The 24-Hour Activity Cycle and Effects on Health: Strategies for the COVID Experience and Beyond
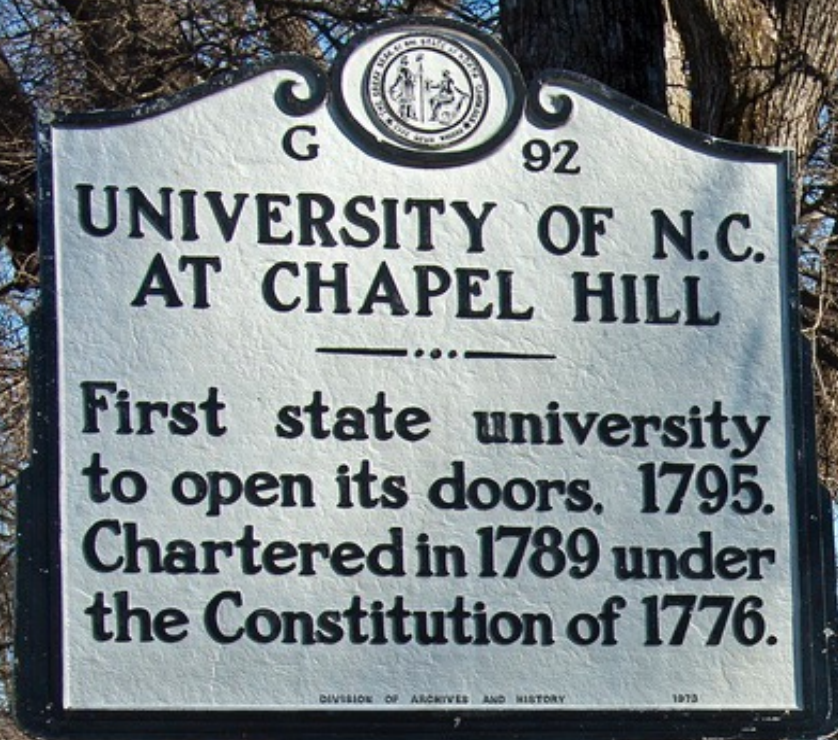
Lee Stoner, PhD, MPH

Delware: PANO
2021-June-17

What are we going to learn?
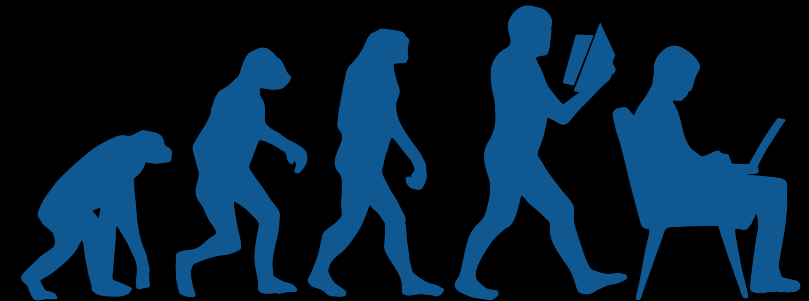
24-hour behavior:
1. What is it?
2. What affects it?
3. How do we improve it?

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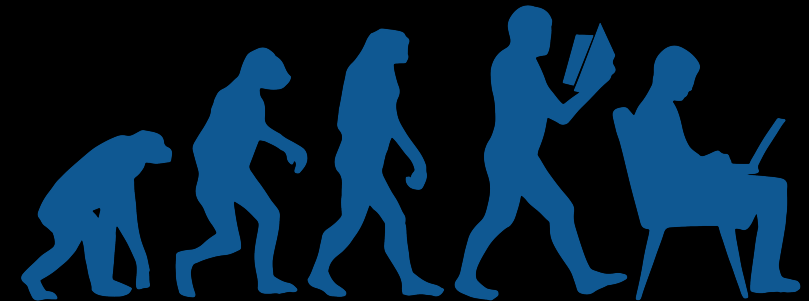
What are we going to learn?

24-hour behavior:
1. What is it?
   - Definitions
   - Recommendations
   - Why important
2. What affects it?
3. How do we improve it?

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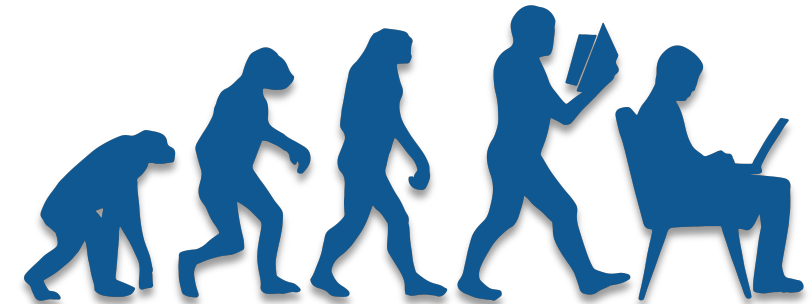
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Definitions

3 behaviors

1. Physical activity
   - **LPA:** Light
   - **MVPA:** moderate-vigorous (exercise)
2. Sedentary Behavior
3. Sleep

Definitions

Physical Activity (PA)

- Body movement via muscle action that ↑ energy expenditure

Exercise

Planned, structured, repetitive, purposeful
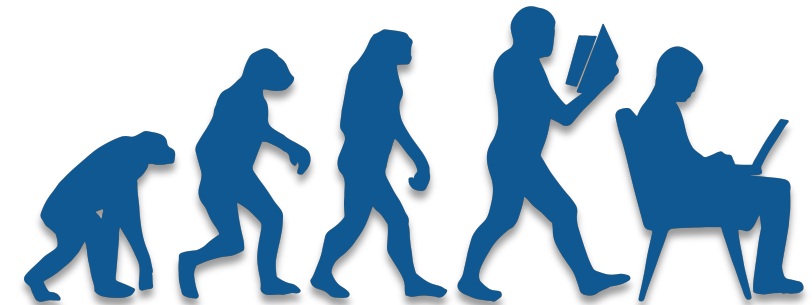- Guidelines: 150 mins **MVPA** per week

Definitions

Sedentary Behavior (SB)

- V. low intensity behaviors (≤1.5 METS) in a seated, reclined, or supine posture

Physical **In**activity

- Not meeting guidelines

Definitions

Sleep

• The absence of wakefulness and by the loss of consciousness of one's surroundings

Definitions

SB
34% (8 h)

Sleep
33% (8 h)

LPA
31% (7.5 h)
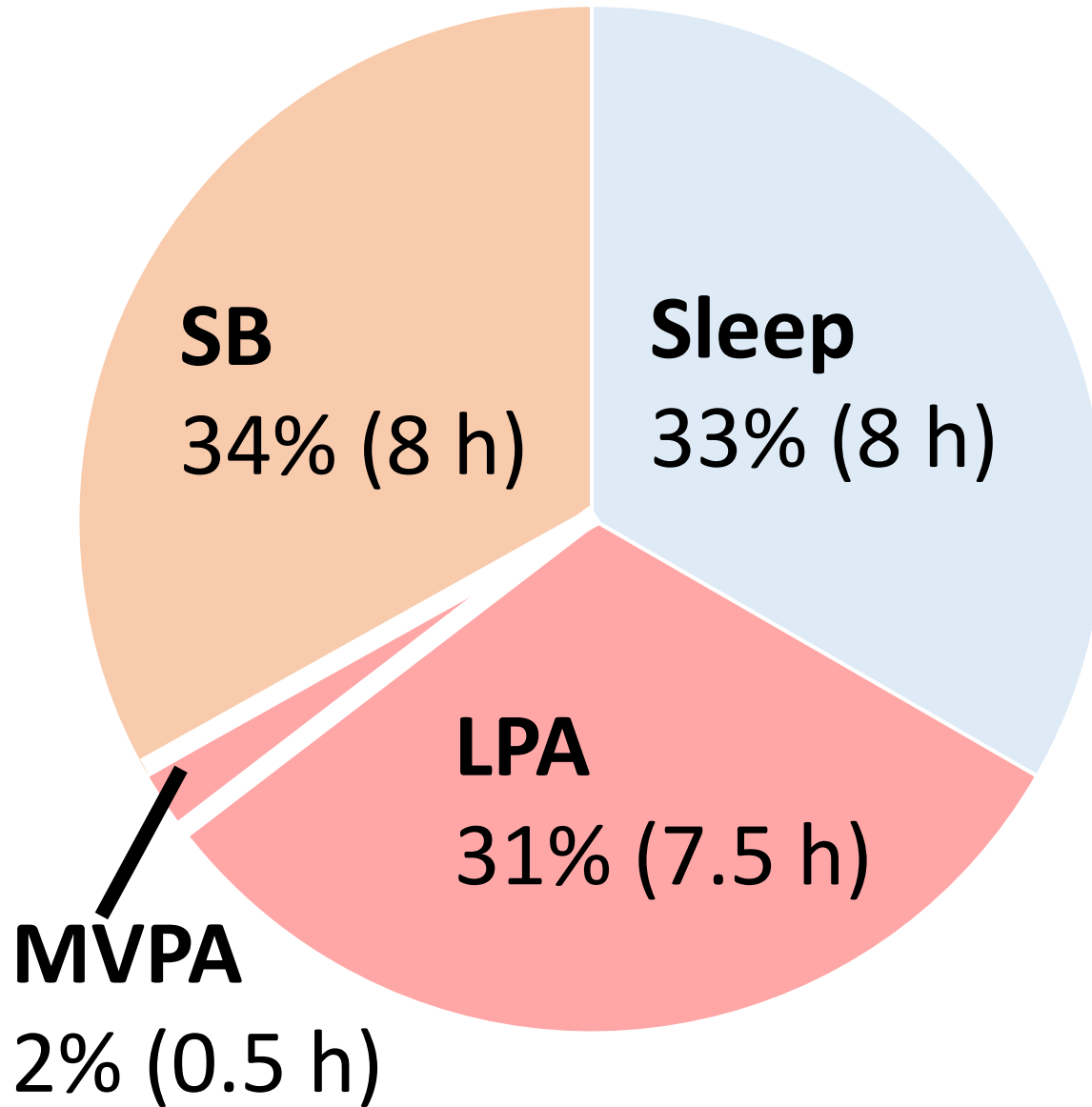
MVPA
2% (0.5 h)

