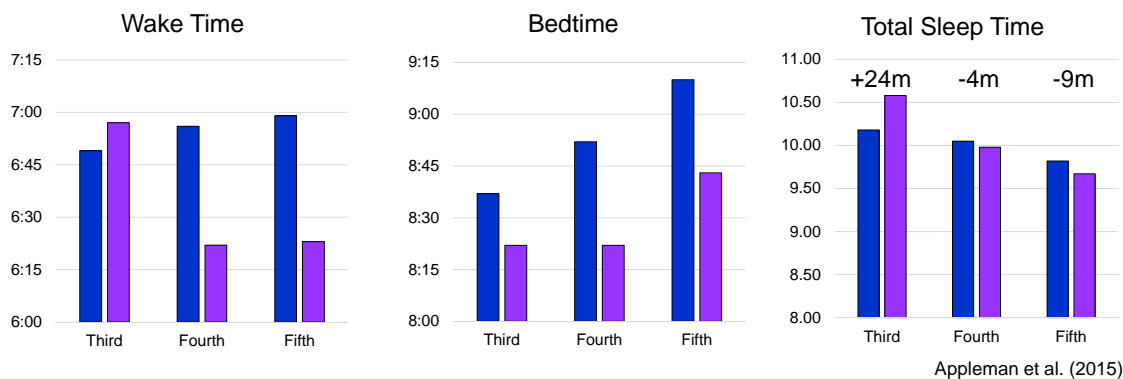


*That's nice, but what about elementary school students?
Won't starting earlier cause them to get less sleep?*

Change to Start Time in Northeast Elementary School

3rd grade: **9:10 a.m.** → **7:45 a.m.**

4th/5th grade: **8:20 a.m.** → **7:45 a.m.**



Minneapolis School District

- School start times changed from 8:40 → 7:40 a.m.
- Students were more alert at start of day and remained energized throughout day
- Students had fewer morning transitions and were more ready to learn
- Teachers and students were more patient and productive in the afternoon
- Fewer behavior problems
- Increased participation in school activities
- Buses were on time at start and end of day

Wahlstrom (1998)

CCSD Historical Trends by Start Time

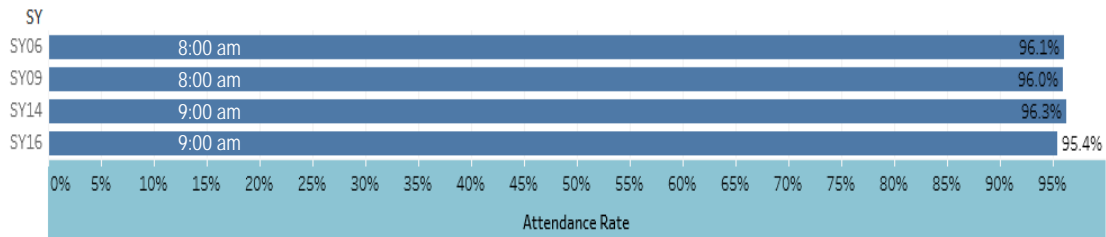
School Year Grouping	School Year (copy)	Grade Level (group)	Reading Standards					Math Standards							
			1	2	3	4	G	1	2	3	4	5	6	G	
8-00 (SY07-SY09)	2007	ES	2.8	2.8	2.8	2.8		2.9	2.8	2.8	2.8	2.8	2.8	2.8	
	2008	ES	2.8	2.8	2.8	2.9		2.9	2.8	2.9	2.9	2.8	2.8		
	2009	ES	2.8	2.8	2.8	2.8		2.9	2.8	2.9	2.9	2.8	2.8		
9-00 (SY10+)	2010	ES	2.8	2.8	2.8	2.8		2.9	2.9	2.9	2.9	2.9	2.9		
	2011	ES	2.8	2.8	2.8	2.8		2.9	2.9	2.9	2.9	2.9	2.9		
	2012	ES	2.8	2.8	2.8	2.8		2.9	2.9	2.9	2.9	2.9	2.9		
	2013	ES	2.8	2.8	2.8	2.9		2.9	2.9	2.9	3.0	2.9	2.9		
	2014	ES	2.8	2.8	2.8			2.8	2.8	2.8	2.8	2.8			
	2015	ES	2.8	2.7	2.8			2.8	2.8	2.8	2.8	2.9			
	2016	ES	2.8	2.7	2.8			2.8	2.8	2.8	2.8	2.8			
	2017	ES	2.7	2.7	2.7			2.7	2.8	2.8	2.8	2.8			

