

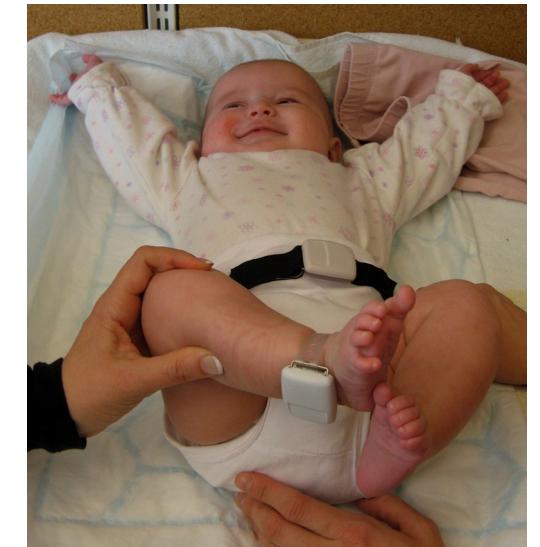
ANALYSIS OF INFANT ACCELEROMETER DATA

November 11, 2016

**Presented by
Jerneja Mislej, Msc student of Bioinformatics**

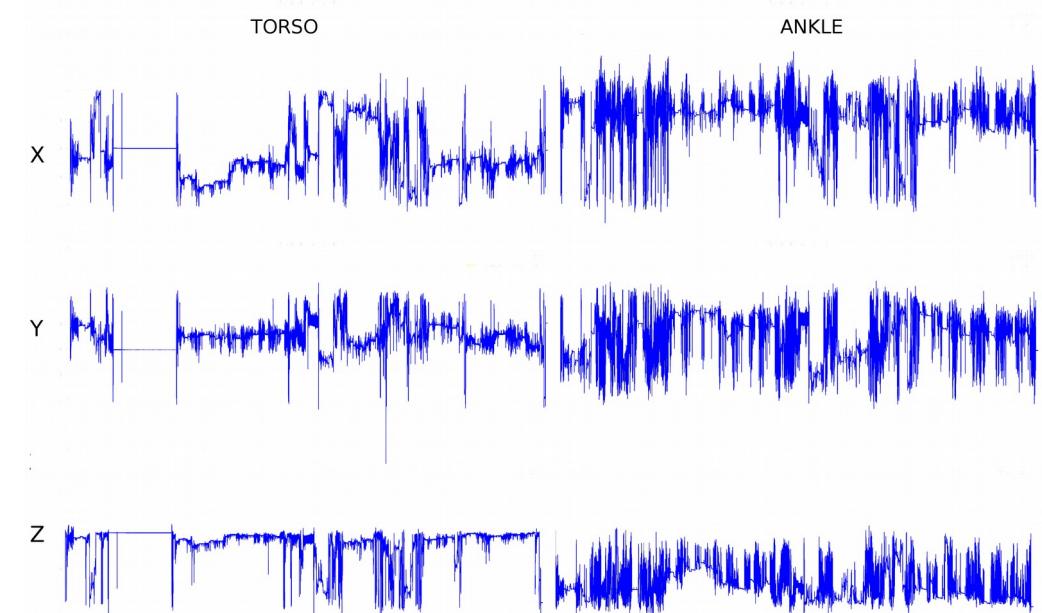
INTRODUCTION

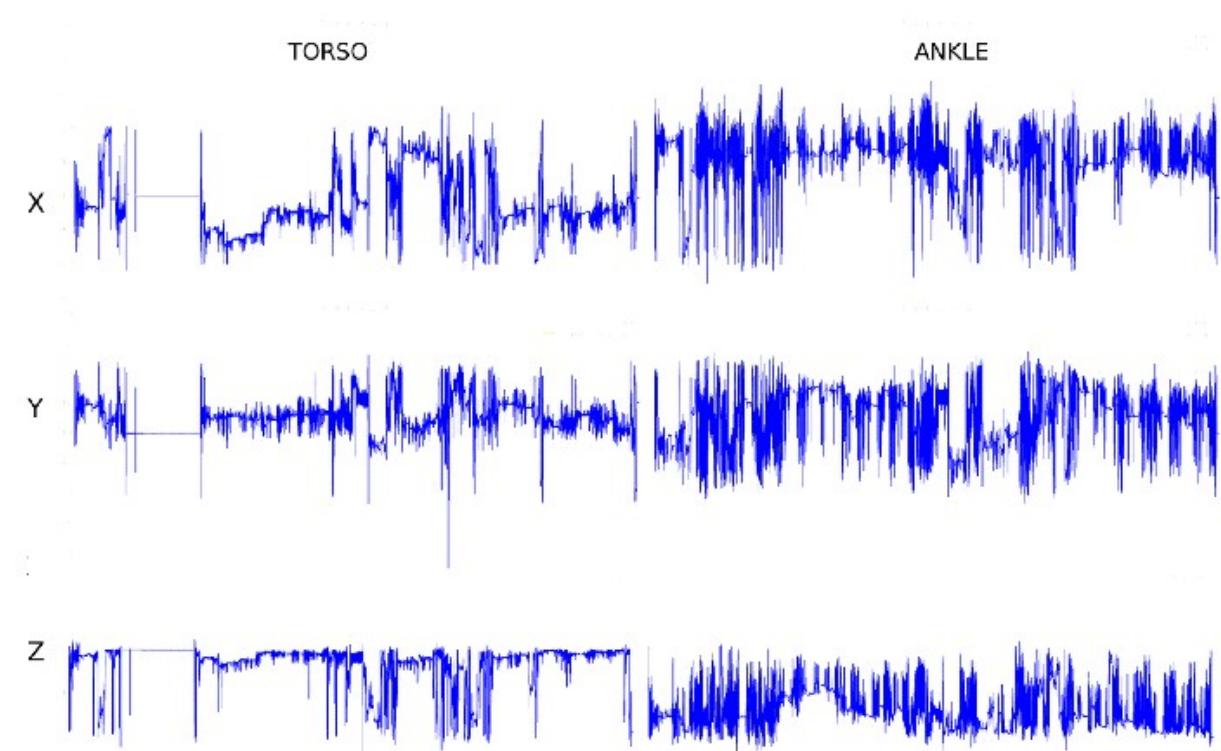
- Data collected during a project which focused on **lifestyle behaviors and pregnancy**.
- Mothers **pre and post-partum** and infants **post-partum** characteristics were measured and obtained.
- Including infants accelerometer data and infants sleeping and feeding diaries
- Focusing on the estimation of **infants physical activity**(PA) and the feasibility of estimation



INTRODUCTION

- Tri-axial accelerometers placed on 30 infants, on the torso and ankle.
- Data sampled at 40 Hz for 48 hours in a free living environment.
- PA estimated based on increased acceleration.
- Measurements can contain **contributing and lacking accelerations** due to environment factors not related to infants own PA.