3 Behaviors:
1. Physical activity
   - **LPA**: Light
   - **MVPA**: mod-vig (exercise)
2. **SB**: Sedentary Behavior
   - Transport
   - TV (screen time)
   - Work / Academic
   - Leisure computer
   - Other
3. Sleep
   - Duration
   - Quality
   - Efficiency
   - Timing
   - Social jetlag

What are we going to learn?

24-hour behavior:
1. What is it?
   - ~~Definitions~~
   - Recommendations
   - Why important
2. What affects it?
3. How do we improve

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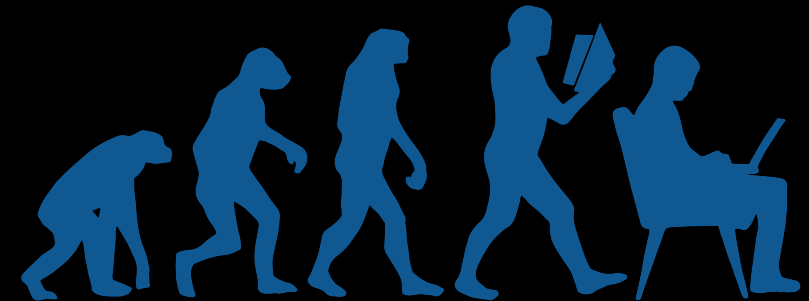
Recommendations: MVPA

- Frequency
  - Mod 5d/w, or
  - Vig 3d/w
- Intensity
  - Mod: 40-60% HRR
  - Vig 60-90% HRR
- Time
  - Mod 30-60 min
  - Vig 20-60 min
- Type
  - Aerobic, involving large muscle groups

- Volume
  - 500-1000 MET-min/wk
- Progression
  - ↑ time during initial phase
    - 5-10 min
  - Total vol should not >10%

Recommendations: MVPA

Adults

- 150 min/week of MVPA
- 2-3 days strengths training

Children

- ≥60min/day mod-vig
  - Including
    - Muscle/bone Strengthening – 3 days
      - https://www.cdc.gov/physicalactivity/basics/children/

Recommendations: Sedentary

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PRONOUNCEMENT

SPECIAL COMMUNICATIONS

Sedentary Behavior and Health: Update from the 2018 Physical Activity Guidelines Advisory Committee

PETER T. KATZMARZYK[1], KENNETH E. POWELL[2], JOHN M. JAKICIC[3], RICHARD P. TROIANO[4], KATRINA PIERCY[5], and BETHANY TENNANT[6], FOR THE 2018 PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE*

- 2018 PAG: Sit less
- But substitute for what???

Critical Gap

- Randomized controlled trials (RCTs) needed to:
  - Test the efficacy SB reduction strategies
  - Advance mechanistic understanding

Lab/acute studies

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C L

Translational Research

Meta-Analysis
Systematic Reviews

Level of Evidence

Interventional

RCT

Observational

Cohort Studies

Case control

No Design

Case Report / Series

Commentaries / editorials

Animal / Laboratory Studies

Why not?

- Why not tell people to sit less?

- Why not tell people to:
  - Exercise more
  - Eat better
  - Sleep better
  - Stop smoking
  - …

Just telling people doesn't work!

SB more amenable to change

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C L

Recommendations: Sleep

SLEEPFOUNDATION.ORG | SLEEP.ORG

Hirshkowitz M, The National Sleep Foundation's sleep time duration recommendations: methodology and results summary, Sleep Health (2015), http://dx.doi.org/10.1016/j.sleh.2014.12.010

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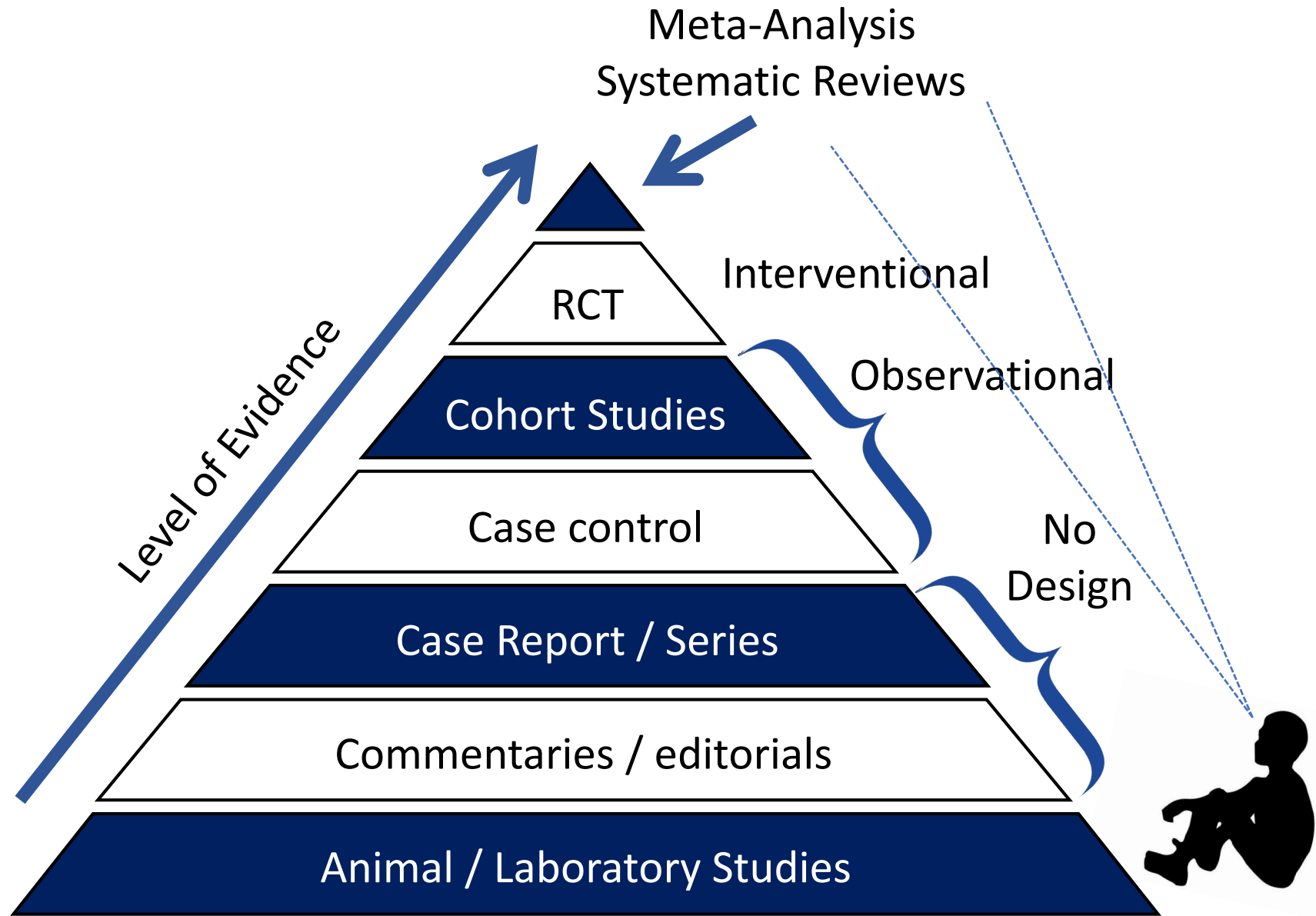RG: researchgate.net/lab/UNC-Cardiometabolic-Lab-Lee-Stoner

What are we going to learn?

