

Supplementary Table 1 Cross-sectional associations (geometric mean (95% confidence interval)) between rest-activity rhythm characteristics and metabolic markers, before and after adjusting for physical activity and sleep.

	Fasting Glucose, mmol/L		Fasting Insulin, pmol/L		HOMA-IR	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Amplitude						
Q1	5.55 (5.46, 5.65) **	5.52 (5.42, 5.62)	91.56 (86.98, 96.38) ***	89.21 (84.61, 94.06) ***	3.77 (3.56, 4.00) ***	3.65 (3.44, 3.88) ***
Q2	5.45 (5.36, 5.54)	5.45 (5.35, 5.54)	87.46 (83.22, 91.91) ***	86.75 (82.51, 91.21) ***	3.54 (3.34, 3.74) ***	3.51 (3.31, 3.71) ***
Q3	5.43 (5.34, 5.52)	5.43 (5.34, 5.53)	80.50 (76.60, 84.59)	80.36 (76.48, 84.45)	3.24 (3.07, 3.43)	3.24 (3.06, 3.43)
Q4 (ref)	5.42 (5.36, 5.48)	5.42 (5.36, 5.48)	79.08 (76.28, 81.98)	79.08 (76.28, 81.98)	3.18 (3.05, 3.31)	3.18 (3.05, 3.31)
<i>p-trend</i>	0.007	0.06	<.0001	<.0001	<.0001	<.0001
Mesor						
Q1	5.52 (5.43, 5.62)	5.54 (5.44, 5.64) *	88.50 (84.12, 93.12) ***	89.04 (84.44, 93.89) ***	3.62 (3.42, 3.84) ***	3.65 (3.44, 3.88) ***
Q2	5.43 (5.35, 5.53)	5.45 (5.36, 5.54)	86.02 (81.85, 90.39) **	86.68 (82.45, 91.13) **	3.46 (3.27, 3.66) *	3.50 (3.31, 3.70) **
Q3	5.45 (5.36, 5.54)	5.46 (5.37, 5.55)	81.48 (77.54, 85.63)	82.00 (78.04, 86.17)	3.29 (3.11, 3.48)	3.32 (3.14, 3.51)
Q4 (ref)	5.44 (5.38, 5.51)	5.44 (5.38, 5.51)	80.41 (77.58, 83.34)	80.41 (77.58, 83.34)	3.24 (3.12, 3.38)	3.24 (3.12, 3.38)
<i>p-trend</i>	0.12	0.08	<.0001	<.0001	<.0001	<.0001
Amplitude:mesor ratio						
Q1	5.51 (5.41, 5.60)	5.45 (5.35, 5.55)	90.83 (86.30, 95.59) ***	88.12 (83.47, 93.03) ***	3.71 (3.51, 3.94) ***	3.57 (3.36, 3.79) **
Q2	5.45 (5.36, 5.54)	5.43 (5.34, 5.52)	85.84 (81.67, 90.21) **	85.01 (80.86, 89.38) *	3.47 (3.28, 3.68) *	3.43 (3.24, 3.63)
Q3	5.38 (5.29, 5.47)	5.38 (5.29, 5.47)	82.80 (78.80, 87.00)	82.92 (78.90, 87.15)	3.31 (3.13, 3.50)	3.31 (3.13, 3.51)
Q4 (ref)	5.44 (5.38, 5.51)	5.44 (5.38, 5.51)	80.18 (77.38, 83.07)	80.18 (77.38, 83.07)	3.24 (3.11, 3.37)	3.24 (3.11, 3.37)
<i>p-trend</i>	0.09	0.72	<.0001	0.0005	<.0001	0.001
Pseudo-F Statistic						
Q1	5.52 (5.43, 5.62)	5.49 (5.39, 5.59)	90.26 (85.74, 95.02) ***	88.15 (83.50, 93.06) ***	3.71 (3.50, 3.93) ***	3.59 (3.38, 3.82) ***
Q2	5.43 (5.34, 5.52)	5.41 (5.32, 5.51)	85.78 (81.59, 90.20) **	84.75 (80.56, 89.17) *	3.46 (3.27, 3.66) **	3.41 (3.22, 3.61) *
Q3	5.38 (5.29, 5.47)	5.37 (5.28, 5.46)	81.57 (77.63, 85.71)	13.5 (12.9, 14.2)	3.26 (3.08, 3.45)	3.24 (3.07, 3.43)
Q4 (ref)	5.44 (5.38, 5.51)	5.44 (5.38, 5.51)	79.41 (76.62, 82.30)	79.41 (76.62, 82.30)	3.21 (3.08, 3.34)	3.21 (3.08, 3.34)
<i>p-trend</i>	0.05	0.27	<.0001	<.0001	<.0001	<.0001
Acrophase^d						
Early	5.47 (5.37, 5.56)	5.52 (5.42, 5.63)	90.43 (85.87, 95.22)	92.65 (87.61, 97.98)	3.67 (3.46, 3.89)	3.79 (3.56, 4.04)
Normal (ref)	5.50 (5.40, 5.60)	5.50 (5.40, 5.60)	87.78 (83.64, 92.12)	87.78 (83.64, 92.12)	3.58 (3.39, 3.78)	3.58 (3.39, 3.78)
Late	5.58 (5.28, 5.91)	5.56 (5.25, 5.88)	92.23 (87.36, 97.38)	88.70 (83.86, 93.83)	3.79 (3.57, 4.04)	3.62 (3.42, 3.83)
<i>p-trend</i>	0.21	0.27	0.64	0.25	0.64	0.34

