

Using SAS ® and R to Create Plot for Temperature Study

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Abstract

Temperature control is important for the health of premature babies. One way to monitor body temperature in premature infants is through continuous measurement of central (abdominal) and peripheral (foot) skin temperature. Fourteen premature infants, born ≤ 32 weeks gestational age and birthweights < 1500 grams were enrolled for study after Institutional Review Board approval and parental consent for participation in this study. Each infant had one skin temperature probe (thermistor) attached to their abdomen and one skin temperature probe to the sole of one foot. Data were stored in the GE Healthcare Omnibed Carestation™ and were downloaded to a laptop computer. . The data for each day included about 86,400 rows. The final datasets for each infant included averaged data for every minute of all variables for 28 days. Lag and several functions in SAS were used to prepare data for analyses. Several programs were used to delete unnecessary rows, create minutes from the time each infant was born to the time infants completed data collection, to replace missing minutes, combine and merge different datasets. GPLOT procedure in SAS and R software were used to create graph. Data creations were performed using SAS/STAT® statistical software, version 9.4.

Keywords: SAS, R, body temperature, infant

Background

Temperature control is important for the health of premature babies. One way to monitor body temperature in premature infants is through continuous measurement of central (abdominal) and peripheral (foot) skin temperature.¹ Abnormal patterns of body temperature with increased central-peripheral temperature difference (CPtd) or a CPtd that is negative (foot higher then abdominal temperature) have been associated with the onset of infection and stressful events in premature infants.² Engineers at G. E. Healthcare developed a research software allowing for display of central and peripheral body temperature and the CPtd on their Giraffe Omnibed Carestation™ hybrid incubators and funded the study of 14 infants using these special incubators in a level four neonatal intensive care unit in the southeastern United States.

Purpose

This paper describes methods to compare GPLOT in SAS and R using infant one dataset.

Methodology

Fourteen premature infants, born at 32 weeks gestational age or less and having birthweights of less than 1500 grams were enrolled for study after Institutional Review Board approval and parental consent for participation in this study. Physiological data were measured and stored for the first 28 days of life using a laptop attached to the research incubator in a RS232 port. Each infant had one skin temperature probe (thermistor) attached to their abdomen and one skin temperature probe to the sole of one foot. Infants were maintained in incubator servo control (36.5°-37.0°C) from the feedback of abdominal temperature. Temperatures were measured every minute for 14 days. A laptop computer on the incubator shelf recorded and stored all data. These data included both skin temperatures, inside incubator temperature, and humidity levels. In the data sets we have date, time, abdominal temperature (ABD), foot temperature (FT), inside incubator air temperature (EXT), air temperature (AS), Abdominal set temperature (ISC), Incubator Power output (IP), Humidity set point (HSP), Humidity measure (HUM), and Heat Respiratory. Minutes since birth (MSB) were calculated from birthdate and time and used to anchor all data longitudinally. Data were cleaned to eliminate low and high temperatures due to temperature probes being off the infant and data were coded

for missing data. Each variable had approximately 40,320 measures for each infant. The data for each day included about 86,400 rows. The final datasets for each infant included average of all measurement by minutes for all 28 days of data. The data were not ready for data analysis. Thus, lag and several functions in SAS used to prepare data for data analysis. Several programs were used to delete unnecessary rows, create minutes from the time the infant was born to the time the infant completed data collection, replace missing minutes, combine, and merge different datasets. GPLOT procedure in SAS and R software were used to create graph. Data creations were performed using SAS/STAT[®] statistical software, version 9.4.³

Data Steps

Table 1 shows an example of data converted from text file to excel file. We use infant one as an example to present the steps that we went through to create the final data set. For this example, the infant was born on 6/6/2018 9:34 am and data collection was complete on 6/26/2018 at 9:41. Data included all measurements for every second in each row. In addition, there is extra row for each data point.