24-hour behavior:
1. What is it?
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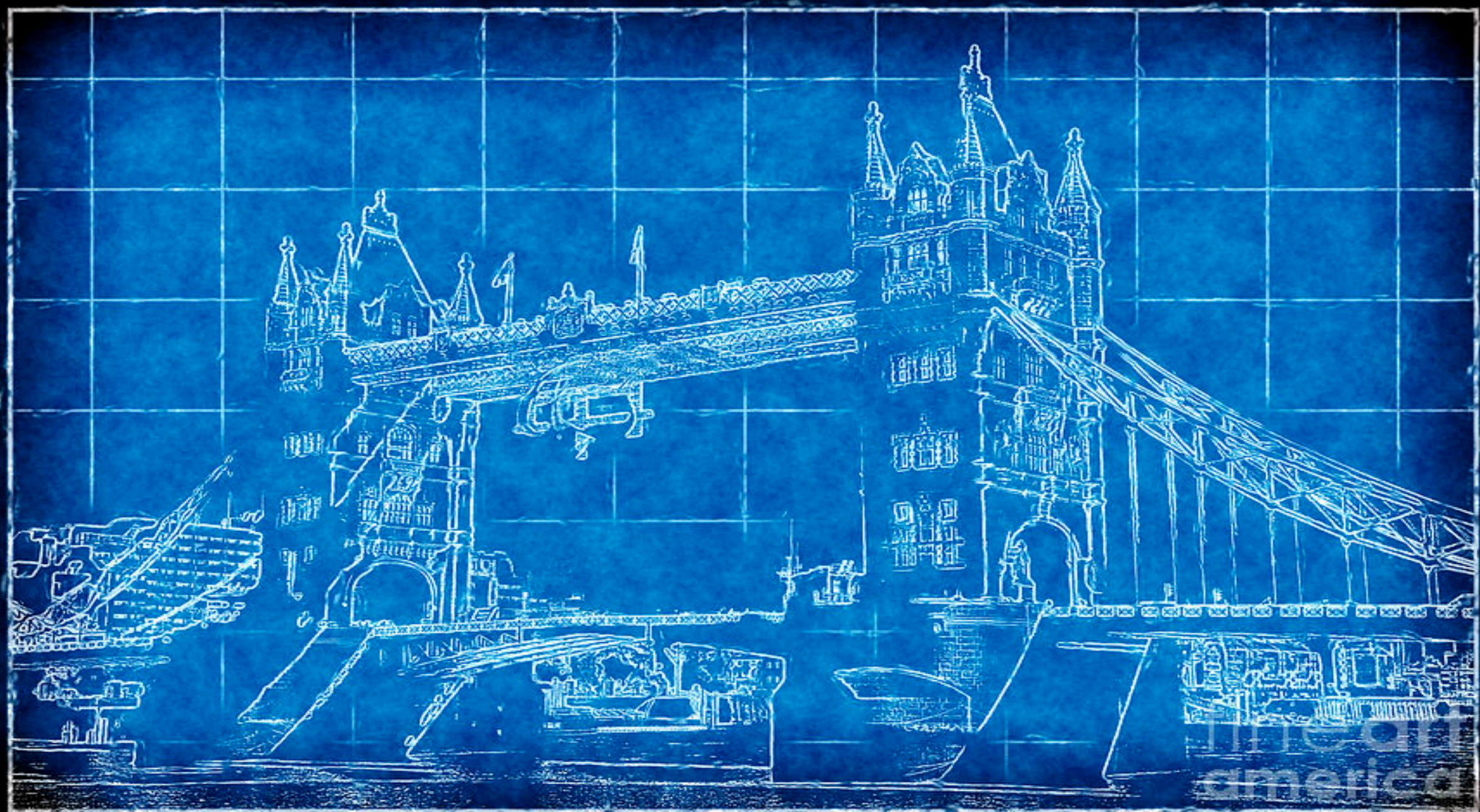
Why important: MVPA

- Musculoskeletal
- Neuromuscular
- Cardiovascular
  - Stoner et al. Perspect Public Health. 2016; 136(1):18-20
- Peak physical fitness!
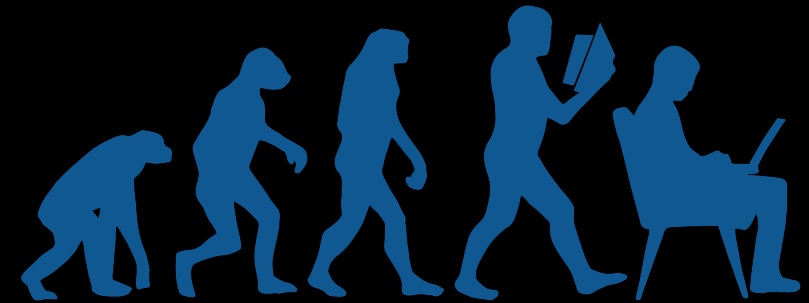 - Booth et al. Compr. Physiol. 2012; 2:1143–211.
- Brain structure
  - Linked to motor skills
    - Chaddock 2011. J Int Neuro Psych Soc. 2011; 17:975-85

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Why important: MVPA

AMERICAN JOURNAL OF **Preventive Medicine**

RESEARCH ARTICLE

Objectively Measured Physical Activity and Mortality Risk Among American Adults

Emily Borgundvaag, MSc,[1] Ian Janssen, PhD[1,2]
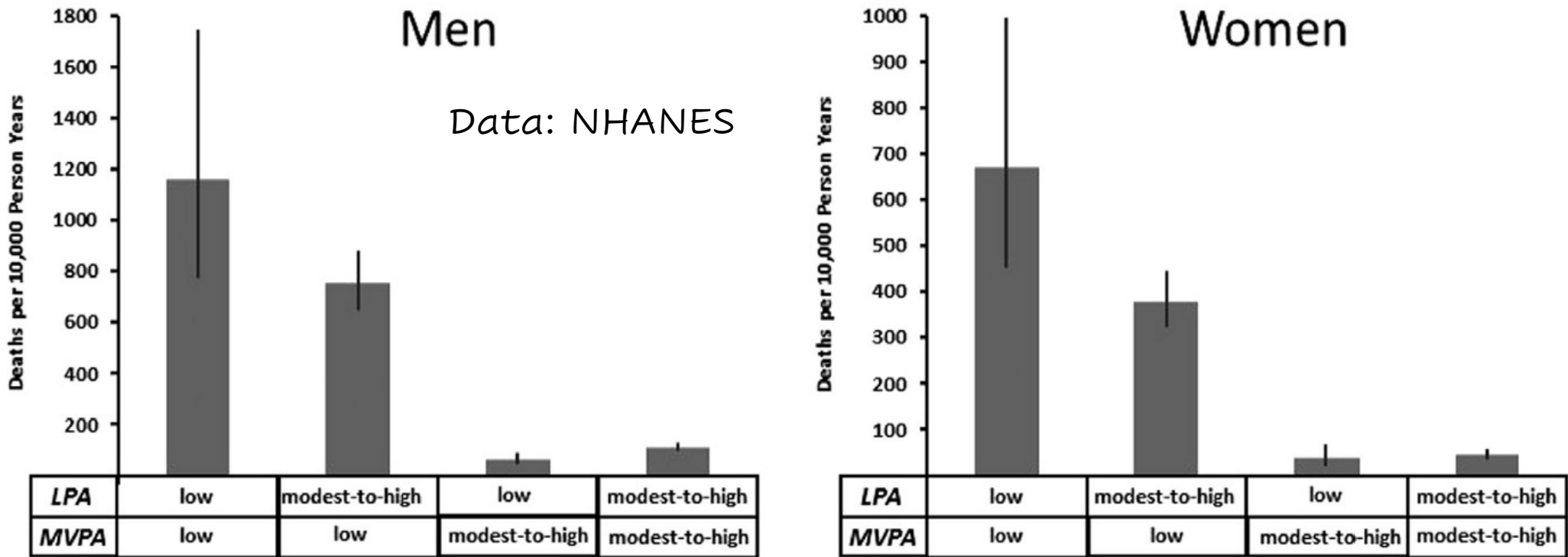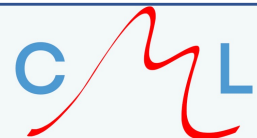
Data: NHANES

Figure 1. Death rates based on combinations of light and moderate to vigorous physical activity.

Notes: Deaths per 10,000 person-years based on combinations of low and modest to high light physical activity (LPA) and moderate to vigorous physical activity (MVPA). Error bars represent 95% CIs. Men (left panel): The low LPA/low MVPA and modest to high LPA/low MVPA combinations are significantly different from the low LPA/modest to high MVPA and modest to high LPA/modest to high MVPA combinations. Women (right panel): All combinations are significantly different from each other with the exception of the comparison between the low LPA/modest to high MVPA and modest to high LPA/modest to high MVPA combinations.

Am J Prev Med. 2017 Jan;52(1):e25-e31.

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THE LANCET]

ORIGINAL ARTICLES

[NOV. 21, 1953

CORONARY HEART-DISEASE AND PHYSICAL ACTIVITY OF WORK

J. N. MORRIS
M.A. Glasg., M.R.C.P., D.P.H.

J. A. HEADY
M.A. Oxfd

OF THE SOCIAL MEDICINE RESEARCH UNIT, MEDICAL RESEARCH COUNCIL

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M.D. Lond., D.P.H., D.I.H.

OF THE MEDICAL DEPARTMENT, LONDON TRANSPORT EXECUTIVE

C. G. ROBERTS
B.A., M.D. Camb.

J. W. PARKS
M.B.E., M.D. Camb., D.C.H.

OF THE TREASURY MEDICAL SERVICE

absences of any duration are so examined. All diagnoses are coded by the internat... deaths and of all retire... and the medical caus... death certificates were... London Transport me... Routine checks are i... Statistics to ensure ac...

By special arrangeme... ill-health retirements, a... assigned to any code... were reported to the me... and cases of coronary... sclerotic, and doubtfu... "notified" to the uni... that all clinical presenta... on or off duty, were i... From the Central...