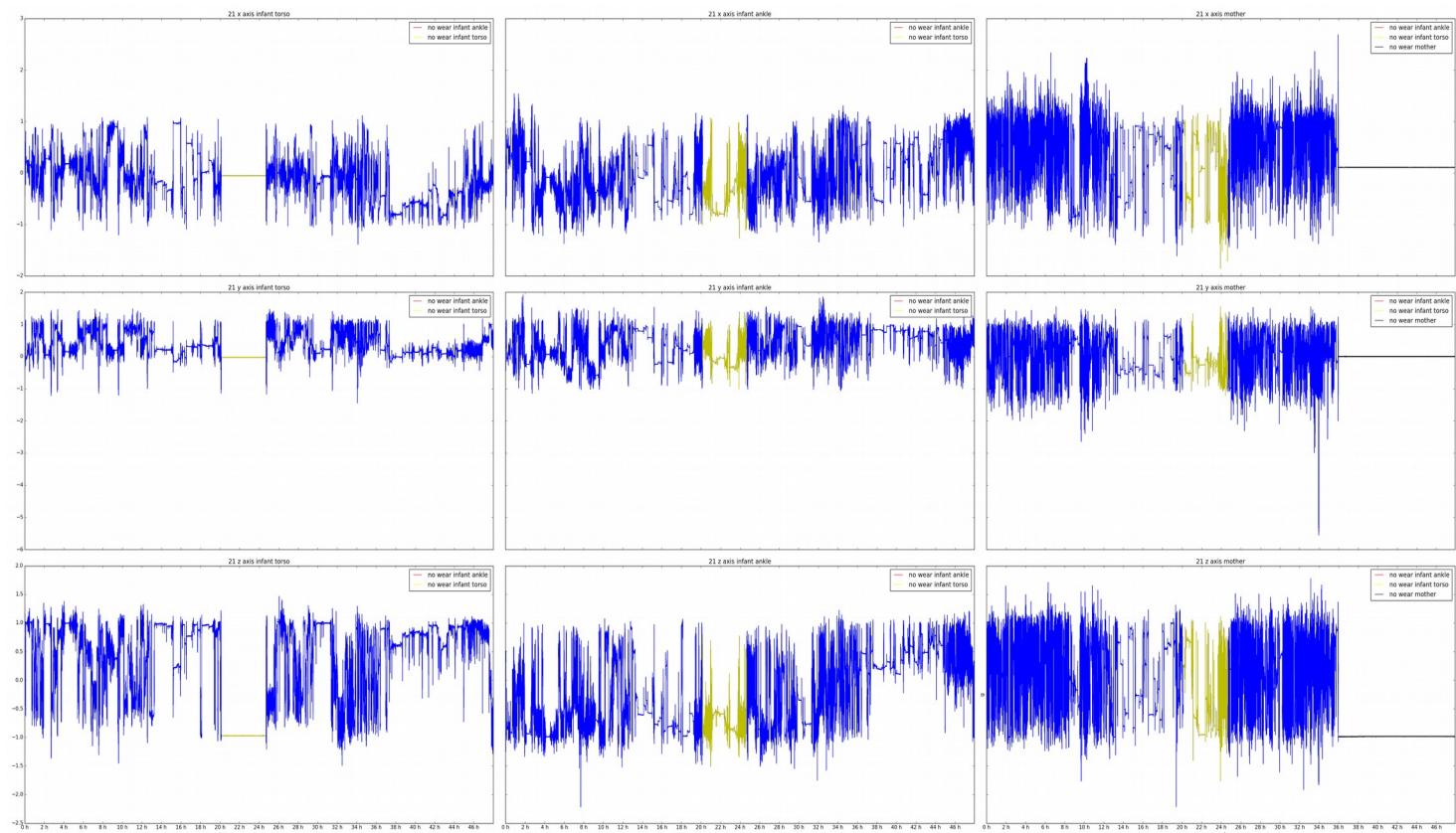




DATA PREPROCESSING

NON-WEAR DETECTION

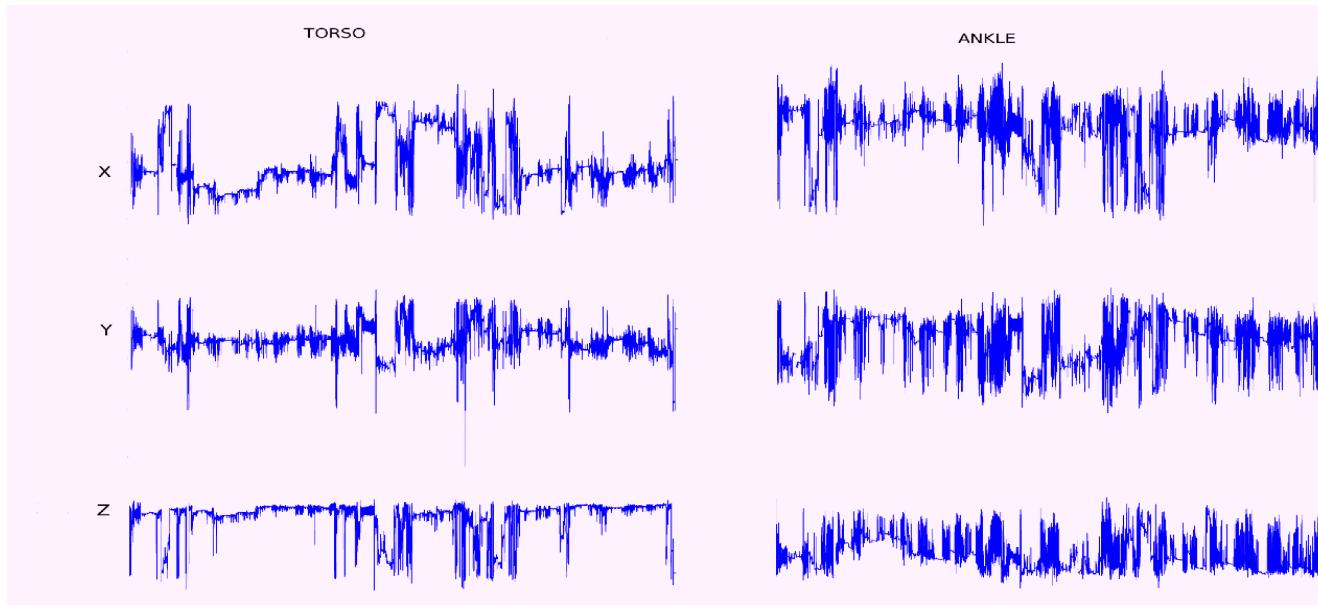
- Non-wear detected based on published methods.
- Detection factors:
 - standard deviation(SD)
 - span from min to max + slope of the fitted line



DATA PREPROCESSING

ACCELERATION SUMMARY

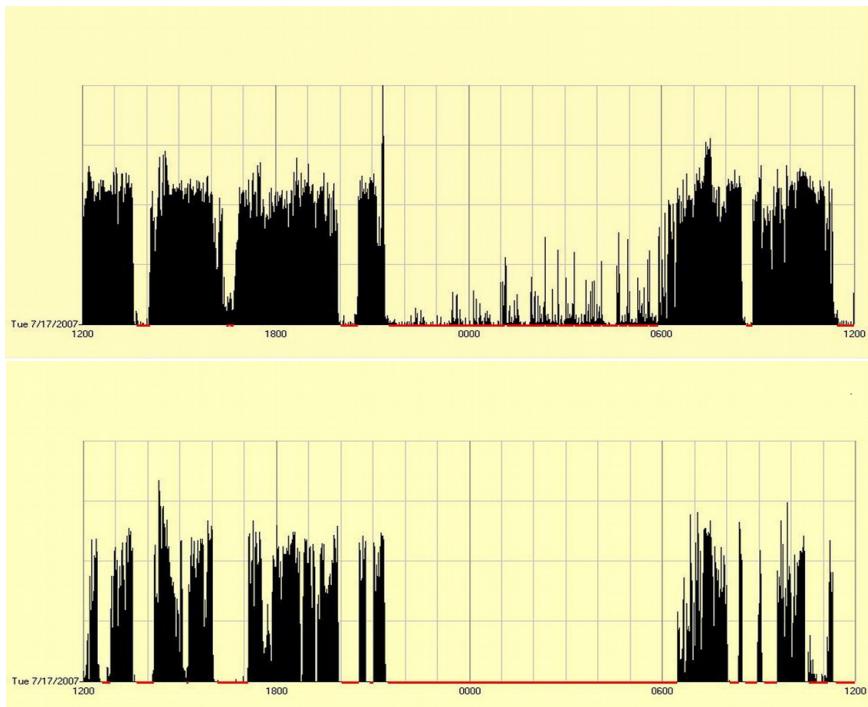
- Summary required due to instrumental noise, relatively high sampling rate and complications arising from multiple axis alignment.
- Commonly used summaries include Euclidean norm and/or bandpass filters.



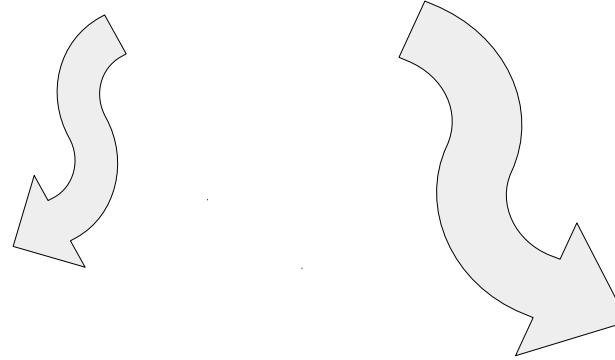
DATA PREPROCESSING

CONTRIBUTING ACCELERATIONS

- There are no published methods for removal of accelerations contributed by the caretakers.



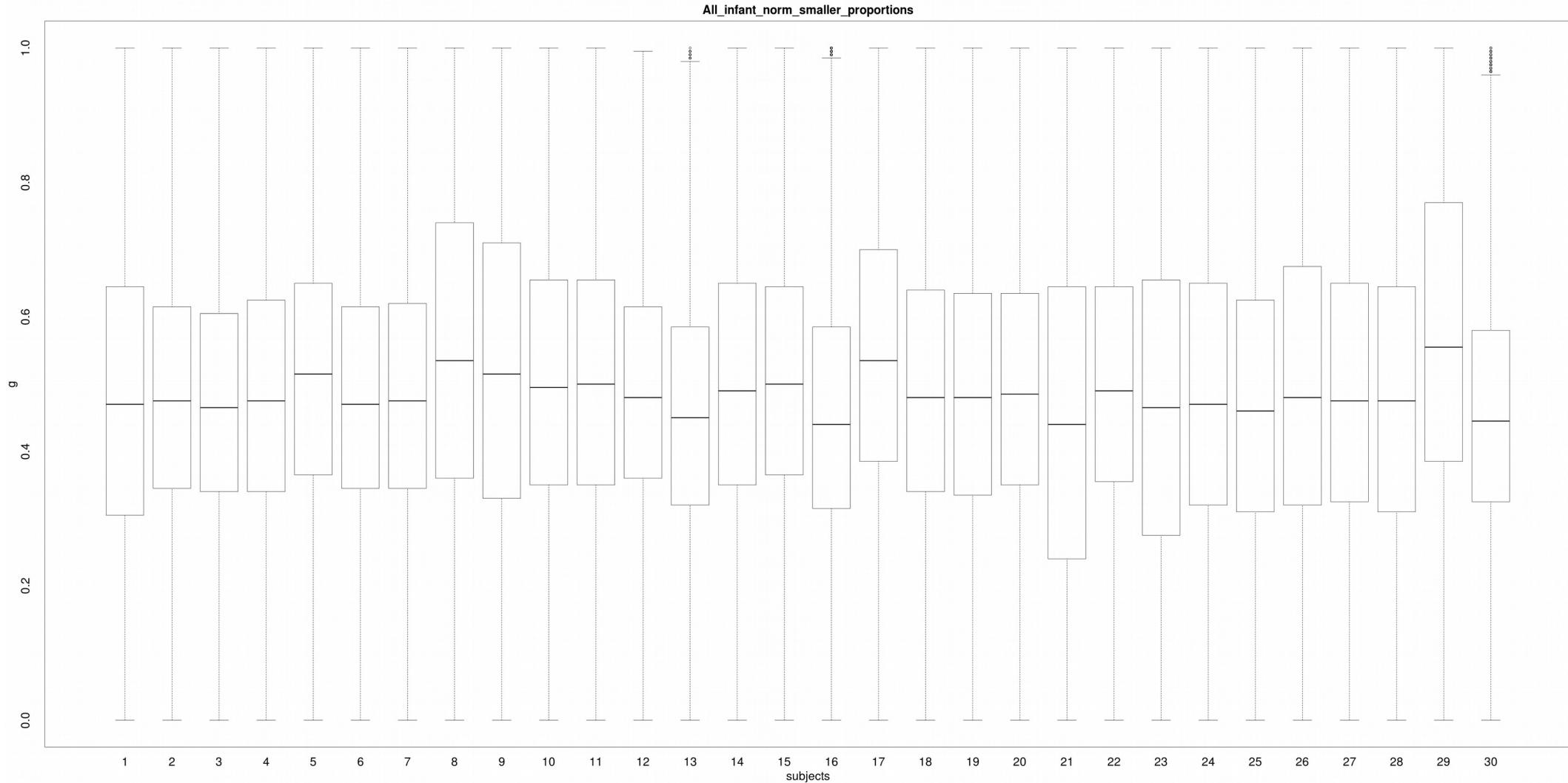
- Issue had been addressed and published along with the feasibility of estimating infants PA.



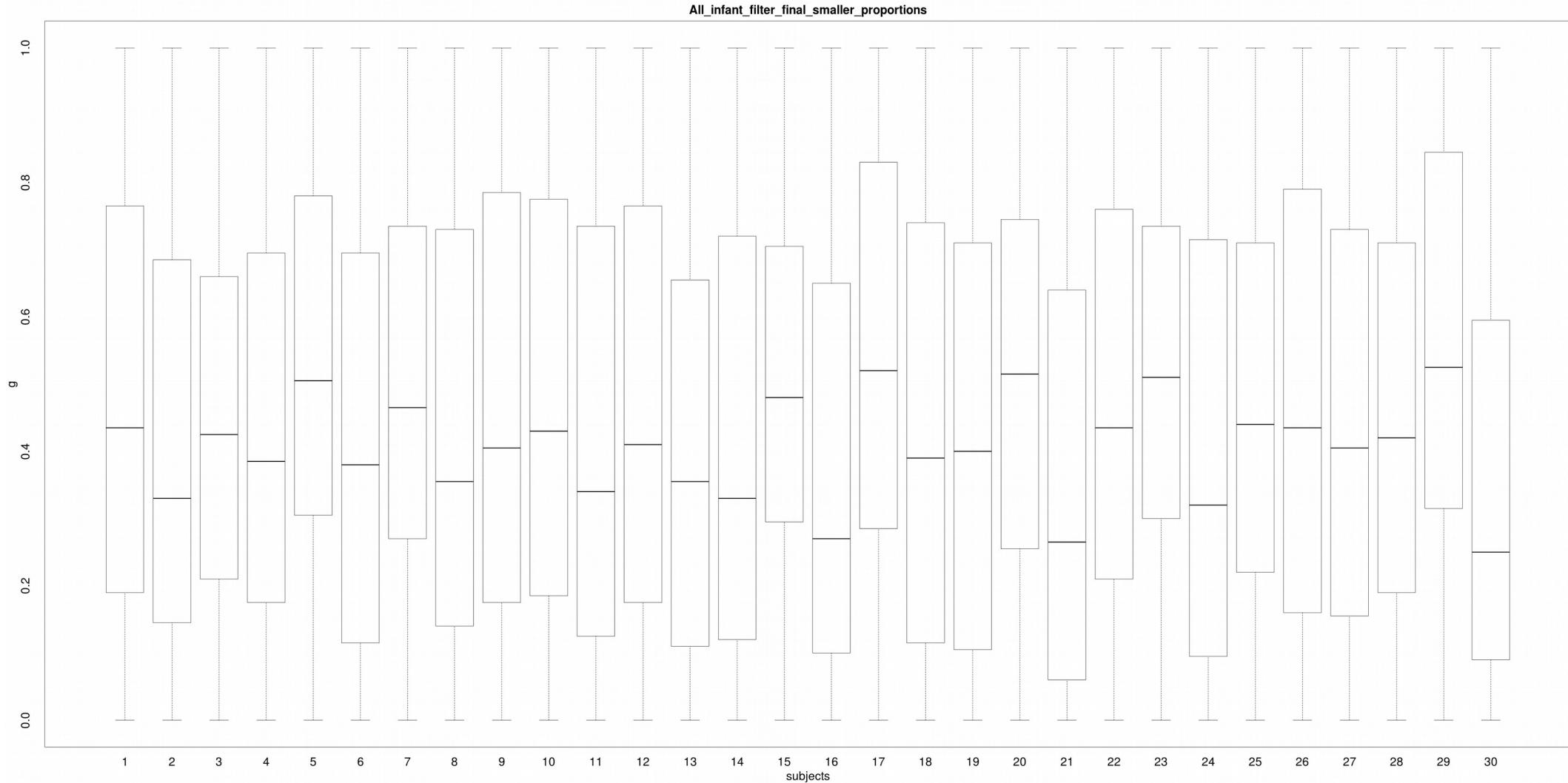
Proportion of contributing accelerations

