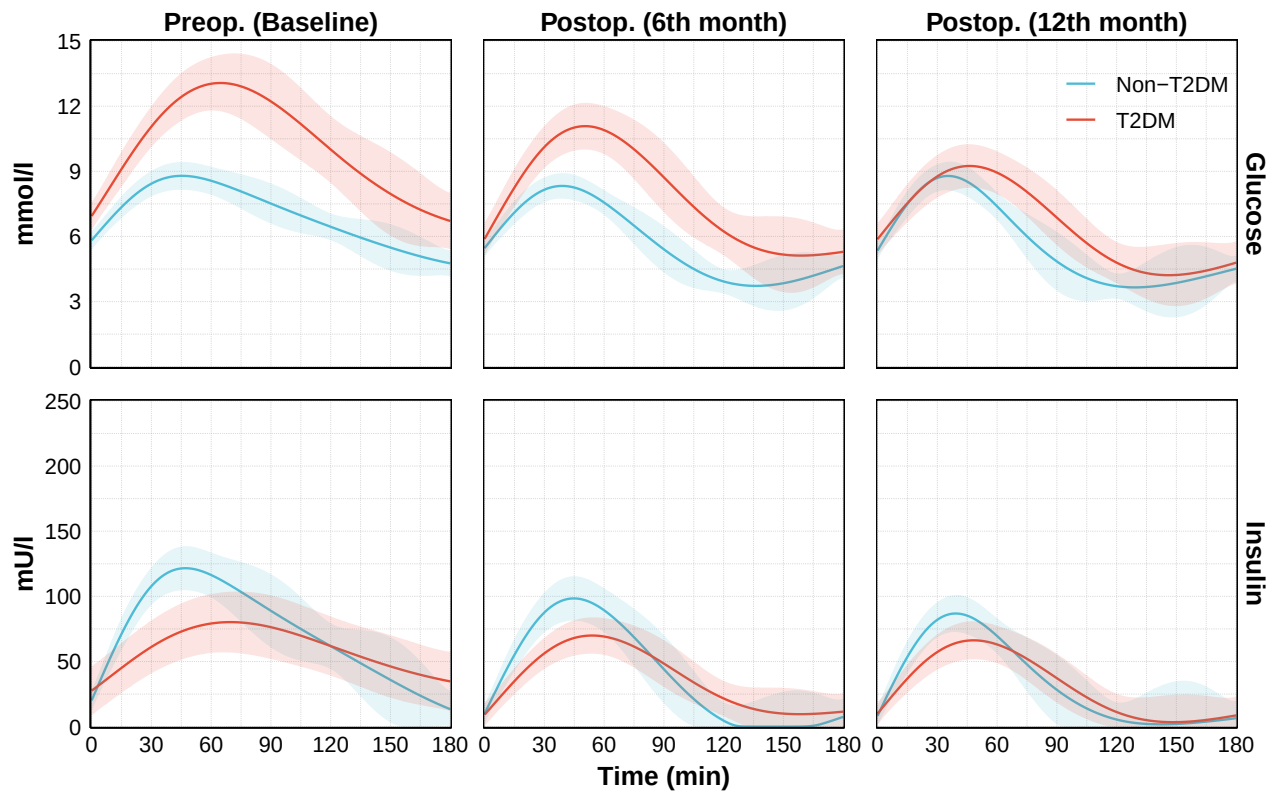
A comparison of the model-predicted average glucose and insulin responses between women and men participants during the mixed meal test (MMT). Shaded areas represent 95% confidence intervals (CI) derived from $n=1000$ simulation samples.

Supplementary Figure 6: Comparison of metabolic metrics by women and men over oral glucose tolerance test (OGTT) and mixed meal test (MMT).