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The man who invented exercise

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- Population:
  - 31,000 men, 35–64 years
  - Observed: 1949–50
- Annual incidence of CHD
  - Drivers: 2.7 per 1,000
  - Conductors: 1.9 per 1,000
- Observation:
  - Drivers sat 90% of shift
  - Conductors ascended/descended 500–750 steps/day

Story: Jim Morris dies aged 99.5 y

"I was the first person to run on Hampstead Heath, in the 1960s. Every Sunday morning…"

Why important: sedentary

- Biological novel risk factor
- Important even if meeting MVPA guidelines
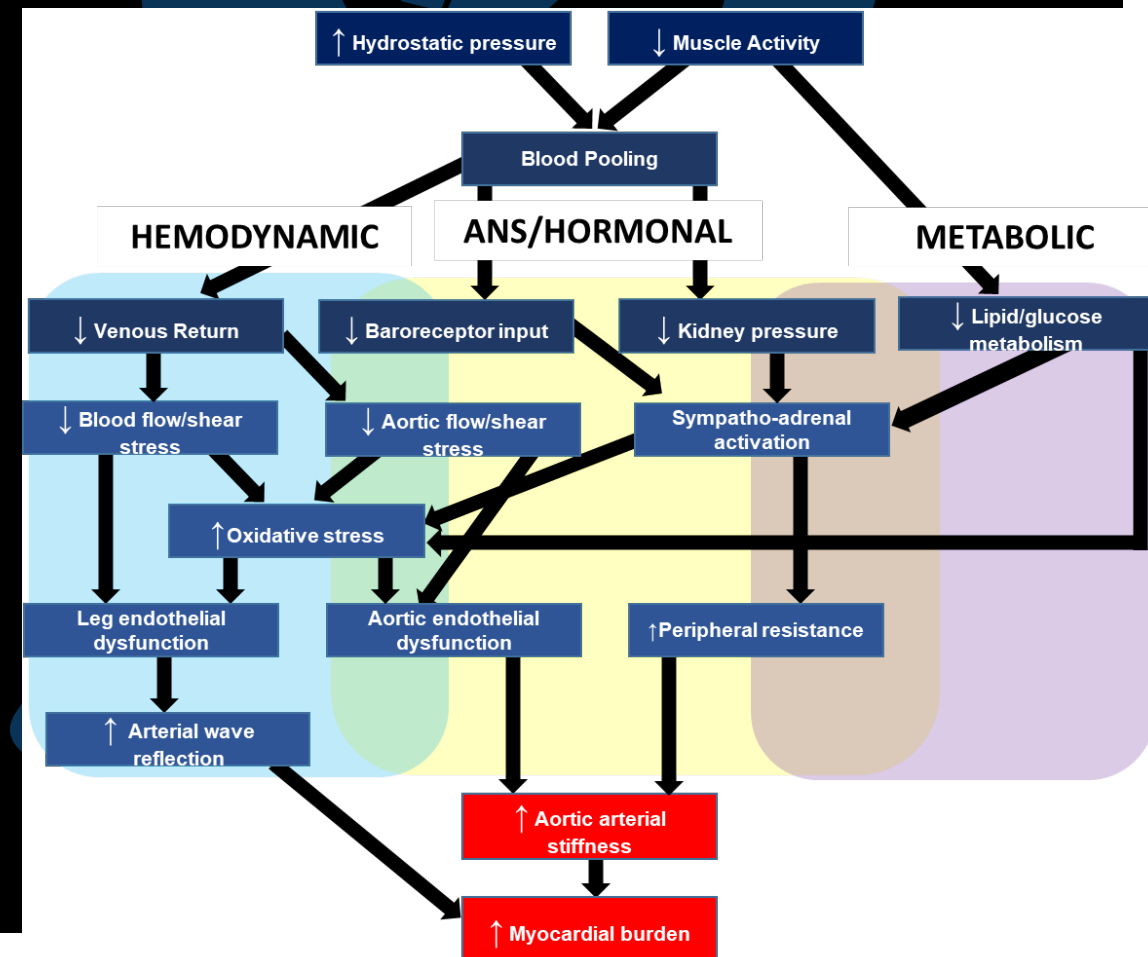
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Sedentary Behavior and Health: Update from the 2018 Physical Activity Guidelines Advisory Committee

PETER T. KATZMARZYK[1], KENNETH E. POWELL[2], JOHN M. JAKICIC[3], RICHARD P. TROIANO[4], KATRINA PIERCY[5], and BETHANY TENNANT[6], FOR THE 2018 PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE*

- Level of evidence for an overall and dose–response association between SB and CVD mortality is '<u>strong</u>'

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Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women

Ulf Ekelund, Jostein Steene-Johannessen, Wendy J Brown, Morten Wang Fagerland, Neville Owen, Kenneth E Powell, Adrian Bauman, I-Min Lee, for the Lancet Physical Activity Series 2 Executive Committe* and the Lancet Sedentary Behaviour Working Group*
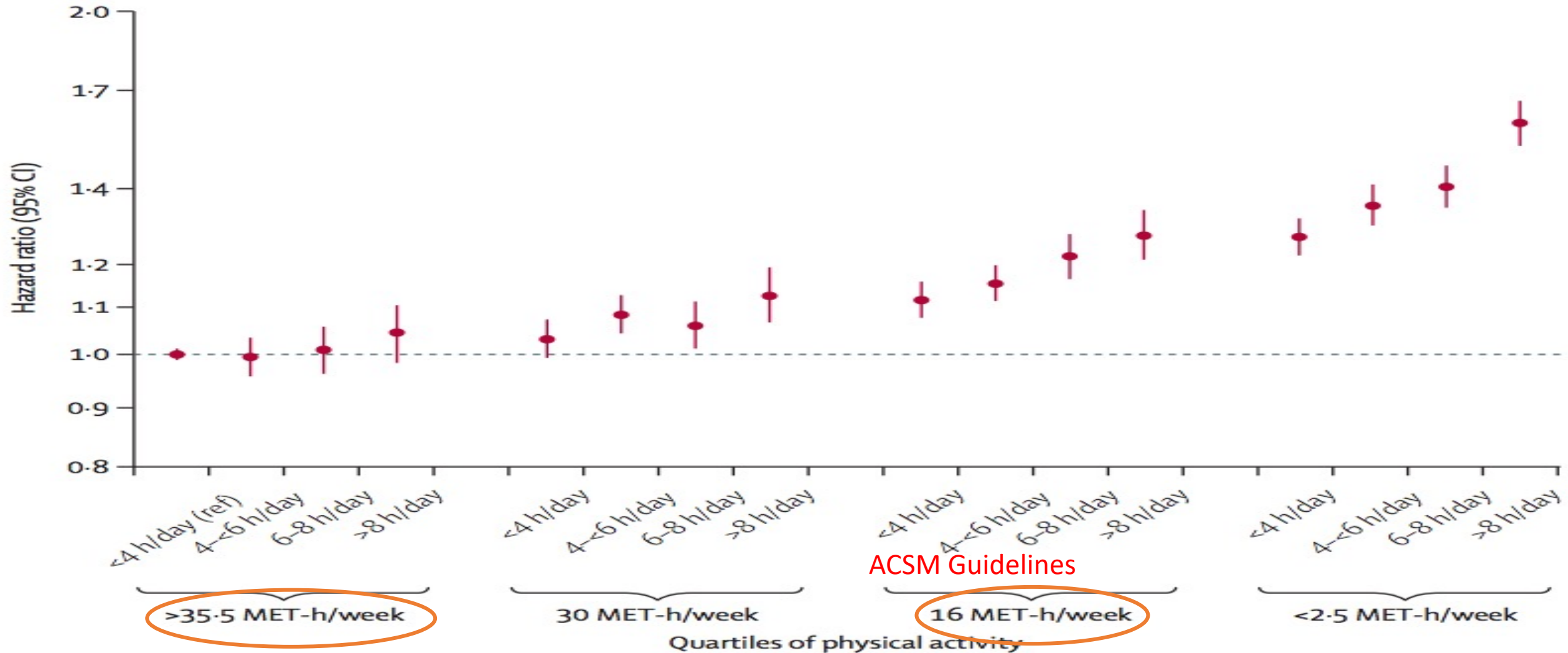
Why important: sleep

- Behavioral strategy
- Theories
  - Inactivity during danger
  - Conserve resources
  - Brain plasticity
  - Restoration of physiological systems
    - Stoner et al. *Perspect Public Health.2016;136(1):18-20*

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C ML

Why important: sleep

- Def: The absence of wakefulness and by the loss of consciousness of one's surroundings
    - Duration
        - Kids: 9-11 hrs
        - Adults: 7-9 hrs
    - Quality
    - Efficiency
    - Timing
    - Social jetlag

CLOCK System

Light/Dark (Eyes)

Creation of Diurnal Oscillation

Central CLOCK (SCN)

Neural/Humoral Connections

Synchronization

Sensitization to ACTH

Peripheral CLOCK (Organs)

Clock Reset/ Phase-delay

HPA Axis

Regulatory Signals from Upper Brain Centers

Hypothalamus (PVN)

