UAB The University of Alabama at Birmingham

Physical Inactivity Contributes to Unhealthy Weight Gain and Adiposity

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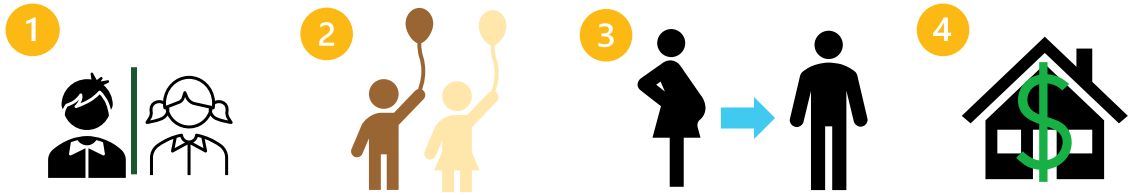
Outline

1. Descriptive Epidemiology & Levels of Prevention
2. Summary of Current Evidence on Physical Activity for Prevention of Weight Gain & Adiposity
3. Research Gaps
   - Exposure Timing
   - Exposure Dose
   - Understudied Periods
4. Recommendations & Conclusions

Epidemiology of Obesity in Children & Adolescents

1 in 5 U.S. children (14.7 million) are living with obesity



CDC, Childhood Obesity Facts; 2024

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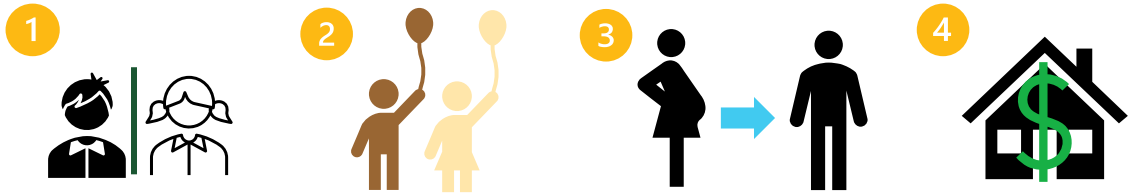
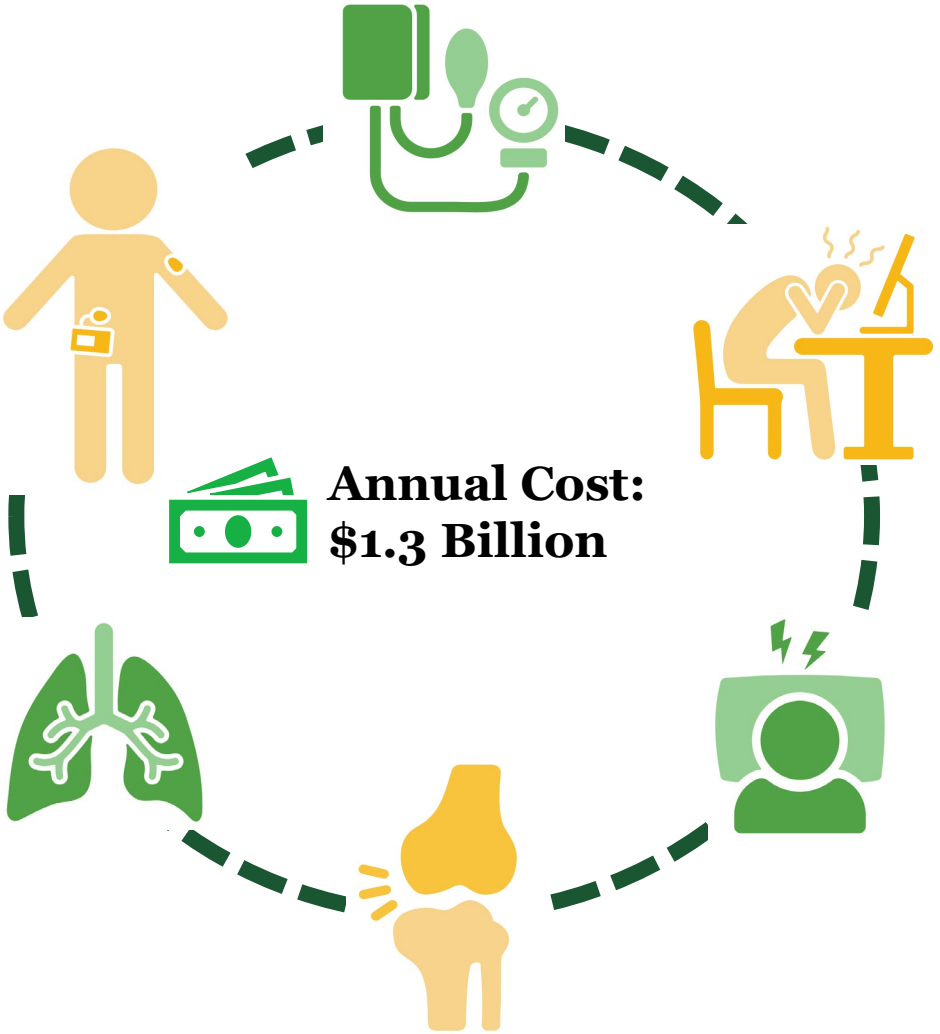
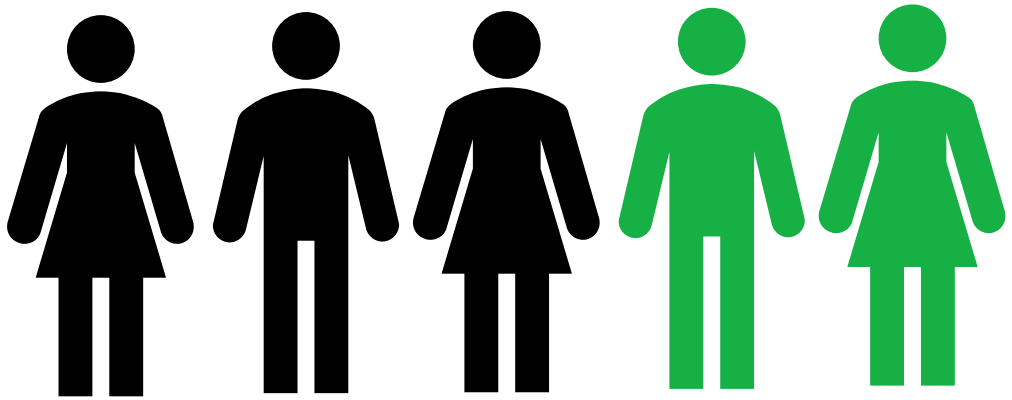