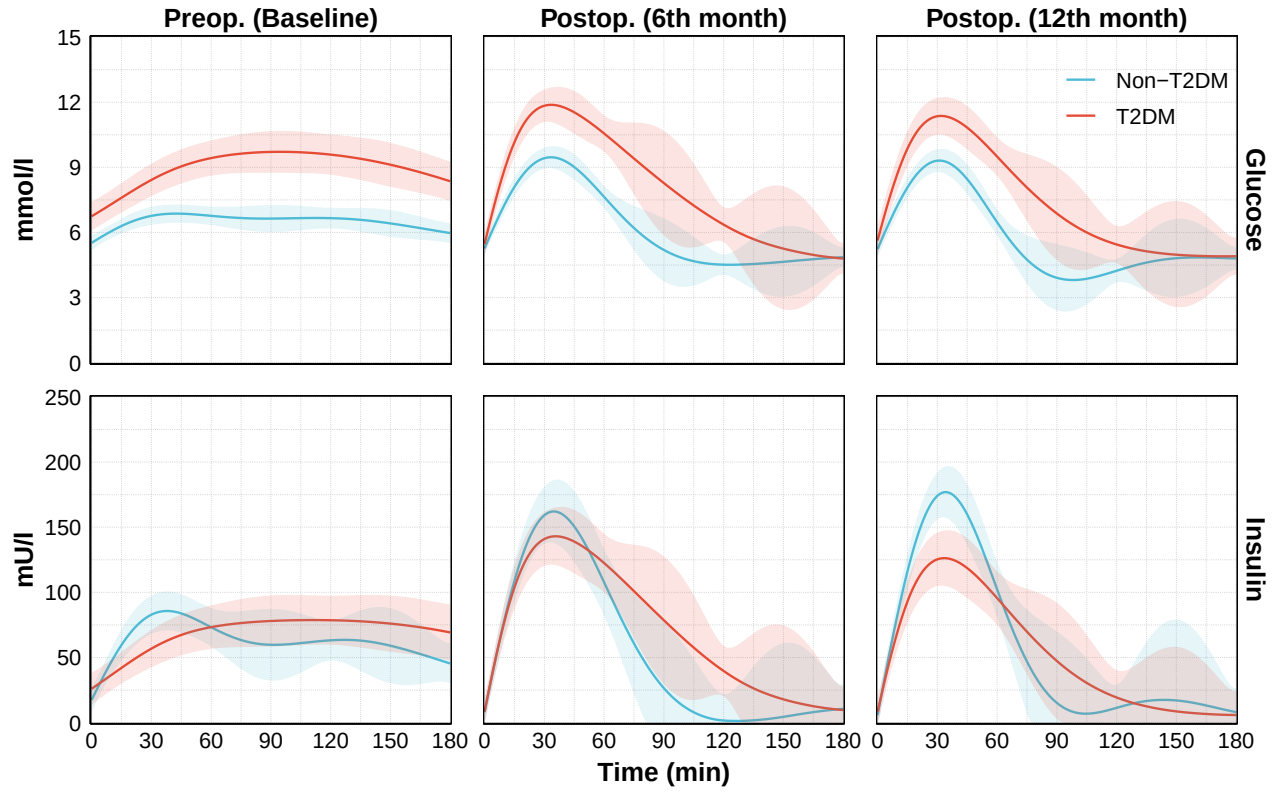
This figure presents a box-plot comparison of each metabolic metric (peaking time (PT), peak value (PV), area under the curve (AUC), and time in the risk zone (TiH)) derived from n=1000 simulation samples. See Supplementary Tables 1-2-3-4 for the detailed 95% CIs and p-values.

Supplementary Figure 7: Oral glucose tolerance test (OGTT) responses by diabetes status.



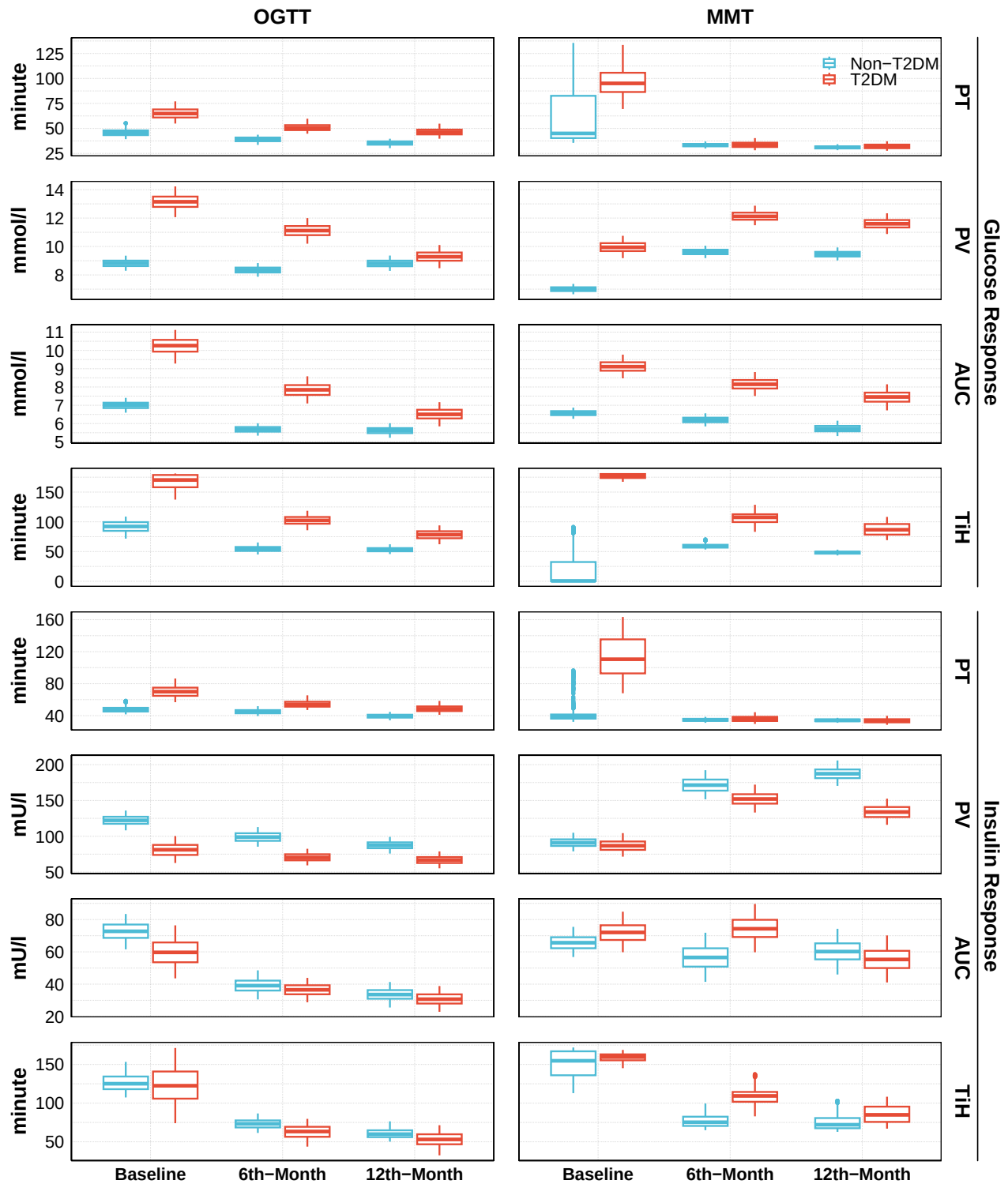
A comparison of the model-predicted average glucose and insulin responses between participants with Type-2 Diabetes (T2DM) and those without (Non-T2DM) during the oral glucose tolerance test (OGTT). Shaded areas represent 95% confidence intervals (CI) derived from $n=1000$ simulation samples.

