Time of Day and Athletic Performance

Does it Matter?

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Acknowledgement

- ATSNJ Research Committee
- ATSNJ Conference Planning committee

ATSNJ
Athletic Trainers' Society of New Jersey

Disclosures/Conflict of Interest

- No conflicts of interest


Evidence-Based Practice
We've Always Done It That Way


FIXED
MINDSET

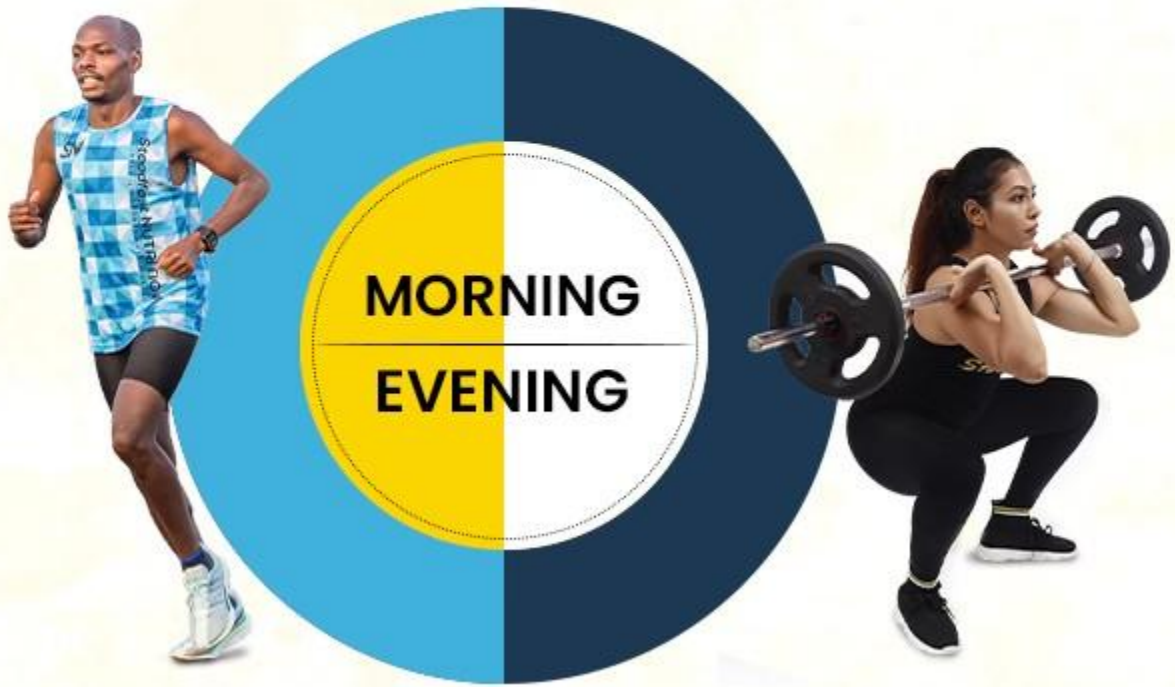

GROWTH
mindset
edgalaxy.com

Objectives

- Evaluate (examine) the literature related to the influence of circadian rhythm on measures of (athletic) performance
- Apply concepts of circadian rhythm to clinical testing and performance.
- Identify the influence of circadian rhythm on trunk stability

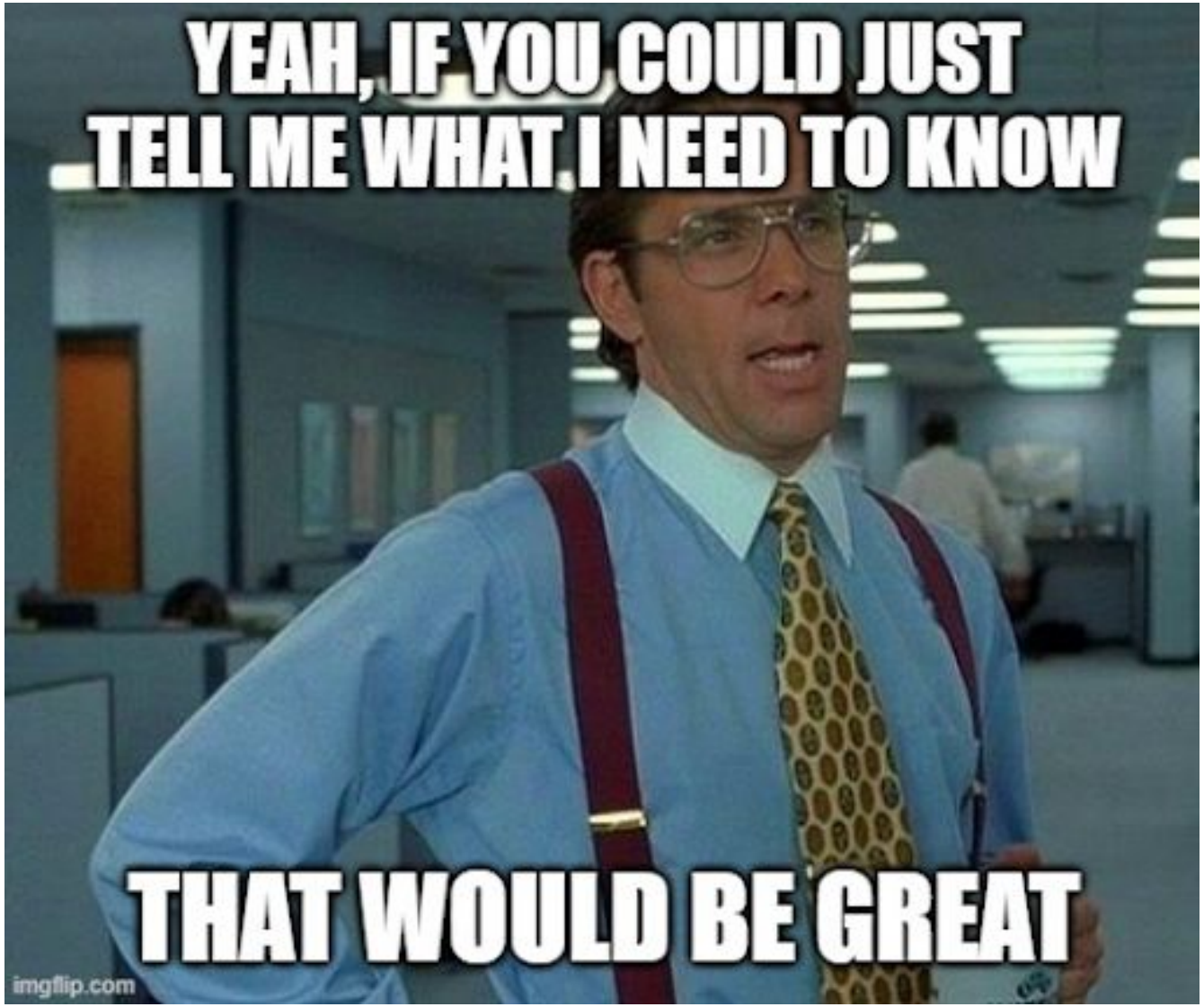
MORNING VS EVENING

What's the Best Time to Exercise?



https://www.steadfastnutrition.in/blogs/news/what-is-the-best-time-to-exercise-morning-or-evening

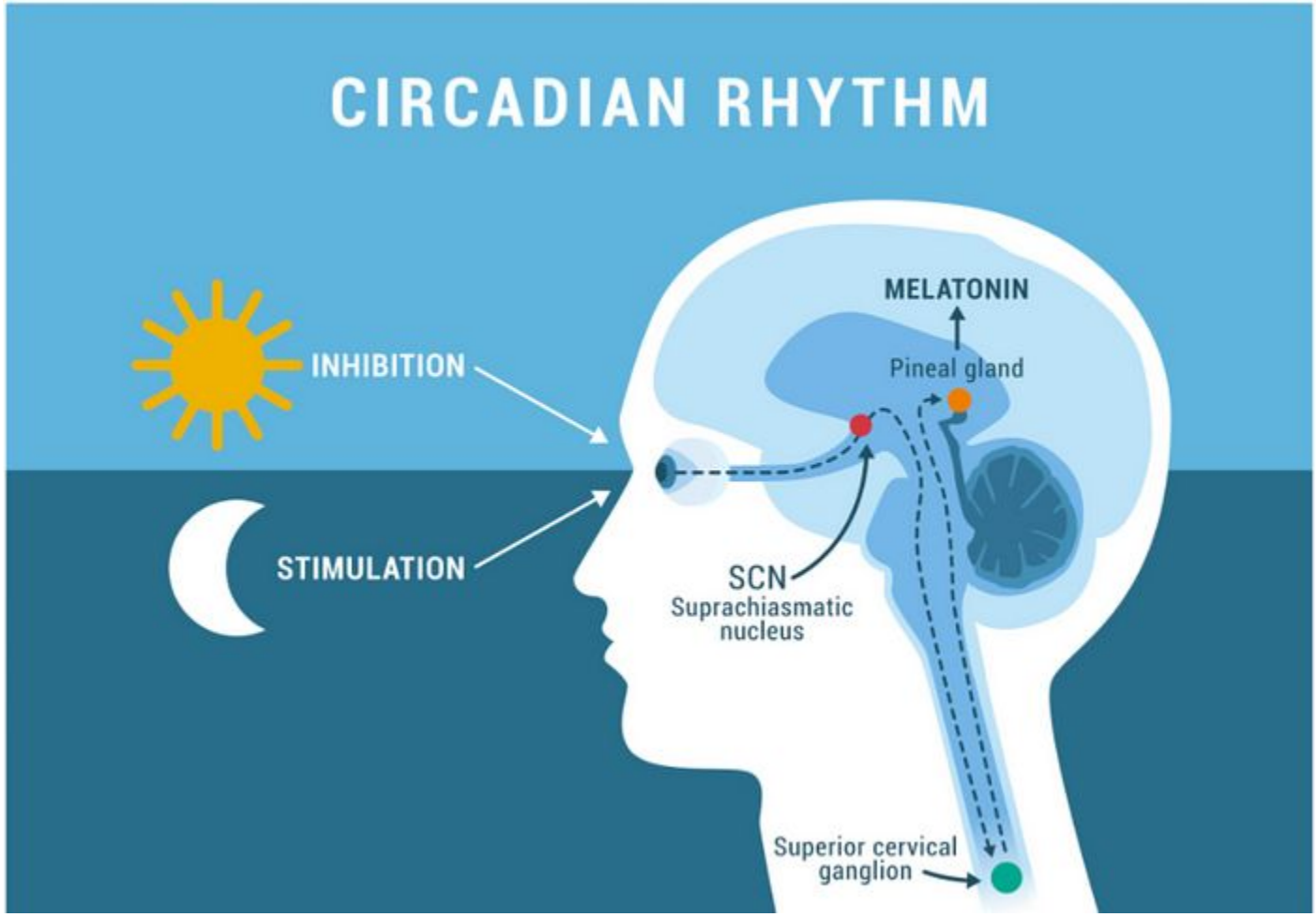

SPOILER
ALERT!



- Aspects of athletic performance vary simply by time of day
  - Strength
  - Cardiovascular Endurance (VO2 Max)
  - Balance
  - Trunk Stability (?)

Circadian Rhythm

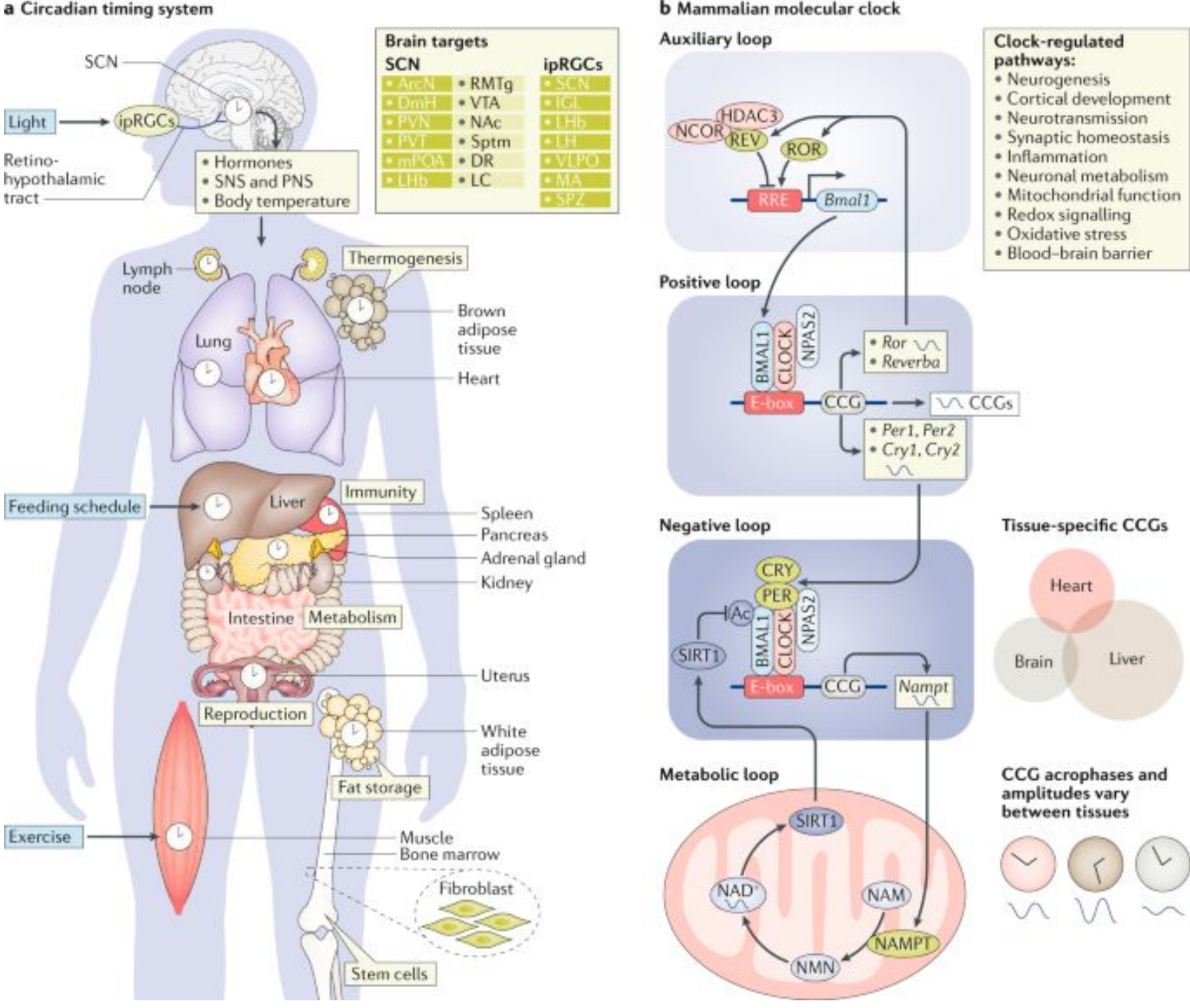
- *Circa diem*
- Changes in psychological and physiological functions relative to time of day
  - 24 hour cycle
- Time keeping system