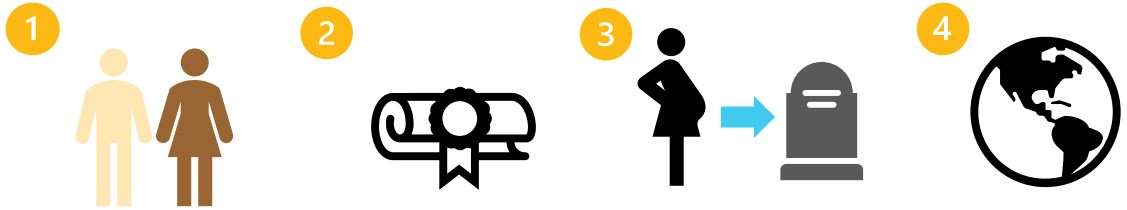


CDC, Childhood Obesity Facts; 2024

Epidemiology of Obesity in Adults

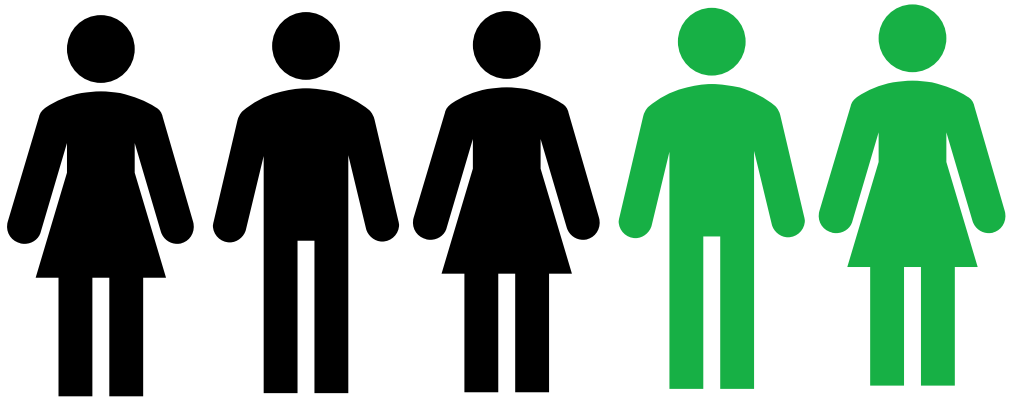


>2 in 5 U.S. adults (>100 million) are living with obesity