Supplementary Figure 8: Mixed meal test (MMT) responses by diabetes status.



A comparison of the model-predicted average glucose and insulin responses between participants with Type-2 Diabetes (T2DM) and those without (Non-T2DM) during the mixed meal test (MMT). Shaded areas represent 95% confidence intervals (CI) derived from $n=1000$ simulation samples.

Supplementary Figure 9: Comparison of metabolic metrics by Type-2 Diabetes (T2DM) and non-Type-2 Diabetes (Non-T2DM) over oral glucose tolerance test (OGTT) and mixed meal test (MMT).



This figure presents a box-plot comparison of each metabolic metric (peaking time (PT), peak value (PV), area under the curve (AUC), and time in the risk zone (TiH)) derived from n=1000 simulation samples. See Supplementary Tables 1-2-3-4 for the detailed 95% CIs and p-values.

Supplementary Table 1: **Peaking time (PT, minute)** of the glucose and insulin responses with 95% confidence intervals and p -values. p -values (except $p(\text{B} \rightarrow 12)$) shows the statistical significance of the difference between adjacent cells. $p(\text{B} \rightarrow 12)$ represents the statistical significance of the difference between Baseline and 12th month values.

Peaking Time (PT)			Baseline	$p(\text{B} \rightarrow 6)$	6th month	$p(\text{B} \rightarrow 12)$	12th month	
Glucose Response	Test	Overall	OGTT	50 (45-62)	0.013	41 (35-45)	0.001	38 (33-42)
			p	0.199	-	0.027	-	0.038
			MMT	77 (44-129)	0.001	32 (28-37)	<0.001	31 (29-35)
	Operation	OGTT	RYGB	52 (45-69)	0.018	41 (35-46)	0.002	39 (34-43)
			p	0.419	-	0.335	-	0.488
			OAGB	51 (43-61)	0.110	43 (37-50)	0.029	39 (32-45)
		MMT	RYGB	84 (47-133)	0.001	33 (28-38)	<0.001	31 (28-35)
			p	0.388	-	0.492	-	0.456
			OAGB	70 (45-125)	<0.001	33 (28-37)	<0.001	32 (28-35)
	Diabetes	OGTT	Non-T2DM	46 (39-55)	0.083	39 (34-44)	0.019	35 (30-40)
			p	0.021	-	0.008	-	0.016
			T2DM	65 (55-77)	0.048	51 (45-60)	0.009	46 (40-55)
		MMT	Non-T2DM	45 (36-134)	0.026	33 (30-37)	0.006	31 (28-34)
			p	0.187	-	0.473	-	0.386
			T2DM	95 (69-136)	0.002	33 (28-40)	<0.001	32 (28-37)
	Sex	OGTT	Women	49 (42-62)	0.078	41 (36-47)	0.002	35 (30-39)
			p	0.208	-	0.495	-	0.001
			Men	55 (48-66)	0.012	41 (35-48)	0.287	51 (45-62)
		MMT	Women	58 (43-126)	0.001	30 (26-34)	<0.001	31 (28-35)
			p	0.206	-	0.002	-	0.306
			Men	93 (56-132)	0.002	41 (36-46)	<0.001	33 (29-36)
Insulin Response	Test	Overall	OGTT	53 (46-71)	0.262	49 (43-59)	0.018	42 (37-46)
			p	0.297	-	0.002	-	0.020
			MMT	44 (37-145)	0.041	35 (31-40)	0.017	33 (30-37)
	Operation	OGTT	RYGB	50 (42-69)	0.348	48 (42-56)	0.054	41 (36-46)
			p	0.149	-	0.374	-	0.217
			OAGB	62 (50-78)	0.120	50 (42-62)	0.033	45 (38-54)
		MMT	RYGB	44 (35-139)	0.274	40 (33-46)	0.021	32 (29-36)
			p	0.153	-	0.122	-	0.334
			OAGB	83 (46-147)	0.001	34 (30-38)	0.001	34 (30-38)
	Diabetes	OGTT	Non-T2DM	47 (42-58)	0.326	45 (39-52)	0.048	39 (34-45)
			p	0.027	-	0.067	-	0.052
			T2DM	70 (57-86)	0.068	54 (47-65)	0.015	48 (41-58)
		MMT	Non-T2DM	39 (32-97)	0.190	35 (31-38)	0.140	34 (31-37)
			p	0.045	-	0.407	-	0.444
			T2DM	111 (68-163)	0.003	36 (30-44)	0.001	34 (29-40)
	Sex	OGTT	Women	53 (44-75)	0.292	48 (43-58)	0.004	38 (33-42)
			p	0.217	-	0.478	-	0.003
			Men	61 (52-75)	0.076	48 (41-61)	0.306	57 (48-69)
		MMT	Women	50 (39-140)	0.002	31 (28-36)	0.001	32 (29-36)
			p	0.257	-	0.001	-	0.159
			Men	90 (40-155)	0.157	48 (41-60)	0.015	35 (32-39)

Supplementary Table 2: **Peak value (PV, mmol/l for glucose, mU/l for insulin)** of the glucose and insulin responses with 95% confidence intervals and p -values. p -values (except $p(\text{B} \rightarrow 12)$) shows the statistical significance of the difference between adjacent cells. $p(\text{B} \rightarrow 12)$ represents the statistical significance of the difference between Baseline and 12th month values.