CRH/AVP

Pituitary gland

ACTH

Adrenal gland

Cortisol

CLOCK/GR Interaction at Local Tissues
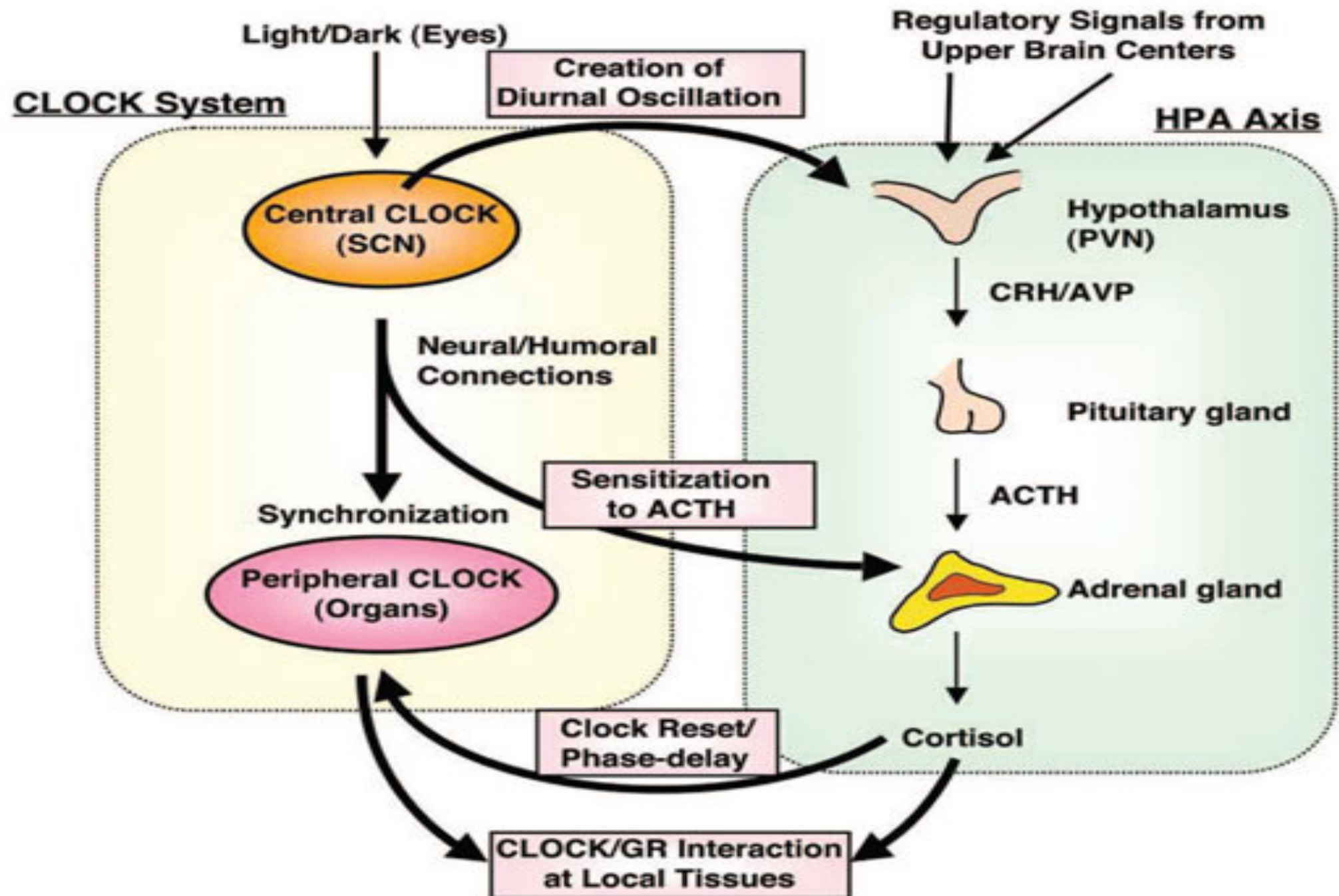
Sleep and Adiposity in Preadolescent Children: The Importance of Social Jetlag

Lee Stoner, PhD, MPH,[1] Nicholas Castro, MAEd,[2,3] Leigh Signal, PhD,[4] Paula Skidmore, PhD,[5] James Faulkner, PhD,[6] Sally Lark, PhD,[2,3] Michelle A. Williams, ScD,[6] Diane Muller, MPH,[4] and Harriet Harrex, MSc[5]

Table 2. Linear Association between Body Composition Measures and Sleep Measures

| | Univariate | | | | Multivariate | | | | | | | |
| | | | | | Model 1 (school adjusted) | | | | Model 2 (multivariate adjusted) | | | |
	β	LCI	UCI	P	β	LCI	UCI	P	β	LCI	UCI	P
Body fat (%)												
Average duration (hours)	−0.513	−1.709	0.682	0.399	−0.293	−2.057	1.471	0.745	−0.293	−1.363	0.777	0.591
Sleep disturbances	0.185	0.018	0.352	0.030	0.162	0.064	0.259	0.001	0.162	−0.012	0.335	0.068
Social jetlag (hours)	3.087	1.401	4.772	<0.001	2.963	0.462	5.463	0.020	2.963	0.398	5.528	0.024
Fat mass (kg)												
Average duration (hours)	−0.753	−1.395	−0.110	0.022	−0.579	−1.580	0.421	0.256	−0.579	−1.298	0.140	0.114
Sleep disturbances	0.118	0.028	0.208	0.010	0.094	0.026	0.162	0.007	0.094	−0.001	0.190	0.053
Social jetlag (hours)	1.845	0.937	2.753	<0.001	1.727	0.256	3.199	0.021	1.727	0.144	3.311	0.033
Fat mass index (kg/m²)												
Average duration (hours)	−0.253	−0.553	0.047	0.098	−0.181	−0.658	0.295	0.456	−0.181	−0.499	0.137	0.264
Sleep disturbances	0.056	0.014	0.098	0.009	0.047	0.018	0.077	0.002	0.047	0.002	0.093	0.041
Social jetlag (hours)	0.806	0.383	1.229	<0.001	0.759	0.185	1.333	0.010	0.759	0.132	1.386	0.018
Body mass index (kg/m²)												
Average duration (hours)	−0.467	−0.867	−0.066	0.023	−0.351	−0.861	0.159	0.177	−0.351	−0.827	0.124	0.148
Sleep disturbances	0.067	0.011	0.124	0.019	0.054	0.001	0.106	0.045	0.054	−0.003	0.110	0.064
Social jetlag (hours)	0.954	0.384	1.525	0.001	0.885	0.422	1.348	0.000	0.885	0.208	1.562	0.010
Waist-to-hip ratio												
Average duration (hours)	−0.008	−0.015	−0.001	0.025	−0.006	−0.014	0.002	0.145	−0.006	−0.012	0.001	0.072
Sleep disturbances	0.000	−0.001	0.001	0.654	0.000	−0.001	0.001	0.981	0.000	−0.001	0.001	0.986
Social jetlag (hours)	0.014	0.004	0.023	0.008	0.013	0.005	0.021	0.002	0.013	0.003	0.023	0.012

Model 2: school decile, ethnicity, sex, age.
Note: the univariate models specify the sleep measures (sleep duration, sleep disturbances, and social jet lag) separately (separate models). The multivariate models include all sleep measures in the same model.

CLINICAL REVIEW

Sleep and cardiometabolic risk in children and adolescents

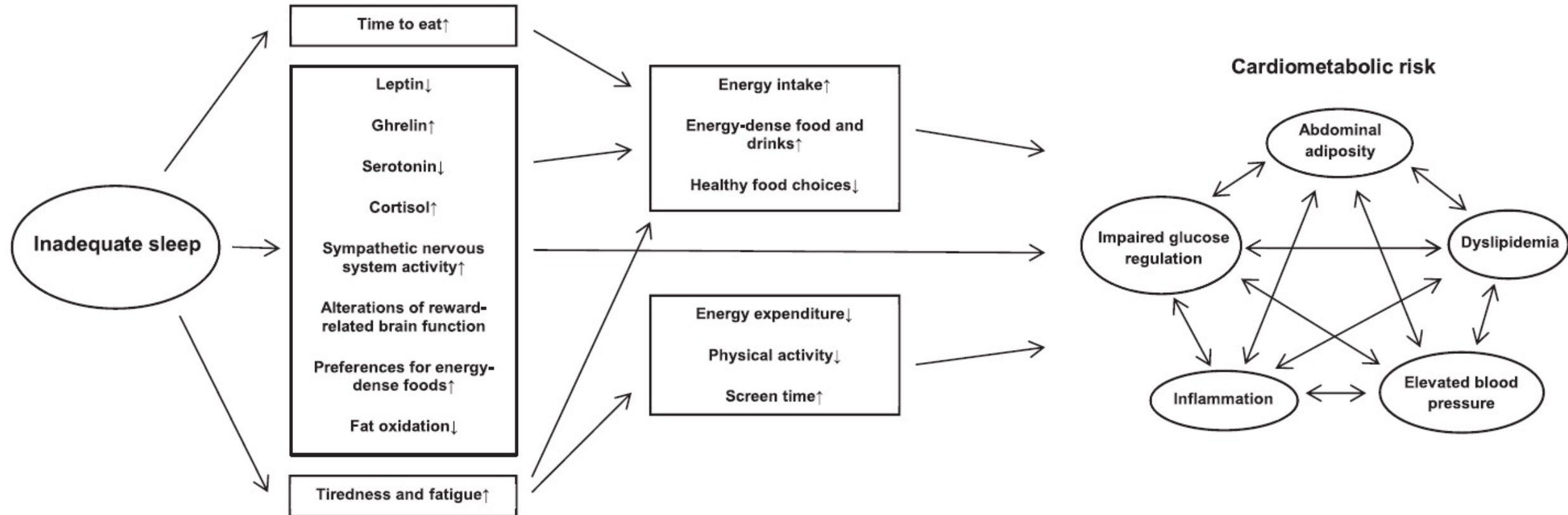Jonas S. Quist [a,*], Anders Sjödin [b], Jean-Philippe Chaput [c], Mads F. Hjorth [b]

Fig. 5. Potential pathways that have been proposed to link inadequate sleep with cardiometabolic risk as well as proposed interrelationships between cardiometabolic risk factors.