CCSD Historical Trends by Start Time

School Year Grouping	Grade Level (group)	Grade Level	Reading Standards					Math Standards						
			1	2	3	4	G	1	2	3	4	5	6	G
8:00 (SY07-SY09)	ES	0	2.8	2.8	2.8	2.9		2.8	2.9	2.9	2.9	2.9	2.9	
		1	2.8	2.8	2.8	2.8		2.9	2.8	2.8	2.9	2.8	2.8	
		2	2.8	2.7	2.8	2.8		2.9	2.8	2.9	2.9	2.8	2.8	
		3	2.8	2.8	2.8	2.8		2.9	2.8	2.8	2.8	2.8	2.8	
		4	2.9	2.8	2.8	2.9		2.9	2.8	2.8	2.9	2.8	2.8	
5	2.9	2.8	2.9	2.9		2.9	2.9	2.9	2.9	2.9	2.9			
9:00 (SY10+)	ES	0	2.8	2.9	2.8	2.9		2.8	2.9	2.9	2.9	2.9	2.9	
		1	2.7	2.8	2.8	2.8		2.9	2.8	2.8	2.9	2.8	2.9	
		2	2.7	2.7	2.7	2.8		2.9	2.8	2.8	2.9	2.9	2.9	
		3	2.8	2.7	2.8	2.8		2.8	2.8	2.8	2.8	2.8	2.8	
		4	2.8	2.7	2.8	2.9		2.8	2.8	2.8	2.9	2.8	2.8	
5	2.9	2.8	2.9	2.9		2.9	2.9	2.9	2.9	2.9	2.9			

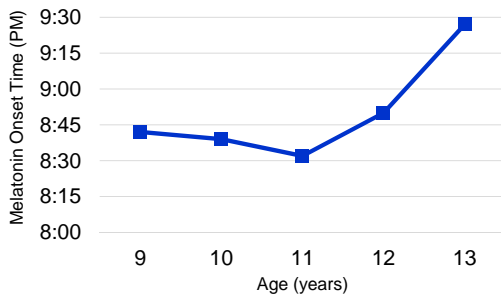
CCSD Historical Trends by Start Time

Test School Year (group)	Test Grade (group)	Test Grade	Reading	Writing	Math
9:00 (SY04-SY06)	ES	03	80%	65%	80%
		04	75%	65%	78%
		05	80%	72%	76%
8:00 (SY07-SY09)	ES	03	77%	61%	77%
		04	74%	61%	79%
		05	77%	69%	75%
9:00 (SY10-SY14)	ES	03	79%	60%	80%
		04	76%	62%	80%
		05	79%	68%	76%

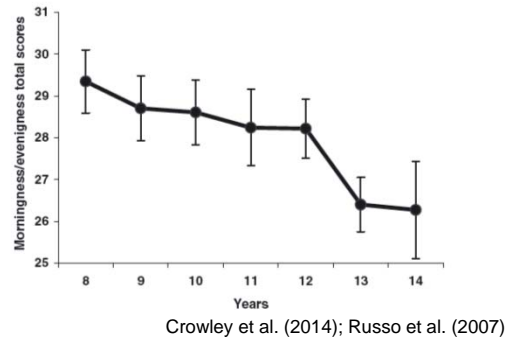


Circadian Rhythms and Elementary School Aged Children

- Change in melatonin onset doesn't begin until between ages 11 and 13



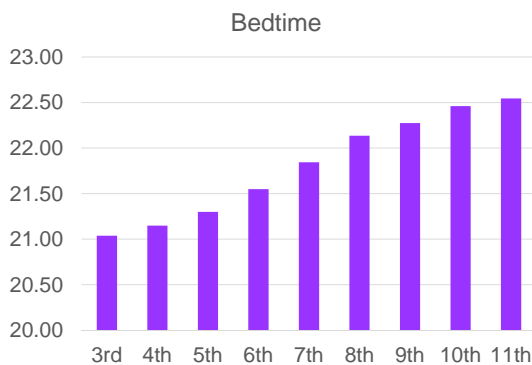
- Self-reported circadian preference changes between ages 12 and 13