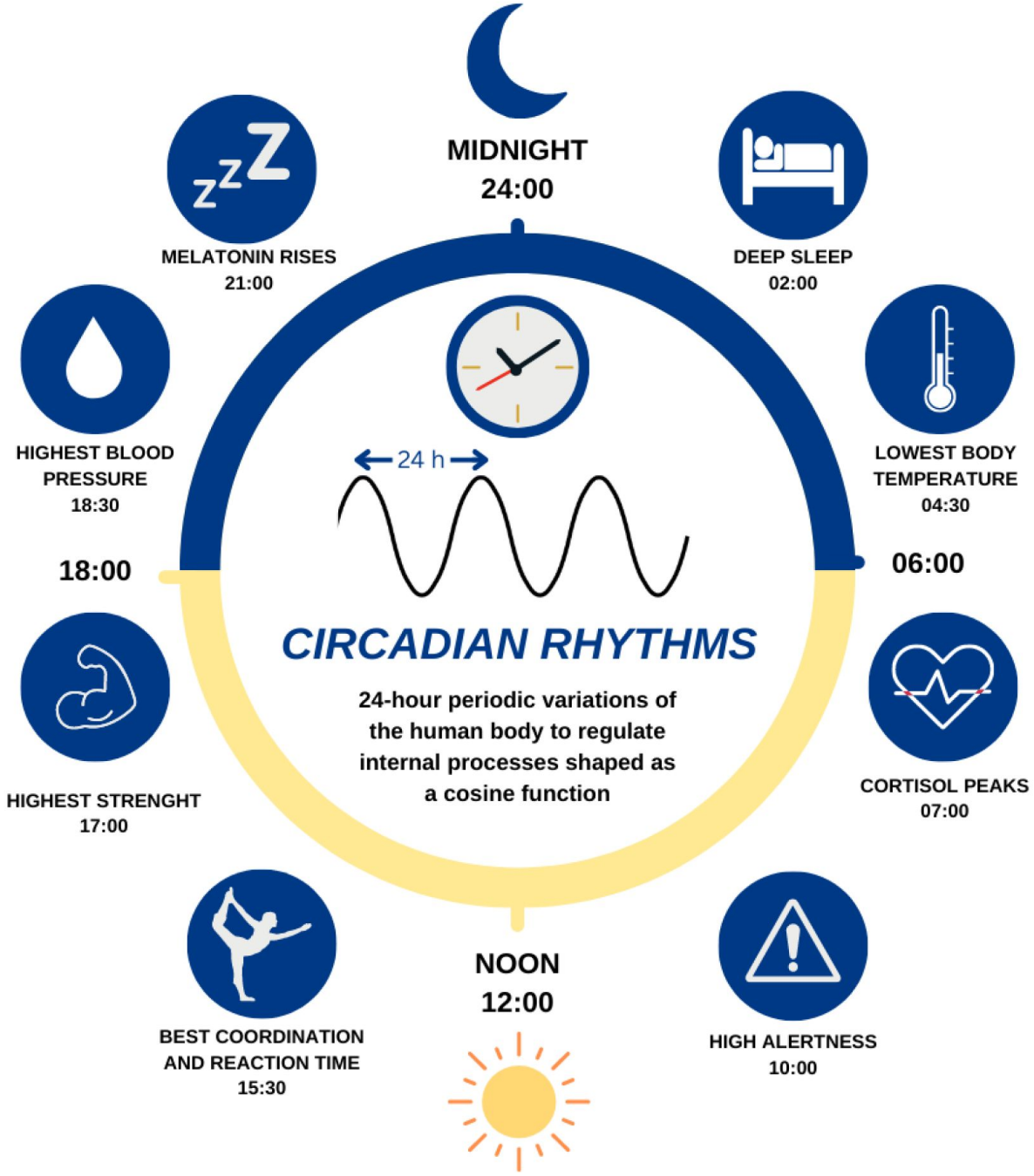
Influenced by light

Pacemaker = Superchiasmatic nucleus (SCN) hypothalamus

Nerve and chemical signals sent out to regulate systems



Logan and McClung, 2019



Vitaterna et al., 2001

- Diurnal vs. Circadian Rhythm
- Can be entrained - ability to be synchronized by external time cues
- Acrophase – time of peak
- Amplitude – diff b/t peak and mean value

TABLE 3. Circadian rhythm in resting physiological variables (91,98).*

Variables	Amplitudes (%)	Acrophases
HR	6.0–6.1	13:50–15:31
$\dot{V}O_2$ ($ml \cdot min^{-1} \cdot kg^{-1}$)	6.6–6.7	17:12–17:13
VE	7.0–9.7	16:39–17:01
Core temperature	0.6–0.8	17:44–19:26

*HR = heart rate; VE = minute ventilation; $\dot{V}O_2$ = oxygen uptake.

Circadian Rhythm and Performance

Review: Time of Day Effect on Athletic Performance: An Update

THOMAS A. CAPPAERT

JSCR 1999 13(4) 412-421

BRIEF REVIEW

THE EFFECT OF TRAINING AT A SPECIFIC TIME OF DAY: A REVIEW

HAMDI CHTOUROU[1,2] AND NIZAR SOUISSI[1,3]

[1]Research Laboratory "Sports Performance Optimization" National Center of Medicine and Science in Sports (CNMSS), Tunis, Tunisia; [2]Research Unit, High Institute of Sport and Physical Education, Sfax University, Tunisia; and [3]High Institute of Sport and Physical Education, Ksar-Saïd, Manouba University, Tunisia

Strength Cond Res 26(7): 1984–2005,2012

Brief Review

the Journal of Strength and Conditioning Research™

Factors Contributing to Diurnal Variation in Athletic Performance and Methods to Reduce Within-Day Performance Variation: A Systematic Review

Hirofumi Kusumoto,[1] Canhnghi Ta,[1] Symone M. Brown,[2] and Mary K. Mulcahey[2]

[1]Tulane University School of Medicine, New Orleans, Louisiana; and [2]Department of Orthopedic Surgery, Tulane University School of Medicine, New Orleans, Louisiana

J Strength Cond Res 35(12S): S119–S135, 2021

Circadian Rhythm and Performance: Summary

Performance Measure	Time of day with peak effect	Reference
VO2 Max (cycling ergometer)	1500-1800	Torri et al., 1992; Hill et al., 1988
Quad strength (isokinetic)	1800-1930	Wyse et al., 1994
Peak cycling power (wingate)	1500-2200	Hill and Smith, 1991; Melheim, 1993; Soussi et al., 2003; Racinais et al, 2010; Chtourou et al., 2012a; Chtourou et al., 2012b
Lower body power (standing broad jump, Margaria stair run; CMJ, VJ)	1700-1900	Reilly & Down, 1992; Bernard et al., 1998; Racinais et al., 2005; Reilly et al., 1983; Chtourou et al., 2012a; Chtourou et al., 2012b

Circadian Rhythm and Performance: Summary

Gauthier et al. (35)	8 Physical education students
Souissi et al. (112)	13 Male physical education students
Souissi et al. (111)	14 Physical education students
Racinais et al. (85)	12 Male physical education students
Racinais et al. (90)	8 Male physical education students
Guette et al. (39)	10 Physical education students
Nicolas et al. (76)	12 Active male participants
Racinais et al. (84)	9 Moderately active male participants
Kin-Isler (59)	14 Undergraduate male students
Nicolas et al. (78)	10 Active male participants
Reilly et al. (95)	8 Male soccer players
	8 Male university soccer players
Giacomoni et al. (37)	20 Subjects, 12 M and 8 F
Racinais et al. (87)	23 Physical education students 15 M and 8 F

THE EFFECT OF TRAINING AT A SPECIFIC TIME OF DAY: A REVIEW

HAMDI CHTOUROU[1,2] AND NIZAR SOUISSI[1,3]

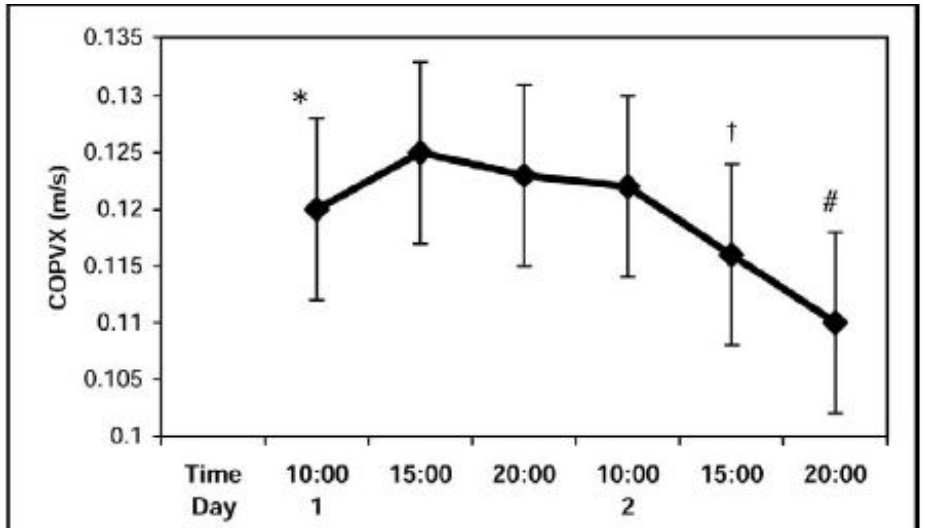
[1]Research Laboratory "Sports Performance Optimization" National Center of Medicine and Science in Sports (CNMSS), Tunis, Tunisia; [2]Research Unit, High Institute of Sport and Physical Education, Sfax University, Tunisia; and [3]High Institute of Sport and Physical Education, Ksar-Said, Manouba University, Tunisia

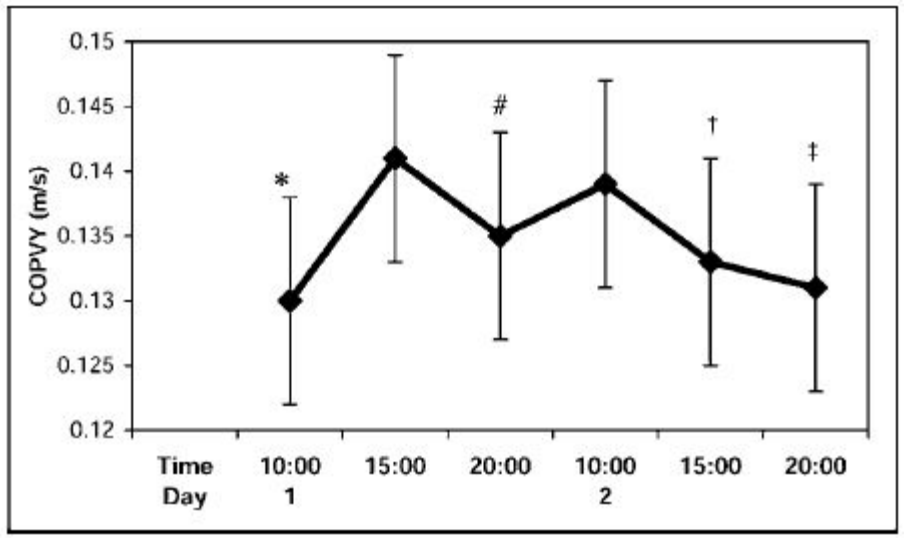
Static and Dynamic Balance – 2007

Gribble et al 2007

Figure 1. Anterior reach direction of the Star Excursion Balance Test.