activity placement \	stroller	carrying	Swiss ball
arm	29%	23%	28%
leg	9%	52%	21%

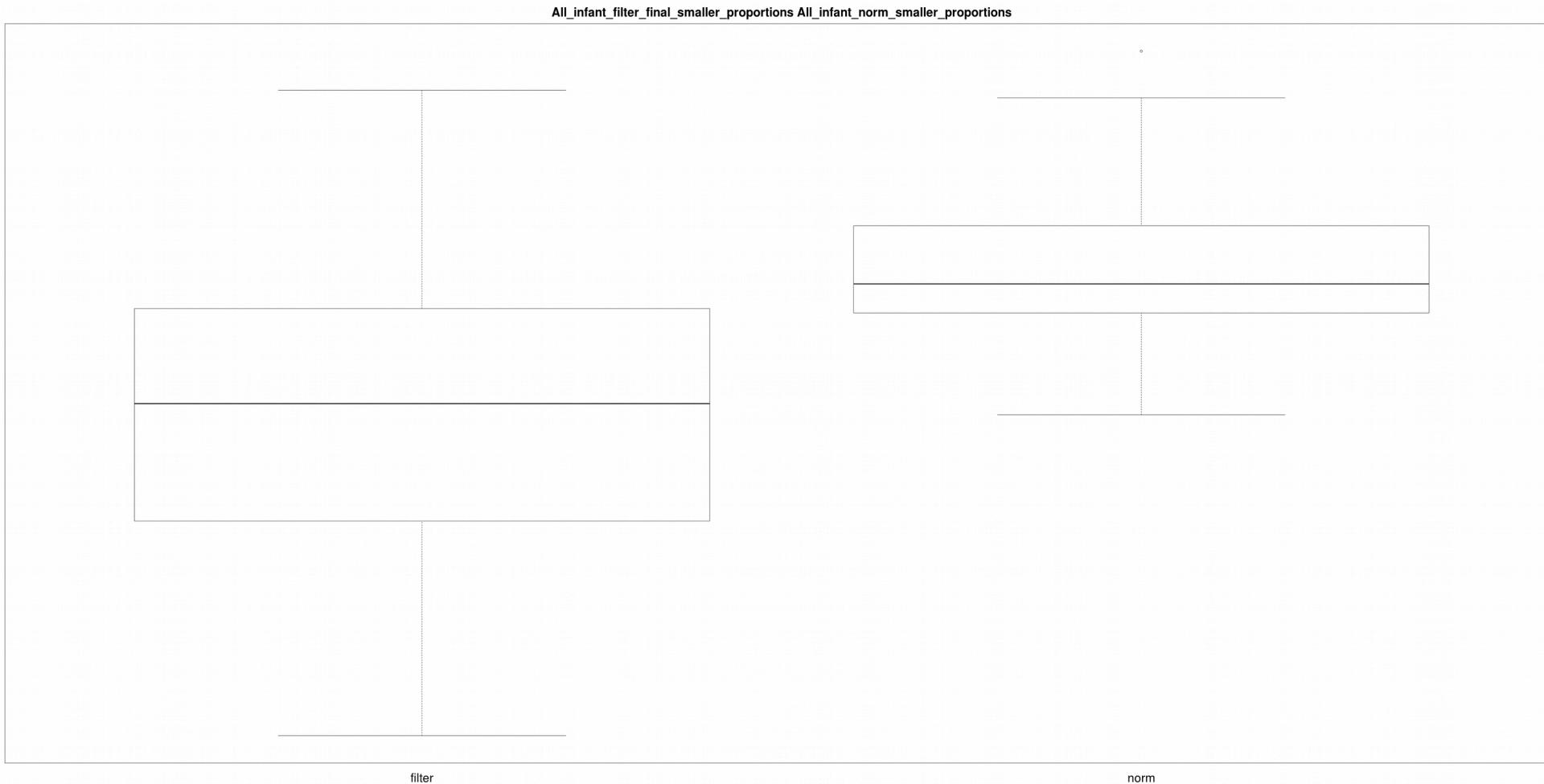
CONSIDERING VARIABILITY



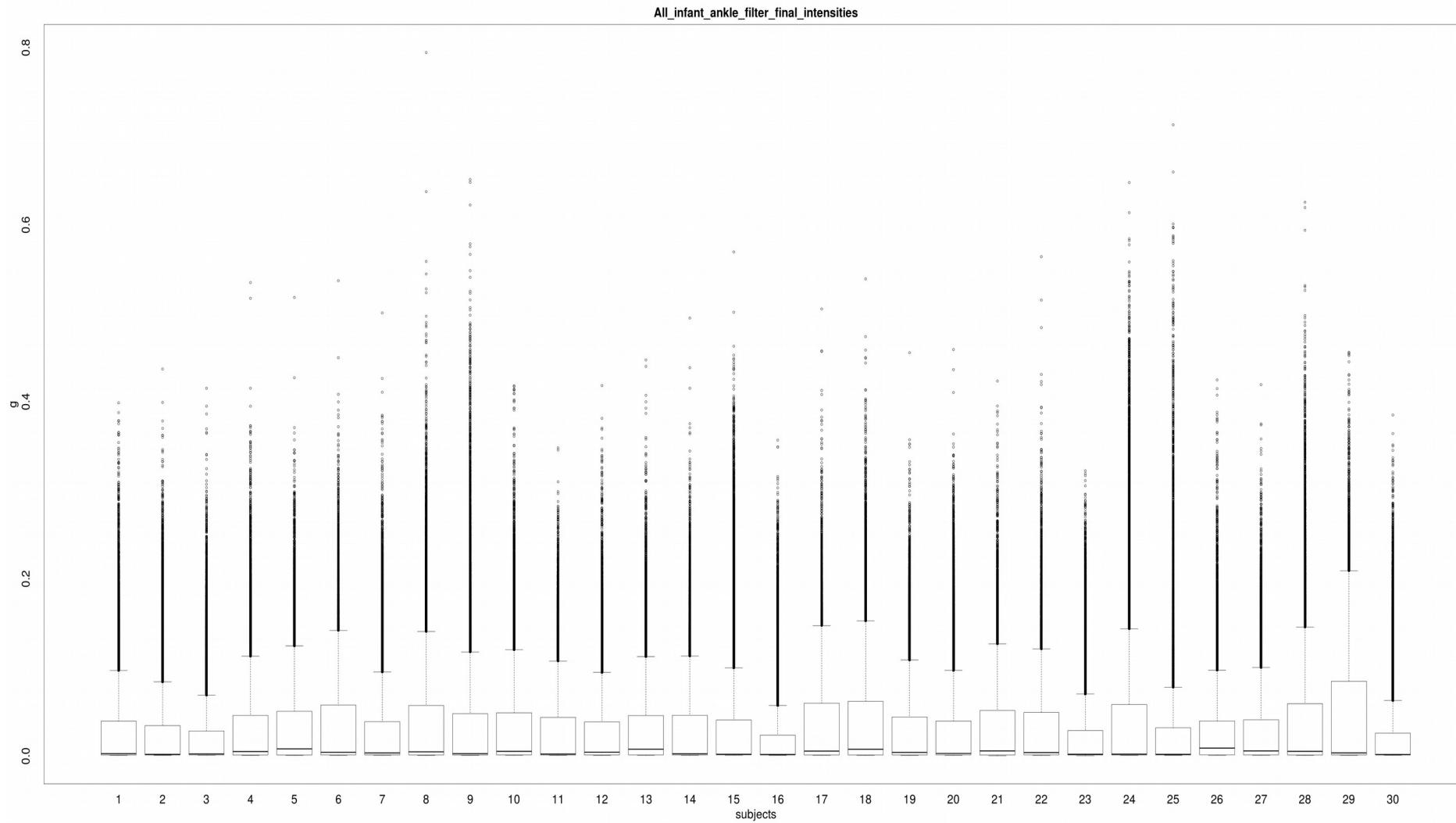
CONSIDERING VARIABILITY



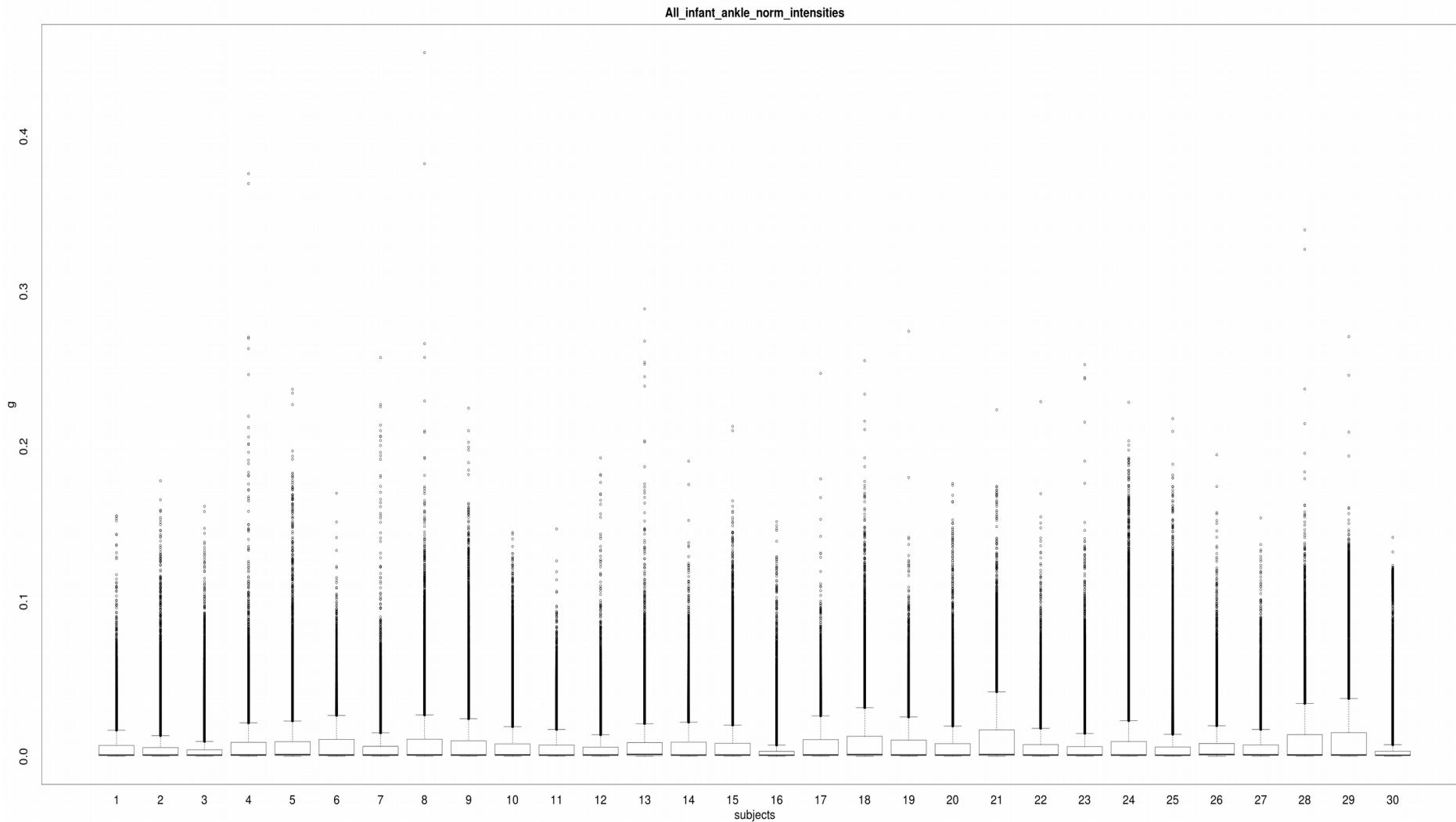
CONSIDERING VARIABILITY



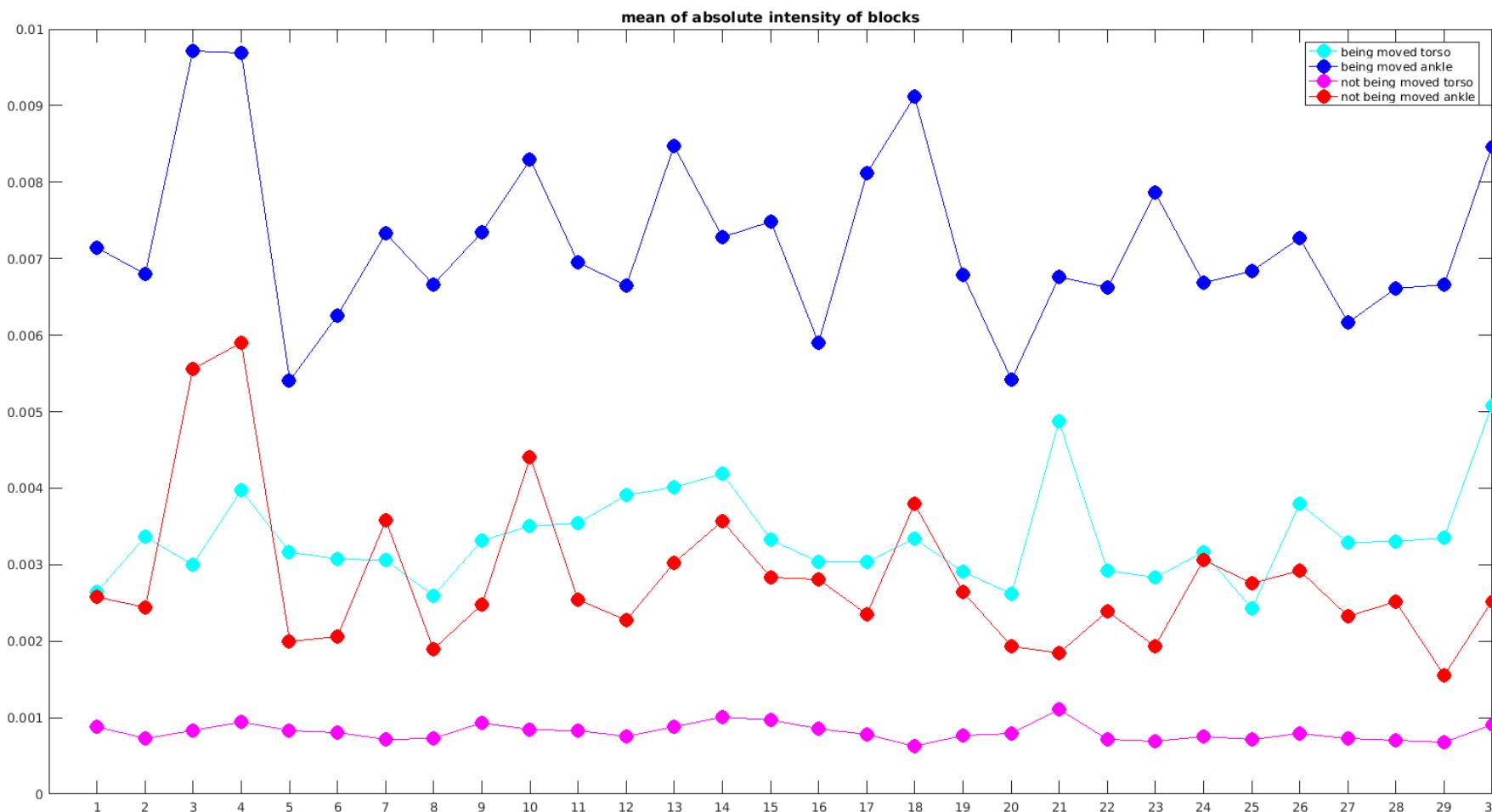
CONSIDERING VARIABILITY



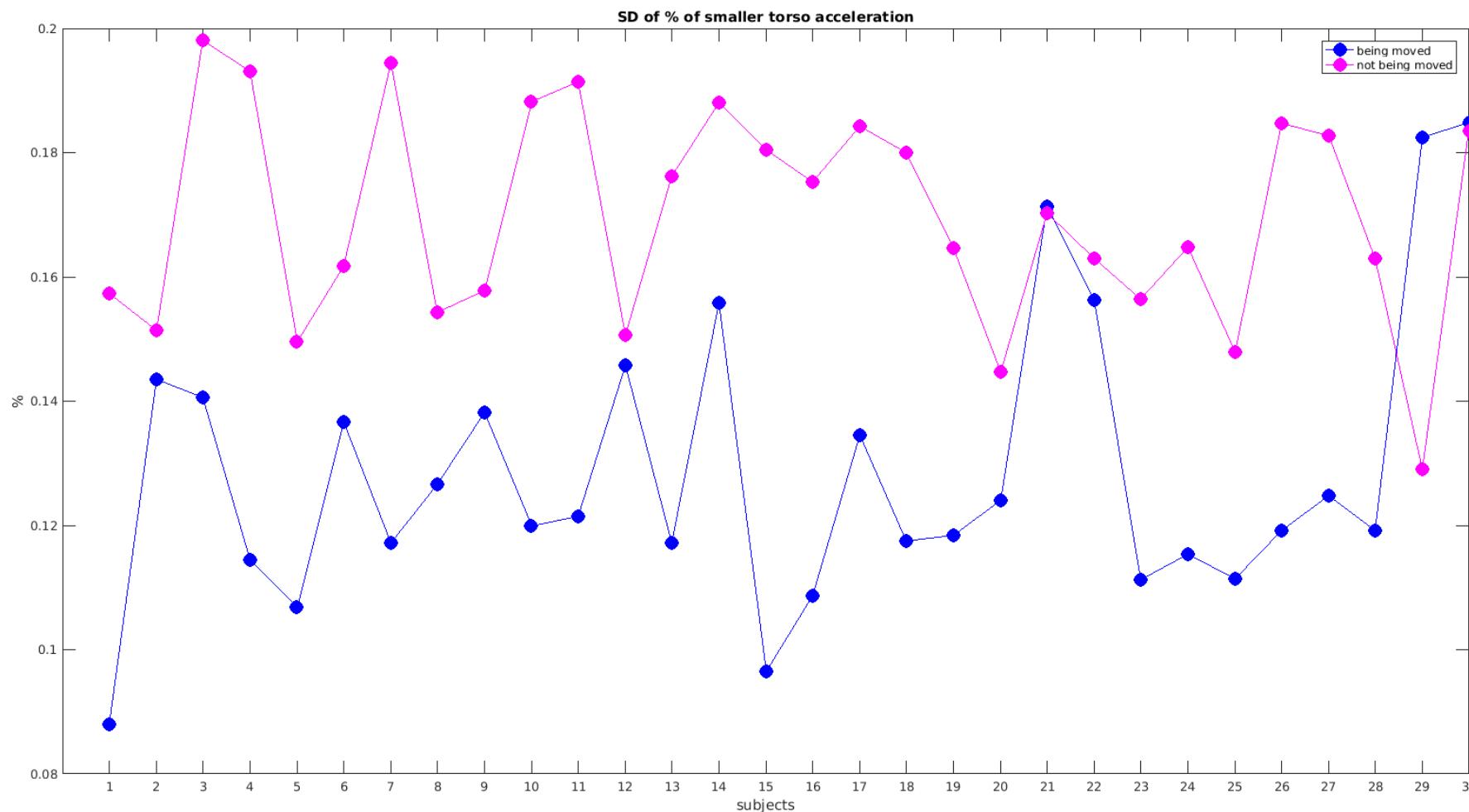
CONSIDERING VARIABILITY



CONSIDERING VARIABILITY



CONSIDERING VARIABILITY



DATA PREPROCESSING

CONTRIBUTING ACCELERATIONS