Table1 Example of data in Excel

Date	Time	MSB	ABD	FT	EXT	AS	ISC	IP	HSP	HUM	Heat Res
6/6/2018	9:34	0									
6/6/2018	12:27:29.147]		31.2	34.3	29.1	36	37	100	0	26	3554
6/6/2018	12:27:29.158]		0								
6/6/2018	12:27:29.158]		31.3	34.3	29.1	36	37	100	0	27	3560
6/6/2018	12:27:29.158]		0								
6/6/2018	12:27:29.158]		31.4	34.3	29.2	36	37	100	0	27	3560
6/6/2018	12:27:29.158]		0								
6/6/2018	12:27:29.158]		31.5	34.3	29.2	36	37	100	0	27	3560
6/6/2018	12:27:29.158]		0								
6/6/2018	12:27:29.158]		31.6	34.3	29.3	36	37	100	0	27	3548
6/6/2018	12:27:29.158]		0								
6/6/2018	12:27:29.158]		31.7	34.3	29.4	36	37	100	0	27	3536
6/6/2018	12:27:29.158]		0								

Table 2 indicates the note for infant one. For example, infant one was born on 6/6/18 at 9:34am. Data collection instruments were attached to the infant in the incubator on 6/6/2018 at 12:27 and data collection was completed on 6/26/2018 at 9:41am. There are several times the incubator was not collecting the data from 6/8/18 at 17:45 to 6/12/18 at 10:44, 6/23/18 at 14:19 to 6/23/18 to 14:14, and 6/24/18 at 6:26 to 6/25/18 at 9:56am. Thus, when we created the data set, we replaced those missing minutes.

Table 2. Data note for infant 1

Note
DOB 6/6/18 TOB 0934
ECU001 6-6-2018_draft 2_RD Wed 6/6/2018 1227 -6/7/2018 1420
ECU001 6-7-2018_draft 2_RD Thurs 6/7/2018 1427-6/8/2018 1107
ECU001 6-8-2018_draft 2_RD Fri 6/8/2019 1113-6/8/2018 1744
Missing data from 6/8/18-6/12/18 am.
ECU001 6-12-2018_draft 2_RD 6/12/2018 1044-6/12/2018 2312

ECU001 6-13-2018_draft 2_RD 6/13/2018 0013-6/13/2018 1226
 ECU001 6-13-2018-2_draft 2_RD 6/13/2018 1245-6/14/2018 1027
 ECU001 6-14-2018_draft 2_RD 6/14/2018 1228-6/15/2018 0924
 ECU001 6-15-2018_draft 2_RD 6/15/2018 0931-6/16/2018 0651
 ECU001 6-16-2018_draft 2_RD 6/16/2018 0655-06/18/2018 0956
 ECU001 6-18-2018_draft 2_RD 6/18/2018 0959-06/19/2018 0942
 ECU001 6-19-2018_draft 2_RD 6/19/2018 0945-6/20/2018 0959
 ECU001 6-20-2018_draft 2_RD 6/20/2018 1002-6/21/2018 0831
 ECU001 6-21-2018_draft 2_RD 6/21/2018 0835-6/22/2018 0940
 ECU001 6-22-2018_draft 2_RD 6/22/2018 0945-6/24/2018 0625
 Missing 6/23/2018 14:10-6/23/2018 14:14
 6/23/2018 1415-6/24/2018 0625
 Missing data 6/24/18 0626-6/25/18 0956
 ECU001 6-22-3018_2_draft 2_RD 6/25/18 0957-6/25/2018 1004
 ECU001 6-25-3018_2_draft 2_RD 6/25/18 1009-6/26/2018 941

Table 3 shows the SAS program to create the master file including id for infant one, date, time (hours and minutes), and Minutes since birth (MSB) from the time the infant was born to the time the infant completed data collection.

Table 3. SAS Program to create master file.