College aged men (13) and women (17)
3x/day x 2 days – static and dynamic balance





SB: AM> PM

DB: AM > PM

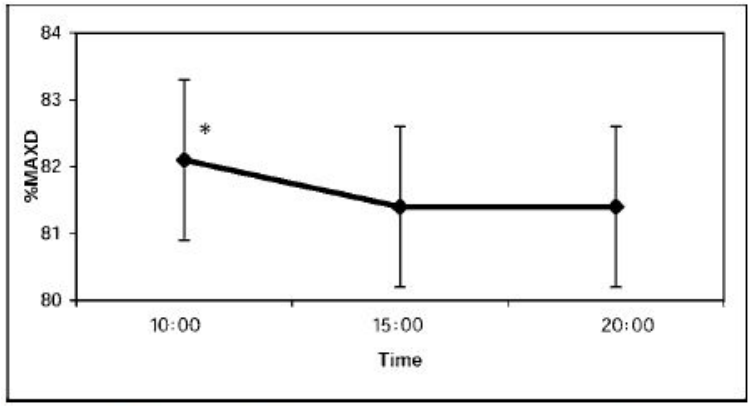


Figure 7. Time main effect in anterior reach (standardized maximum reach distance [%MAXD] ± SE). *Indicates $P < .05$.

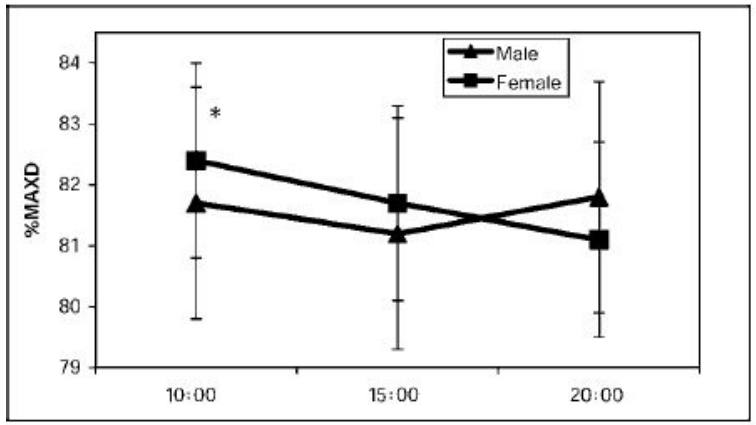


Figure 6. Time-by-sex interaction for the anterior reach of the Star Excursion Balance Test (standardized maximum reach distance [%MAXD] ± SE). *Indicates $P < .05$.

Static and Dynamic Balance – 2014

male (10) and female (14)

3x/day x 2 days – static and dynamic balance

SB: AM> PM

DB: AM > PM

Kwon et al 2014

Original Article

The Influence of Time of Day on Static and Dynamic Postural Control in Normal Adults

YONG HYUN KWON, PhD, PT[1)], YONG WON CHOI, MS, PT[1)], SEOK HYUN NAM, MS, PT[2)], MYOUNG HEE LEE, PhD, PT[3)]*

Table 1. Static and dynamic postural control abilities at three different times of the day

			Time of day		
			9:00 AM	1:00 PM	5:00 PM
Static postural control	AP distance (mm)	Raw	131.3±65.1	157.7±46.0	151.4±64.7
		Normalized	0.8±0.2	0.9±0.1*	0.9±0.2
	ML distance (mm)	Raw	8.1±7.0	15.00±10.6*	10.7±5.9
		Normalized	0.5±0.3	0.8±0.3*	0.7±0.3†
	COP Velocity (mm/s)	Raw	7.1±2.8	10.4±8.9	9.3±8.3
		Normalized	0.7±0.2	0.8±0.2	0.7±0.3
Dynamic postural control	Perform time (sec)	Raw	19.6±10.4	27.1±14.0	27.4±19.1
		Normalized	0.7±0.2	0.9±0.2*	0.8±0.2†
	Total distance (mm)	Raw	2167.0±943.0	3142.9±1704.8	2896.8±1582.5
		Normalized	0.7±0.2	0.8±0.3*	0.7±.02

The results of post hoc analysis are indicated by superscripts. An asterisk (*) indicates significance at the $p<0.05$ level in comparison between 9:00 AM and at1:00 PM, and an obelisk (†) indicates comparison between 9:00 AM and 5:00 PM.

Static and Dynamic Balance – 2015

College aged men (16)
and women (18)
3x/day x 2 days –

SL stance
YBT LQ
YBT UQ

SB: AM < PM

DP: AM = PM

The effect of time-of-day on static and dynamic balance in recreational athletes

ERIKA M. HEINBAUGH[1], DEREK T. SMITH[1], QIN ZHU[1], MARGARET A. WILSON[2], & BOYI DAI[1]

[1]*Division of Kinesiology and Health, University of Wyoming, Laramie, WY, USA*
[2]*Department of Theatre and Dance, University of Wyoming, Laramie, WY, USA*

Table I. Balance performance (mean ± standard deviation) and *p* values as a function of time-of-day, between-day, and limb-of-preference.

		Preferred limb				Non-preferred limb				*p* Values of main effects		
		Day 1		Day 2		Day 1		Day 2				
		Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Time-of-day	Between-day	Limb-of-preference
Eyes open SLS	ST (s)	20.00 ± 0.00	20.00 ± 0.00	19.84 ± 0.92	20.00 ± 0.00	19.70 ± 1.68	19.92 ± 0.47	19.81 ± 1.11	19.67 ± 1.46	0.598	0.508	0.105
	SA (cm^2)	10.92 ± 3.71	9.99 ± 3.64	9.85 ± 2.77	9.17 ± 2.78	10.32 ± 2.78	9.51 ± 2.63	10.51 ± 3.37	9.47 ± 2.63	**0.002**	0.107	0.91
	SS (cm/s)	4.97 ± 1.25	4.80 ± 1.13	4.99 ± 1.04	4.82 ± 1.13	5.14 ± 1.46	4.91 ± 1.19	5.23 ± 1.28	4.96 ± 1.30	**0.002**	0.516	**0.012**
Eyes closed SLS	ST (s)	15.67 ± 5.08	16.59 ± 4.36	17.30 ± 3.58	17.61 ± 3.35	15.38 ± 5.05	16.46 ± 4.30	16.74 ± 4.43	17.13 ± 4.12	**0.031**	**≤0.001**	0.241
	SA (cm^2)	32.10 ± 19.60	28.05 ± 11.50	30.52 ± 15.69	27.46 ± 11.03	29.97 ± 14.98	26.94 ± 10.06	28.12 ± 12.35	26.11 ± 13.47	**0.029**	0.392	0.208
	SS (cm/s)	10.42 ± 3.34	10.44 ± 3.00	10.12 ± 2.65	9.83 ± 2.44	10.40 ± 2.58	10.31 ± 3.44	10.37 ± 2.87	9.87 ± 2.82	0.268	0.076	0.85
Lower YBT	Distance (leg length)	1.02 ± 0.06	1.02 ± 0.08	1.03 ± 0.08	1.03 ± 0.08	1.00 ± 0.07	1.02 ± 0.08	1.03 ± 0.08	1.03 ± 0.07	0.133	**≤0.001**	0.297
Upper YBT	Distance (arm length)	0.88 ± 0.10	0.90 ± 0.10	0.90 ± 0.10	0.90 ± 0.11	0.90 ± 0.09	0.91 ± 0.09	0.90 ± 0.10	0.91 ± 0.10	**0.024**	**0.02**	**0.026**
Landing balance	DPSI (body weight)	0.34 ± 0.04	0.34 ± 0.04	0.33 ± 0.03	0.33 ± 0.04	0.34 ± 0.04	0.33 ± 0.04	0.33 ± 0.04	0.33 ± 0.03	0.378	**0.004**	0.891

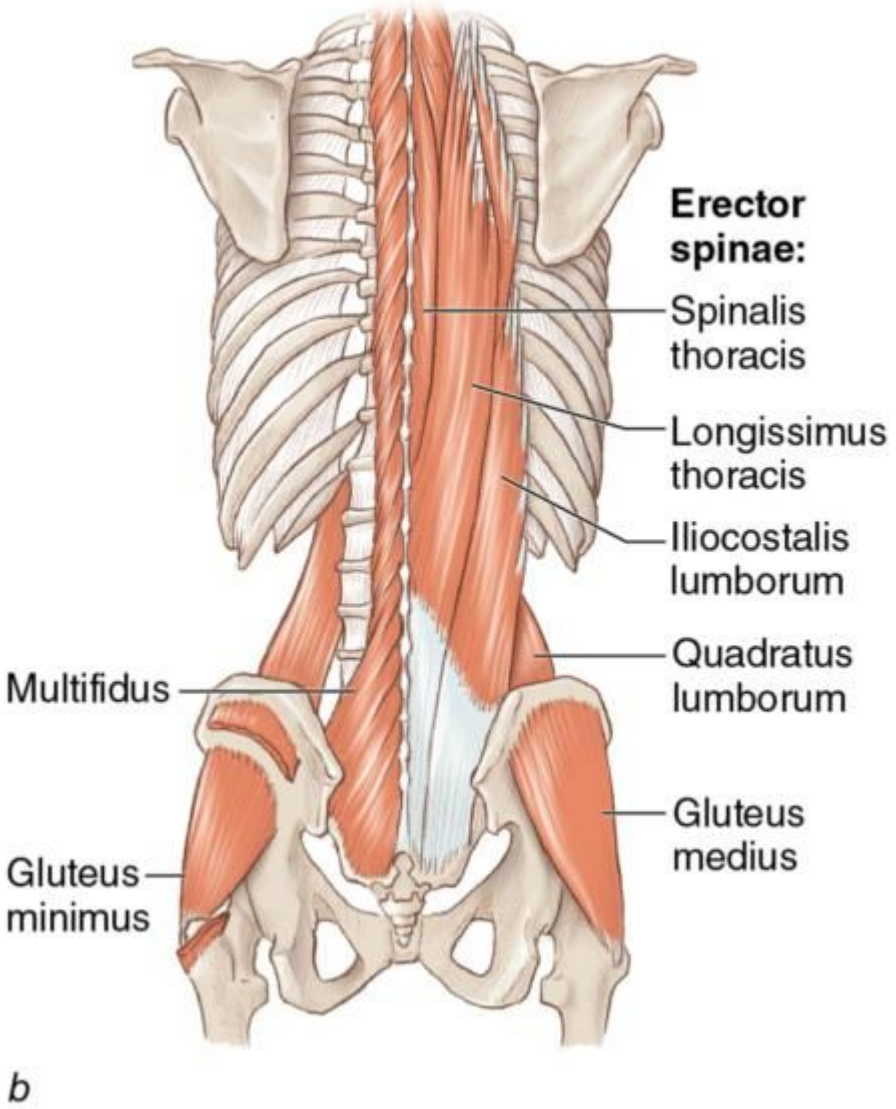
Notes: SLS: single-leg stance test; YBY: Y-balance test; ST: stance time; SA: sway area; SS: sway speed; DPSI: dynamic postural stability index.