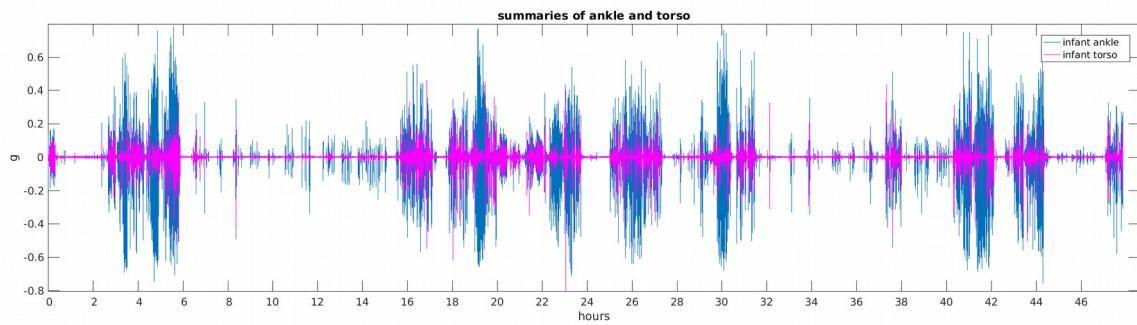
- Several approaches implemented and tested:
 - A) Simple subtraction of measurements
 - B) Subtraction of windowed intensities
 - C) Correction based on the ratio of windowed intensities
 - D) Correction based on correlation of windowed intensities
 - E) Complete removal of blocks where infant was moved



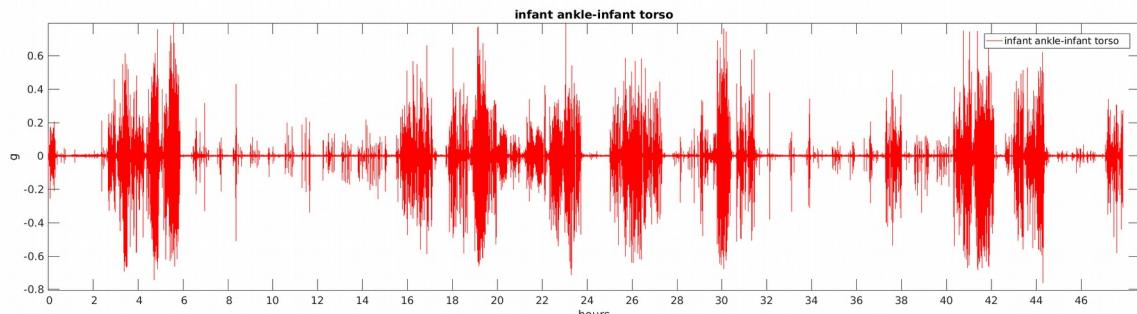
DATA PREPROCESSING

CONTRIBUTING ACCELERATIONS

A) Simple subtraction of measurements inefficient mainly due to point to point difference between torso and ankle.