SAS Program
<pre> libname temp 'd:\ABBAST\temp\test\'; *** add times from date of birth to time recoded ***; data one; timest='06jun2018:09:34:00'dt; timeed='26jun2018:09:41:00'dt; msb=.; interval=intck('minute',timest,timeed); do i = 1 to interval by 1; timest=intnx('minute',timest,1,'same'); date = datepart(timest); timea = timepart(timest); output; end; drop timeed timest i interval; format timea time8. date mmddyy10.; run; data one; set one; id = _n_; timeb=timea; tmp=put(timea,time5.); format timea time8. timeb time5. ; drop tmp ; run; data two; set one; msb=id -1; run; data temp.ECUM(keep= id DATE TIMEb MSB) ; retain id DATE TIMEb MSB ; set two;</pre>

```
format date mmddyy10. ; run;
```

Table 4 shows an example of first 20 observations for the master file, which creates MSB from the time the infant was born to the time the infant completed data collection. The data includes id, date, time (hours and minutes), and MSB.

Table 4 Sample of data master for first 20 observation

Obs	id	date	timeb	Msb
1	1	06/06/2018	9:34	0
2	2	06/06/2018	9:35	1
3	3	06/06/2018	9:36	2
4	4	06/06/2018	9:37	3
5	5	06/06/2018	9:38	4
6	6	06/06/2018	9:39	5
7	7	06/06/2018	9:40	6
8	8	06/06/2018	9:41	7
9	9	06/06/2018	9:42	8
10	10	06/06/2018	9:43	9
11	11	06/06/2018	9:44	10
12	12	06/06/2018	9:45	11
13	13	06/06/2018	9:46	12
14	14	06/06/2018	9:47	13
15	15	06/06/2018	9:48	14
16	16	06/06/2018	9:49	15
17	17	06/06/2018	9:50	16
18	18	06/06/2018	9:51	17
19	19	06/06/2018	9:52	18
20	20	06/06/2018	9:53	19

Table 5 shows the SAS program to import data from excel to the SAS dataset. We used this procedure for all datasets for all infants. For example, for infant1, we imported 15 datasets from excel to SAS datasets.

Table 5 SAS program to import excel file to SAS dataset.

SAS Program
<pre>libname temp 'd:\ABBAST\temp\test\'; PROC IMPORT OUT= temp.inf1 DATAFILE= libname temp "d:\ABBAST\temp\test\ DBMS=xlsx REPLACE; SHEET="auto"; GETNAMES=YES;RUN;</pre>

Table 6 indicates the SAS program to combine all datasets for each infant. In addition, we created the average for all measurement by minutes.

Table6 SAS Program to combine all datasets and create average by minutes.

SAS Program

```

libname temp 'd:\ABBAST\temp\test\';

data one;
set temp.INF1 - temp.INF15; *** List all of the data sets here for each infant ***;
stime=time;
timeb=substr(stime,1,8);
timea = input(substr(timeb,1,2) !! ':' !! substr(timeb,4,2) !! ':' !! substr(timeb,7,2),time8.);
drop stime time timeb;
format timea time8. ;run;

data two (rename= ( timea=time));;
set one ;
cptd = abd - ft; *** Creat new variable Central-peripheral temperature difference (ABd-FT);
ID=1;
retain abd ft cptd ext aS isc ip HSP HUM HEATRES;;run;

data temp.INFall(keep= abd ft cptd ext aS isc ip HSP HUM HEATRES ) ;
retain abd ft cptd ext aS isc ip HSP HUM HEATRES;
set two ;
format date mmddyy10.;run;

data three;
set temp.infall;
timeb=time;
tmp=put(time,time5.);

l=lag(tmp);
if _n_ = 1 then msb=msb+0;
else if l ne tmp then msb+1 ;
format time time8. timeb time5. ;
drop tmp l;run;

data four;
set three ;
by id;
if first.id then idn=1;
else idn+1;run;

proc means data=four n mean std min max noprint maxdec=2 ;
class MSB;
var abd ft cptd ext aS isc ip HSP HUM HEATRES;
id abd ft cptd ext aS isc ip HSP HUM HEATRES;;
output out=avgtwob mean= mabd mft mcptd mext maS misc mip mHSP mHUM mHEATRES;;
title ' means ';
title2 ' Temperature Study '; run;

data five;
set avgtwob;
RUN;
data temp.avgecu1all
(keep= IDN ID SITE DATE TIMEb mabd mft mcptd mext maS misc mip mHSP mHUM mHEATRES ;
retain IDN ID SITE DATE TIMEb mabd mft mcptd mext maS misc mip mHSP mHUM mHEATRES;
set five;
format MABD MFOOT 8.2 MSB 8. ;
If _type_=1;
drop _type_ _freq_ ; run;