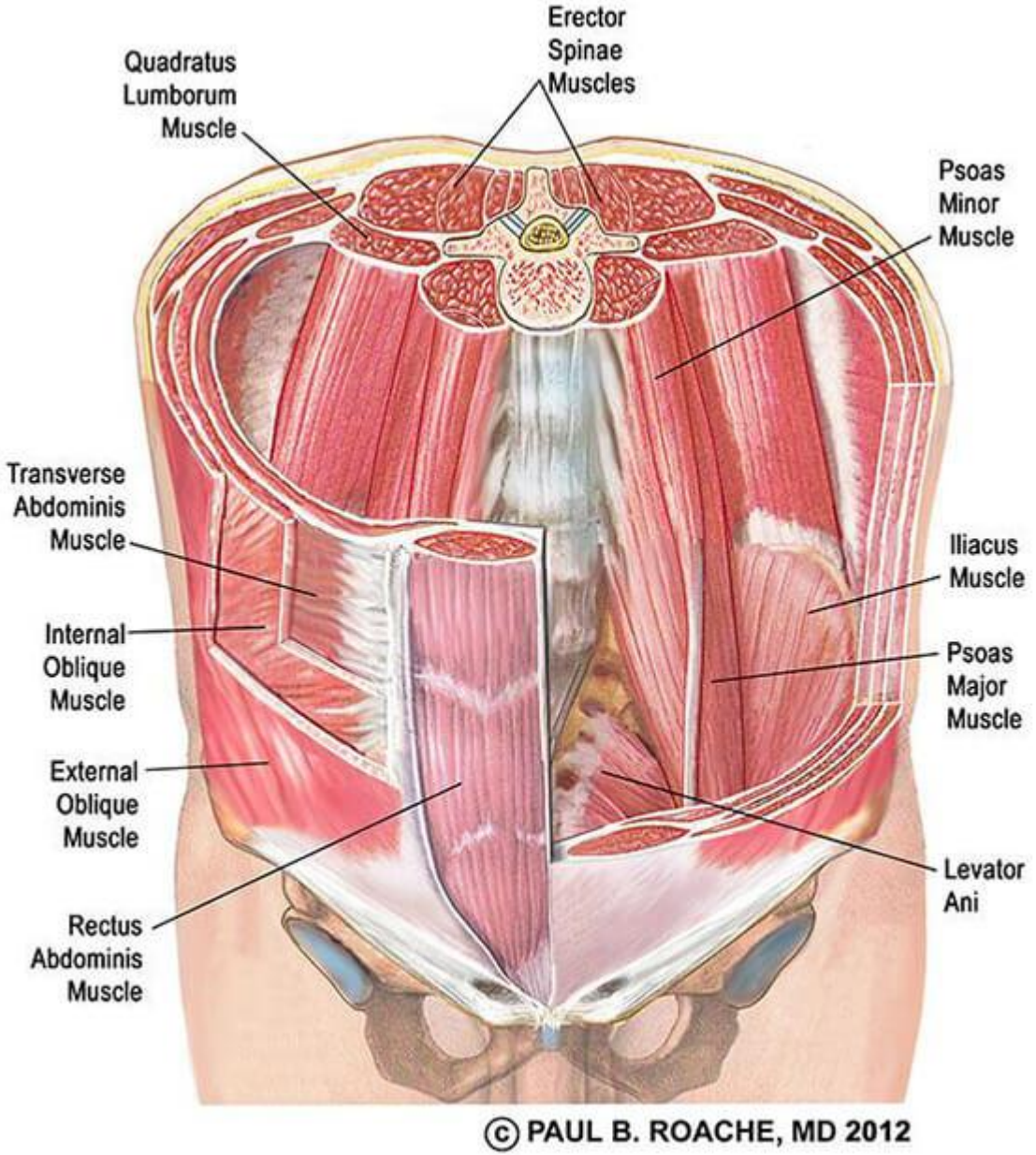
Heinbaugh et al 2015

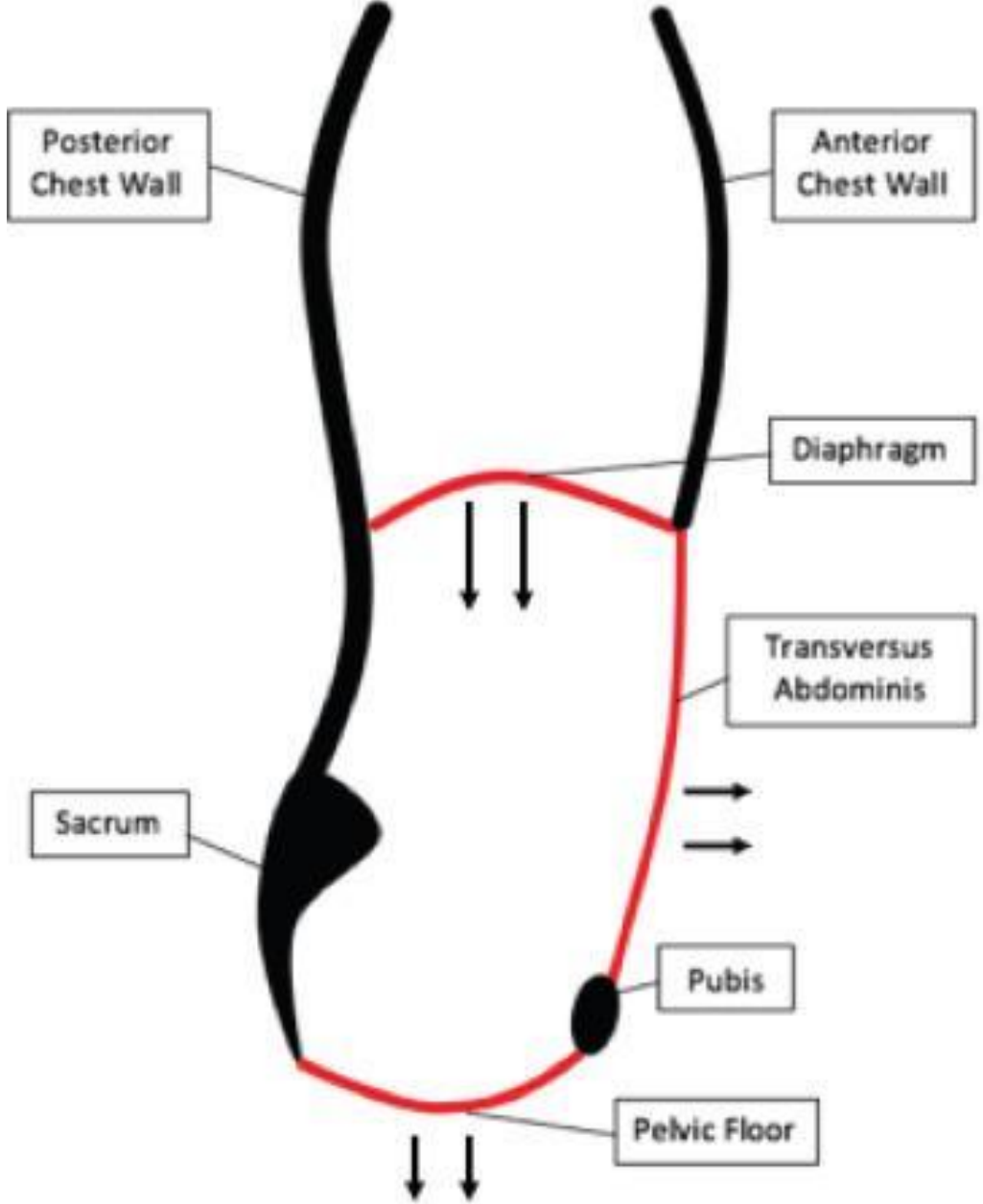
What do we know about the influence of circadian rhythm and performance?