CDC, Adult Obesity Facts; 2024

Epidemiology of Obesity in Adults



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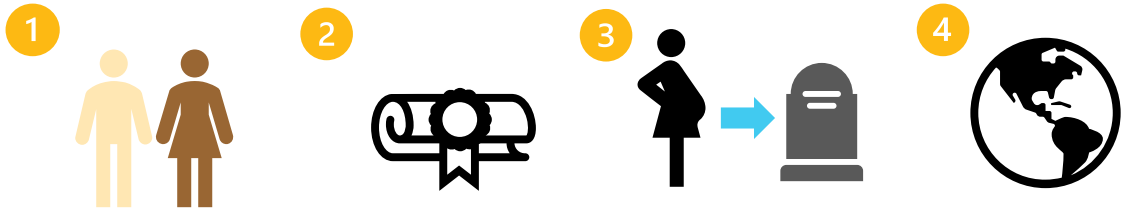
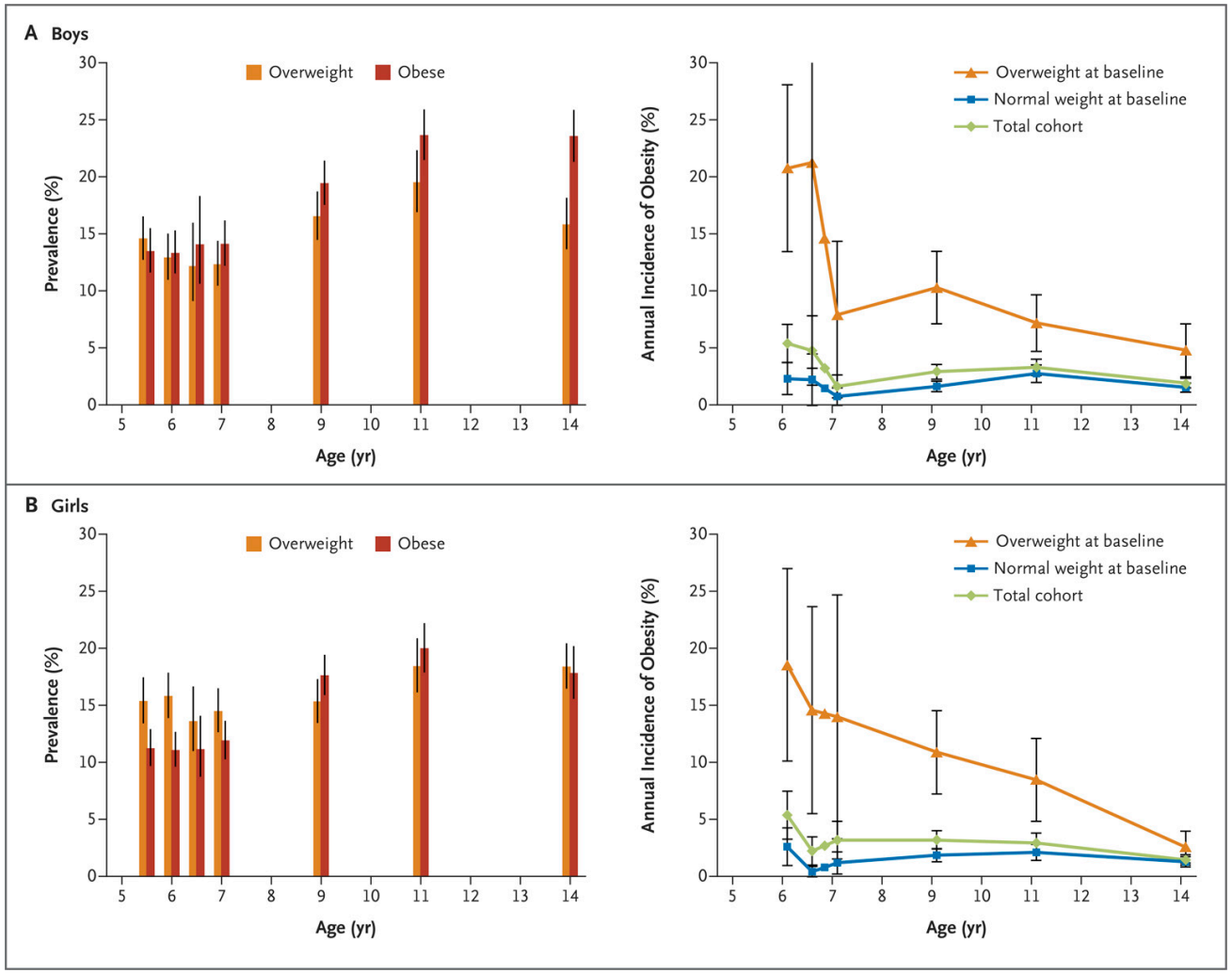