```

Table 7 indicates SAS datasets for 15 observations for all measurement. This dataset created average of all measurements from seconds to minutes. We combined all data sets for infant1 from the time the infant was born to the time data collection was completed on each infant. In this dataset, MSB is only correct when there are no missing minutes. For this reason, we merged this dataset with first dataset that we created as master file.

Table7 SAS dataset to combine data and create average measurement by MSB.

Obs	DATE	TIMEB	MSB	MABD	MFT	MCPTD	MEXT	MAS	MISC	MIP	MHSP	MHUM	MHEATRES	id
1	06/07/2018	14:21	1727	.	.	.	.	.	.	.	.	.	.	1
2	06/07/2018	14:22	1728	.	.	.	.	.	.	.	.	.	.	1
3	06/07/2018	14:23	1729	.	.	.	.	.	.	.	.	.	.	1
4	06/07/2018	14:24	1730	.	.	.	.	.	.	.	.	.	.	1
5	06/07/2018	14:25	1731	.	.	.	.	.	.	.	.	.	.	1
6	06/07/2018	14:26	1732	.	.	.	.	.	.	.	.	.	.	1
7	06/07/2018	14:27	1733	36.40	36.20	0.20	37.35	37.30	36.50	81.60	0.00	24.00	5616.42	1
8	06/07/2018	14:28	1734	36.40	36.20	0.20	37.20	37.30	36.50	100.00	0.00	24.00	2833.33	1
9	06/07/2018	14:29	1735	36.40	36.20	0.20	37.13	37.30	36.50	97.20	0.00	24.13	1779.10	1
10	06/07/2018	14:30	1736	36.40	36.20	0.20	37.08	37.30	36.50	92.80	0.00	24.47	1310.10	1
11	06/07/2018	14:31	1737	36.40	36.11	0.29	37.00	37.30	36.50	99.87	0.00	23.40	1065.43	1
12	06/07/2018	14:32	1738	36.43	36.10	0.33	37.08	37.30	36.50	56.47	0.00	23.77	889.30	1
13	06/07/2018	14:33	1739	36.50	36.18	0.32	37.24	37.30	36.50	27.00	0.00	24.00	959.43	1
14	06/07/2018	14:34	1740	36.50	36.20	0.30	37.36	37.30	36.50	32.00	0.00	24.00	1218.07	1
15	06/07/2018	14:35	1741	36.50	36.20	0.30	37.48	37.30	36.50	19.50	0.00	24.20	1492.17	1

Table 8 indicates SAS program to merge the combined dataset with the master file. This program correctly inserted the missing MSB if there is any in dataset. The final dataset created in this program was used for data analysis.

Table 8 SAS program dataset to merged combine data and master dataset.

SAS Program
<pre> libname temp 'd:\ABBAST\temp\test\'; data one; set temp.ecum; timec=put(timeb,tod5.); run; proc sort data=one; by date timec; run; data two; set temp.avgecu11combine; timec=put(timeb,tod5.); run; proc sort data=two; by date timec; run; data all; merge one (in=a) two (in=b); by date timec; aa=a; bb=b; drop aa bb;run; data temp.avgcu11combaall; set all; run; </pre>

Day created from MSB.