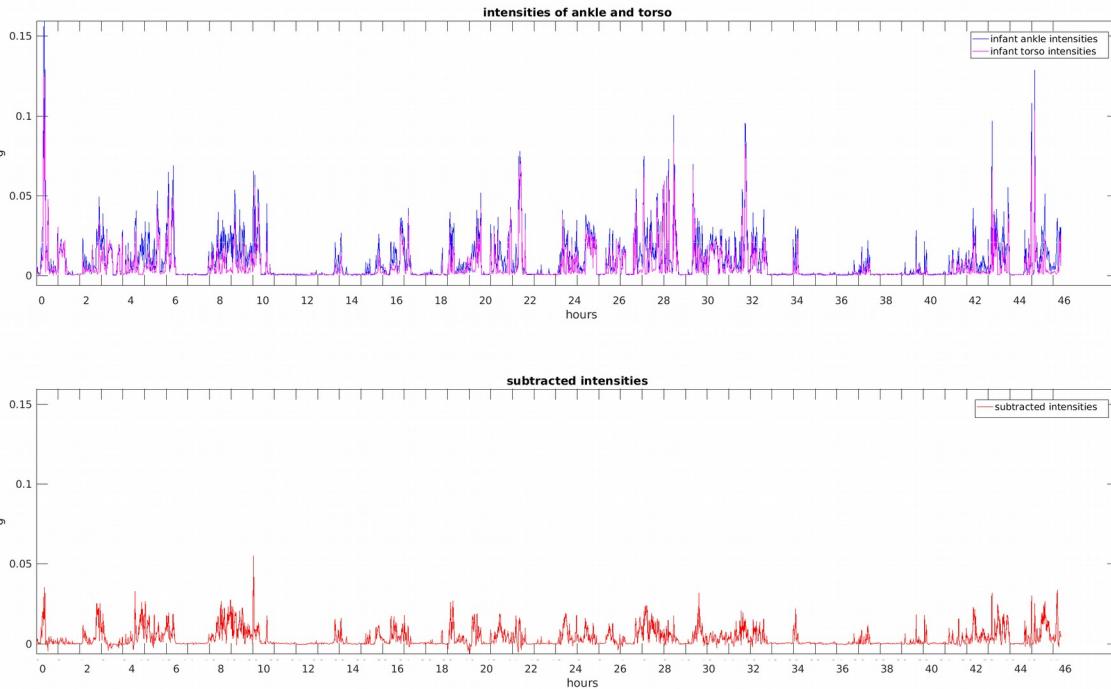
- SD increased by ~15%, absolute intensity by ~20%.



DATA PREPROCESSING

CONTRIBUTING ACCELERATIONS

B) Subtraction of windowed intensities slightly improves results.

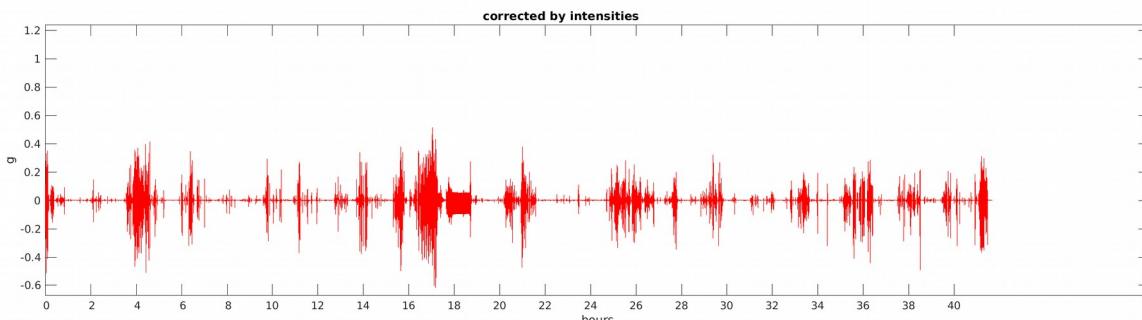
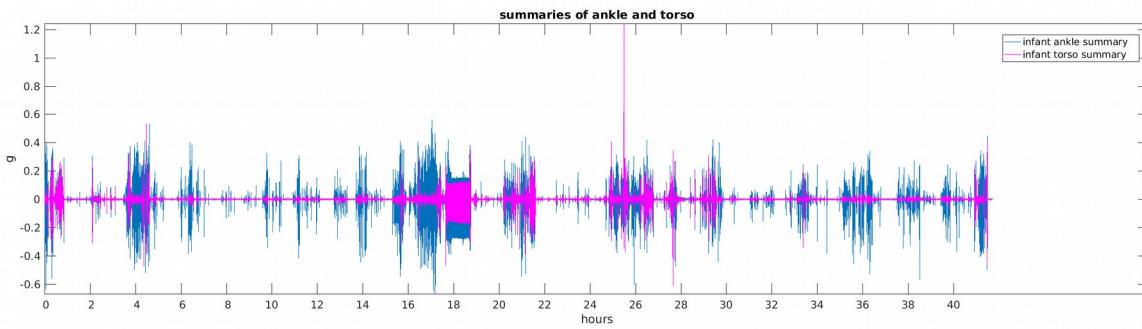


- Reduced point to point difference and proportion of smaller acceleration on ankle.

DATA PREPROCESSING

CONTRIBUTING ACCELERATIONS

C) Correction based on the ratio of windowed intensities, where the ankle measurement is decreased by the ratio of the absolute intensities.

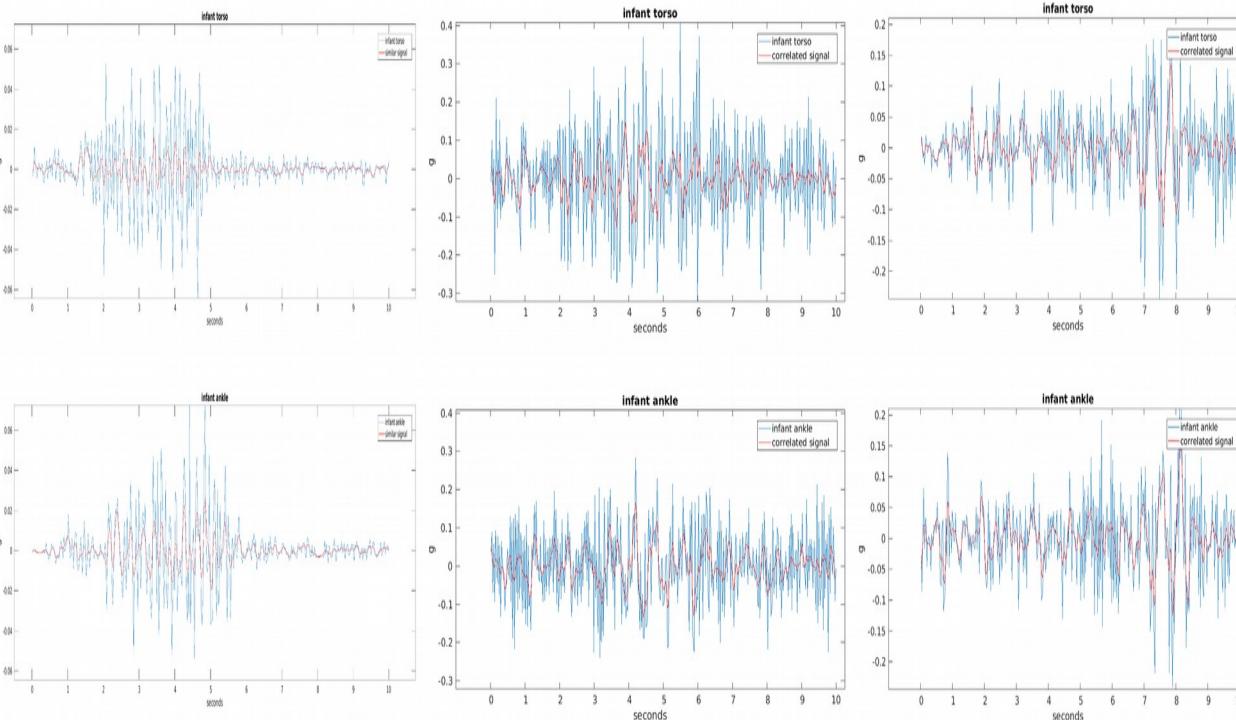


- SD decreased by ~44%, absolute intensity by ~47%.

DATA PREPROCESSING

CONTRIBUTING ACCELERATIONS

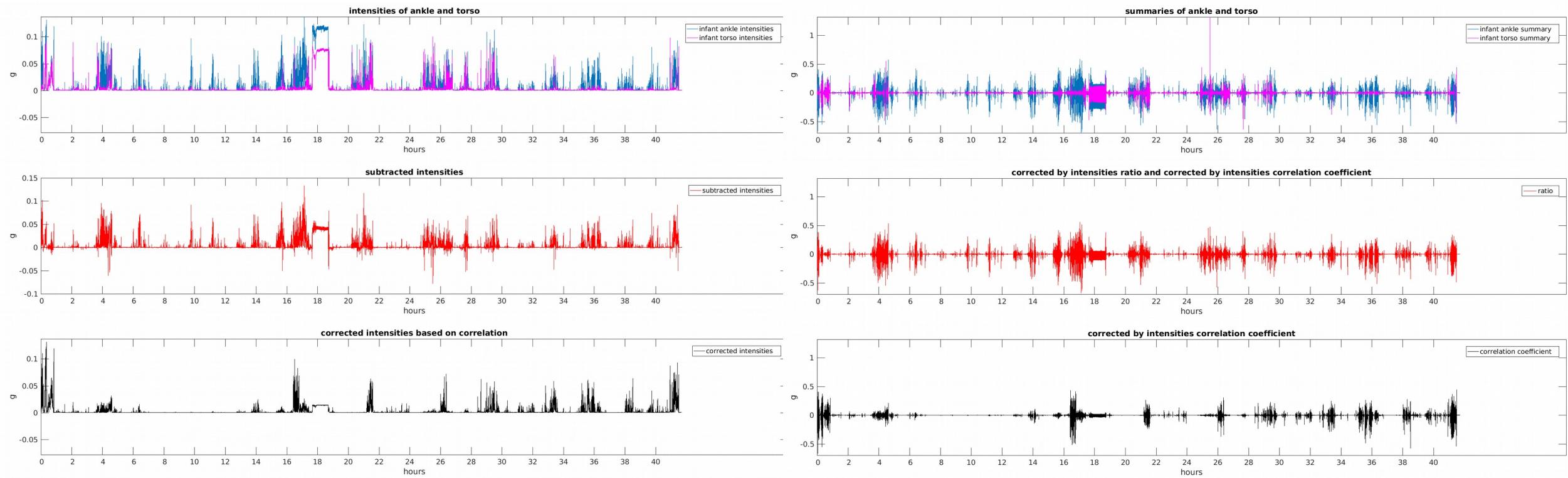
D) Correction based on correlation of windowed intensities, where the ankle measurement is decreased by the correlation coefficient of the absolute intensities.



- Correction based on similarity and allowing larger torso accelerations.
- SD and absolute intensity decreased by ~58%.