Peak Value (PV)			Baseline	$p(\text{B} \rightarrow 6)$	6th month	$p(\text{B} \rightarrow 12)$	12th month	
Glucose Response	Test	Overall	OGTT	9.9 (9.4-10.4)	0.011	9.0 (8.5-9.4)	0.018	9.0 (8.5-9.5)
			p	<0.001	-	<0.001	-	0.004
			MMT	7.8 (7.4-8.2)	<0.001	10.3 (9.9-10.7)	<0.001	10.2 (9.7-10.6)
	Operation	OGTT	RYGB	10.0 (9.5-10.6)	0.020	9.0 (8.4-9.6)	0.474	10.0 (9.4-10.6)
			p	0.230	-	0.336	-	<0.001
			OAGB	9.6 (8.8-10.4)	0.102	8.8 (8.1-9.4)	0.004	7.8 (7.1-8.5)
		MMT	RYGB	7.8 (7.3-8.2)	<0.001	11.4 (10.9-11.9)	<0.001	11.7 (11.2-12.1)
			p	0.388	-	<0.001	-	<0.001
			OAGB	7.6 (7.0-8.2)	0.006	8.8 (8.3-9.3)	0.002	9.1 (8.5-9.7)
	Diabetes	OGTT	Non-T2DM	8.8 (8.3-9.4)	0.138	8.3 (7.9-8.8)	0.488	8.8 (8.3-9.4)
			p	<0.001	-	<0.001	-	0.214
			T2DM	13.1 (12.1-14.2)	0.010	11.1 (10.2-12.0)	<0.001	9.3 (8.5-10.1)
		MMT	Non-T2DM	6.9 (6.6-7.3)	<0.001	9.5 (9.1-9.9)	<0.001	9.3 (8.9-9.8)
			p	<0.001	-	<0.001	-	<0.001
			T2DM	9.8 (9.1-10.6)	<0.001	11.9 (11.3-12.6)	0.008	11.4 (10.7-12.1)
	Sex	OGTT	Women	9.3 (8.7-9.9)	0.051	8.5 (8.0-9.1)	0.087	8.7 (8.1-9.2)
			p	0.006	-	0.026	-	0.003
			Men	10.8 (10.0-11.6)	0.045	9.6 (8.8-10.5)	0.377	10.5 (9.6-11.5)
MMT		Women	7.7 (7.2-8.2)	<0.001	9.8 (9.4-10.2)	<0.001	9.6 (9.1-10.0)	
		p	0.280	-	0.002	-	<0.001	
		Men	8.0 (7.4-8.7)	<0.001	11.4 (10.6-12.2)	<0.001	11.8 (10.9-12.8)	
Insulin Response	Test	Overall	OGTT	97 (86-109)	0.054	83 (74-93)	0.016	79 (70-89)
			p	0.036	-	<0.001	-	<0.001
			MMT	80 (70-90)	<0.001	154 (139-168)	<0.001	158 (144-172)
	Operation	OGTT	RYGB	108 (94-123)	0.398	104 (91-119)	0.029	87 (75-100)
			p	0.062	-	<0.001	-	0.062
			OAGB	86 (68-106)	0.091	69 (55-81)	0.124	71 (61-83)
		MMT	RYGB	88 (76-101)	<0.001	217 (191-241)	<0.001	187 (169-204)
			p	0.040	-	<0.001	-	<0.001
			OAGB	70 (57-82)	<0.001	122 (106-138)	<0.001	126 (109-142)
	Diabetes	OGTT	Non-T2DM	122 (108-136)	0.028	99 (85-113)	<0.001	87 (76-99)
			p	0.006	-	0.004	-	0.020
			T2DM	81 (63-100)	0.218	70 (59-83)	0.140	67 (55-79)
		MMT	Non-T2DM	87 (75-100)	<0.001	162 (144-182)	<0.001	177 (161-195)
			p	0.360	-	0.120	-	<0.001
			T2DM	83 (68-99)	<0.001	144 (126-163)	0.001	127 (110-145)
	Sex	OGTT	Women	90 (77-103)	0.203	81 (71-92)	0.288	84 (74-94)
			p	<0.001	-	0.469	-	0.068
			Men	152 (125-176)	<0.001	81 (65-97)	<0.001	67 (51-84)
MMT		Women	81 (70-92)	<0.001	149 (133-164)	<0.001	157 (142-173)	
		p	0.340	-	0.087	-	0.281	
		Men	76 (60-93)	<0.001	175 (146-205)	<0.001	148 (127-170)	

Supplementary Table 3: Time-normalized **Area Under Curve (AUC)**, mmol/l for glucose, mU/l for **insulin**) of the glucose and insulin responses with 95% confidence intervals and p -values. p -values (except $p(\text{B} \rightarrow 12)$) shows the statistical significance of the difference between adjacent cells. $p(\text{B} \rightarrow 12)$ represents the statistical significance of the difference between Baseline and 12th month values.