Table 9 Example of Macro for graph

SAS Program

Create Day

```
if 0<=msb<1441 then day=1;
else if 1440<msb<2881 then day=2;
else if 2880<msb<4321 then day=3;
else if 4320<msb<5761 then day=4;
else if 5760<msb<7201 then day=5;
else if 7200<msb<8641 then day=6;
else if 8640<msb<10081 then day=7;
else if 10080<msb<11521 then day=8;
else if 11520<msb<12961 then day=9;
else if 12960<msb<14401 then day=10;
else if 14400<msb<15841 then day=11;
else if 15840<msb<17281 then day=12;
else if 17280<msb<18721 then day=13;
else if 18720<msb<20161 then day=14;
else if 20160<msb<21601 then day=15;
else if 21600<msb<23041 then day=16;
else if 23040<msb<24481 then day=17;
else if 24480<msb<25921 then day=18;
else if 25920<msb<27361 then day=19;
else if 27360<msb<28801 then day=20;
else if 28800<msb<30241 then day=21;
else if 30240<msb<31681 then day=22;
else if 31680<msb<33121 then day=23;
else if 33120<msb<34561 then day=24;
else if 34560<msb<36001 then day=25;
else if 36000<msb<37441 then day=26;
else if 37440<msb<38881 then day=27;
else if 38880<msb<40321 then day=28;
else if 40320<msb<41761 then day=29;
else if 41760<msb<43201 then day=30;
```

** Plot *** ;

```
goptions device = jpeg xpixels = 1500 xmax = 10.5in ypixels = 900 ymax = 6.5in
ftext = 'Swiss' htext = 10pt cback = white ;
%let name=powerpoint;
```

```
ods _all_ close;
ods powerpoint file="&name..ppt" style=htmlblue;
options nodate nonumber;
```

```
proc gplot data=one;
  symbol1 i = join color = blue line = 1 w=3 v=point;
  symbol2 i = join color = red line = 1 w = 3 v = point;
  symbol3 i = join color = green line = 1 w = 3 v = point;
  symbol4 i = join color = orange line = 1 w = 3 v= point;
  axis1 order=25 to 40 by 1 label=none;
  axis2 label=none;
  label msb = 'Minutes since birth';
  legend1 label=none
  position=(top center inside)
  mode=share;
  plot mabt*msb = 1 mft*msb = 2 mext*msb = 3 misc*msb=4
    /overlay legend=legend1 vaxis=axis1 legend;
  by day ;
  *title "Infant2:#BYVAL1";
  title ' Plots/infant 1';      run;
```

```
quit;ods _all_ close;run;
```

Figure1 shows several types of plots used for each measurement to report the data. These graphs created for infant 1 by days in SAS.

Table 10: Setting Work Directory, installing “readxl,” Creating Data Set

R Program
<pre>> setwd("C:/Bennett/dail/saspaper24") > install.packages("readxl") #select CRAN mirror preference > library(readxl) > baby1 <- read_excel("babymbs1.xlsx", skip=0, n_max=1442, col_names = TRUE)</pre>

Table 10 shows the process of setting a work directory, installing the package “readxl” which allows you to directly read in Excel sheets as data frames to R, and reading in the Excel sheet containing our data. “skip=0” indicates that we want to read in data starting at row 1, and “n_max=1442” indicates a stopping point at row 1442 in the Excel sheet.