DATA PREPROCESSING

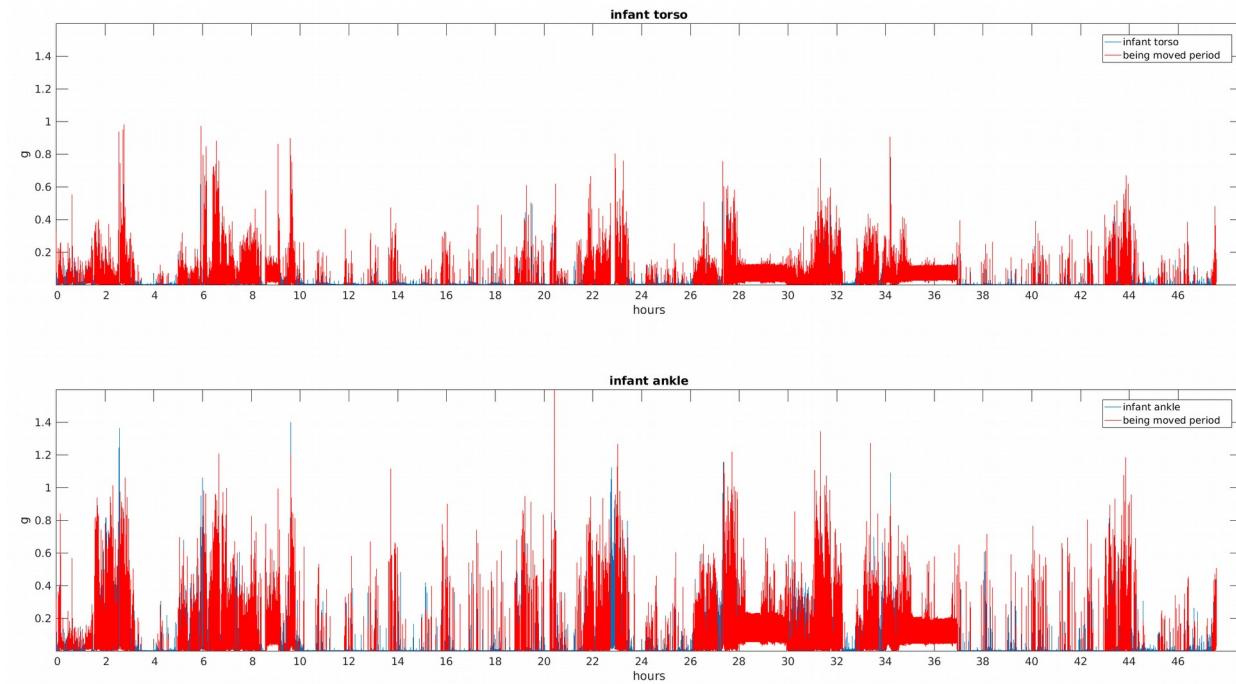
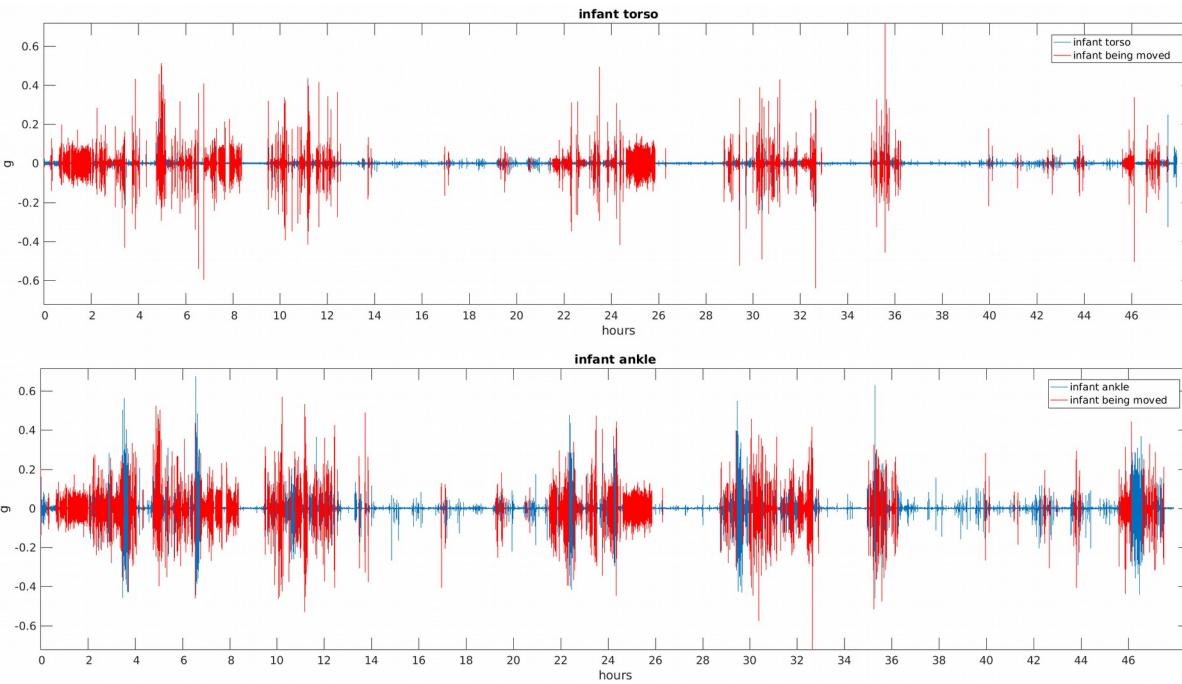
CONTRIBUTING ACCELERATIONS



DATA PREPROCESSING

CONTRIBUTING ACCELERATIONS

E) Complete removal of periods where the infant was moved.



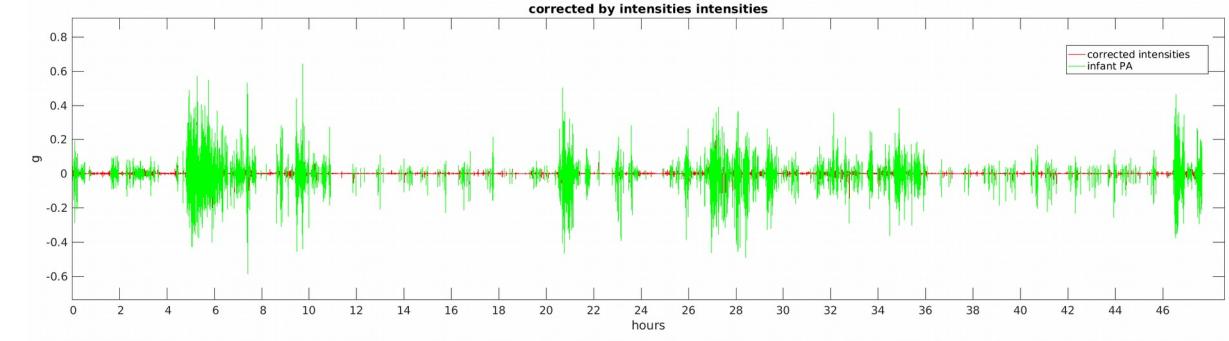
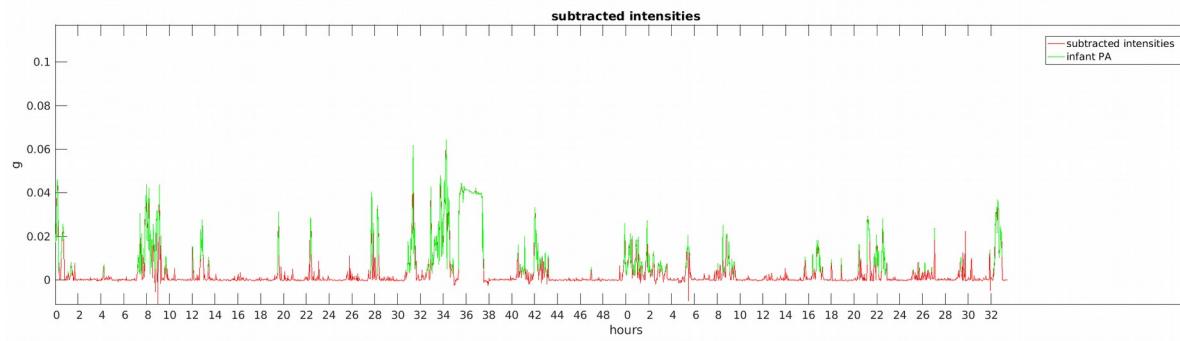
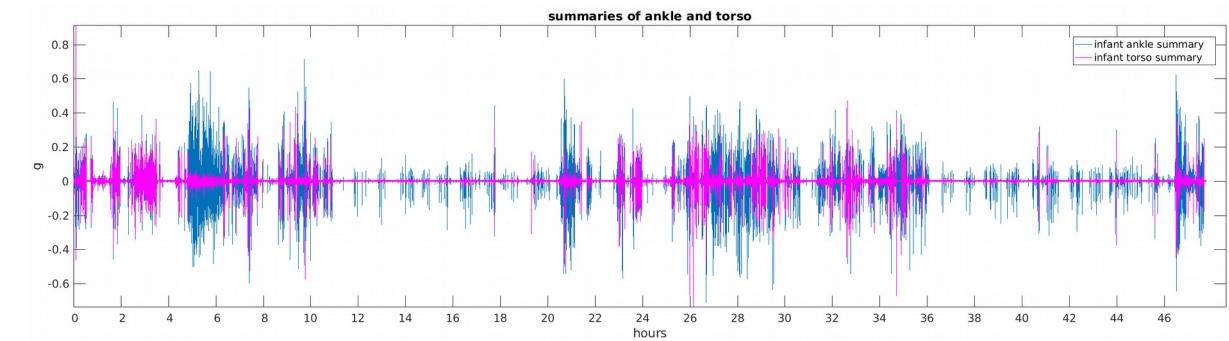
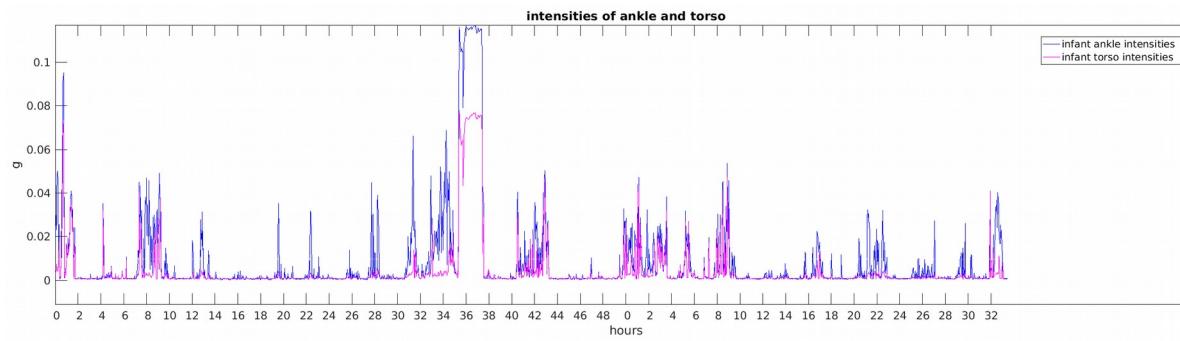
PHYSICAL ACTIVITY

- PA extracted from the remaining or corrected ankle measurement.
- Extraction based on threshold for windowed SD, or absolute intensity size.
- Considering the assumption that infant can not move his own torso:

PA ~ proportion of increased ankle accelerations that do not have corresponding increased torso accelerations
→ over 30 infants: from ~20% to ~50%