AM	PM
Dynamic balance Static balance	Strength Static balance Lower body power

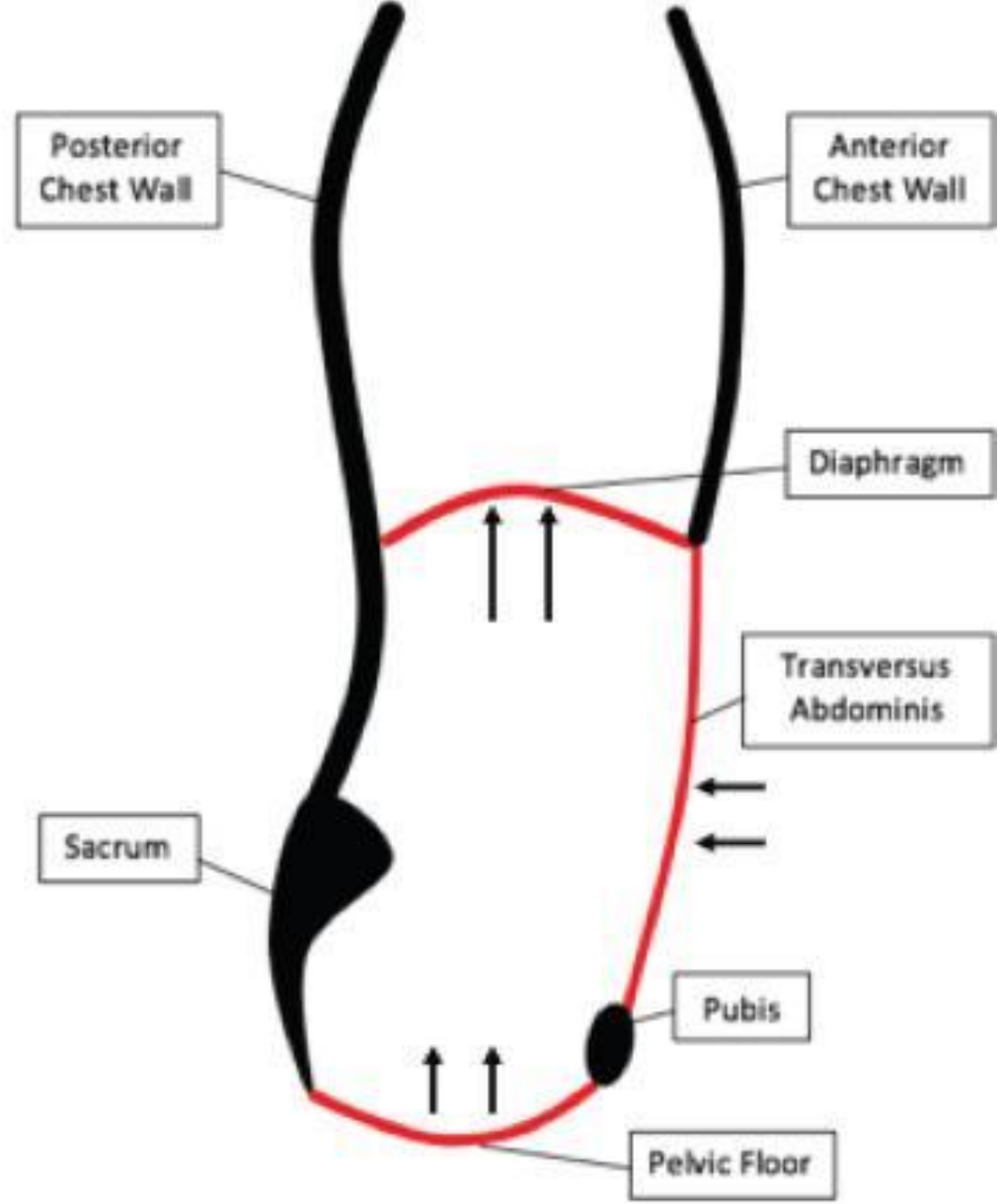
The core… aka the trunk





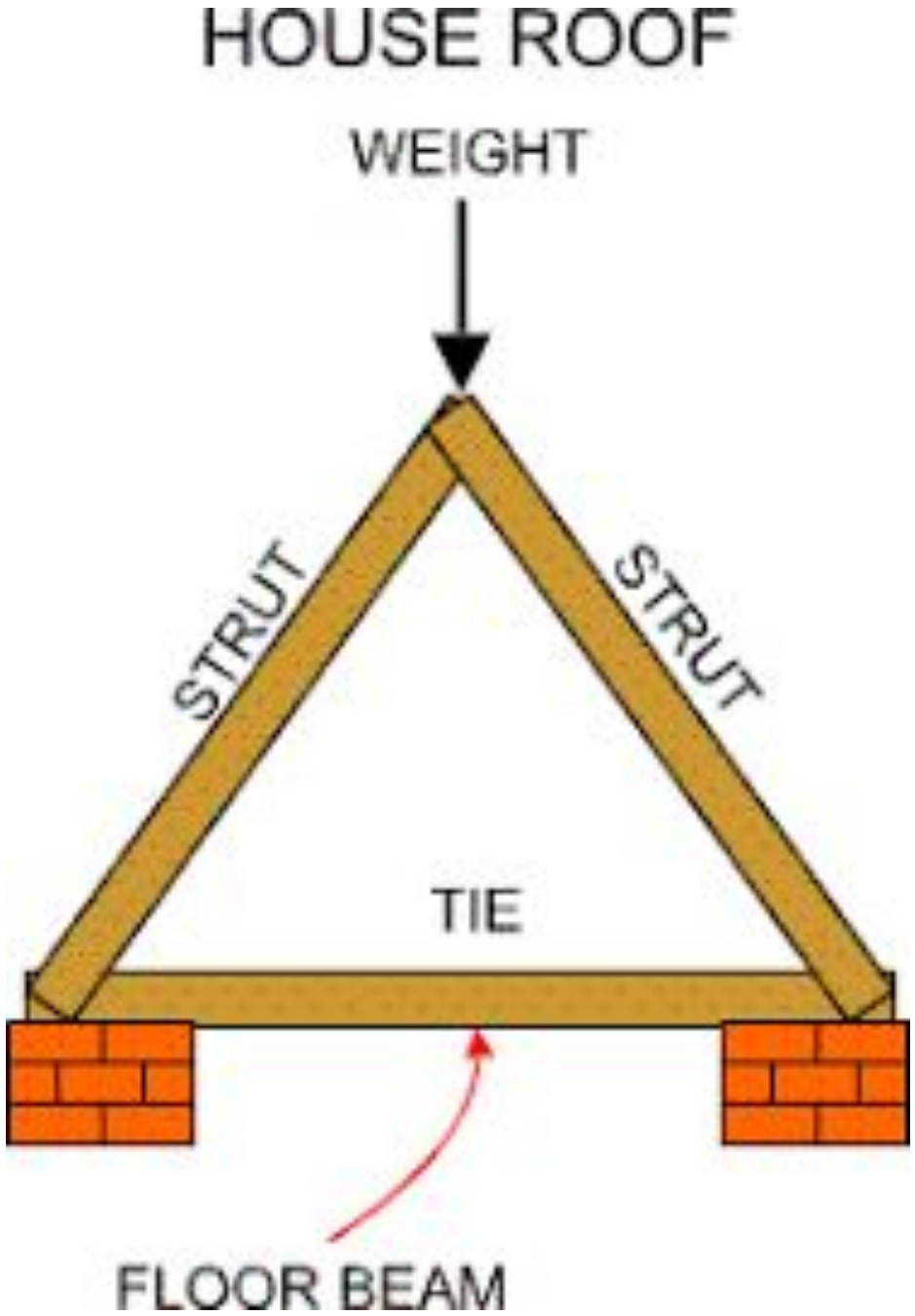


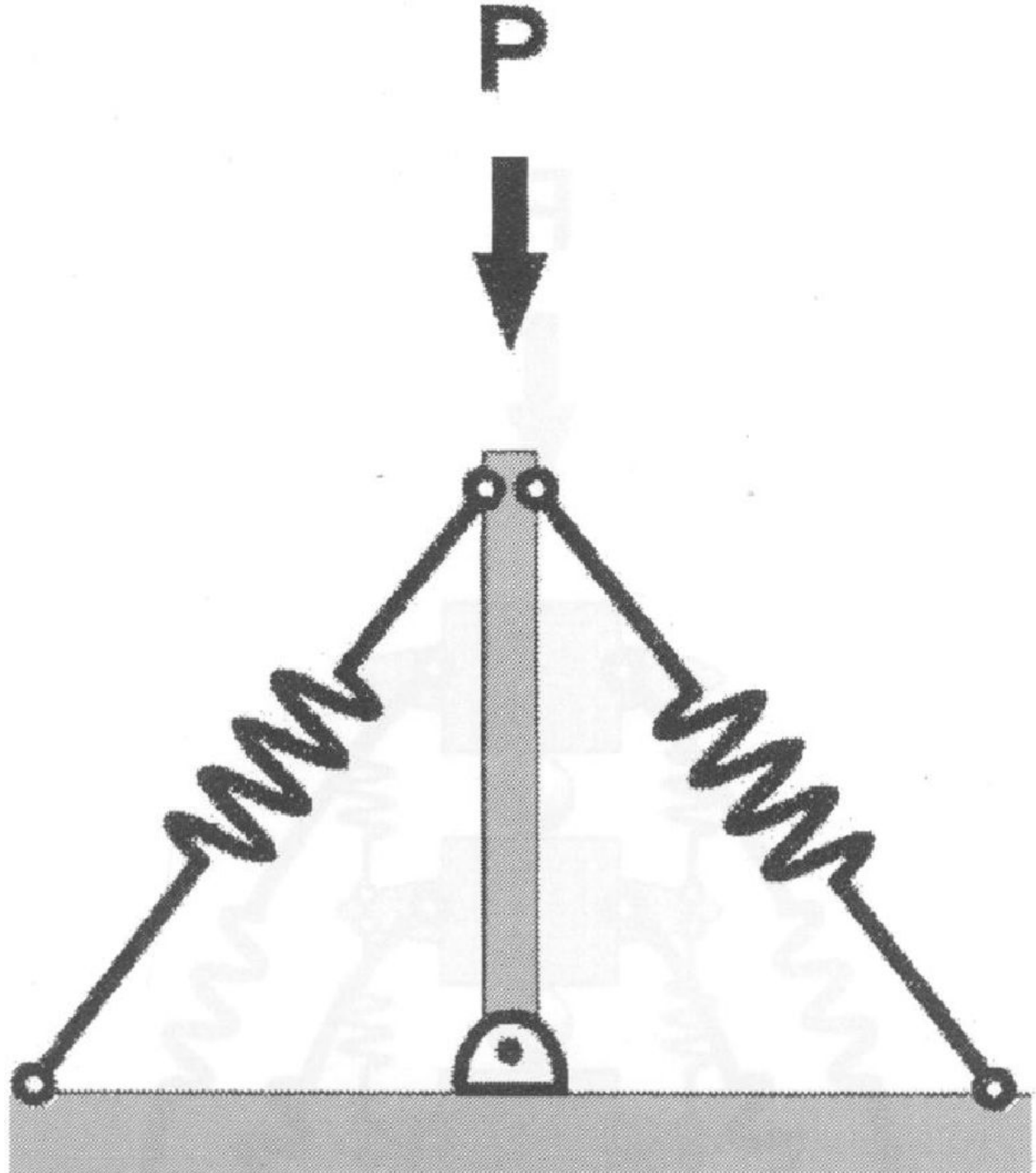
Active Inhalation



Active Exhalation

https://www.physio-pedia.com/Core_Muscles


HOUSE ROOF
WEIGHT
STRUT
STRUT
TIE
FLOOR BEAM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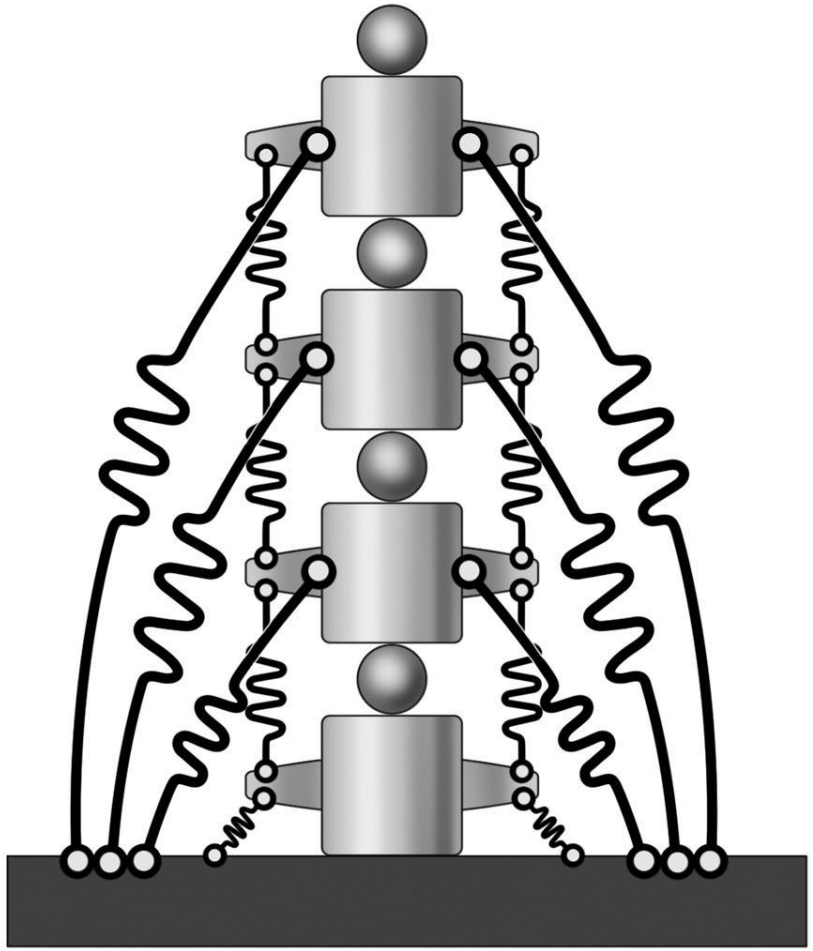
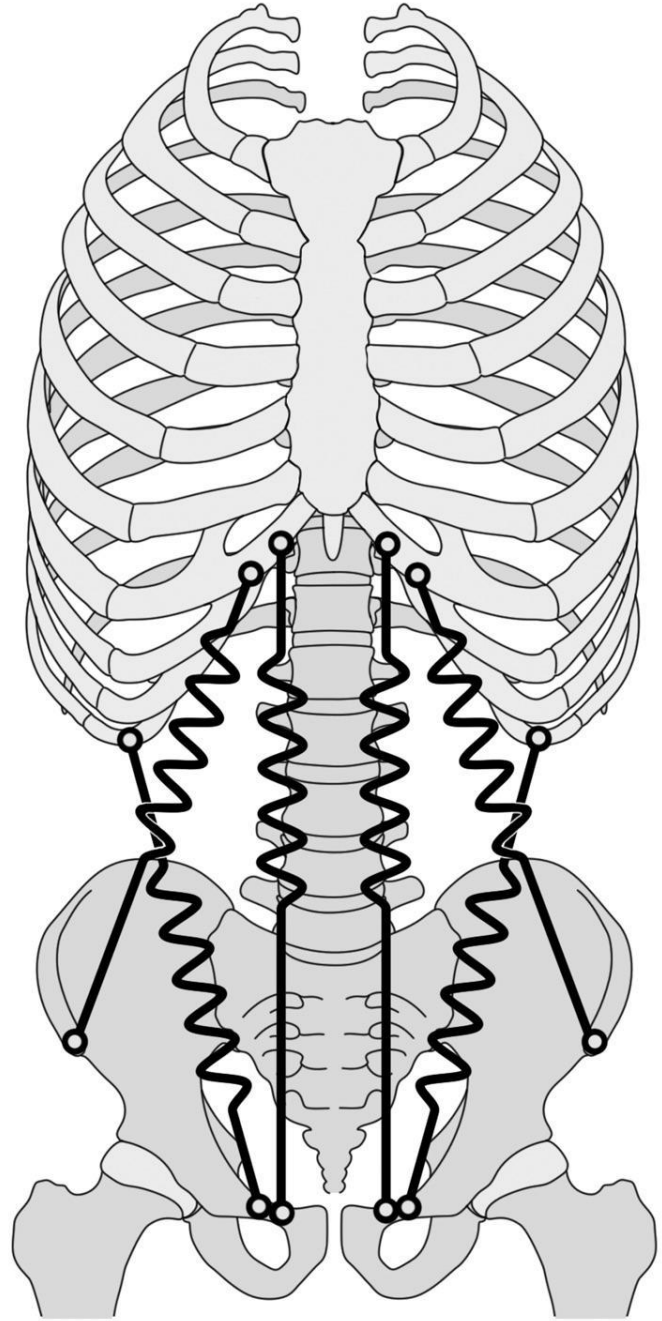
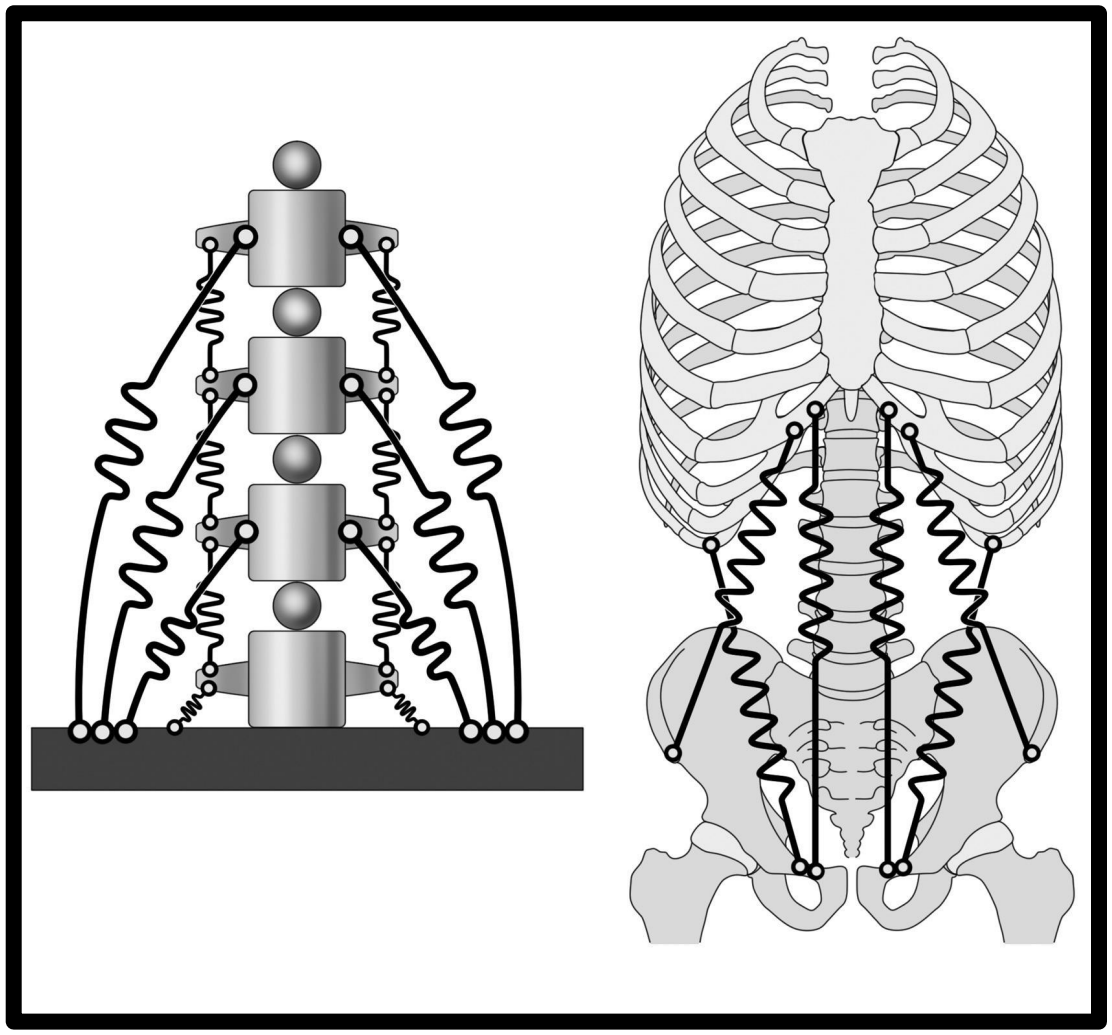
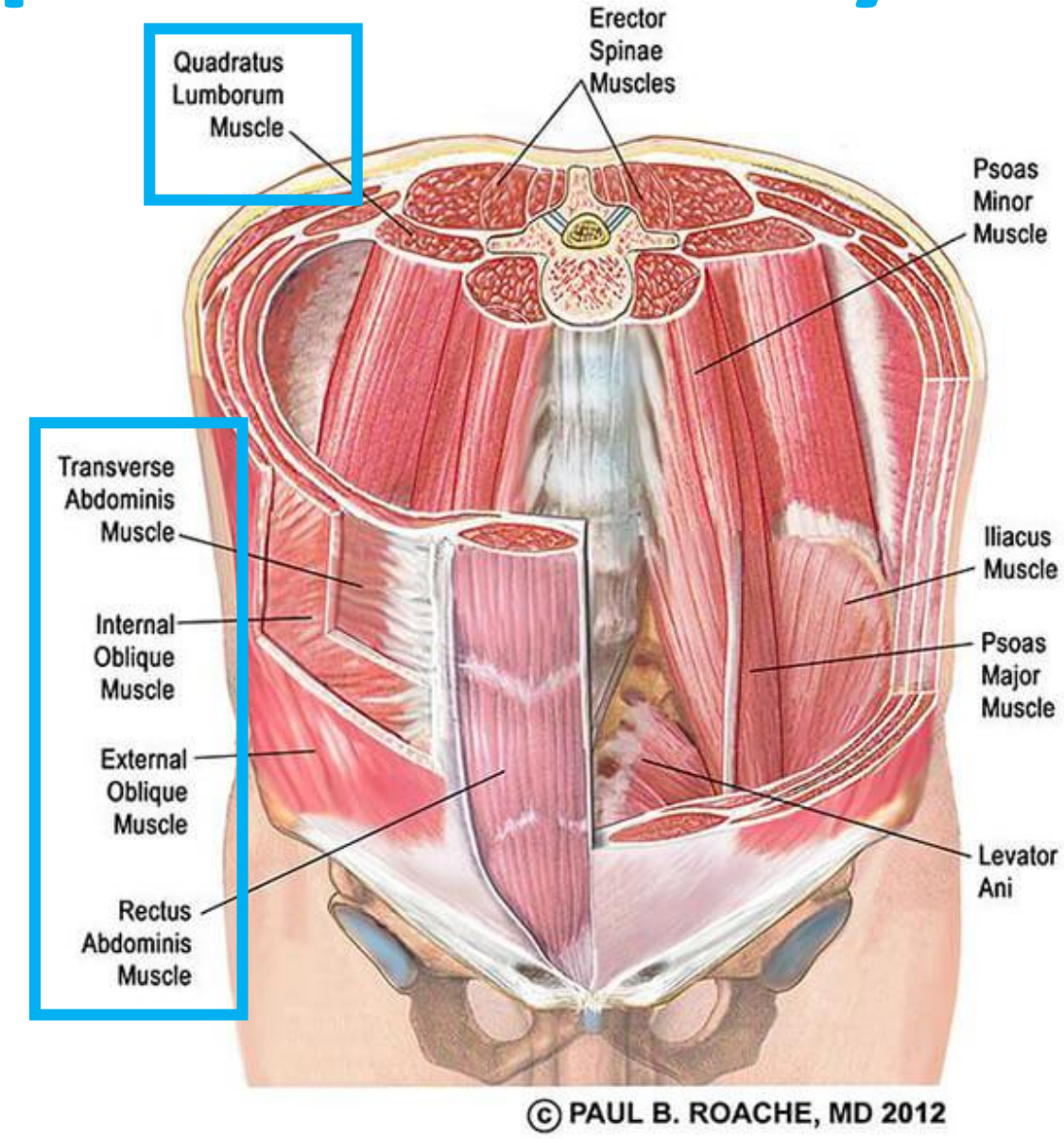




