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Supplemental Material

Serum Half-Lives for Short- and Long-Chain Perfluoroalkyl Acids after Ceasing Exposure from Drinking Water Contaminated by Firefighting Foam

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Figure S2. Box plot of specific gravity adjusted urinary concentration of PFHpA, PFOA, PFPeS, PFHxS L-PFOS and 2/6m-PFOS at each sampling. PFHxS showed higher concentration than the rest of the PFAS, thus note a different scale on y-axis. The descriptive data are listed in Table S7.

Figure S3. Pattern of change in urine/serum ratio of a) PFPeS and b) L-PFOS for each individual over four paired samplings.

Table S1. Overview of the perfluoroalkyl substances (PFAS) analytes and internal standards

Compounds	Abbreviations	Molar weight
Perfluoropentanoic acid	PFPeA	264.0
Perfluorohexanoic acid	PFHxA	314.0
Perfluoroheptanoic acid	PFHpA	364.1
Perfluorooctanoic acid	PFOA	414.1
Perfluorononanoic acid	PFNA	464.1
Perfluorodecanoic acid	PFDA	514.1
Perfluoroundecanoic acid	PFUnDA	564.1
Perfluorododecanoic acid	PFDoDA	614.1
Perfluorobutane sulfonic acid	PFBS	300.1
Perfluoropentane sulfonic acid	PFPeS	350.1
Perfluorohexane sulfonic acid	PFHxS	400.1
Perfluoroheptane sulfonic acid	PFHpS	450.1
Perfluorooctane sulfonic acid	L-PFOS	500.1
Perfluoro-1-methylheptanesulfonate	1m-PFOS	500.1
Perfluoro-2/6-methylheptanesulfonate (Σ)	2/6m-PFOS ^a	500.1
Perfluoro-3/4/5-methylheptanesulfonate (Σ)	3/4/5m-PFOS ^b	500.1
Internal standard		
Perfluoro-n-[1,2,3,4,6- ¹³ C ₅] hexanoic acid	¹³ C ₅ -PFHxA	
Perfluoro-n-[1,2,3,4- ¹³ C ₄] heptanoic acid	¹³ C ₄ -PFHpA	
Perfluoro-n-[¹³ C ₈] octanoic acid	¹³ C ₈ -PFOA	
Sodium perfluoro-1-[2,3,4- ¹³ C ₃] butanesulfonate	¹³ C ₃ -PFBS	
Sodium perfluoro-1-[1,2,3- ¹³ C ₃] hexanesulfonate	¹³ C ₃ -PFHxS	
Sodium perfluoro-1-[¹³ C ₈] octanesulfonate	¹³ C ₄ -PFOS	

^a 2/6m-PFOS corresponds to the sum of 2m-PFOS and 6m-PFOS.

^b 3/4/5m-PFOS corresponds to the sum of 3m-PFOS, 4m-PFOS and 5m-PFOS.

Table S2. Selected reaction monitoring parameters for the quantifier transitions of PFAS and their internal standards

PFAS	Transition	Collision energy (V)	DP(V)	Internal standard	Transition	Collision energy (V)	DP (V)
PFPeA	263/219	-13	-25	¹³ C ₅ -PFPeA	268/223	-13	-25
PFHxA	313/269	-14	-30	¹³ C ₅ -PFHxA	318/273	-14	-25
PFHpA	363/169	-26	-25	¹³ C ₄ -PFHpA	367/322	-26	-25
PFOA	413/369	-16	-25	¹³ C ₈ -PFOA	421/376	-16	-25
PFNA	463/419	-15	-40	¹³ C ₉ -PFNA	472/427	-15	-25
PFDA	513/469	-16	-25	¹³ C ₆ -PFDA	519/474	-16	-25
PFUnDA	563/519	-15	-40	¹³ C ₇ -PFUnDA	570/525	-15	-25
PFDoDA	613/569	-20	-25	¹³ C ₂ -PFDoDA	615/570	-20	-25
PFBS	299/99	-35	-100	¹³ C ₃ -PFBS	302/99	-35	-100
PFPeS	349/80	-80	-150				
PFHxS	399/80	-90	-130	¹³ C ₃ -PFHxS	402/99	-80	-130
PFHpS	449/99	-100	-150				
L-PFOS	499/99.3	-95	-150	¹³ C ₈ -PFOS	507/99	-95	-150
1m-PFOS	499/419	-40	-150				
3/4/5m-PFOS	499/80	-120	-150				
2/6m-PFOS	499/169	-40	-150				

Note: PFAS abbreviations see Table S1.