Area Under Curve (AUC)			Baseline	$p(\text{B} \rightarrow 6)$	6th month	$p(\text{B} \rightarrow 12)$	12th month	
Glucose Response	Test	Overall	OGTT	7.8 (7.4-8.2)	<0.001	6.1 (5.7-6.4)	<0.001	6.0 (5.6-6.4)
			p	0.098	-	0.026	-	0.117
			MMT	7.4(7.0-7.7)	0.033	6.8 (6.4-7.1)	0.004	6.4 (6.0-6.9)
	Operation	OGTT	RYGB	8.0 (7.5-8.4)	<0.001	6.1 (5.6-6.5)	<0.001	6.3 (5.8-6.8)
			p	0.129	-	0.460	-	0.094
			OAGB	7.5 (6.8-8.1)	0.004	6.1 (5.6-6.7)	<0.001	5.7 (5.1-6.3)
		MMT	RYGB	7.3 (6.8-7.6)	0.381	7.1 (6.7-7.6)	0.120	6.8 (6.3-7.3)
			p	0.494	-	0.012	-	0.156
			OAGB	7.2 (6.7-7.8)	0.013	6.3 (5.8-6.7)	0.034	6.3 (5.8-6.9)
	Diabetes	OGTT	Non-T2DM	7.0 (6.6-7.4)	<0.001	5.7 (5.3-6.0)	<0.001	5.6 (5.2-6.0)
			p	<0.001	-	<0.001	-	0.025
			T2DM	10.3 (9.3-11.1)	0.002	7.8 (7.1-8.6)	<0.001	6.5 (5.8-7.2)
		MMT	Non-T2DM	6.5 (6.2-6.8)	0.090	6.2 (5.8-6.5)	0.005	5.7 (5.3-6.1)
			p	<0.001	-	<0.001	-	<0.001
			T2DM	9.0 (8.4-9.6)	0.049	8.1 (7.4-8.7)	0.004	7.4 (6.7-8.1)
	Sex	OGTT	Women	7.6 (7.1-8.0)	<0.001	5.9 (5.5-6.3)	<0.001	5.7 (5.3-6.1)
			p	0.116	-	0.092	-	0.016
			Men	8.1 (7.5-8.8)	0.002	6.5 (5.8-7.2)	0.034	6.9 (6.1-7.8)
		MMT	Women	7.3 (6.8-7.7)	0.008	6.4 (6.0-6.8)	0.009	6.3 (5.9-6.8)
			p	0.326	-	0.008	-	0.167
			Men	7.4 (6.9-8.0)	0.428	7.5 (6.9-8.1)	0.189	6.9 (6.1-7.8)
Insulin Response	Test	Overall	OGTT	64 (55-73)	<0.001	38 (31-44)	<0.001	33 (27-39)
			p	0.490	-	<0.001	-	<0.001
			MMT	64 (57-72)	0.470	63 (51-75)	0.180	56 (45-68)
	Operation	OGTT	RYGB	68 (58-79)	0.008	46 (36-55)	<0.001	36 (28-44)
			p	0.200	-	0.040	-	0.203
			OAGB	58 (44-74)	0.006	32 (23-40)	0.002	30 (22-38)
		MMT	RYGB	68 (59-79)	0.020	96 (77-112)	0.336	64 (51-79)
			p	0.093	-	<0.001	-	0.048
			OAGB	57 (48-66)	0.162	48 (36-60)	0.104	46 (34-58)
	Diabetes	OGTT	Non-T2DM	73 (62-83)	<0.001	39 (31-49)	<0.001	34 (26-41)
			p	0.132	-	0.354	-	0.337
			T2DM	60 (44-76)	0.018	37 (29-44)	0.005	31 (23-39)
		MMT	Non-T2DM	63 (55-72)	0.197	54 (40-69)	0.289	58 (44-71)
			p	0.261	-	0.079	-	0.353
			T2DM	69 (57-81)	0.408	71 (57-85)	0.078	53 (40-67)
	Sex	OGTT	Women	61 (51-73)	<0.001	36 (30-43)	<0.001	32 (25-39)
			p	0.009	-	0.446	-	0.494
			Men	95 (75-112)	<0.001	38 (26-49)	<0.001	32 (22-42)
		MMT	Women	64 (57-73)	0.141	55 (42-68)	0.151	55 (43-68)
			p	0.400	-	0.042	-	0.454
			Men	62 (49-75)	0.107	79 (60-97)	0.316	57 (41-72)

Supplementary Table 4: **Time in the Risk Zone (TiH, minute)**, where hyperglycemia and hyperinsulinemia are defined as glucose > 7.0mmol/l and insulin > 50mU/l, respectively, with 95 % confidence intervals and *p*-values. *p*-values (except *p*(B→12)) shows the statistical significance of the difference between adjacent cells. *p*(B→12) represents the statistical significance of the difference between Baseline and 12th month values.