Weekday Sleep Driven by Wake Time (which is driven by school start times)

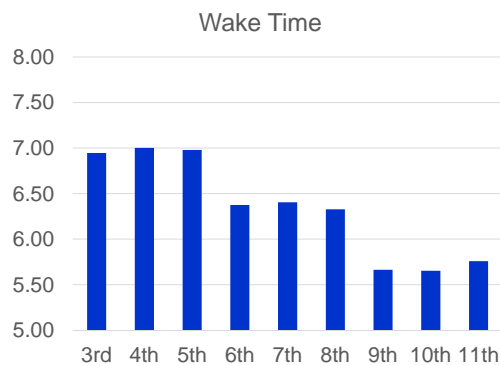
- Bedtimes increase steadily with increasing grade

ES → MS: 40 m, MS → HS: 34 m



- Wake times consistent across school level

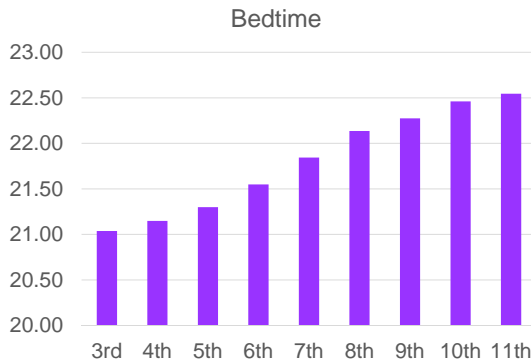
ES: 6:58, MS: 6:33, HS: 5:41



Weekday Sleep Driven by Wake Time (which is driven by school start times)

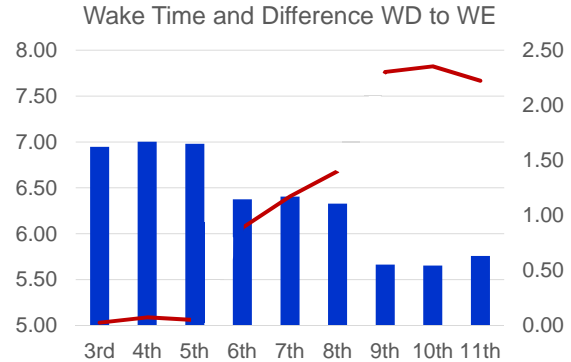
- Bedtimes increase steadily with increasing grade

ES → MS: 40 m, MS → HS: 34 m









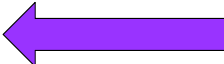



- Wake times consistent across school level

ES: 6:58, MS: 6:33, HS: 5:41



But what about all those studies showing how earlier start times are bad for elementary school students?

References:		
[1] "University of Kentucky study: Early school start times may be detrimental to young children." Lexington Herald-Leader. August 19, 2014. http://www.kentucky.com/news/local/education/article44504058.html		Kentucky Study
[2] "How Much Sleep Do We Really Need?" National Sleep Foundation. http://www.sleepfoundation.org/article/how-sleep-works/how-much-sleep-do-we-really-need		9-11 hours
[3] "More Sleep Linked to Improved Child Alertness, Behavior." American Academy of Pediatrics. October 15, 2012. https://www.aap.org/en-us/about-the-aap/aap-press-room/pages/More-Sleep-Linked-to-Improved-Child-Alertness-Behavior.aspx		Avg 9.3 hr +27m vs -54m
[4] Lexington Herald-Leader. "University of Kentucky study ... detrimental to young children." Op cit.		Kentucky Study
[5] "Less Sleep, More Struggles for Elementary and Middle School Students". Brown Medical School and Bradley Hospital. SLEEP December 2005. https://www.brown.edu/Administration/News_Bureau/2005-06/05-046.html		8 hrs 1 st /2 nd 6.5 hrs ≥3 rd