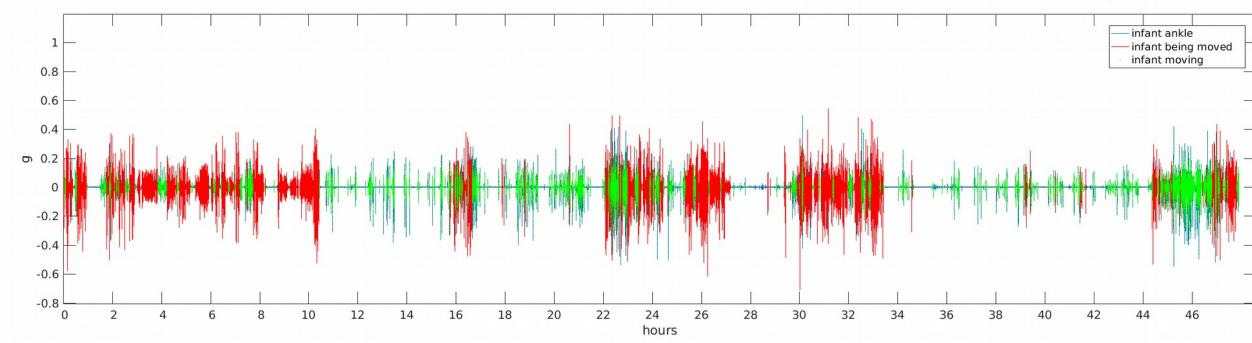
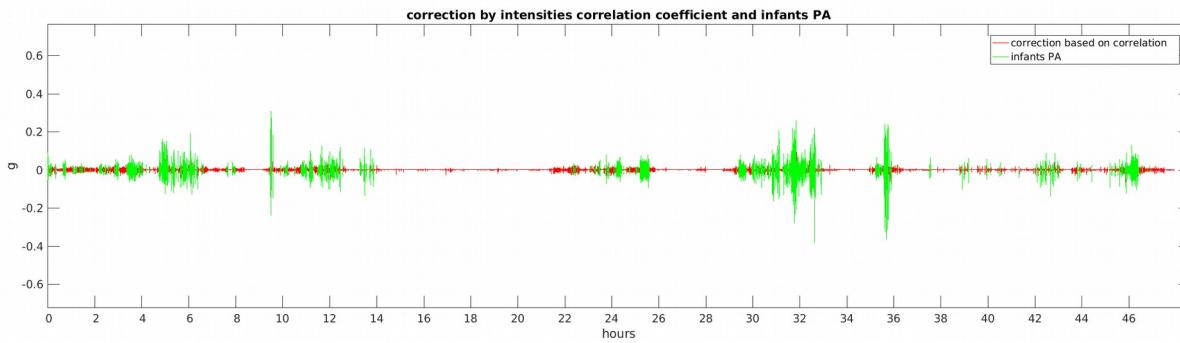
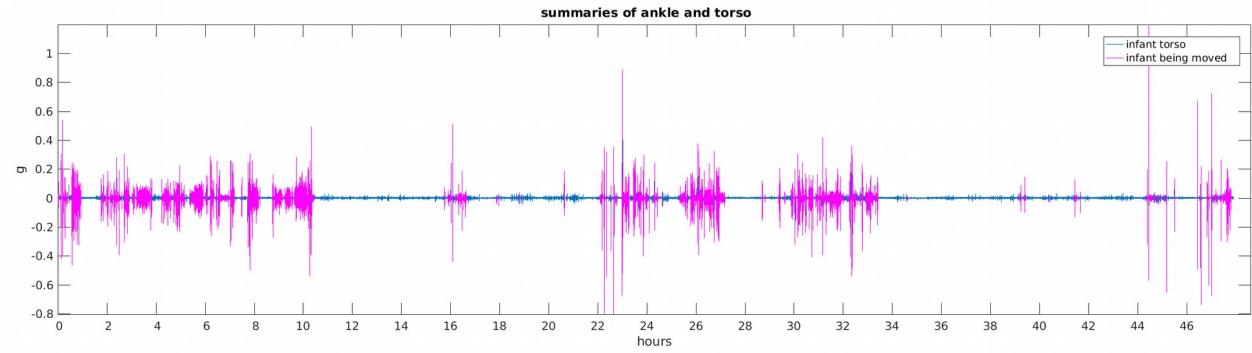
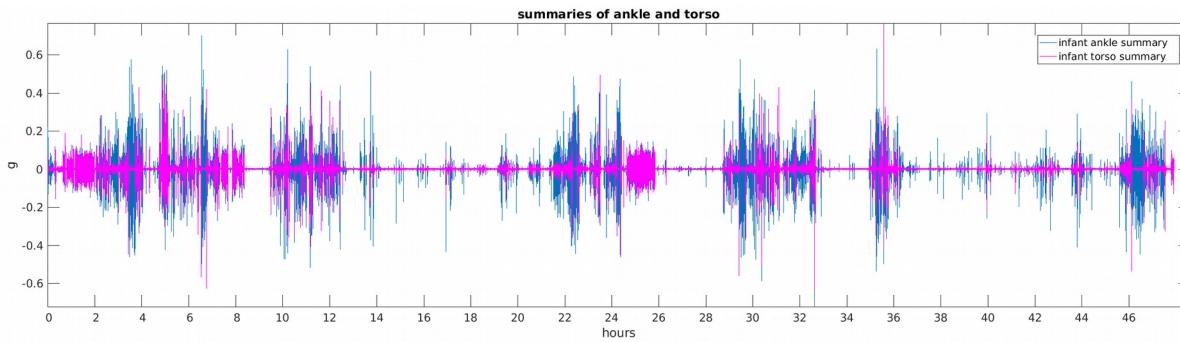
PHYSICAL ACTIVITY

- Approaches **B** and **C**:



PHYSICAL ACTIVITY

- Approaches D and E:



PHYSICAL ACTIVITY

- Proportion of time in PA versus proportion of time being moved:

	Spearmans rho
Approach A	0.84***
Approach B	0.48**
Approach C	0.64***
Approach D	0.41*
Approach E	-0.42*

DIARIES AND VALIDATION

- During the free living experiment, the mothers were instructed to keep a diary consisting of printed forms:

Startdatum: 11/3 KL 10⁰⁰
Stopdatum: 21/3 KL 10⁰⁰

Monitor Dagbok

Anmärkningarna Gäller:				Tids av:	Anmärkning	84P077	Tids på igen:	
Achievment	PDT	GFMHEA	Datum	KL			Datum	KL
X			13/3	08.30	Sov utan		13/3	09.00
X			14/3	00.10	- -		14/3	09.25
X			15/3	00.25	- -		15/3	09.50
X			15/3	23.45	- -		16/3	09.40
X			16/3	23.40	- -		17/3	06.15
	X		16/3	23.40	- -		17/3	10.45
X			17/3	22.35	- -		18/3	08.50
X			18/3	22.40	- - + glömda		19/3	12.15
X			19/3	2225	- -		20/3	10.15
X			20/3	23...	- -		21/3	8.-
X	X		21/3	10 ⁰⁰	SUT :)			

DIARIES AND VALIDATION

- During the free living experiment, the mothers were instructed to keep a diary consisting of printed forms:

Sovschema

Studiekod: 103P076B

Instruktioner:

Marker med ett streck vid vilka klockslag och under hur lång tid ditt barn sover (enligt exemplet nedan) under de 5 efterföljande dagarna till erat besök.

Mån	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
-----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Datum: 090327 00

30/3	Mån	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
31/3	Tis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Ons																								
	Tor																								
22/3	Fre	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23/3	Lör	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(Dop)	Sön	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

{tidsområden, +1h}

Anmärkningar/förtäganden:

Skrift ut reta exakt alla gånger himnen inte alltid anträder på egen gång

ungefärligt antal:
nattörnum (1 längd dagsovernattning + 12 yttre natts
per diagnos)

DIARIES AND VALIDATION

- During the free living experiment, the mothers were instructed to keep a diary consisting of printed forms:
 - Diaries begins at midnight, second day.
 - Data in the diaries needs to be digitized.

Matdagbok

Studiekod: 103P076B

Dygn (1-5): 1 27/3 00⁰⁰

Klockslag	Längd	Amning/Tillägg	Ev. mängd	Måltid	Mys
02:00	20 min?	amning båda sidor		x	
06:00	2 min	en sida, amning			x
07:00	2 min	en sida, amning			x
07:30	15 min	båda sidor, amning		x	
10:00	10 min	tillägg Nestlé(0-4) 1	100 ml	x	
10:45	5 min	en sida, amning			x



DIARIES AND VALIDATION

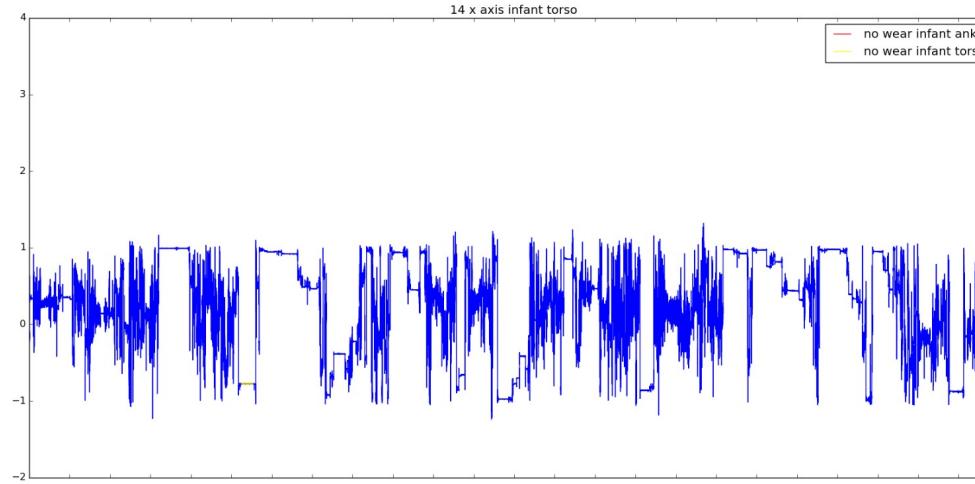
- Digitized data resulted as very approximate and prone to contain errors.
- Comparison and validation against such data is likely not be useful or invalid itself.

feeding start	feeding finish	sleeping start	sleeping finish	torso monitor detached	torso monitor reattached
2009-02-10 08:20:00	2009-02-10 08:50:00	2009-02-10 00:00:00	2009-02-10 08:10:00	2009-02-09 11:30:00	2009-02-09 16:00:00
2009-02-10 09:30:00	2009-02-10 10:00:00	2009-02-10 13:00:00	2009-02-10 13:40:00	2009-02-09 18:30:00	2009-02-09 20:00:00
2009-02-10 10:00:00	2009-02-10 11:00:00	2009-02-10 15:00:00	2009-02-10 15:25:00	2009-02-10 21:10:00	2009-02-11 08:15:00
2009-02-10 14:15:00	2009-02-10 15:00:00	2009-02-10 19:00:00	2009-02-10 19:40:00		
2009-02-10 15:50:00	2009-02-10 16:20:00	2009-02-10 22:20:00	2009-02-11 08:25:00		
2009-02-10 17:30:00	2009-02-10 17:45:00	2009-02-11 10:30:00	2009-02-11 11:40:00		
2009-02-10 20:00:00	2009-02-10 20:30:00	2009-02-11 13:25:00	2009-02-11 14:00:00		
2009-02-10 21:00:00	2009-02-10 21:15:00	2009-02-11 19:30:00	2009-02-11 20:05:00		
2009-02-11 08:20:00	2009-02-11 09:30:00	2009-02-11 22:00:00	2009-02-12 08:25:00		
2009-02-11 11:30:00	2009-02-11 11:45:00				
2009-02-11 14:15:00	2009-02-11 15:00:00				
2009-02-11 15:00:00	2009-02-11 16:00:00				
2009-02-11 16:50:00	2009-02-11 17:15:00				
2009-02-11 17:30:00	2009-02-11 17:45:00				
2009-02-11 19:15:00	2009-02-11 19:35:00				
2009-02-11 20:30:00	2009-02-11 21:00:00				
2009-02-11 21:15:00	2009-02-11 21:30:00				

DIARIES AND VALIDATION

NON-WEAR TIME DETECTION

- Non-wear detection directly compared to the diary data.
- On average, exact times differed for an hour, while the plots showed non-wear time to be exact.