Table S3. Limit of detection (LOD) for each PFAS in water, serum and urine samples

Compounds		LOD Water (ng/L)	LOD Serum (ng/ml)	LOD Urine (ng/ml)
PFCA	PFBA	0.6	NA ^a	NA
	PFPeA	0.6	0.08	NA
	PFHxA	0.3	0.07	0.1 ^b
	PFHpA	0.3	0.05	0.01
	PFOA	0.3	0.09	0.01
	PFNA	0.6	0.05	NA
	PFDA	0.6	0.09	NA
	PFUnDA	2	0.1	NA
	PFDoDA	2	0.2	NA
	PFSA	PFBS	0.3	0.05
PFPeS		0.3	0.02	0.01
PFHxS		0.3	0.1	0.01
PFHpS		0.3	0.1	0.01 ^b
L-PFOS		0.2	0.2	0.01
1m-PFOS		NA ^a	0.05	0.01
3/4/5m-PFOS		NA	0.01	0.02
2/6m-PFOS		NA	0.3	0.02
Fluorotelomer sulfonic-acid	6:2 FTS	0.3	NA	NA

Note: PFCA, perfluorinated carboxylic acid; PFSA, perfluorinated sulfonic acid. PFBA, perfluorobutanoic acid; 6:2 FTS, fluorotelomer sulfonic acid. Other PFAS abbreviations see Table S1.

^a Not measured in samples.

^b Estimated from urine matrix.

Table S4. Concentrations and coefficient of variation in the quality control samples (QC) in serum analysis

Compounds	QC1 ^a		QC2 ^a		QC3 ^b	
	concentration (ng/ml)	Precision (%)	concentration (ng/ml)	Precision (%)	concentration (ng/ml)	Precision (%)
PFPeA	<LOD ^c		<LOD		110	5
PFHxA	0.39	36	0.36	36	110	5
PFHpA	<LOD		<LOD		100	7
PFOA	1.3	7	1.6	9	110	6
PFNA	1.1	7	1.0	8	110	6
PFDA	0.30	13	0.29	12	110	7
PFUnDA	0.46	9	0.45	12	110	6
PFDoDA	<LOD		<LOD		110	6
PFBS	<LOD		<LOD		100	7
PFPeS	0.13	17	0.22	19	0.05	40
PFHxS	8.3	7	14	8	110	5
PFHpS	0.39	14	0.67	22	0.28	17
L-PFOS	6.6	8	9.8	10	110	5
1m-PFOS	1.3	14	0.33	19	0.79	15
3/4/5m-PFOS	3.8	20	2.2	14	2.5	14
2/6m-PFOS	1.5	20	2.5	16	1.4	20

Note: PFAS abbreviations see Table S1. LOD, limit of detection.

^a QC1 and QC2 were prepared in-house by pooling equal volumes of serum samples containing different levels of PFAS.

^b QC3 was prepared with additional spiking with PFAS standard solutions.

^c LOD are listed in table S3.

Table S5. Initial serum PFAS levels (ng/mL) for males and females from 26 airport employees