Table 11: Checking the Data

R Program
<pre>> head(baby1) # A tibble: 6 x 14 DATE TIMEB MSB MABT MFT MCPTD MEXT MAS MISC MIP MHSP MHUM MHEATRES day <dtm> <dtm> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> 1 2018-06-06 00:00:00 1899-12-31 09:34:00 0 NA NA NA NA NA NA NA NA NA NA 1 2 2018-06-06 00:00:00 1899-12-31 09:35:00 1 NA NA NA NA NA NA NA NA NA NA 1 3 2018-06-06 00:00:00 1899-12-31 09:36:00 2 NA NA NA NA NA NA NA NA NA NA 1 4 2018-06-06 00:00:00 1899-12-31 09:37:00 3 NA NA NA NA NA NA NA NA NA NA 1 5 2018-06-06 00:00:00 1899-12-31 09:38:00 4 NA NA NA NA NA NA NA NA NA NA 1 6 2018-06-06 00:00:00 1899-12-31 09:39:00 5 NA NA NA NA NA NA NA NA NA NA 1 > tail(baby1) # A tibble: 6 x 14 DATE TIMEB MSB MABT MFT MCPTD MEXT MAS MISC MIP MHSP MHUM MHEATRES day <dtm> <dtm> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> 1 2018-06-07 00:00:00 1899-12-31 09:30:58 1436 36.7 36.2 0.490 35.2 35 36.5 8.33 0 26.1 5239. 1 2 2018-06-07 00:00:00 1899-12-31 09:31:58 1437 36.7 36.2 0.5 35.2 35 36.5 9.33 0 26 5685. 1 3 2018-06-07 00:00:00 1899-12-31 09:32:58 1438 36.7 36.2 0.5 35.2 35 36.5 19.2 0 26 5978. 1 4 2018-06-07 00:00:00 1899-12-31 09:33:58 1439 36.7 36.2 0.5 35.1 35 36.5 26.3 0 26.0 5905. 1 5 2018-06-07 00:00:00 1899-12-31 09:34:58 1440 36.7 36.2 0.5 35.1 35 36.5 36.1 0 26.2 5501. 1 6 2018-06-07 00:00:00 1899-12-31 09:35:58 1441 36.7 36.2 0.5 35 35 36.5 52.8 0 26.2 4849. 2</pre>

Table 11 shows the first 6 observations and last 6 observations of infant 1, read in as data set “baby1”. Note that the first 6 observations do not contain any data.

Table 12: Creating the Temperature Plot

R Program
<pre>> x<-baby1\$MSB > plot(x, baby1\$MABT, type = "l", col = "blue", xlim = c(0, 1500), ylim = c(25, 40), lty = 1, xlab = "Minutes since birth", ylab = "", main = "Plots/Infant 1, \nday = day1", lwd=2.5) > lines(x,baby1\$MFT,col="red", lwd=2.5) > lines(x,baby1\$MEXT,col="green", lwd=2.5) > lines(x,baby1\$MISC,col="orange", lwd=2.5) > legend("bottomright", legend=c("MABT","MFT","MEXT","MISC"), col=c("blue","red","green","orange"), lty=c(1,1,1,1), lwd=c(2.5,2.5,2.5,2.5)) > axis(1, at = seq(0, 1500, by = 20), labels = FALSE) > axis(1, at = seq(0, 1500, by = 100), labels = seq(0, 1500, by = 100)) > axis(2, at = seq(25, 40, by = 1)) > axis(2, at = seq(25, 40, by = 0.2), labels = FALSE)</pre>

Table 12 shows the process to create a graph for the temperature changes of infant 1 on day 1 for variables MABT, MFT, MEXT, and MISC . The “par” statement allows you to adjust margins, and it was utilized to extend the bottom margins to allow space for the headers. The “plot” function comes with base R and was used to create the initial line plot defining MSB as the X-axis, while the “lines” functions were used to add the additional variables.

Figure 1. Temperature changes for minutes for day 1 (infant 1 Using SAS).