CDC, Adult Obesity Facts; 2024

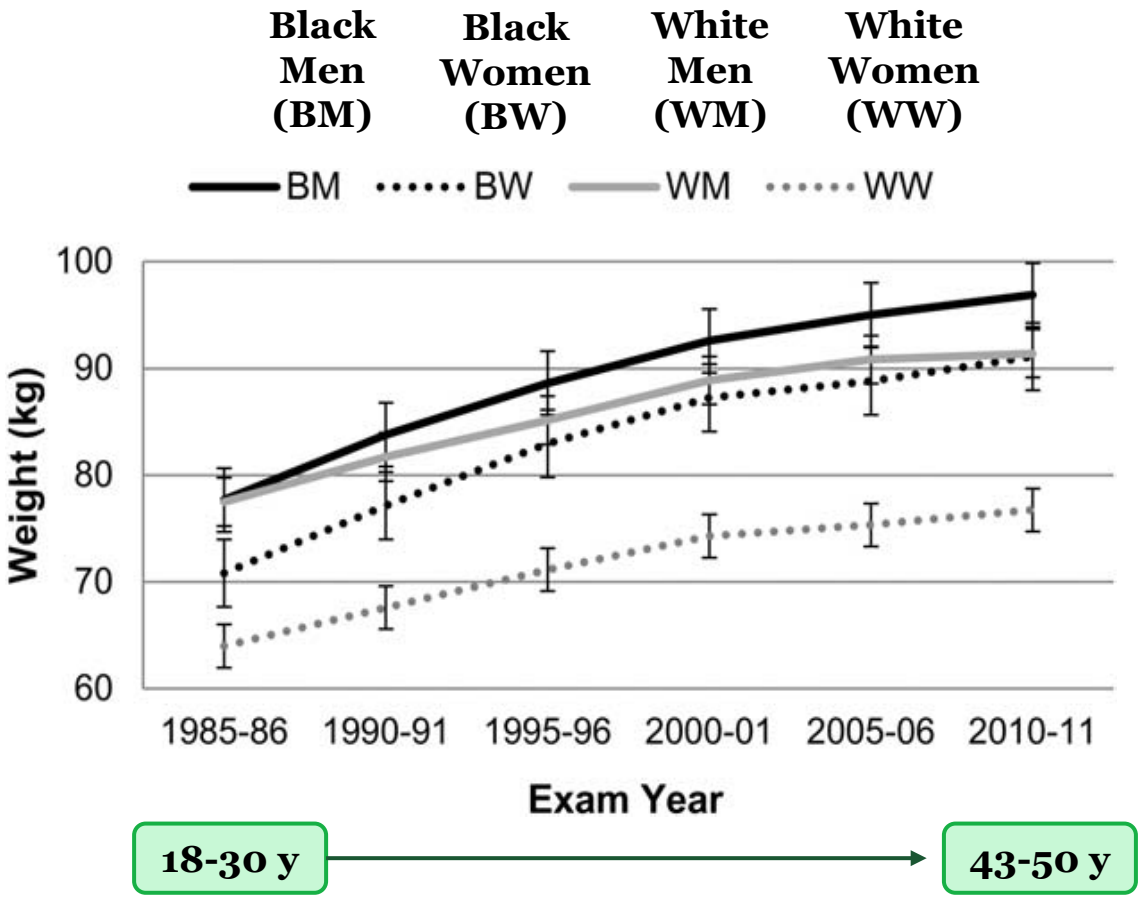
Longitudinal Studies of Weight Gain



- In kindergarten, 14.9% and 12.4% had overweight or obesity. By 8th grade, the prevalence increased to 17.0% and 20.8%