- A few blocks turned out to be false positive and false negatives, all being very short.

DIARIES AND VALIDATION

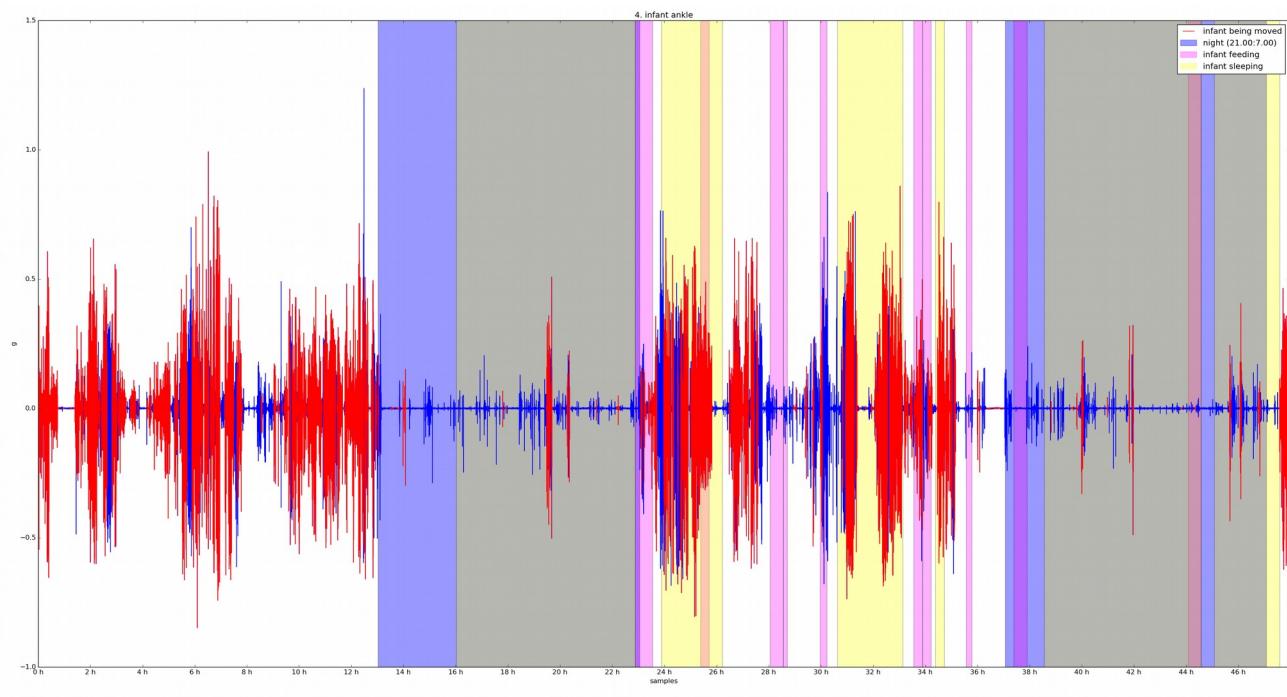
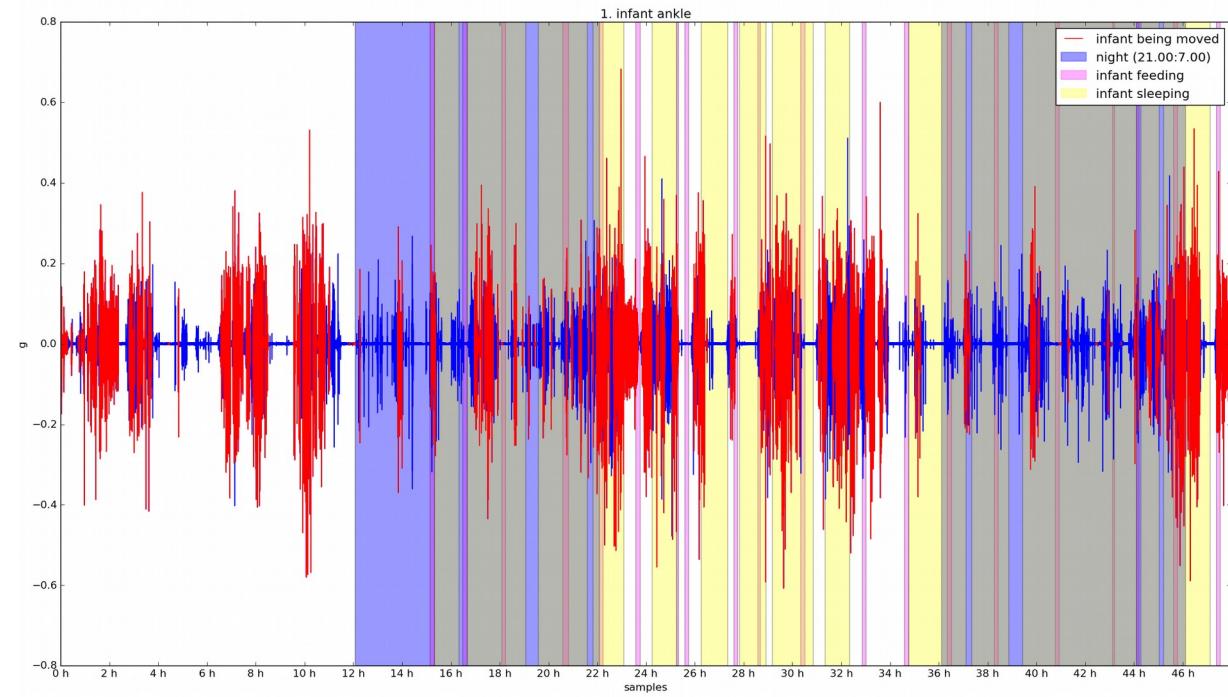
BEING MOVED DETECTION

- Due to the amount of error in the diaries and the frequency of sleeping and feeding, direct comparison turned to be uninformative.
- Proportions of time in different activities were extracted instead:

overall subjects	inside of a sleeping and feeding block	inside of a sleeping block only	inside of a feeding block only	close to start or end of a sleeping and feeding block	inside of a sleeping block but also close to the start or end of a feeding block	inside of a feeding block but also close to the start or end of a sleeping block	close to start or end of a sleeping block only	close to start or end of a feeding block only	not in or near feeding or sleeping block
mean	0.69%	38.10%	3.49%	2.88%	2.79%	0.65%	16.45%	5.52%	29.39%
min	0%	26.40%	0%	0%	0%	0%	8.41%	0.27%	16.37%
max	4.77%	59.02%	23.87%	6.62%	11.79%	3.36%	27.81%	16.64%	45.61%
SD	1.18%	9.51%	6.98%	1.70%	2.98%	0.85%	5.00%	3.56%	9.74%

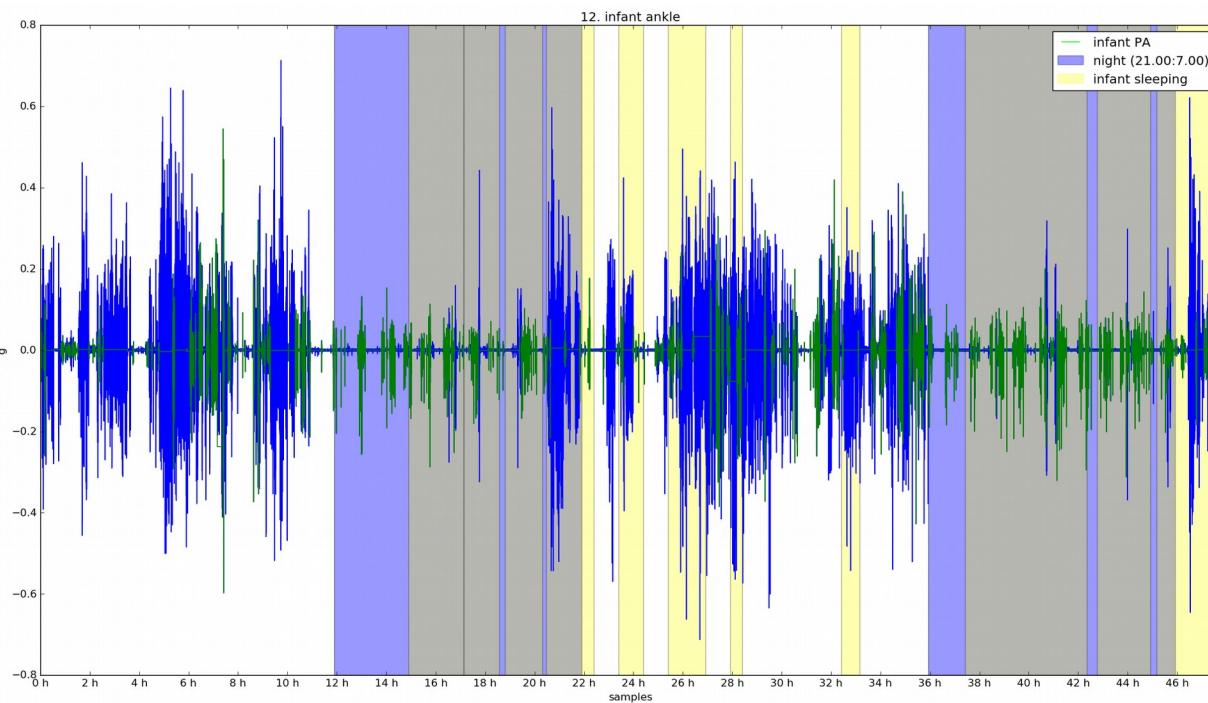
DIARIES AND VALIDATION

- Two examples of very different sleeping and feeding habits:



DIARIES AND VALIDATION

- Extracted PA compared against sleeping and awake blocks.
- Average proportion of PA occurring while infant awake was lower than expected.



	approach C	approach D	approach E
mean	48.12%	45.87%	35.48%
min	30.60%	23.98%	14.21%
max	61.51%	61.13%	59.02%
SD	10.83%	09.02%	12.71%

CLOSURE

CONCLUSIONS

- Substantial difference between the torso and ankle placed measurements on a local scale → good enough summary has to be derived.
- Torso measurement is not necessarily smaller than the ankle measurement → subtracting is inefficient and results in impaired further analysis.
- Correction based on signal similarities is a potentially good approach to correct contributing accelerations.

CLOSURE

CONCLUSIONS

- Removal of the periods where the infant might be moved can interfere with the extraction of PA.
- Variability in the data has to be considered and appropriate analysis of between and within variance applied.
- Appropriate and valid means of validation are necessary.

CLOSURE

DISCUSSION

- Summary derivation and variance seem to be related.
- Value of the between torso and ankle windowed correlation coefficient and its impact on the correction should be assessed.
- Is activity measured mainly during sleep an appropriate representation of infant overall activity levels?
- What is the true correlation of infant PA proportion with the proportion of infant being moved?

CLOSURE

POSSIBLE FUTURE WORK

- Derive several summaries and analyze variance.
- Preform clustering to separate periods where the infant is being moved from the rest.
- Use these different classes of periods to analyze the difference in the between torso and ankle correlation coefficient and its impact on the correction.

CLOSURE

POSSIBLE FUTURE WORK

- Maternal wrist acceleration data is still to be used.
- Tilt angle and baseline shifts can be analyzed in order to assess the detection of the infant being moved periods.
- Make everybody in the office carry a doll and analyze how well can the comparison between torso and ankle measurements result in zero PA.