References:		
[1] "University of Kentucky study: Early school start times may be detrimental to young children." Lexington Herald-Leader. August 19, 2014. http://www.kentucky.com/news/local/education/article44504058.html		Kentucky Study
[2] "How Much Sleep Do We Really Need?" National Sleep Foundation. http://www.sleepfoundation.org/article/how-sleep-works/how-much-sleep-do-we-really-need		9h: 9:30p-6:30a 10h: 8:30p-6:30a 11h: 7:30p-6:30a
Impact of Sleep Extension and Restriction on Children's Emotional Lability and Impulsivity Reut Gruber, Jamie Cassoff, Sonia Frenette, Sabrina Wiebe and Julie Carrier <i>Pediatrics</i> 2012;130:e1155; originally published online October 15, 2012; DOI: 10.1542/peds.2012-0564		Avg 9.3 hr +27m vs -54m
[4] Lexington Herald-Leader. "University of Kentucky study ... detrimental to young children." Op cit.		Kentucky Study
Experimental Restriction of Sleep Opportunity in Children: Effects on Teacher Ratings Gahan Fallone, PhD, Christine Acebo, PhD, Ronald Seifer, PhD, Mary A. Carskadon, PhD <i>E. P. Bradley Hospital, East Providence, RI; Department of Psychiatry and Human Behavior, Brown Medical School, Providence, RI</i>		8 hrs 1 st /2 nd 6.5 hrs ≥3 rd

Kentucky Study

Journal of Educational Psychology
2015, Vol. 107, No. 1, 236–245


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0022-0663/15/\$12.00 <http://dx.doi.org/10.1037/a0037195>

Earlier School Start Times as a Risk Factor for Poor School Performance: An Examination of Public Elementary Schools in the Commonwealth of Kentucky

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Shuang Bi, and Eric A. Haak
University of Kentucky

Joseph A. Buckhalt
Auburn University

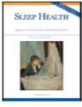
Sleep Health 3 (2017) 113–118



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Earlier school start times are associated with higher rates of
behavioral problems in elementary schools

Peggy S. Keller, PhD*, Lauren R. Gilbert, PhD, Eric A. Haak, MS, Shuang Bi, MS, Olivia A. Smith, BS
University of Kentucky



Sleep and Academic Performance

- Statistical models to predict how school start times impact academics and behavior
- Start time calculated as minutes since midnight (so no comparison of early vs. late starting schools)

$$\text{NAPDMATH}_{ij} = B_{j0} + B_{j1} (\text{STARTTIME}_{ij})$$

$$+ B_{j2} (\text{FREELUNCH}_{ij}) + B_{j3} (\text{TIMEXLUNCH}_{ij})$$

$$+ B_{j4} (\text{AFRICAN AMERICAN}_{ij})$$

$$+ B_{j5} (\text{HISPANIC}_{ij}) + B_{j6} (\text{TSRATIO}_{ij})$$

9:00–9:10	102 (14.2%)
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Keller et al. (2014)

Sleep and Academic Performance

Table 3
Model Results for Interactions Between Elementary School Start Times and Fraction of Students Receiving Free or Reduced-Cost Lunches