Core, Trunk or **Lumbopelvic Stability**





- "Mills et al., 2005

Functional LPS

- "complex interaction among local, global, and load transfer muscles, neuromuscular control, and the specific demands of the task being performed" (Huxel Bliven., et al 2013

Huxel Bliven et al., 2013

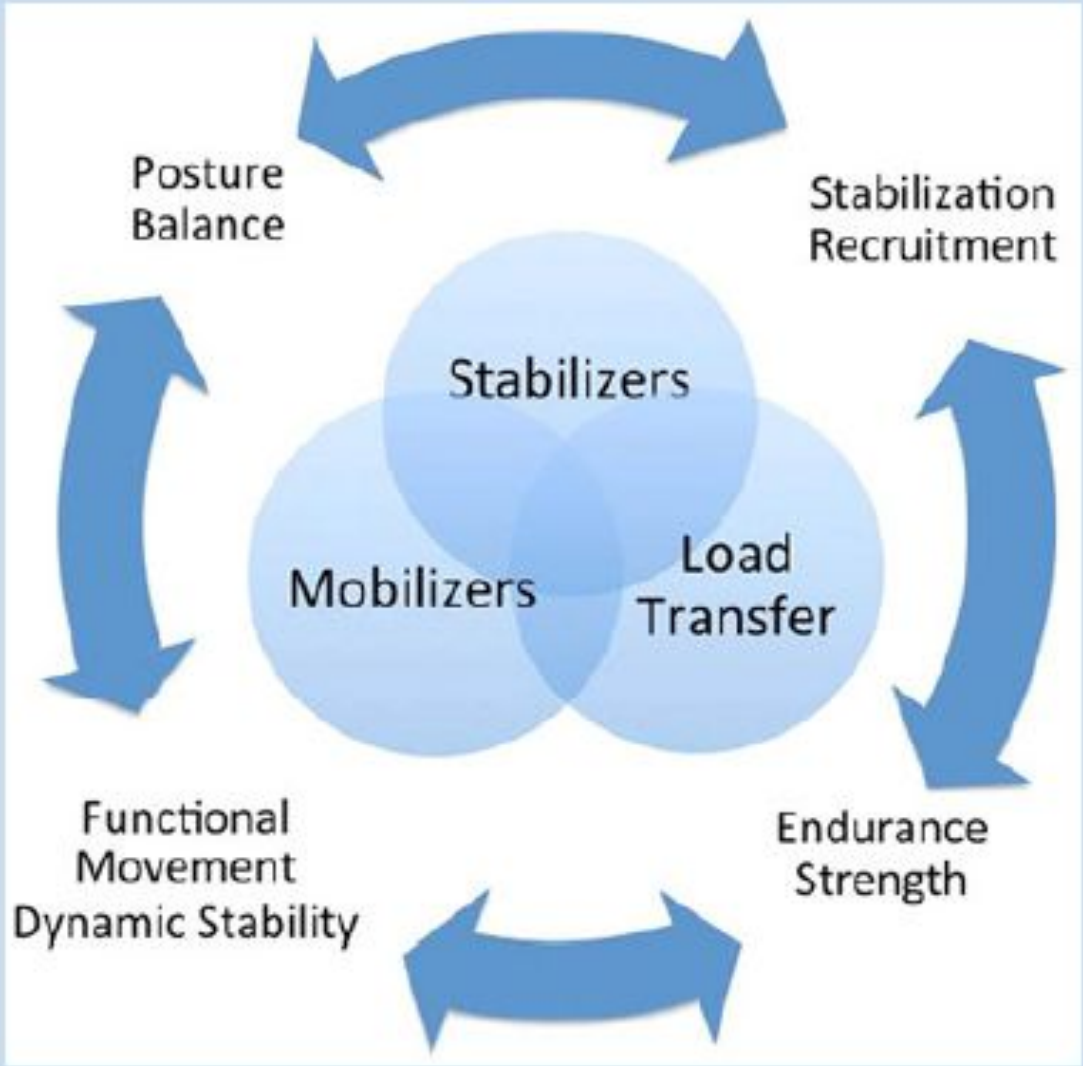


Figure 1. Functional core stability. This figure illustrates the various components and roles that interact to achieve functional core stabilization.

Importance of LPS

- Athletic Performance
  - facilitates the production, transfer, and control of force and movement to and through the extremities (Waldhelm and Li, 2012)

  BUT……
  - 6 weeks of swiss ball training – no improvement in running economy Stanton e al., 2004
  - 7 weeks core training – no change in performance – FB athletes Lewarchick, et al., 2003
  - Reed et al.., 2012: mixed results at best
- Movement – Injury Risk?
  - Core training ↑ SEBT performance T&F – 6 weeks – Sandrey and Mitzel, 2013
  - Reduced injury risk? ↓ LBP? Peate et al., 2007; Huxel Bliven et al., 2013

Measuring LPS

- Typically isolate a single measure
  - Recruitment
    - EMG, palpation
  - Strength and endurance
    - McGill, Biering-Sorenson
  - Postural control/balance
    - SLS, YBT
  - Movement patterns
    - FMS?
- Waldhelm & Li 2012
  - “core endurance tests are the most reliable measurements”

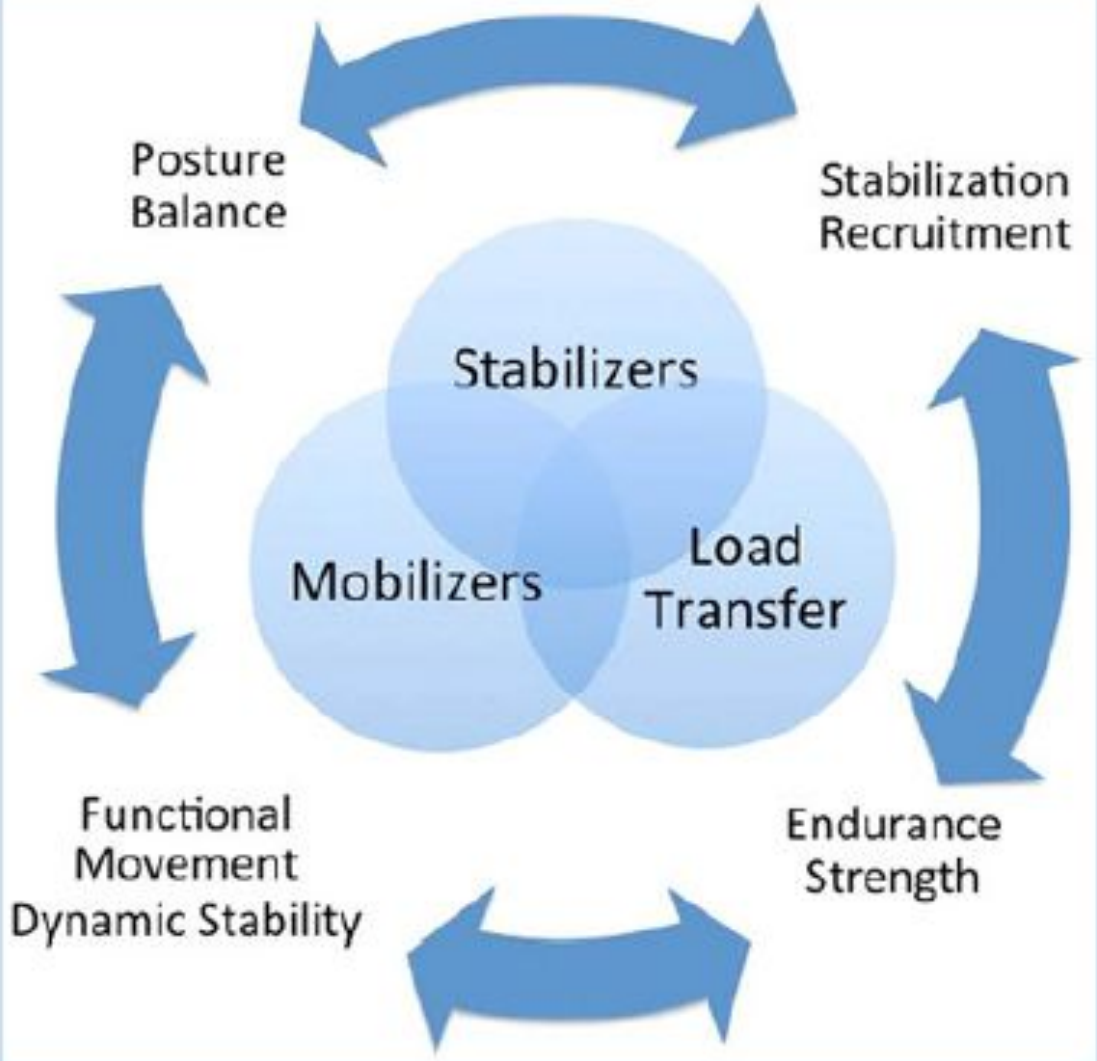


Figure 1. Functional core stability. This figure illustrates the various components and roles that interact to achieve functional core stabilization.

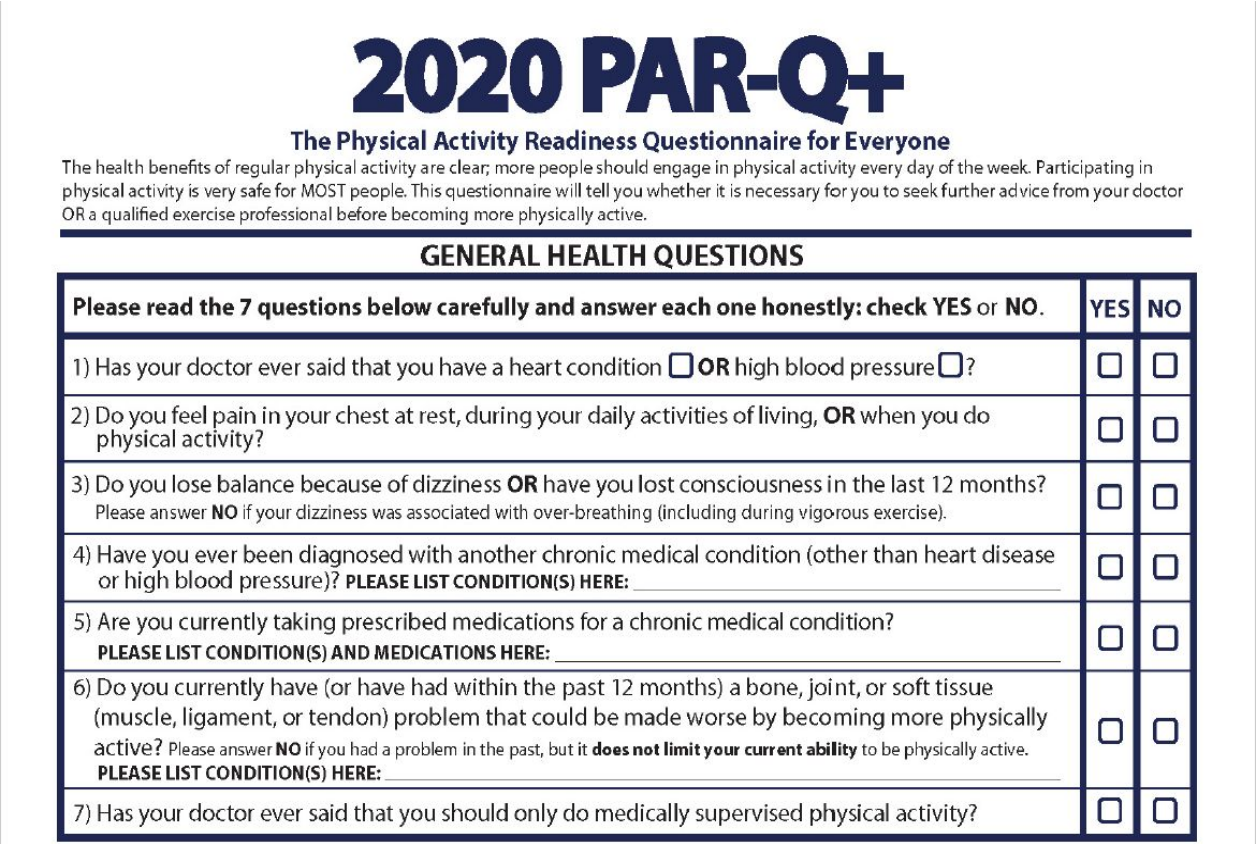
In **physically active individuals**, what is the effect of time of day on lumbopelvic (trunk) stability?