	PFAS	Males (N=19)			Females (N=7)			Difference between sexes
		Min	Median	Max	min	median	max	p-values ^a
Perfluorinated carboxylic-acid (PFCA)	PFHxA	0.16	0.42	1.1	0.19	0.24	0.54	0.015
	PFHpA	0.07	0.45	2.0	0.08	0.46	2.2	0.90
	PFOA	2.9	11	31	5.0	6.7	20	0.40
Perfluorinated sulfonic-acid (PFSA)	PFBS	<LOD ^b	0.32	1.1	0.06	0.39	1.3	0.78
	PFPeS	1.4	7.2	17	3.5	5.1	15	0.40
	PFHxS	17	78	402	21	74	183	0.61
	PFHpS	0.28	1.4	6.2	0.49	1.1	2.2	0.28
	L-PFOS	5.4	10	28	5.5	9.3	13	0.40
	1m-PFOS	0.25	1.1	4.1	0.39	0.58	1.1	0.31
	3/4/5m-PFOS	1.2	4.9	17	1.7	2.9	5.4	0.15
	2/6m-PFOS	0.84	2.5	7.5	1.0	1.4	2.8	0.094

Note: PFAS abbreviations see Table S1.

^a p values were derived from Mann-Whitney U Test comparing males and females.

^b LOD are listed in table S3.

Table S6. The concentration and relative composition of PFAS measured in drinking water and serum used for figure 1 (molar basis) and figure S1 (weight basis)

PFAS	Molar basis		Weight basis	
	Airport drinking water concentration (relative composition)	Serum ^a concentration (relative composition)	Airport drinking water concentration (relative composition)	Serum ^a concentration (relative composition)
PFHxA	1.05 (19.9%)	0.0012 (0.4%)	330 (16.8%)	0.38 (0.3%)
PFHpA	0.27 (5.0%)	0.0013 (0.5%)	97 (5.0%)	0.46 (0.4%)
PFOA	0.72 (13.7%)	0.022 (8.1%)	300 (15.3%)	9.1 (8.2%)
PFBS	0.67 (12.6%)	0.0011 (0.4%)	200 (10.2%)	0.33 (0.3%)
PFPeS	0.51 (9.7%)	0.020 (7.3%)	180 (9.2%)	6.9 (6.3%)
PFHxS	1.77 (33.6%)	0.19 (70.4%)	710 (36.2%)	76 (68.9%)
PFHpS	0.036 (0.7%)	0.0029 (1.1 %)	16 (0.8%)	1.3 (1.2%)
PFOS (linear)	0.12 (2.3%)	0.019 (7.0%)	62 (3.2%)	9.5 (8.6%)
PFOS (branched)	0.13 (2.4%)	0.013 (4.7%)	64 (3.3%)	6.4 (5.8%)
total	5.28 (100%)	0.27 (100%)	1959 (100%)	110 (100%)

Note: PFAS abbreviations see Table S1.

a. Serum concentration was the median level observed in the first serum samples from all 26 airport employees.

Table S7. Descriptive table of specific gravity adjusted urinary PFAS levels from 17 airport employees attending repeated sampling

PFAS	Sampling date	Specific gravity adjusted urinary level (ng/mL)					
		count	Min	25 percentile	Median	75 percentile	Max
PFHpA	2 nd sampling (October 2018)	17	<LOD ^a	0.02	0.03	0.04	0.05
	3 rd sampling (November, 2018)	16	<LOD	0.01	0.02	0.03	0.08
	4 th sampling (December 2018)	14	<LOD	0.01	0.02	0.03	0.06
	5 th sampling (January 2019)	12	<LOD	<LOD	0.02	0.03	0.06
PFOA	2 nd sampling (October 2018)	17	0.01	0.02	0.03	0.04	0.07
	3 rd sampling (November, 2018)	16	0.01	0.02	0.03	0.04	0.07
	4 th sampling (December 2018)	14	0.01	0.02	0.04	0.05	0.13
	5 th sampling (January 2019)	12	0.02	0.03	0.03	0.04	0.07
PFPeS	2 nd sampling (October 2018)	17	0.04	0.06	0.07	0.08	0.11
	3 rd sampling (November, 2018)	16	0.02	0.05	0.07	0.09	0.12
	4 th sampling (December 2018)	14	0.03	0.07	0.08	0.08	0.12
	5 th sampling (January 2019)	12	0.05	0.06	0.07	0.08	0.09
PFHxS	2 nd sampling (October 2018)	17	0.03	0.06	0.09	0.13	0.28
	3 rd sampling (November, 2018)	16	0.03	0.05	0.07	0.13	0.26
	4 th sampling (December 2018)	14	0.04	0.05	0.12	0.17	0.73
	5 th sampling (January 2019)	12	0.06	0.07	0.08	0.11	0.31
L-PFOS	2 nd sampling (October 2018)	17	<LOD	<LOD	<LOD	0.01	0.08
	3 rd sampling (November, 2018)	16	<LOD	<LOD	0.01	0.02	0.03
	4 th sampling (December 2018)	14	<LOD	<LOD	<LOD	0.02	0.05
	5 th sampling (January 2019)	12	<LOD	<LOD	<LOD	0.01	0.04
2/6m-PFOS	2 nd sampling (October 2018)	17	<LOD	<LOD	<LOD	<LOD	<LOD
	3 rd sampling (November, 2018)	16	<LOD	<LOD	<LOD	<LOD	0.04
	4 th sampling (December 2018)	14	<LOD	<LOD	<LOD	<LOD	1.60
	5 th sampling (January 2019)	12	<LOD	<LOD	<LOD	<LOD	0.03