Variable	NAPD						School rank	Attendance rate	Retention rate
	Language	Reading	Math	Science	Social Studies	Writing			
Intercept									
Intercept (π_{10})	68.145***	62.875***	62.481***	90.430***	80.10***	57.719***	52.937***	95.718***	0.365***
APPALACHIAN (π_{10})	-9.126***	-6.863***	-6.354***	-8.814***	-6.288**	-4.963**	-16.165***	-1.520***	0.313**
TSRATIO									
Intercept	1.520***	1.103***	.673**	.851***	1.226***	.798**	1.777***	.080***	-.041*
AFRICAN AMERICAN									
Intercept	-.523***	-.472***	-.417***	-.432***	-.413***	-.324***	-1.031***	-.005*	-.001
HISPANIC									
Intercept	-.487***	-.495***	-.402***	-.410***	-.347***	-.162*	-.692***	-.011**	-.009**
School Start Time									
Intercept (π_{11})	.059*	.038	.044*	.017	.058**	.055**	.137**	.002	.002*
FREE LUNCH									
Intercept (π_{12})	-.637*	-.705***	-.562**	.001	-.248	-.301	-.602	-.009	-.015
Start Time \times LUNCH									
Intercept (π_{13})	-.017*	-.015***	-.012*	-.010*	-.010**	-.013**	-.029***	-.001*	.000

Note. Columns indicate the dependent variable being predicted. Statistical notation provided in parentheses corresponds to the equations provided in the analysis section.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Keller et al. (2014)

Sleep and Academic Performance

Table 4
Results of Probing Interactions Between School Start Times and Percentage of Students Receiving Free or Reduced-Cost Lunches

Effects and differences of start times	NAPD						School rank	Attendance rate
	Language	Reading	Math	Science	Social Studies	Writing		
Estimated effect of school start times								
Schools with lower FREELUNCH	.115*	.088*	.050*	.084*	.091*	.098**	.233***	.002*
Schools with higher FREELUNCH	.003	-.012	-.016	.004	.025	.012	.041	-.001
Difference in schools starting 1 hr apart								
Schools with lower FREELUNCH	6.90	6.23	3.01	5.03	5.48	5.90	14.01	0.32
Schools with higher FREELUNCH	0.18	-0.72	-0.96	0.24	1.50	0.72	2.46	-0.06

Note. The first two rows show the simple slopes for the effect of school start time on the dependent variable (see column heading) for lower and higher values of the moderator (FREELUNCH). The bottom two rows illustrate the expected difference in the dependent variable for schools starting 1 hr later than another school.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Keller et al. (2014)

Sleep and Academic Performance

Conclusion: Earlier school start times can be associated with poorer school performance in elementary schools

Keller et al. (2014)

Sleep and Behavior

Table 3

Estimated coefficients from models including interactions between elementary school start times and Appalachian county designation as predictors of the total number of students receiving discipline or engaged in behavioral problems

	Total discipline	Corporal punishment	In-school removal	Out-of-school suspension	Expelled with services	Expelled without services	Total behavior problems	Harassment
Intercept (π_{10})	20.70	-.41	6.42	14.11*	-.01	.16	23.98	8.31**
APPAL (π_{20})	6.70	2.26**	1.14	3.34	.01	.03	6.11	.03
Enrollment	.06***	.00	.04***	.02***	.00	.00	.07***	.01***
School rank	-.11	.00	-.03	-.08**	.00	.00	-.11	-.02
TSRATIO	-2.03*	.00	-1.16	-.79*	.00	-.01	-2.23*	-.62**
FREELUNCH (π_{12})	.17	.04	.54	-.38	.00	.00	.17	.07
AFRICAN AMERICAN	.82***	.00	.55***	.25***	.001*	.00	.74***	.10**
HISPANIC	.38	.00	.30	.07	.00	.00	.32	.04
School start time (π_{11})	-.30***	.00	-.20**	-.09**	-.0002*	.00	-.29***	-.06***
Start time \times APPAL (π_{21})	.24*	-.01	.16	.06	.00	.00	.21	.05

Columns indicate the dependent variable being predicted. Statistical notation provided in parentheses corresponds to the equations provided in the analysis section. * $P < .05$, ** $P < .01$, *** $P < .001$.

Keller et al. (2017)

Sleep and Behavior

- Low base rate of 3% of students K-6
 - 1.6% of incidents were in 6th graders
 - Outcomes driven by 6th graders? If yes, more reason to change middle school start times...
- One study, has not been replicated
 - MANY studies showing negative impact of early start times on adolescents
 - MANY studies showing benefits for adolescents of later start times