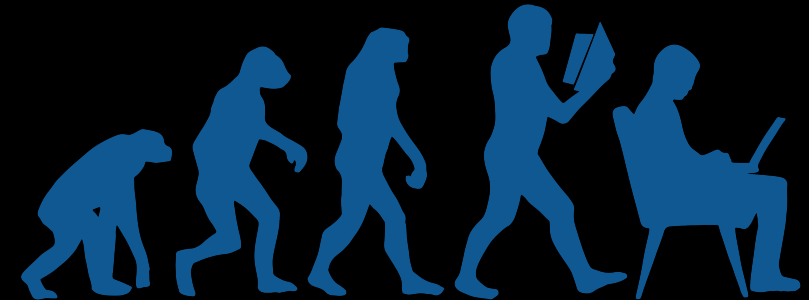# What are we going to learn?

24-hour behavior:
1. ~~What is it?~~
2. What affects it?
   - Covid
   - Beyond
3. How do we improve it?

What affects it: COVID

- Quarantining

- Social restrictions

- Altered work / school practices
  - Frontline workers – longer/altered shifts

- ↑ screen time

- Lack of separation leisure vs. work

Changes: physical activity

- Adults
  - COVID:
    - ↓2,000 steps/day across nations (USA, UK, France, Australia)
      - Karageorghis et al. *BMC Public Health*. 2021 May 27;21(1):988

- Children
  - Prior to COVID:
    - 10% children (5-17 yr) met guidelines
      - Bates et al. *Children*. 2020 Sep 16;7(9):138.
  - COVID:
    - 3.6% kids (5-11 yr)
    - 2.6% of adolescents (12-17 yr)
      - Bates et al. *Children*. 2020 Sep 16;7(9):138.

Changes: sedentary

- Adults
  - Prior to COVID:
    - sit ~8 hr/day
  - COVID:
    - ↑
    - Likely at the expense of LPA and MVPA
      - Zieff et al. *Transl Behav Med.* 2021 Apr 7;11(3):826-831
- Children
  - Prior to COVID: ~50% >2 hr screen time
  - COVID: ↑ 20-66%
    - Bates et al. *Children.* 2020 Sep 16;7(9):138.

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Changes: sleep

- Adults
  - COVID:
    - ~40% of pop. (across 14 countries) report sleep problems
    - 75% for COVID patients
      - Jahrami et al. J Clin Sleep Med. 2021 Feb 1;17(2):299-313

- Children
  - COVID:
    - ↑ sleep
    - ↑ unscheduled sleep
      - Bates et al. Children. 2020 Sep 16;7(9):138.

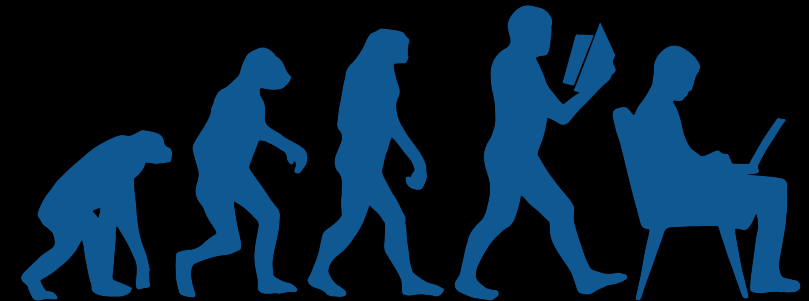# What are we going to learn?

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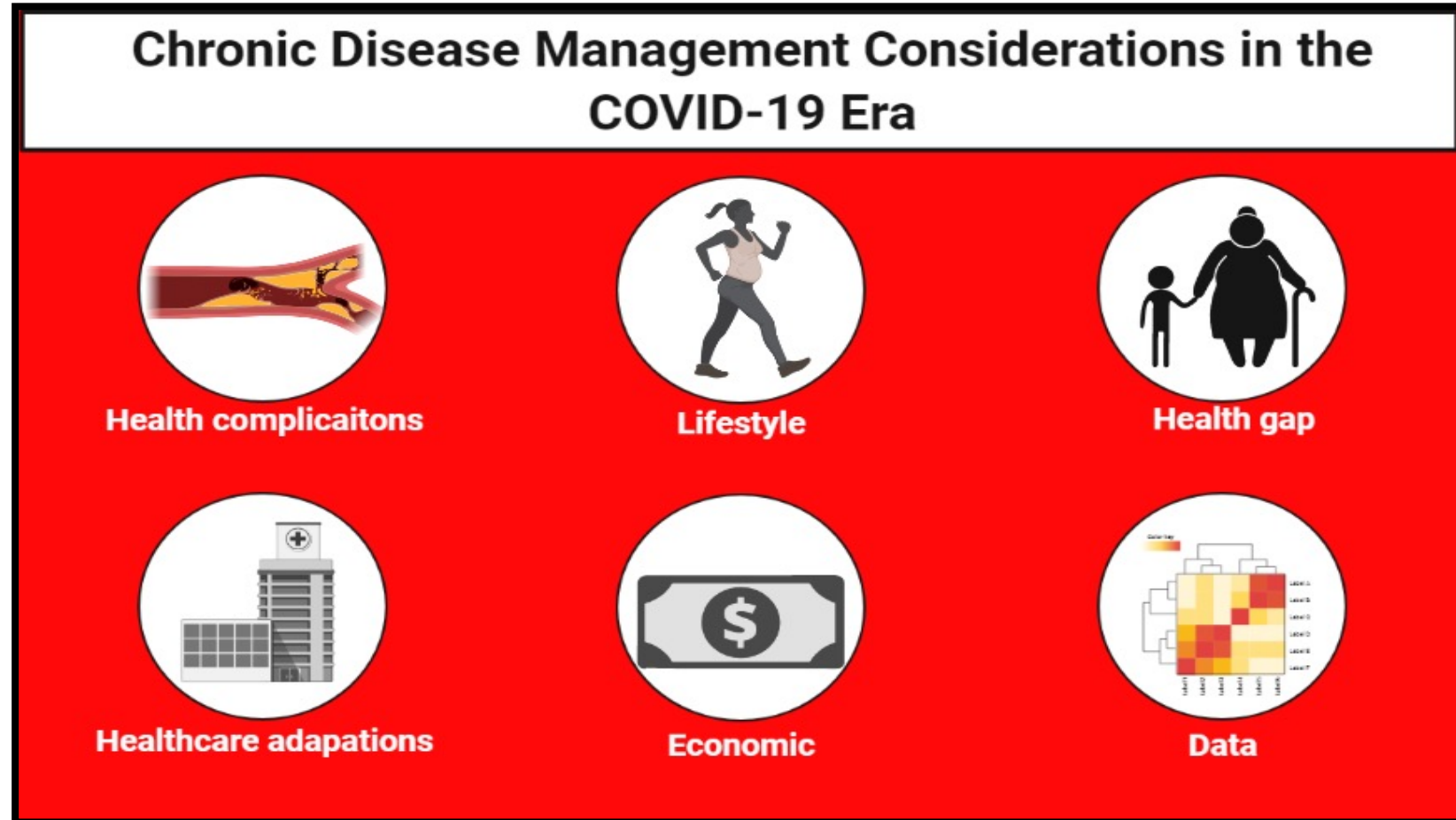1. ~~What is it?~~
2. What affects it?
   - ~~Covid~~
   - Beyond
3. How do we improve it?

What affects it: Beyond

- New normal?
  - ↑ remote work?
  - ↑ schooling?
- Long-term healthcare?

Chronic Disease Management Considerations in the COVID-19 Era

Health complicaitons
Lifestyle
Health gap
Healthcare adapations
Economic
Data

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What are we going to learn?