Note: PFAS abbreviations see Table S1.

^a LOD are listed in table S3.

Table S8: Descriptive table of serum PFAS levels from 17 airport employees attending repeated sampling

		Count	Min	25 percentile	Median	75 percentile	Max
PFHxA	1 st sampling (September 2018)	17	0.16	0.24	0.37	0.48	0.92
	2 nd sampling (October 2018)	17	0.14	0.26	0.31	0.51	1.2
	3 rd sampling (November, 2018)	17	0.13	0.27	0.34	0.56	1.4
	4 th sampling (December 2018)	16	0.08	0.22	0.30	0.46	0.87
	5 th sampling (January 2019)	16	0.11	0.21	0.33	0.52	1.2
PFHpA	1 st sampling (September 2018)	17	0.20	0.45	0.53	1.1	2.2
	2 nd sampling (October 2018)	17	0.07	0.18	0.33	0.83	2.0
	3 rd sampling (November, 2018)	17	0.08	0.09	0.27	0.75	2.0
	4 th sampling (December 2018)	16	0.05	0.09	0.15	0.72	1.8
	5 th sampling (January 2019)	16	<LOD ^a	<LOD	0.10	0.50	1.4
PFOA	1 st sampling (September 2018)	17	5.0	8.7	13	16	31
	2 nd sampling (October 2018)	17	4.1	8.3	11	14	28
	3 rd sampling (November, 2018)	17	4.6	7.9	11	14	28
	4 th sampling (December 2018)	16	4.3	7.5	10	13	27
	5 th sampling (January 2019)	16	4.4	8.0	10	14	27
PFBS	1 st sampling (September 2018)	17	0.22	0.32	0.46	0.68	1.3
	2 nd sampling (October 2018)	17	<LOD	0.11	0.17	0.31	0.70
	3 rd sampling (November, 2018)	17	<LOD	<LOD	0.09	0.28	0.65
	4 th sampling (December 2018)	16	<LOD	<LOD	0.08	0.24	0.52
	5 th sampling (January 2019)	16	<LOD	<LOD	0.06	0.11	0.30
PFPeS	1 st sampling (September 2018)	17	3.6	5.8	7.6	13	17
	2 nd sampling (October 2018)	17	2.3	4.9	6.8	11	14
	3 rd sampling (November, 2018)	17	2.1	4.4	6.3	11	14
	4 th sampling (December 2018)	16	1.8	4.0	6.5	11	14
	5 th sampling (January 2019)	16	1.9	4.4	6.2	9.9	13
PFHxS	1 st sampling (September 2018)	17	21	63	133	155	402
	2 nd sampling (October 2018)	17	18	57	122	144	363
	3 rd sampling (November, 2018)	17	20	57	119	150	392