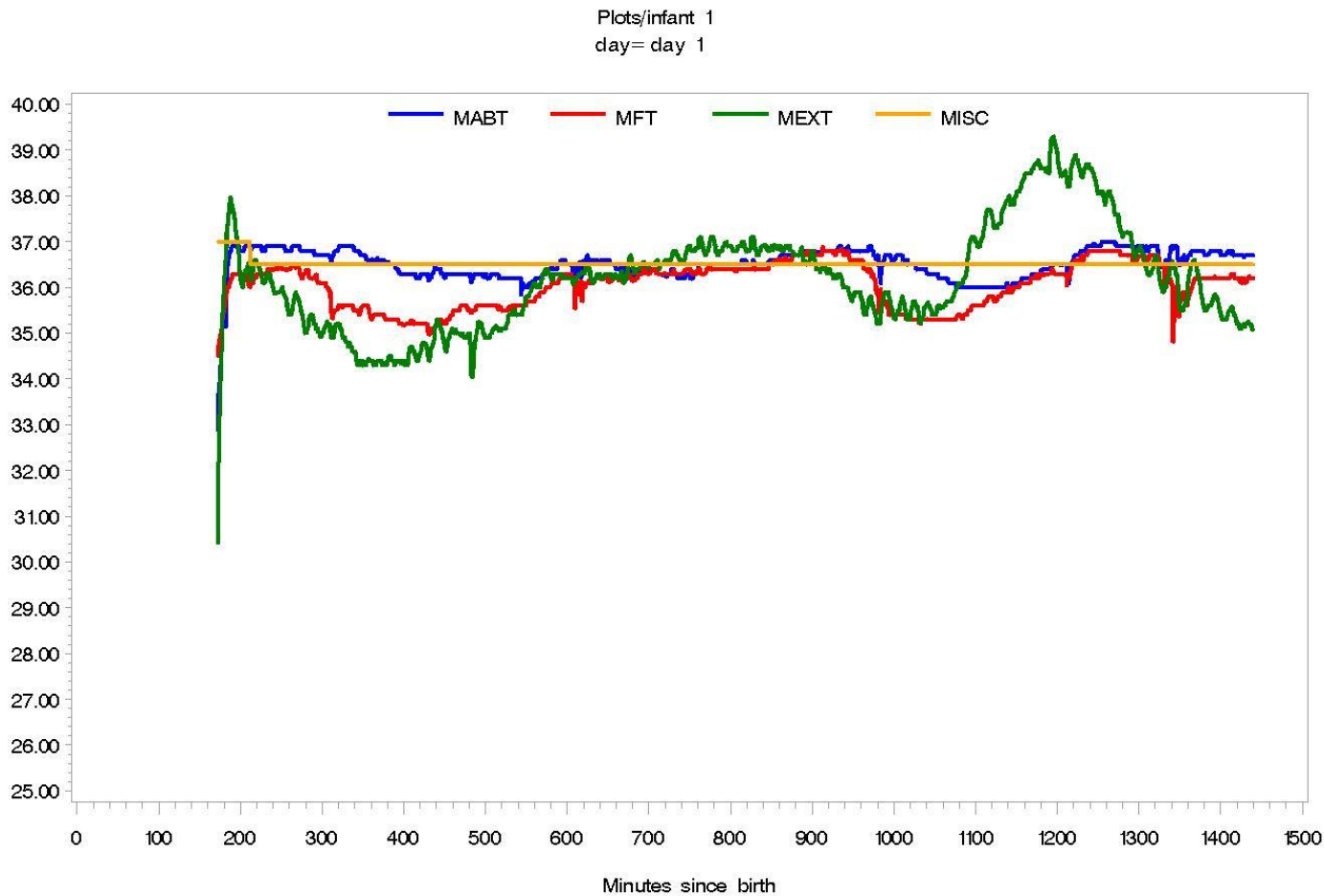
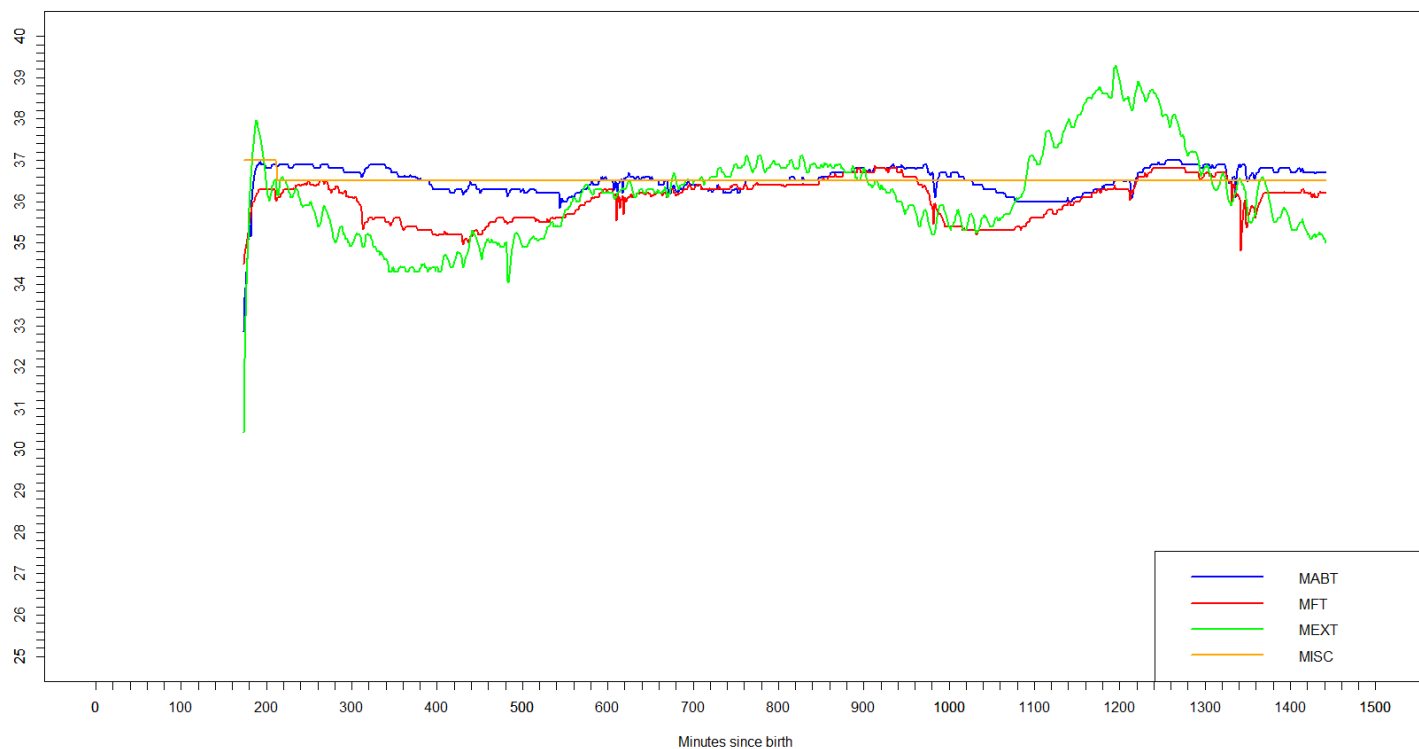