24-hour behavior:

1. ~~What is it?~~
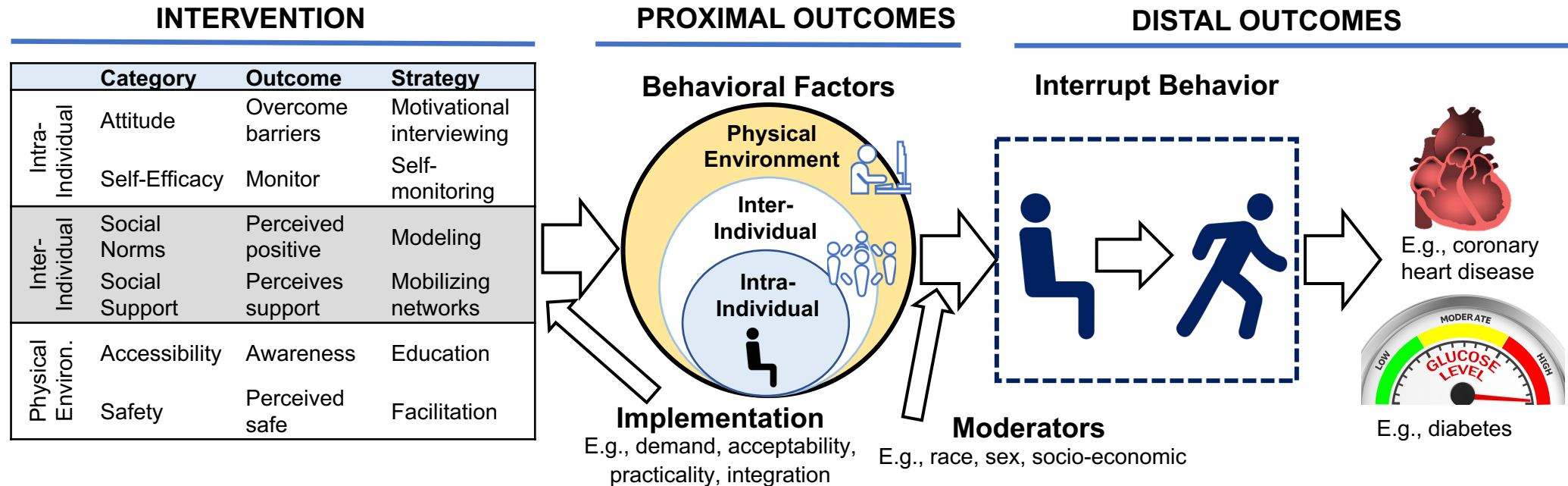2. ~~What affects it?~~
3. How do we improve
   - Adults
   - Children
   - Special populations

How do we improve it?

INTERVENTION

	Category	Outcome	Strategy
Intra-Individual	Attitude	Overcome barriers	Motivational interviewing
	Self-Efficacy	Monitor	Self-monitoring
Inter-Individual	Social Norms	Perceived positive	Modeling
	Social Support	Perceives support	Mobilizing networks
Physical Environ.	Accessibility	Awareness	Education
	Safety	Perceived safe	Facilitation

PROXIMAL OUTCOMES

Behavioral Factors

Physical Environment

Inter-Individual

Intra-Individual

Implementation
E.g., demand, acceptability, practicality, integration

Moderators
E.g., race, sex, socio-economic

DISTAL OUTCOMES

Interrupt Behavior

E.g., coronary heart disease

E.g., diabetes

TBM

Targeting sedentary behavior as a feasible health strategy during COVID-19

Gabriel Zieff,[1,2,] Lauren C. Bates,[1,2] Zachary Y. Kerr,[1] Justin B. Moore,[3] Erik D. Hanson,[1] Claudio Battaglini,[1] Lee Stoner[1,2]

Policy
Government guidelines
Public health messages (TV/radio/internet)

Environment
Sit-stand desks
Parks and recreation spaces

Inter-individual
Wearable physical activity monitors
Social support

Intra-individual
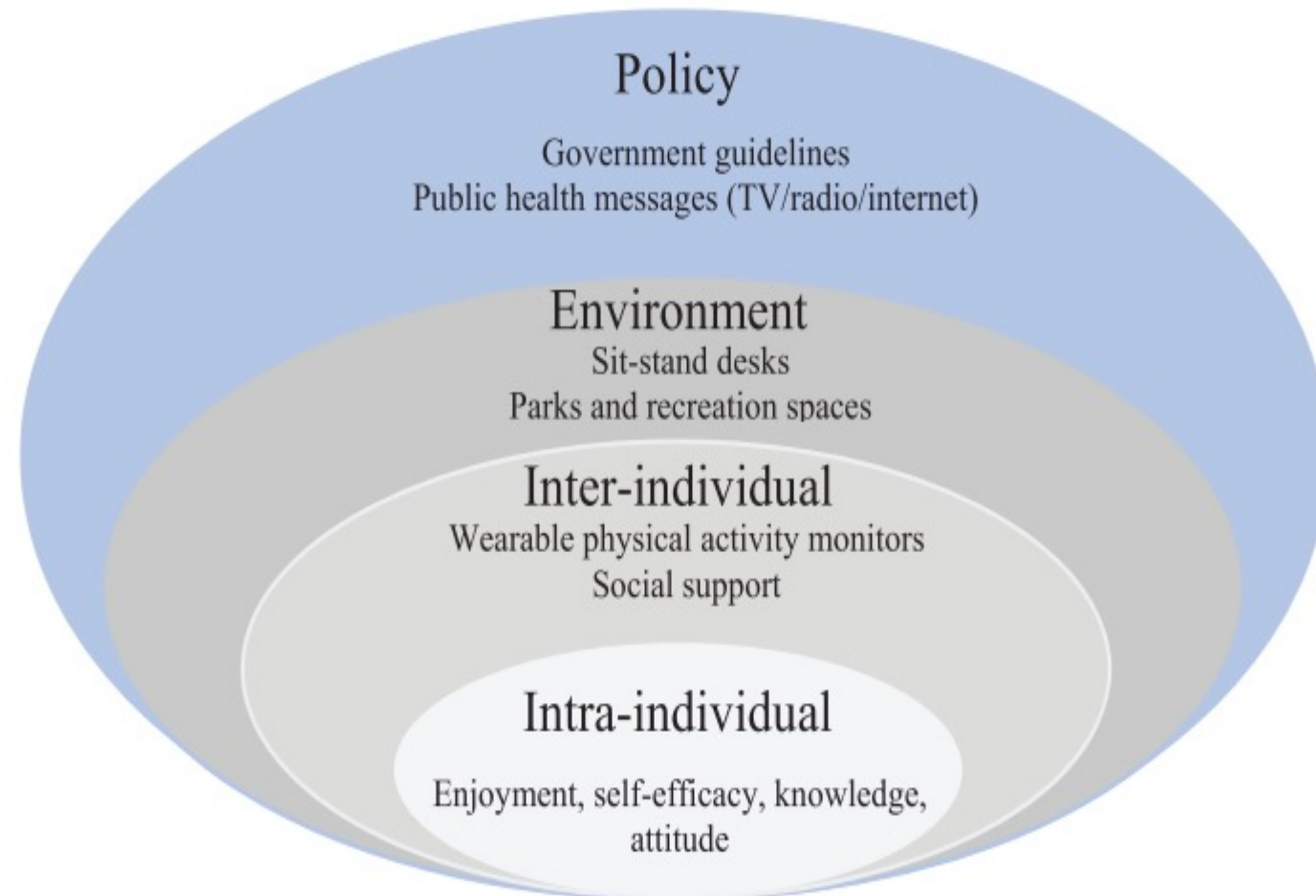Enjoyment, self-efficacy, knowledge, attitude

Table 1 | Best evidence for breaking up sedentary behavior in the context of feasibility and reducing cardiometabolic disease risk

Best evidence for sitting interruption [55]	
Frequency	Every 20–30 min
Intensity	Light
Time	2–5 min
Type	Walking and standing

What are we going to learn?

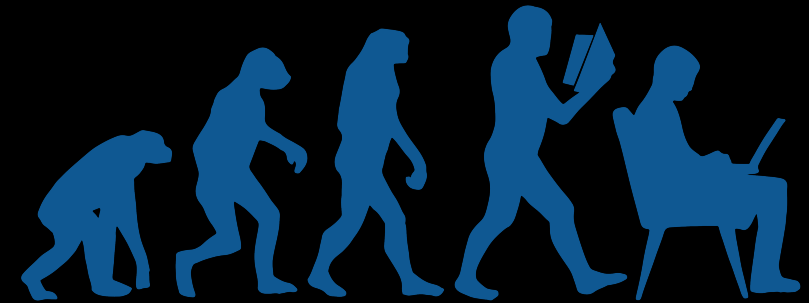## 24-hour behavior:

1. ~~What is it?~~
2. ~~What affects it?~~
3. How do we improve it?
   - ~~Adults~~
   - Children
   - Special populations

children

MDPI

Commentary

COVID-19 Impact on Behaviors Across the 24-Hour Day in Children and Adolescents: Physical Activity, Sedentary Behavior, and Sleep

Lauren Bates,[1] Gabriel Zieff,[1] Katie Stanford,[1] Justin B. Moore,[2] Zachary Y. Kerr,[1] Erik D. Hanson[1], Bethany Barone Gibbs[3], Christopher E. Kline[3], Lee Stoner[1]

Socio-Ecological Model

Intra-Individual
- Find physical activity that is enjoyable
- Break up sedentary behavior by dancing or walking with a family member/pet
- Mindfulness practice before sleep

Inter-Individual
- Neighborhood Facebook group physical activity challenges
- Family challenge to stand every hour
- Talk to family to promote feelings of connectiveness before sleep

Environment
- Physical activity engagement with objects found at home
- Parents/guardians establish screen time limits
- No screen time prior to sleep