Time in the Risk Zone (TiH)			Baseline	<i>p</i> (B→6)	6th month	<i>p</i> (B→12)	12th month	
Glucose Response	Test	Overall	OGTT	116 (103-135)	<0.001	66 (56-78)	<0.001	63 (54-75)
			<i>p</i>	0.118	-	0.259	-	0.400
			MMT	144 (109-166)	0.006	72 (63-93)	0.004	61 (55-78)
	Operation	OGTT	RYGB	125 (110-147)	<0.001	67 (55-80)	<0.001	70 (61-85)
			<i>p</i>	0.088	-	0.500	-	0.040
			OAGB	105 (84-126)	0.007	67 (53-82)	<0.001	47 (20-66)
		MMT	RYGB	133 (84-162)	0.054	83 (70-101)	0.033	69 (62-91)
			<i>p</i>	0.458	-	0.014	-	0.056
			OAGB	136 (27-174)	0.090	53 (45-65)	0.091	54 (45-68)
	Diabetes	OGTT	Non-T2DM	92 (72-109)	0.004	54 (45-65)	<0.001	53 (46-62)
			<i>p</i>	<0.001	-	<0.001	-	0.016
			T2DM	170 (137-181)	0.004	102 (86-119)	<0.001	78 (62-94)
		MMT	Non-T2DM	2 (1-74)	0.082	58 (53-68)	0.116	47 (43-52)
			<i>p</i>	<0.001	-	0.001	-	0.001
			T2DM	176 (166-181)	<0.001	106 (82-126)	<0.001	85 (69-107)
	Sex	OGTT	Women	114 (93-141)	<0.001	61 (49-74)	<0.001	52 (45-62)
			<i>p</i>	0.359	-	0.096	-	0.001
			Men	120 (104-144)	<0.001	76 (62-92)	0.014	89 (74-104)
		MMT	Women	136 (65-168)	0.047	61 (55-83)	0.044	58 (52-75)
			<i>p</i>	0.442	-	0.026	-	0.141
			Men	144 (88-169)	0.059	91 (76-106)	0.028	68 (59-93)
Insulin Response	Test	Overall	OGTT	121 (102-148)	<0.001	70 (58-82)	<0.001	59 (50-74)
			<i>p</i>	0.053	-	0.081	-	0.071
			MMT	165 (127-170)	0.004	89 (72-107)	0.001	74 (64-102)
	Operation	OGTT	RYGB	125 (107-152)	0.005	80 (68-93)	<0.001	63 (53-79)
			<i>p</i>	0.301	-	0.036	-	0.253
			OAGB	112 (75-154)	0.022	57 (31-74)	0.014	55 (40-71)
		MMT	RYGB	168 (124-173)	0.018	108 (90-126)	0.004	80 (68-107)
			<i>p</i>	0.160	-	0.028	-	0.154
			OAGB	148 (83-163)	0.037	67 (57-97)	0.034	64 (55-96)
	Diabetes	OGTT	Non-T2DM	125 (107-153)	0.002	73 (61-87)	<0.001	60 (50-76)
			<i>p</i>	0.450	-	0.202	-	0.278
			T2DM	122 (74-171)	0.034	63 (44-80)	0.023	53 (33-71)
		MMT	Non-T2DM	148 (106-171)	0.009	74 (64-98)	0.009	71 (62-101)
			<i>p</i>	0.378	-	0.051	-	0.283
			T2DM	158 (141-167)	0.017	108 (82-132)	0.003	83 (66-106)
	Sex	OGTT	Women	120 (94-152)	0.004	67 (56-81)	0.002	56 (47-71)
			<i>p</i>	0.152	-	0.490	-	0.493
			Men	144 (121-166)	<0.001	68 (48-87)	<0.001	56 (15-77)
		MMT	Women	163 (125-169)	0.001	77 (64-105)	0.002	74 (64-104)
			<i>p</i>	0.403	-	0.102	-	0.484
			Men	158 (96-170)	0.075	103 (87-122)	0.033	76 (62-107)

Supplementary Table 5: Metabolic features of the participants by different operations, sexes, and diabetes over each visit. **B** represents baseline visit, while **6th** and **12th** corresponds to 6th and 12th month visits.