	4 th sampling (December 2018)	16	17	50	109	146	381
	5 th sampling (January 2019)	16	42	64	117	153	399
PFH ₂ S	1 st sampling (September 2018)	17	0.49	0.96	1.6	2.5	6.2
	2 nd sampling (October 2018)	17	0.45	0.95	1.5	2.1	6.1
	3 rd sampling (November, 2018)	17	0.47	0.94	1.4	1.9	6.3
	4 th sampling (December 2018)	16	0.35	0.93	1.5	2.1	5.9
	5 th sampling (January 2019)	16	0.45	1.1	1.5	2.2	6.2
L-PFOS	1 st sampling (September 2018)	17	5.5	7.7	11	15	28
	2 nd sampling (October 2018)	17	4.1	7.6	10	16	24
	3 rd sampling (November, 2018)	17	4.7	7.3	11	16	23
	4 th sampling (December 2018)	16	4.4	7.4	9.8	14	24
	5 th sampling (January 2019)	16	4.5	9.1	10	16	23
1m-PFOS	1 st sampling (September 2018)	17	0.32	0.48	1.0	1.8	4.1
	2 nd sampling (October 2018)	17	0.26	0.54	0.89	1.4	4.0
	3 rd sampling (November, 2018)	17	0.24	0.54	0.88	1.5	4.4
	4 th sampling (December 2018)	16	0.24	0.47	0.91	1.3	4.3
	5 th sampling (January 2019)	16	0.26	0.51	0.97	1.3	4.5
3/4/5m-PFOS	1 st sampling (September 2018)	17	1.7	2.7	4.9	6.3	17
	2 nd sampling (October 2018)	17	1.3	2.4	4.1	4.8	15
	3 rd sampling (November, 2018)	17	1.0	2.5	4.2	5.1	16
	4 th sampling (December 2018)	16	1.0	2.1	3.6	4.9	16
	5 th sampling (January 2019)	16	1.0	2.7	4.0	4.9	16
2/6m-PFOS	1 st sampling (September 2018)	17	1.0	1.4	2.6	3.6	7.5
	2 nd sampling (October 2018)	17	0.97	1.5	2.2	2.8	7.2
	3 rd sampling (November, 2018)	17	0.66	1.3	2.3	3.5	8.1
	4 th sampling (December 2018)	16	0.57	0.96	1.9	2.9	7.1
	5 th sampling (January 2019)	16	0.83	1.2	2.1	2.7	7.0

Note: PFAS abbreviations see Table S1.

^a LOD are listed in table S3.

Supplementary Figures:

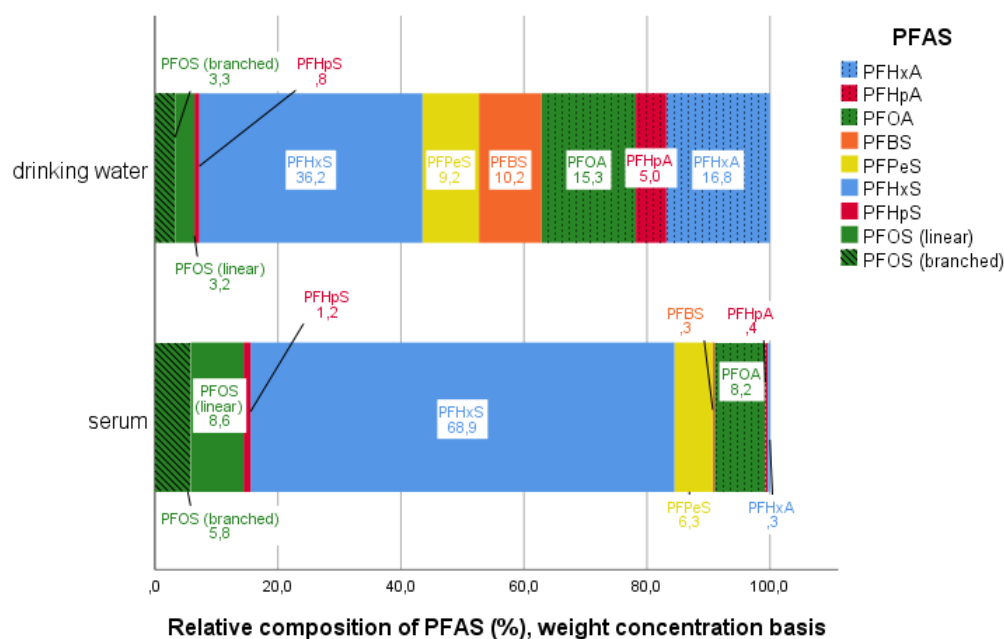


Figure S1: Composition (weight concentration basis) of perfluorinated carboxylic acid (PFCA, dotted bars) and perfluorinated sulfonic acid (PFSA, open bars; branched PFOS in hatched bar) in drinking water and in first serum samples obtained from 26 airport employees. PFCA and PFSA with same number of carbons in the carbon chain (i.e. PFHxA vs. PFHxS, PFHpA vs. PFHpS, and PFOA vs. PFOS) are illustrated with same color. Although PFBA and PFPeA were elevated in the drinking water, they were below LOD in all the serum samples, so they were not presented.

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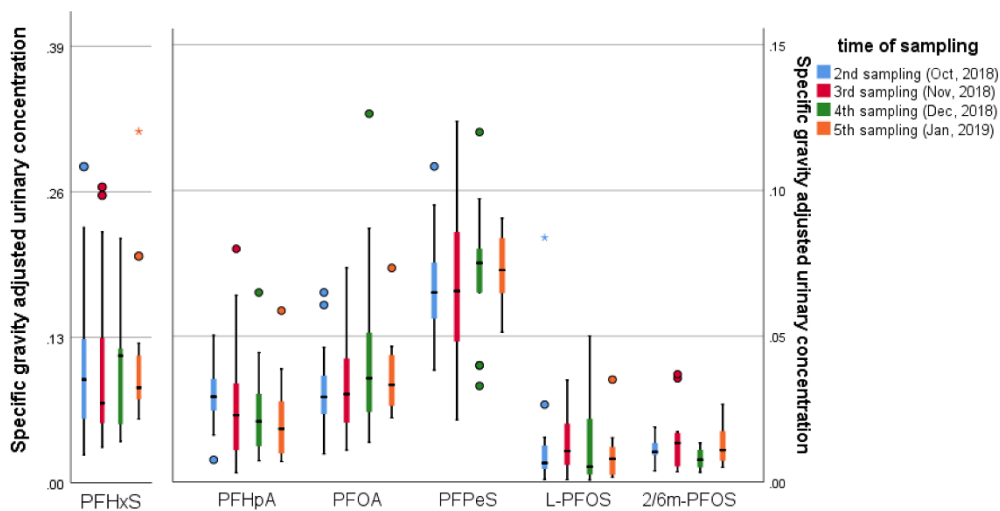


Figure S2: Box plot of specific gravity adjusted urinary concentration of PFHpA, PFOA, PFPeS, PFHxS L-PFOS and 2/6m-PFOS at each sampling. PFHxS showed higher concentration than the rest of the PFAS, thus note a different scale on y-axis. The descriptive data are listed in Table S7.

Note: PFAS abbreviations see Table S1.