Figure 2. Temperature changes for minutes for day 1 (infant 1 Using R).

Plots/Infant 1,
day = day1



SAS and R Software produced the same plot. The plot in SAS is clearer than R. However, it requires more programming in SAS to create the same as R. To aid clarity, we had to test what line width (lwd) would make the lines on the R graph appear thicker.

Conclusion

Data collected for this Infant Temperature study went through several steps to be prepared for data analyses. Lag and several functions in SAS were used to prepare data for data analyses. Several programs were used to delete unnecessary rows, create minutes from the time the infant was born to the time the infant completed data collection, replace missing minutes, combine, and merge different datasets. Data creations were performed using SAS/STAT® statistical software, version 9.4. GPLOT procedure in SAS and R 4.3.3 software were used to create the graphs.

While R's computational speed may be limited in handling large datasets due to its reliance on random-access memory (RAM), its succinct syntax for dataset creation and graphing enhances potential efficiency compared to SAS. While constructing the dataset for the graphs, R offers the advantage of direct referencing for selecting specific observation rows, streamlining the code. However, for graph generation, R necessitates individual plotting of each variable as a separate command per variable. The process of labeling the Y and X axes in R also posed a minor problem when graphing, as you cannot create labels using a different sequence than what the axis is being labeled with. SAS allows for much easier axes labeling than R due to this issue.

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