Policy
- Close streets to allow for socially distance physical activity
- Educate parents about breaking up sedentary behavior
- Spread importance of sleep schedules/quality

COVID-19 Recommendations for Children & Adolescents

Commentary

COVID-19 Impact on Behaviors Across the 24-Hour Day in Children and Adolescents: Physical Activity, Sedentary Behavior, and Sleep

Lauren Bates,[1] Gabriel Zieff,[1] Katie Stanford,[1] Justin B. Moore[2], Zachary Y. Kerr[1], Erik D. Hanson[1],
Bethany Barone Gibbs[3], Christopher E. Kline[3], Lee Stoner[1]

RECOMMENDED

24-HOUR DAY FOR CHILDREN & ADOLESCENTS

DURING COVID-19

PHYSICAL ACTIVITY

≥ 60 minutes of moderate-vigorous per day

Aerobic full-body activity
Bone loading & muscle
strengthening 3 x per week

• • • • **Recommendations** • • • •

Exercise outdoors (if safe)   Activity trackers
Family physical activities   Social media
Walk your dog   challenges

SEDENTARY BEHAVIOR

≤ 2 hours of recreational screen time per day

Several hours of light activity
(walking/playing) to interrupt sedentary
bouts

• • • • **Recommendations** • • • •

Create schedule for breaks from sitting
60 sec dance parties every hour
Set a timer to remember to move

SLEEP

9-11 hours uninterrupted sleep per night

Bedtimes & waketimes should be
established and not vary by more than
30 minutes from night to night

• • • • **Recommendations** • • • •

Screen free bedroom/No use before sleep
Reassure feelings of safety
Set bed time and wake time

What are we going to learn?
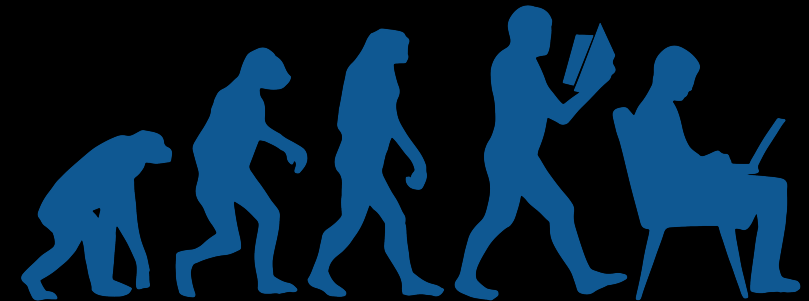
24-hour behavior:
1. ~~What is it?~~
2. ~~What affects it?~~
3. How do we improve it?
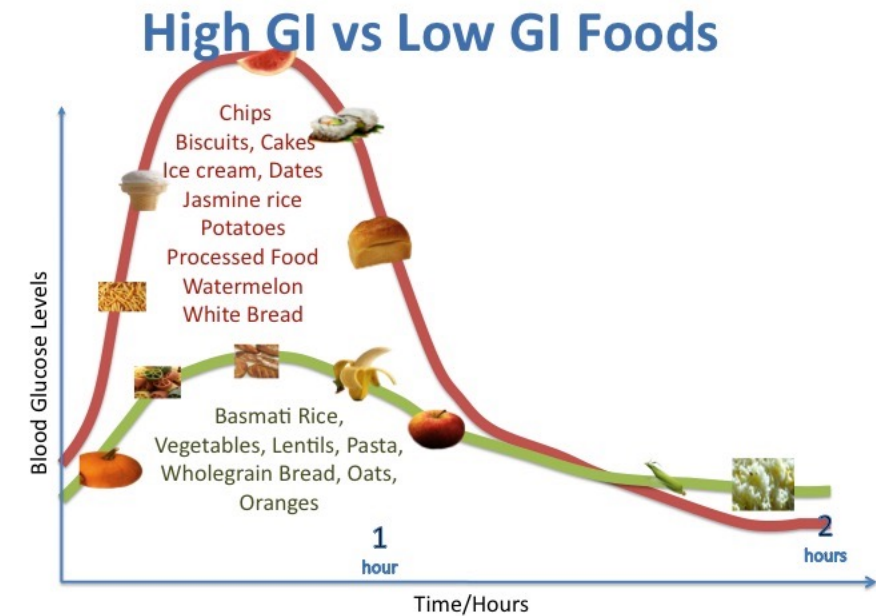   - ~~Children~~
   - ~~Adults~~
   - Special populations

Clinical Populations

- E.g., Type II Diabetes
  - High CVD risk
  - Different sitting mechanisms
  - Control of glycemia therapeutic taraet
    - Particularly hyperglycemic spikes
    - Occur after large meals

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Special Populations

- E.g., spinal cord injured
  - Special considerations for breaking-up sitting

A Socio-Ecological Model for Physical Activity and Sedentary Behavior for People with SCI During COVID-19

| **Individual**	**Social**	**Physical**	**Policy**
Enjoyment	Connection	COVID-safe	Funding
Self-monitoring	Community	facilities	Accessible public
Timed reminders	Support groups	Home modification	resources

Physical Activity: any voluntary bodily movement produced by skeletal muscles that requires energy expenditure

Sedentary Behavior: any waking behavior in a seated or reclining position < 1.5 Metabolic Equivalents

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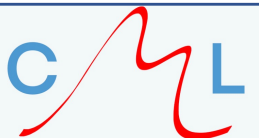
COVID-19 & Minority Health

Theoretical framework for Sedentary Behavior, Minority Health, and COVID-19 Severity

Minority Health Status → ↑ Underlying Cardiometabolic Risk → New Normal: Social Distancing, Quarantine, Remote Work → ↓ Mental Health / ↑ Sedentary Behavior → ↑ Severity of COVID-19 Outcomes
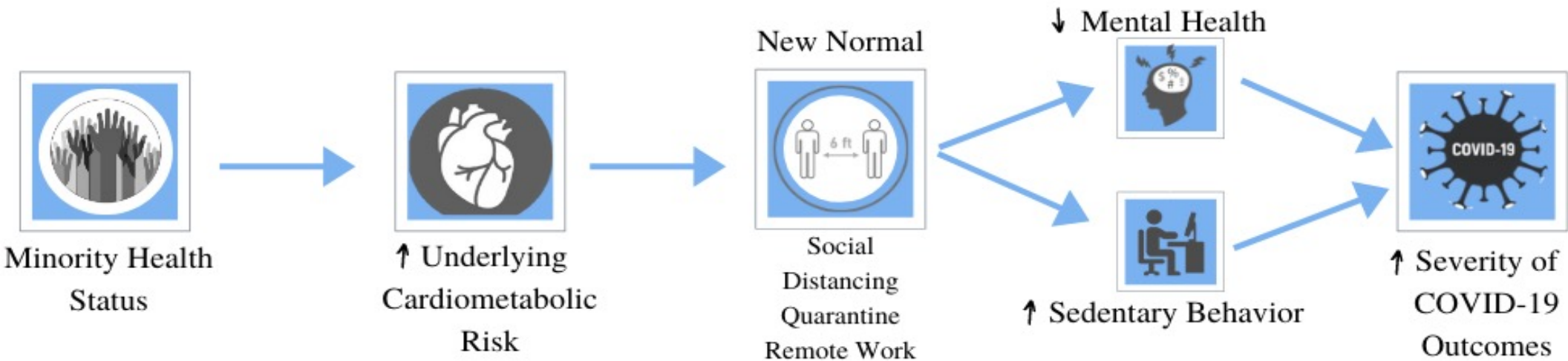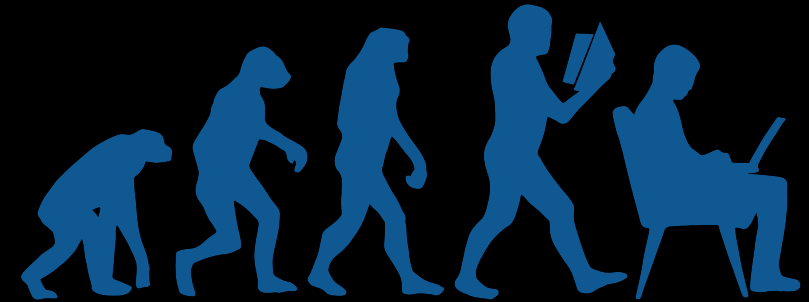
Table 1. Case, Hospitalization, and Death Rate Ratios by Race/Ethnicity

Rate ratios compared to Non-Hispanic persons	American Indian*	Non-Hispanic Black	Hispanic
Cases	1.8x	1.4x	1.7x
Hospitalizations	4.0x	3.7x	4.1x
Death	2.6x	2.8x	2.8x

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CML

What did we learn?

24-hour behavior:
1. What is it?
2. What affects it?
3. How do we improve it?

Reading list

- **Physical activity**
  - ACSM Position Stands
    - http://www.acsm.org/access-public-information/position-stands
- **Sedentary behavior**
  - WHO Guidelines on PA/SB (new!!)
    - https://www.who.int/publications/i/item/9789240015128
- **Sleep**
  - NSF – COVID
    - https://www.sleepfoundation.org/sleep-guidelines-covid-19-isolation
  - NSF – Sleep Hygiene
    - https://www.sleepfoundation.org/sleep-hygiene/healthy-sleep-tips

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UNC CardioMetabolic Lab
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