Hypotheses

- Hypotheses
  - Lumbopelvic stability will be significantly greater (longer hold times) in the afternoon.

Methods - Participants

- Recreationally active college students (18-30 yrs old)
  - Blend of activity levels
- Exclusion Criteria
  - "YES" to ≥ 1 questions on PAR-Q
  - Actively being treated by a healthcare provider for a lower extremity injury
  - Has sustained an injury to the lower extremity (foot, ankle, knee, or hip), lumbar spine, or shoulder within the previous 6 months.



2020 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

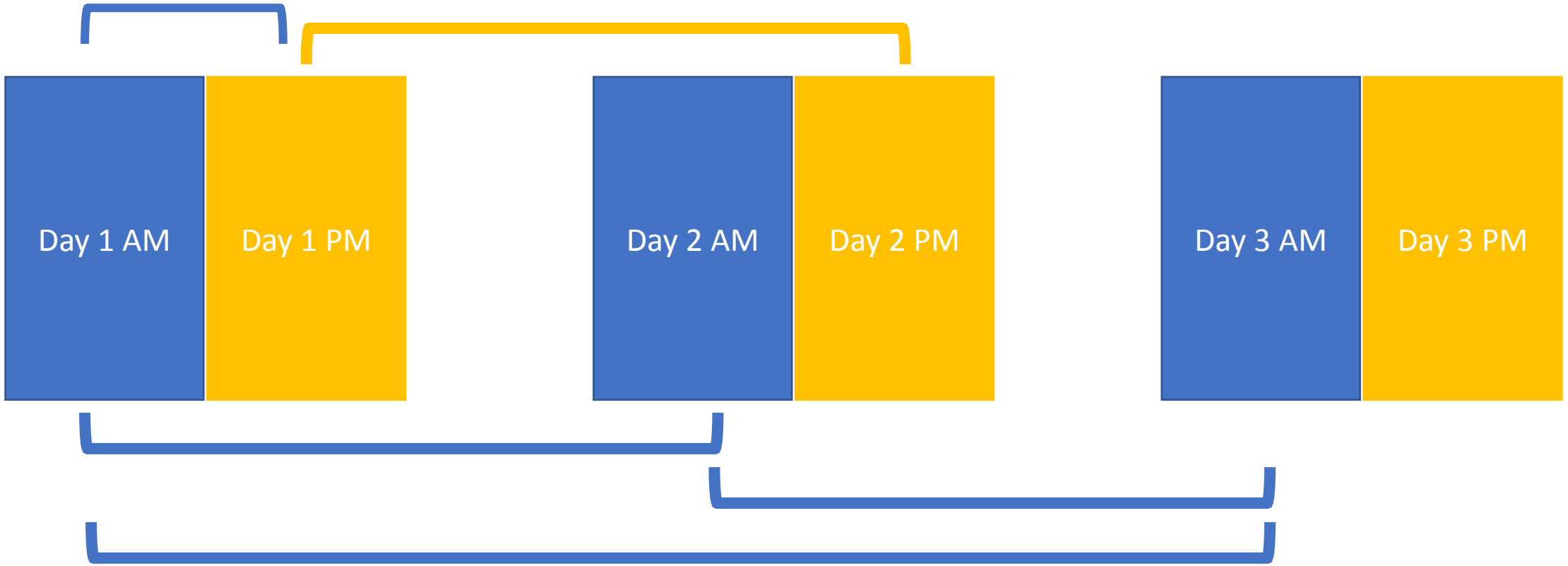
The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

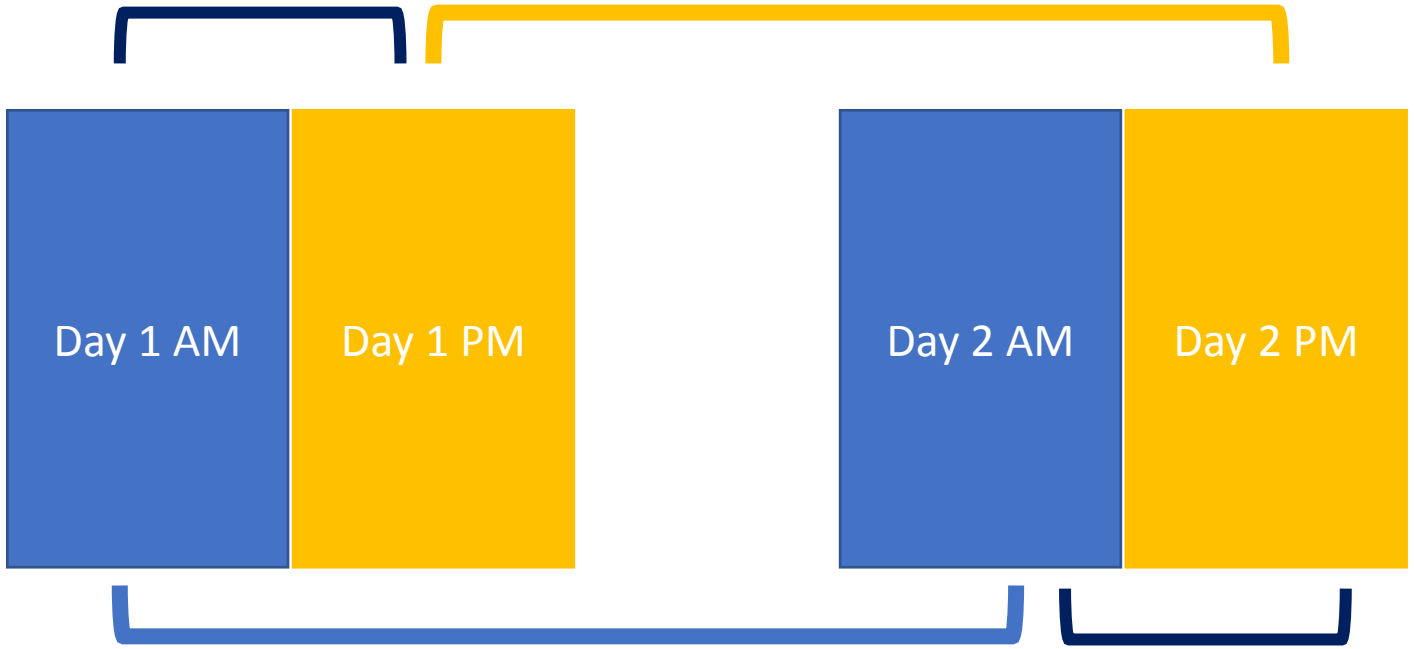
Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	**YES**	**NO**
1) Has your doctor ever said that you have a heart condition ☐ **OR** high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** _____	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it **does not limit your current ability** to be physically active. **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

Procedures: Measuring Lumbopelvic Stability

Process and Analyses - Planned



Process and Analyses - Actual



Sex	Height (M)	Mass (KG)	Age
M (n=3)	1.8 ± 0.1	80.51 ± 14.74	21 ± 1
F (n=7)	1.64 ± 0.1	71.79 ±26.24	20 ± 1.4