Model 2: adjusted for age, study site, education, marital status, race, smoking, alcohol, healthy diet score, and season of data collection.

Model 3: adjusted for variables in Model 2 and physical activity score and total sleep time, sleep efficiency and midpoint of sleep, all as continuous variables.

Supplementary table 2 Cross-sectional associations^a between rest-activity rhythm characteristics and impaired fasting glucose and type 2 diabetes.

	IFG vs. Normal		Diabetes vs. Normal	
	No. of IFG (% ^b)	RRR (95% CI)	No. of Diabetes (% ^b)	RRR (95% CI)
Amplitude				
Q1	172 (29.3)	1.08 (0.83, 1.41)	97 (16.5)	1.67 (1.17, 2.40) **
Q2	154 (24.8)	0.79 (0.61, 1.03)	79 (12.7)	1.17 (0.81, 1.68)
Q3	172 (28.2)	0.95 (0.74, 1.23)	78 (12.8)	1.19 (0.83, 1.71)
Q4	193 (30.5)	ref	70 (11.1)	ref
<i>p-trend</i>		0.97		0.009
Mesor				
Q1	153 (25.8)	0.82 (0.63, 1.07)	90 (15.2)	1.31 (0.92, 1.87)
Q2	164 (26.6)	0.80 (0.62, 1.04)	77 (12.5)	1.02 (0.71, 1.45)
Q3	174 (28.6)	0.88 (0.69, 1.14)	80 (13.2)	1.06 (0.75, 1.52)
Q4	200 (31.7)	ref	77 (12.2)	ref
<i>p-trend</i>		0.10		0.18
Amplitude:mesor ratio				
Q1	172 (29.4)	1.08 (0.83, 1.40)	96 (16.4)	1.38 (0.97, 1.96)
Q2	168 (27.0)	0.91 (0.70, 1.18)	81 (13.0)	1.06 (0.75, 1.52)
Q3	168 (27.0)	0.91 (0.70, 1.18)	72 (11.6)	0.98 (0.68, 1.40)
Q4	183 (29.5)	ref	75 (12.1)	ref
<i>p-trend</i>		0.65		0.07
Pseudo-F				
Q1	176 (30.0)	1.08(0.83, 1.41)	98 (16.7)	1.38 (0.97, 1.96)
Q2	153 (24.8)	0.76 (0.58, 0.99)	78 (12.7)	0.91 (0.64, 1.30)
Q3	172 (27.6)	0.84 (0.65, 1.08)	69 (11.1)	0.78 (0.55, 1.13)
Q4	190 (30.5)	ref	79 (12.7)	ref
<i>p-trend</i>		0.82		0.05
Acrophase^c				
Early	87 (24.9)	0.75 (0.57, 0.99) *	52 (14.9)	1.01 (0.71, 1.43)
Normal	530 (29.7)	ref	217 (12.1)	ref
Late	74 (23.6)	0.79 (0.59, 1.06)	55 (17.6)	1.35 (0.95, 1.91)
<i>p-trend</i>		0.67		0.21

^a Models were adjusted for age, study site, education, marital status, race, smoking, alcohol, healthy diet score, and season of data collection.