<i>Metabolic Features</i>		Overall	OAGB	RYGB	Male	Female	T2DM	Non-T2DM
Age (years)	B	46.0 $\pm$ 7.0	46.6 $\pm$ 7.4	45.4 $\pm$ 6.6	50.7 $\pm$ 7.4	43.9 $\pm$ 5.8	44.3 $\pm$ 6.3	47.3 $\pm$ 7.3
	6th	46.5 $\pm$ 7.0	47.1 $\pm$ 7.4	45.9 $\pm$ 6.6	51.2 $\pm$ 7.4	44.4 $\pm$ 5.8	44.8 $\pm$ 6.3	47.8 $\pm$ 7.3
	12th	47.0 $\pm$ 7.0	47.6 $\pm$ 7.4	46.4 $\pm$ 6.6	51.7 $\pm$ 7.4	44.9 $\pm$ 5.8	45.3 $\pm$ 6.3	48.3 $\pm$ 7.3
Weight (kg)	B	130 $\pm$ 19	127 $\pm$ 15	135 $\pm$ 23	138 $\pm$ 22	127 $\pm$ 17	132 $\pm$ 21	130 $\pm$ 18
	6th	102 $\pm$ 16	99 $\pm$ 14	107 $\pm$ 19	109 $\pm$ 18	101 $\pm$ 16	101 $\pm$ 16	104 $\pm$ 17
	12th	98 $\pm$ 16	94 $\pm$ 14	103 $\pm$ 18	106 $\pm$ 19	95 $\pm$ 15	95 $\pm$ 16	101 $\pm$ 17
Bmi (kg/m ²)	B	45 $\pm$ 6	44 $\pm$ 6	46 $\pm$ 6	42 $\pm$ 5	46 $\pm$ 6	46 $\pm$ 6	44 $\pm$ 6
	6th	35 $\pm$ 5	35 $\pm$ 6	36 $\pm$ 5	34 $\pm$ 5	37 $\pm$ 5	35 $\pm$ 5	36 $\pm$ 5
	12th	34 $\pm$ 5	33 $\pm$ 6	35 $\pm$ 5	33 $\pm$ 5	35 $\pm$ 5	34 $\pm$ 6	35 $\pm$ 5
Hba1c (mmol/mol)	B	39 $\pm$ 10	38 $\pm$ 6	41 $\pm$ 13	38 $\pm$ 7	40 $\pm$ 11	47 $\pm$ 12	34 $\pm$ 4
	6th	34 $\pm$ 5	34 $\pm$ 3	33 $\pm$ 6	34 $\pm$ 4	34 $\pm$ 5	37 $\pm$ 4	32 $\pm$ 4
	12th	34 $\pm$ 7	34 $\pm$ 3	35 $\pm$ 10	35 $\pm$ 6	34 $\pm$ 7	38 $\pm$ 8	31 $\pm$ 4
Cholesterol (mmol/l)	B	4.5 $\pm$ 0.9	4.5 $\pm$ 1.0	4.6 $\pm$ 0.7	4.3 $\pm$ 1.3	4.6 $\pm$ 0.7	4.5 $\pm$ 1.1	4.5 $\pm$ 0.8
	6th	3.8 $\pm$ 0.7	3.7 $\pm$ 0.7	3.9 $\pm$ 0.6	3.5 $\pm$ 0.8	3.9 $\pm$ 0.6	3.7 $\pm$ 0.8	3.9 $\pm$ 0.6
	12th	3.9 $\pm$ 1.0	3.8 $\pm$ 0.7	4.3 $\pm$ 1.2	3.8 $\pm$ 1.1	4.1 $\pm$ 0.9	3.8 $\pm$ 0.9	4.1 $\pm$ 1.1
HDL Cholesterol (mmol/l)	B	1.2 $\pm$ 0.2	1.2 $\pm$ 0.2	1.2 $\pm$ 0.2	1.2 $\pm$ 0.2	1.3 $\pm$ 0.2	1.2 $\pm$ 0.3	1.2 $\pm$ 0.2
	6th	1.2 $\pm$ 0.2	1.2 $\pm$ 0.2	1.3 $\pm$ 0.2	1.2 $\pm$ 0.2	1.2 $\pm$ 0.2	1.1 $\pm$ 0.2	1.3 $\pm$ 0.2
	12th	1.4 $\pm$ 0.3	1.4 $\pm$ 0.2	1.4 $\pm$ 0.3	1.4 $\pm$ 0.3	1.4 $\pm$ 0.3	1.3 $\pm$ 0.3	1.5 $\pm$ 0.2
LDL Cholesterol (mmol/l)	B	2.9 $\pm$ 0.8	2.8 $\pm$ 0.9	3.0 $\pm$ 0.7	2.8 $\pm$ 1.1	2.9 $\pm$ 0.6	2.8 $\pm$ 0.9	2.9 $\pm$ 0.8
	6th	2.3 $\pm$ 0.7	2.2 $\pm$ 0.7	2.4 $\pm$ 0.6	2.0 $\pm$ 0.7	2.4 $\pm$ 0.6	2.3 $\pm$ 0.7	2.3 $\pm$ 0.6
	12th	2.3 $\pm$ 0.8	2.2 $\pm$ 0.8	2.3 $\pm$ 0.8	2.1 $\pm$ 1.1	2.3 $\pm$ 0.6	2.2 $\pm$ 0.8	2.3 $\pm$ 0.7
Triglyceride (mmol/l)	B	1.4 $\pm$ 0.7	1.4 $\pm$ 0.6	1.4 $\pm$ 0.8	1.3 $\pm$ 0.6	1.5 $\pm$ 0.7	1.7 $\pm$ 0.9	1.3 $\pm$ 0.5
	6th	1.1 $\pm$ 0.4	1.1 $\pm$ 0.4	1.1 $\pm$ 0.3	0.9 $\pm$ 0.3	1.2 $\pm$ 0.3	1.2 $\pm$ 0.4	1.0 $\pm$ 0.3
	12th	1.0 $\pm$ 0.3	0.9 $\pm$ 0.3	1.0 $\pm$ 0.3	0.9 $\pm$ 0.3	1.0 $\pm$ 0.3	1.1 $\pm$ 0.3	0.9 $\pm$ 0.3
Fasting Glucose (mmol/l)	B	6.1 $\pm$ 1.0	5.9 $\pm$ 0.9	6.3 $\pm$ 1.2	6.1 $\pm$ 0.9	6.1 $\pm$ 1.1	6.8 $\pm$ 1.1	5.6 $\pm$ 0.6
	6th	5.4 $\pm$ 0.7	5.4 $\pm$ 0.6	5.4 $\pm$ 0.8	5.7 $\pm$ 0.8	5.3 $\pm$ 0.6	5.6 $\pm$ 1.0	5.3 $\pm$ 0.4
	12th	5.4 $\pm$ 0.9	5.4 $\pm$ 0.8	5.5 $\pm$ 1.0	5.8 $\pm$ 1.2	5.3 $\pm$ 0.7	5.7 $\pm$ 1.2	5.2 $\pm$ 0.5
Fasting Insulin (mU/l)	B	20.3 $\pm$ 17.2	20.5 $\pm$ 14.7	20.1 $\pm$ 20.0	19.1 $\pm$ 14.5	20.9 $\pm$ 18.5	24.8 $\pm$ 23.6	17.2 $\pm$ 9.8
	6th	8.2 $\pm$ 4.4	8.8 $\pm$ 4.6	7.7 $\pm$ 4.2	8.4 $\pm$ 4.6	8.2 $\pm$ 4.4	7.9 $\pm$ 3.9	8.5 $\pm$ 4.8
	12th	6.6 $\pm$ 4.1	7.1 $\pm$ 4.6	6.2 $\pm$ 3.5	6.7 $\pm$ 3.7	6.7 $\pm$ 4.3	7.0 $\pm$ 4.1	6.4 $\pm$ 4.1
Fat mass (kg)	B	64 $\pm$ 13	62 $\pm$ 12	65 $\pm$ 15	61 $\pm$ 16	65 $\pm$ 12	64 $\pm$ 12	63 $\pm$ 14
	6th	43 $\pm$ 12	41 $\pm$ 11	45 $\pm$ 12	39 $\pm$ 14	45 $\pm$ 10	39 $\pm$ 9	46 $\pm$ 13
	12th	38 $\pm$ 12	36 $\pm$ 13	39 $\pm$ 12	31 $\pm$ 14	40 $\pm$ 11	35 $\pm$ 11	40 $\pm$ 13
Fat ratio (percent)	B	49 $\pm$ 6	49 $\pm$ 6	49 $\pm$ 7	44 $\pm$ 7	51 $\pm$ 4	49 $\pm$ 5	49 $\pm$ 7
	6th	41 $\pm$ 7	41 $\pm$ 8	41 $\pm$ 7	35 $\pm$ 8	43 $\pm$ 5	39 $\pm$ 7	42 $\pm$ 8
	12th	37 $\pm$ 9	37 $\pm$ 10	38 $\pm$ 9	30 $\pm$ 9	41 $\pm$ 6	36 $\pm$ 8	39 $\pm$ 9