Repeated Measures Analysis of Variance

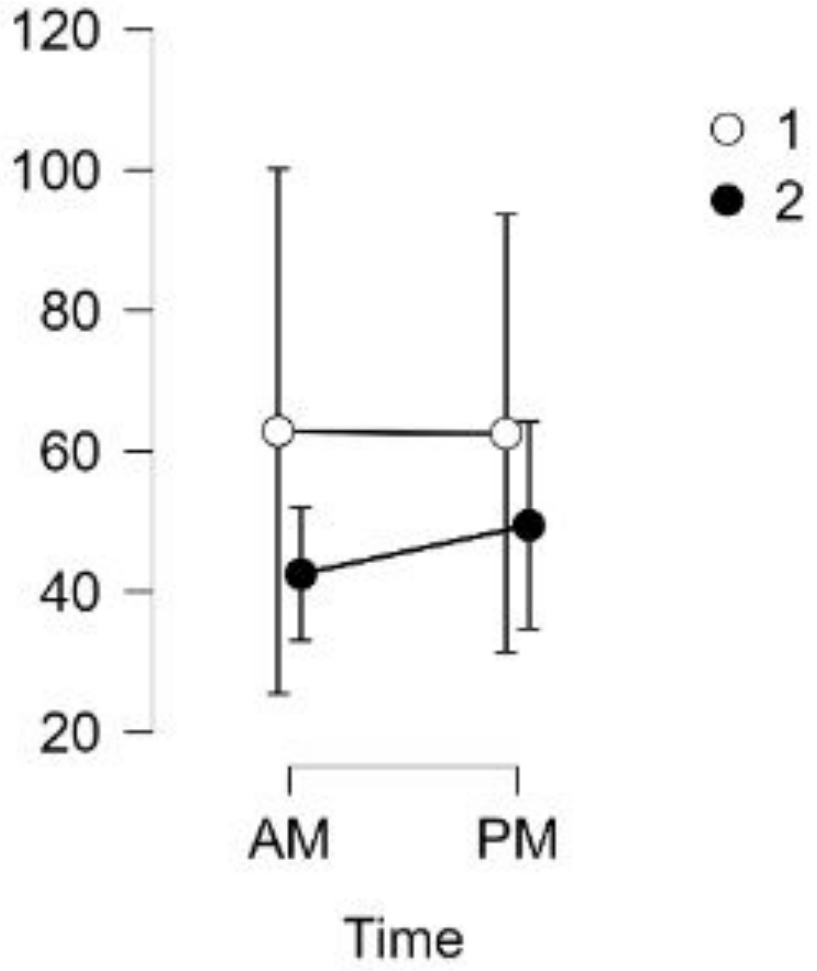
Day

Time

For all McGill positions

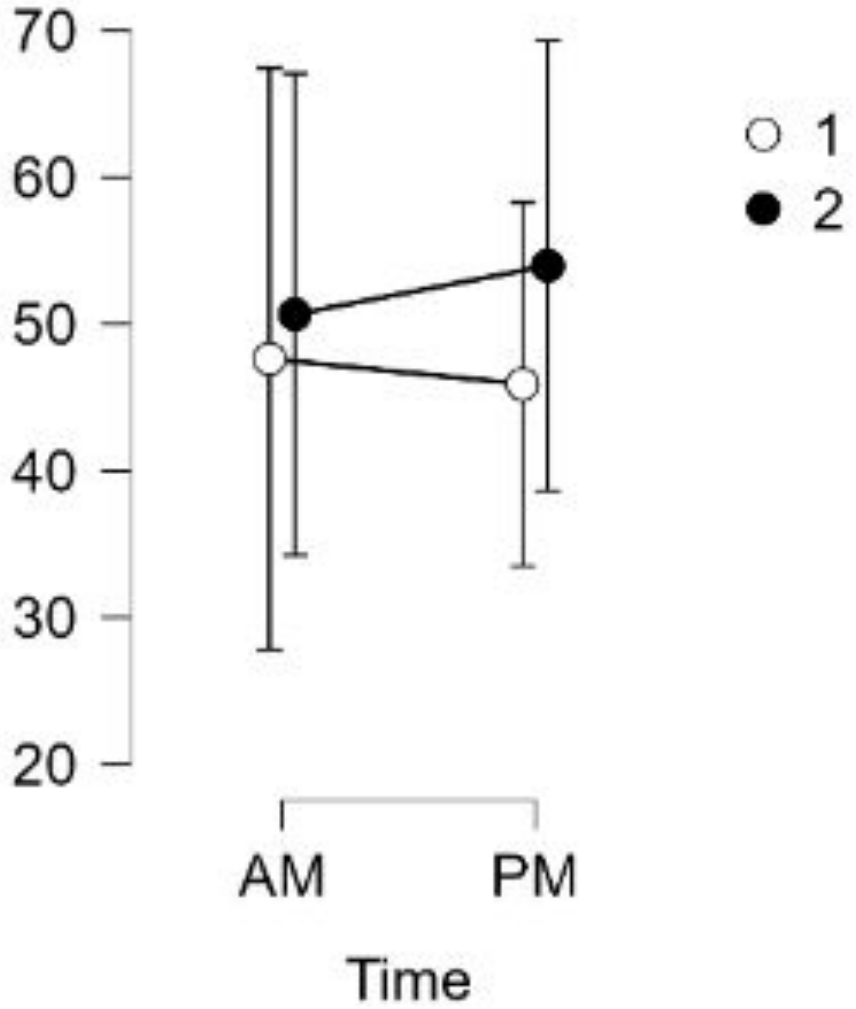
Results

Flexor



Partial Eta Squared – effect size
0.08

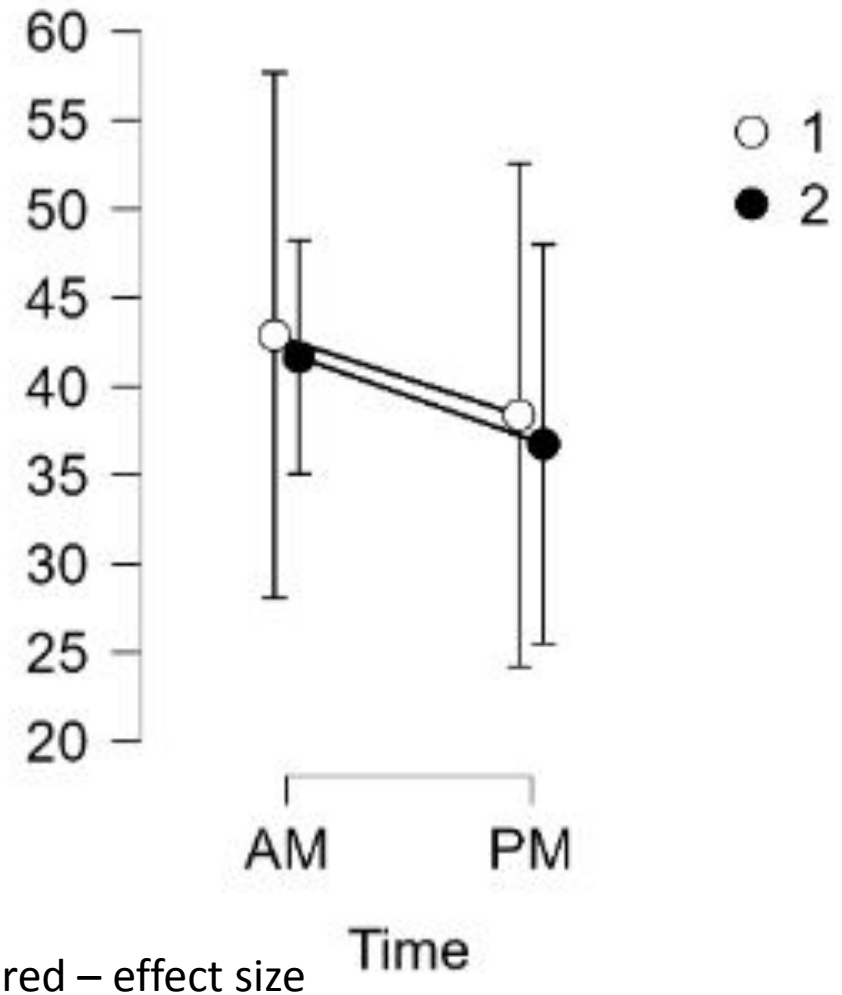
Extensor



Partial Eta Squared – effect size
0.13

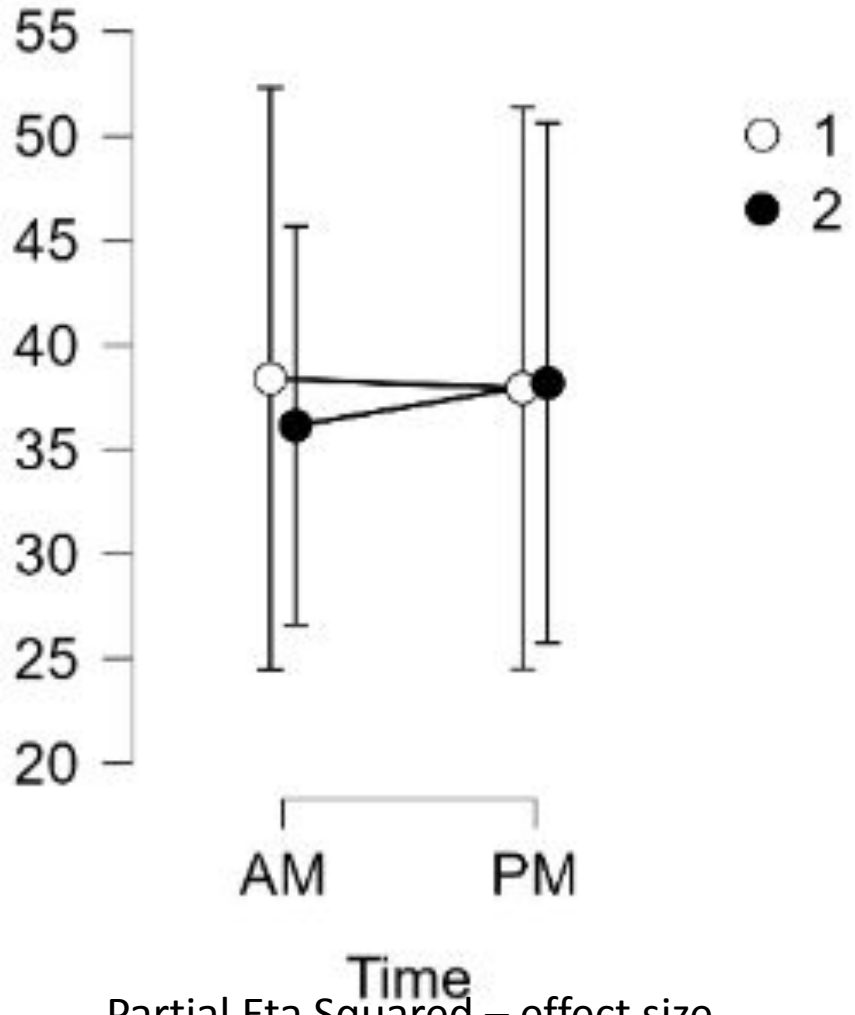
Results

L Side Bridge



Partial Eta Squared – effect size 0.04

R Side Bridge



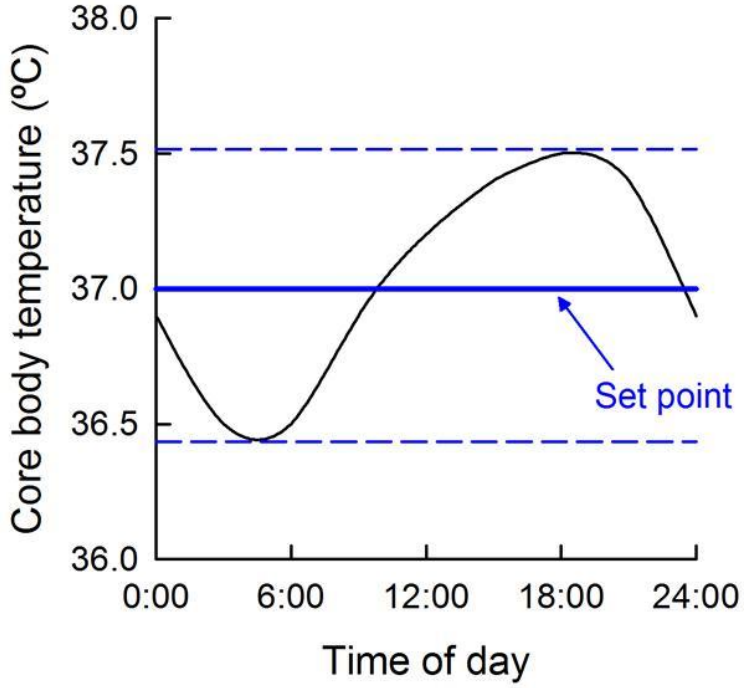
Partial Eta Squared – effect size 0.02

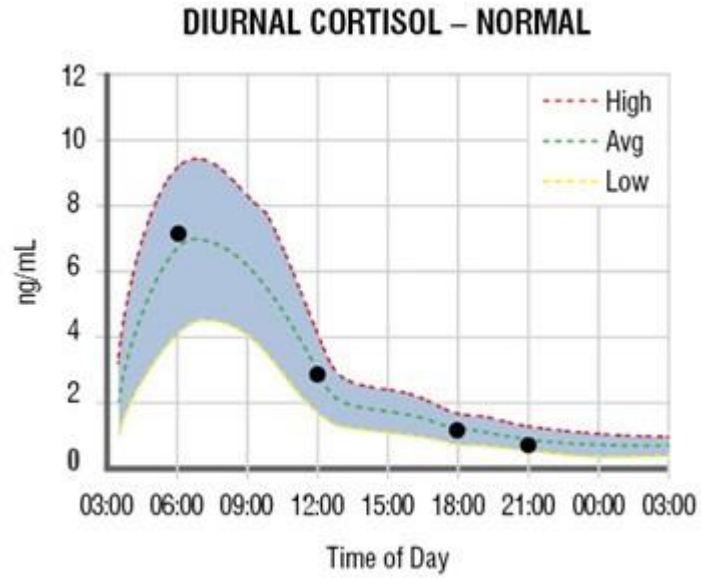
How does this increase what we know?

- Endurance times were not significantly different between AM and PM
  - Minimal effect sizes
  - Not consistent with previous studies investigating balance
- Between Days
  - No significant differences – minimal learning effect

Limitations

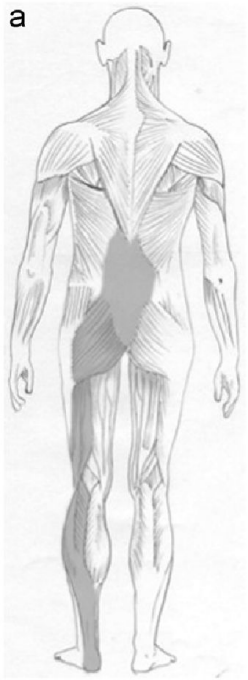
- SMALL sample size
  - Data collection on going – pilot study
- Males and females analyzed as single group (Heinbaughm, et al, 2015; Gribble et al, 2007)
- “Physically active” college students
  - Range of PA levels
- Confirm circadian rhythm?
  - Cortisol? Body Temp
- Sleep patterns, chronotype
- Other Trunk stability measures?

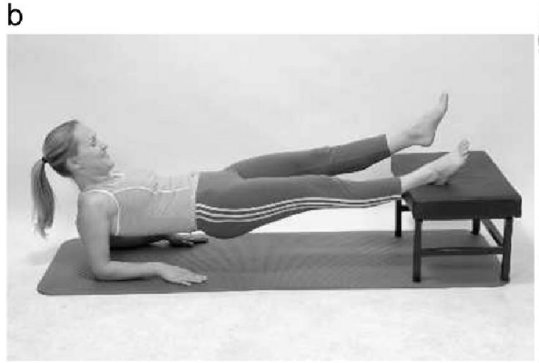


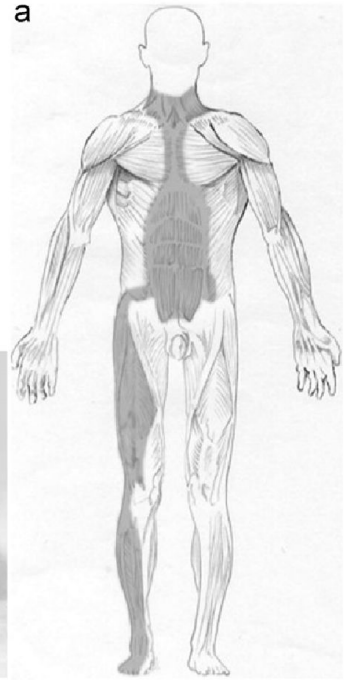


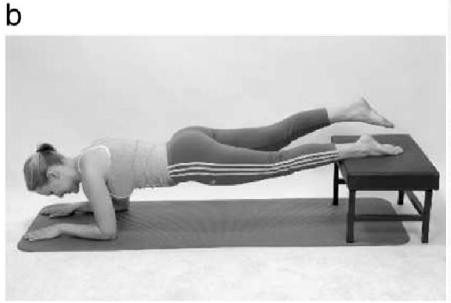
Bunkie Test

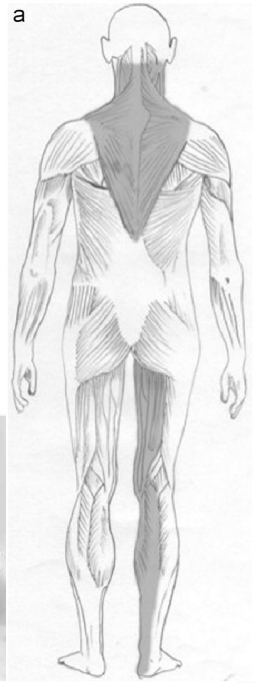
deWitt & venter, 2009



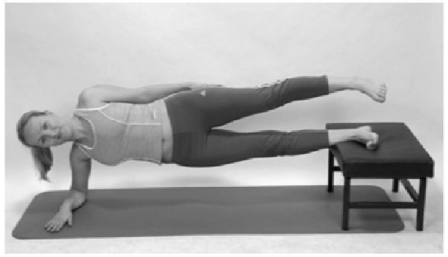


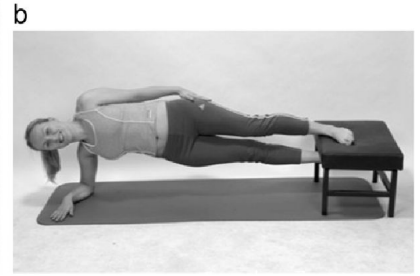






- Superficial Front Line
- Superficial Back Line
- Lateral Line (2 sides)
- Spiral Line
- Arm Lines (4)
- Functional Lines (2–front and back)
- Deep Front Line





Implications: What can we do to achieve more consistent performance?

- Designing training programs
- Control variable in research design?
- Window of testing may be confounding – BUT more realistic
- Scheduling of events
  - Competition times
  - Training
  - Rehabilitation sessions

Future Directions

- MORE SUBJECTS!!!!
- Link between low back pain and trunk stability
  - Industrial/occupational athletes?
    - Shift Work
  - Tactical athletes?
    - Sleep quality/chronotype – performance
- Intervention?

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RIDER BRONCS

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