^b Percentages represent the % of participants in the quartile or category of the rest-activity rhythm characteristic that had diabetes or IFG at baseline.

^c Acrophase was categorized as early (mean - 1 SD, <13:04), normal (mean $\pm$ 1 SD, 13:04-15:29) and late (mean + 1 SD, > 15:29).

* P-value<0.05.

** P-value<0.01.

Abbreviations: CI, confidence interval; IFG, impaired fasting glucose; RRR, relative risk ratio.

Supplementary table 3 Prospective associations ^a between rest-activity rhythm characteristics and the odds of high increase ^b in metabolic markers between baseline (2003-2005) and follow-up (2007-2009).

	OR (95% CI)		
	Glucose	Insulin	HOMA-IR
Amplitude			
Q1	1.27 (0.80, 2.02)	1.35 (0.85, 2.15)	1.53 (0.96, 2.43)
Q2	1.33 (0.86, 2.05)	1.39 (0.90, 2.13)	1.58 (1.03, 2.42) *
Q3	1.11 (0.72, 1.70)	0.96 (0.62, 1.48)	0.84 (0.54, 1.30)
Q4	ref	ref	ref
<i>p-trend</i>	<i>0.21</i>	<i>0.08</i>	<i>0.009</i>
Mesor			
Q1	1.01 (0.65, 1.59)	1.16 (0.75, 1.81)	1.43 (0.92, 2.23)
Q2	1.31 (0.86, 2.00)	1.05 (0.69, 1.61)	1.16 (0.76, 1.78)
Q3	0.81 (0.52, 1.25)	0.61 (0.39, 0.96) *	0.65 (0.41, 1.03)
Q4	ref	ref	ref
<i>p-trend</i>	<i>0.43</i>	<i>0.19</i>	<i>0.03</i>
Amplitude:mesor ratio			
Q1	1.15 (0.74, 1.80)	1.07 (0.69, 1.66)	1.30 (0.83, 2.04)
Q2	1.05 (0.67, 1.62)	0.72 (0.46, 1.12)	0.95 (0.61, 1.48)
Q3	1.22 (0.81, 1.84)	0.92 (0.61, 1.38)	1.27 (0.84, 1.91)
Q4	ref	ref	ref
<i>p-trend</i>	<i>0.71</i>	<i>0.87</i>	<i>0.51</i>
Pseudo-F			
Q1	1.30 (0.84, 2.00)	1.59 (1.01, 2.49)	1.48 (0.95, 2.31)
Q2	0.91 (0.59, 1.41)	1.23 (0.79, 1.91)	1.14 (0.73, 1.76)
Q3	0.79 (0.51, 1.21)	1.05 (0.68, 1.62)	0.87 (0.57, 1.35)
Q4	ref	ref	ref
<i>p-trend</i>	<i>0.21</i>	<i>0.04</i>	<i>0.05</i>
Acrophase ^c			
Early	1.71 (1.12, 2.63) *	1.69 (1.10, 2.61) *	1.91 (1.24, 2.95) **
Normal	ref	ref	ref
Late	1.10 (0.69, 1.77)	1.10 (0.68, 1.80)	1.10 (0.67, 1.80)
<i>p-trend</i>	<i>0.10</i>	<i>0.11</i>	<i>0.04</i>

^a Models were adjusted for age, study site, education, marital status, race, smoking, alcohol, healthy diet score, and season of data collection.

^b For this binary variable, we assigned a value of 1 to those in the top 25% for changes in each marker, defined as follow-up value minus baseline value, and the rest of the subjects were assigned 0.

^c Acrophase was categorized as early (mean - 1 SD, <13:04), normal (mean $\pm$ 1 SD, 13:04-15:29) and late (mean + 1 SD, > 15:29).

* P-value<0.05.

** P-value<0.01.

Abbreviations: CI, confidence interval; OR, odds ratio.