Supplementary Table 6: **The comparison of HMOGP predictions (model) with fundamental statistical analysis on the data distribution (data).** The comparison shows that fundamental statistical analysis of the data distribution gives unreliable peaking time (PT) and peak value (PV) results as they only rely on the timing of the observations. On the other hand, HMOGP predicts consistent AUC and TiH estimations with improved uncertainty compared to the conventional data analysis.

<i>Glucose Response</i>			Baseline	$p(B \rightarrow 6)$	6th month	$p(B \rightarrow 12)$	12th month	<i>Unit</i>
Peaking Time (PT)	Data Statistics	OGTT	60 (30-120)	0.409	30 (30-60)	0.417	30 (0-60)	<i>minute</i>
		p	0.250	-	0.391	-	0.386	
		MMT	60 (30-180)	0.150	30 (30-60)	0.179	30 (30-60)	
	HMOGP Predictions	OGTT	50 (45-62)	0.013	41 (35-45)	0.001	38 (33-42)	
		p	0.199	-	0.027	-	0.038	
		MMT	77 (44-129)	0.001	32 (28-37)	<0.001	31 (29-35)	
Peak Value (PV)	Data Statistics	OGTT	10.2 (6.2-16.5)	0.364	9.8 (6.5-17.3)	0.403	9.6 (6.3-21.7)	<i>mmol/l</i>
		p	0.105	-	0.297	-	0.371	
		MMT	8.0 (5.7-12.7)	0.162	11.1 (7.4-16.5)	0.205	10.7 (6.9-16.4)	
	HMOGP Predictions	OGTT	9.9 (9.4-10.4)	0.011	9.0 (8.5-9.4)	0.018	9.0 (8.5-9.5)	
		p	<0.001	-	<0.001	-	0.004	
		MMT	7.8 (7.4-8.2)	<0.001	10.3 (9.9-10.7)	<0.001	10.2 (9.7-10.6)	
Area Under Curve (AUC)	Data Statistics	OGTT	7.4 (5.3-13.5)	0.061	6.2 (4.9-11.9)	0.222	6.1 (4.7-13.7)	<i>mmol/l</i>
		p	0.368	-	0.312	-	0.371	
		MMT	7.1 (5.6-11.1)	0.300	6.9 (5.3-10.7)	0.308	6.3 (4.9-11.3)	
	HMOGP Predictions	OGTT	7.8 (7.4-8.2)	<0.001	6.1 (5.7-6.4)	<0.001	6.0 (5.6-6.4)	
		p	0.098	-	0.026	-	0.117	
		MMT	7.4 (7.0-7.7)	0.033	6.8 (6.4-7.1)	0.004	6.4 (6.0-6.9)	
Time in the Risk Zone (TiH)	Data Statistics	OGTT	104 (0-181)	0.136	70 (0-179)	0.236	60 (0-181)	<i>minute</i>
		p	0.474	-	0.391	-	0.414	
		MMT	120 (0-181)	0.400	78 (10-172)	0.397	62 (0-176)	
	HMOGP Predictions	OGTT	116 (103-135)	<0.001	66 (56-78)	<0.001	63 (54-75)	
		p	0.118	-	0.259	-	0.400	
		MMT	144 (109-166)	0.006	72 (63-93)	0.004	61 (55-78)	