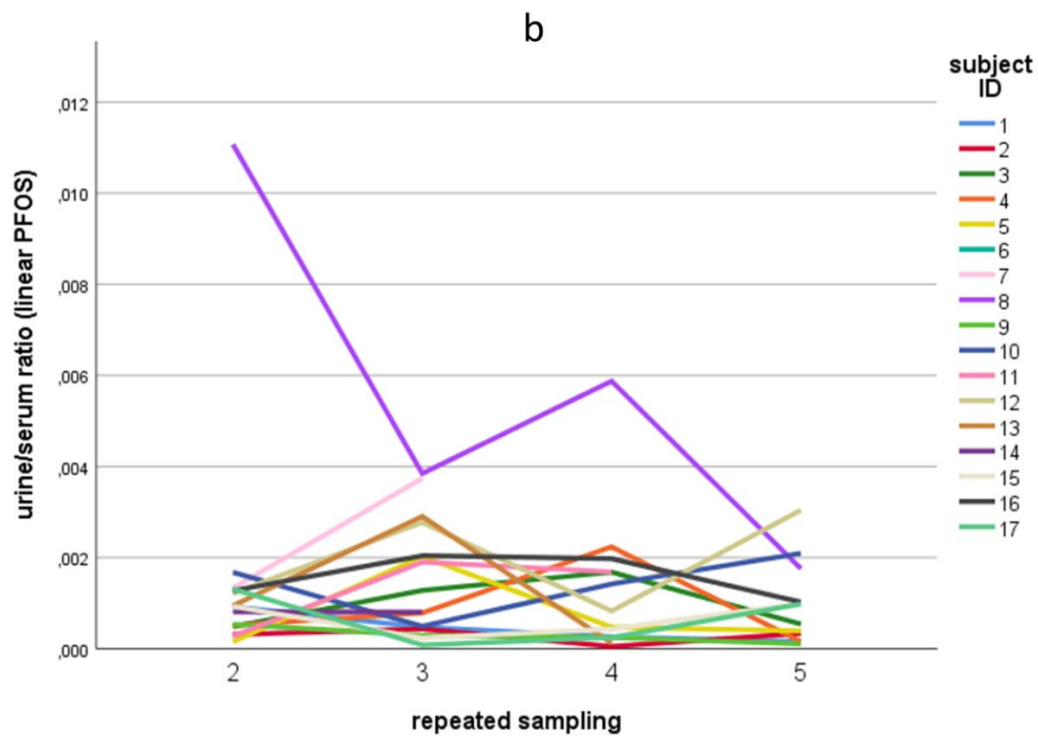
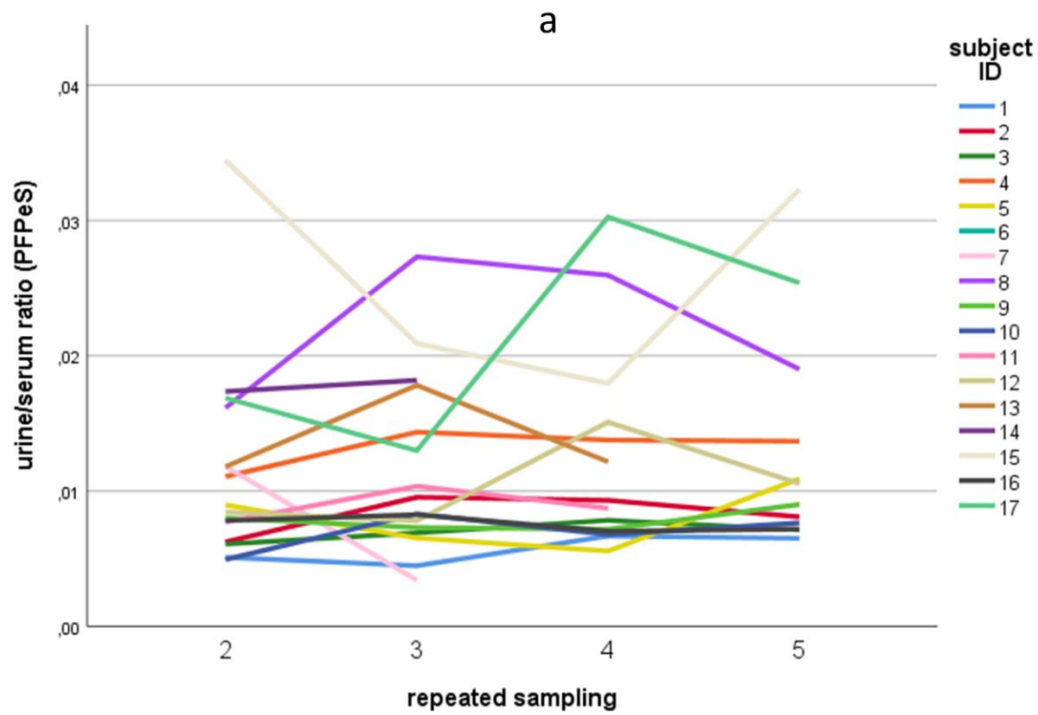


Figure S3: Pattern of change in urine/serum ratio of a) PFPeS and b) L-PFOS for each individual over four paired samplings.

Note: PFAS abbreviations see Table S1.