- Incident obesity between the ages of 5-14 years was more likely to have occurred at younger ages
  - Kindergarteners with overweight had over 4x the odds of having obesity by age 14 compared to normal weight peers

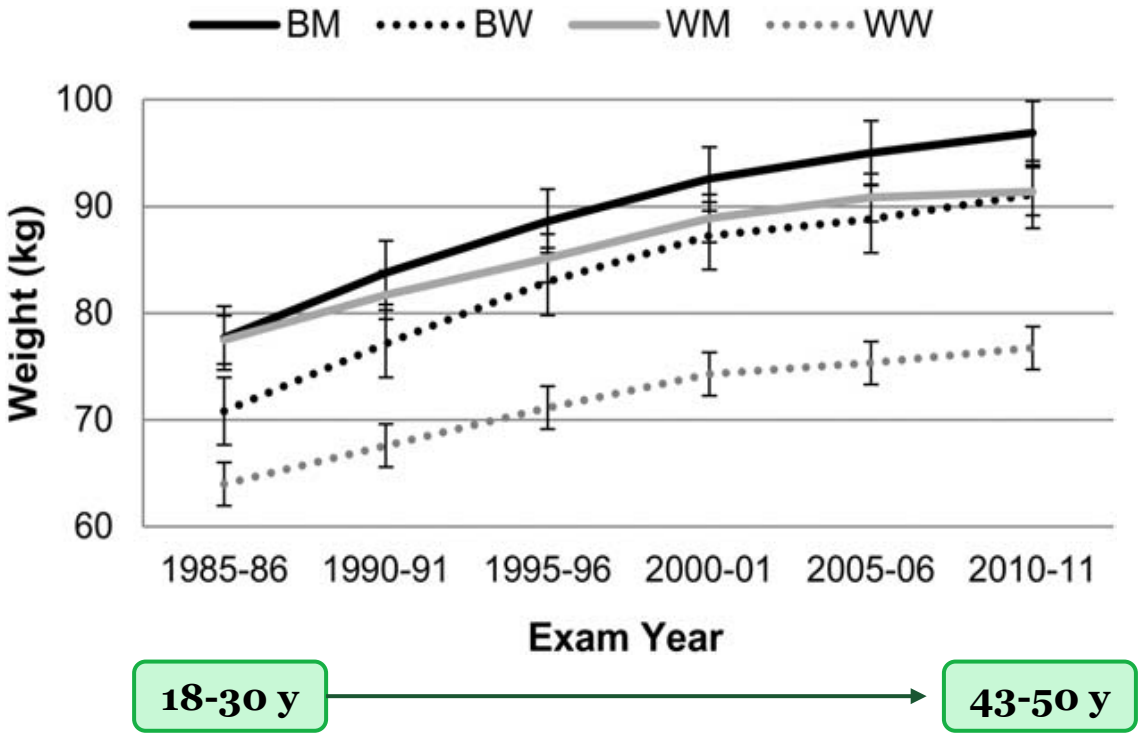
Cunningham et al., NEJM; 2014

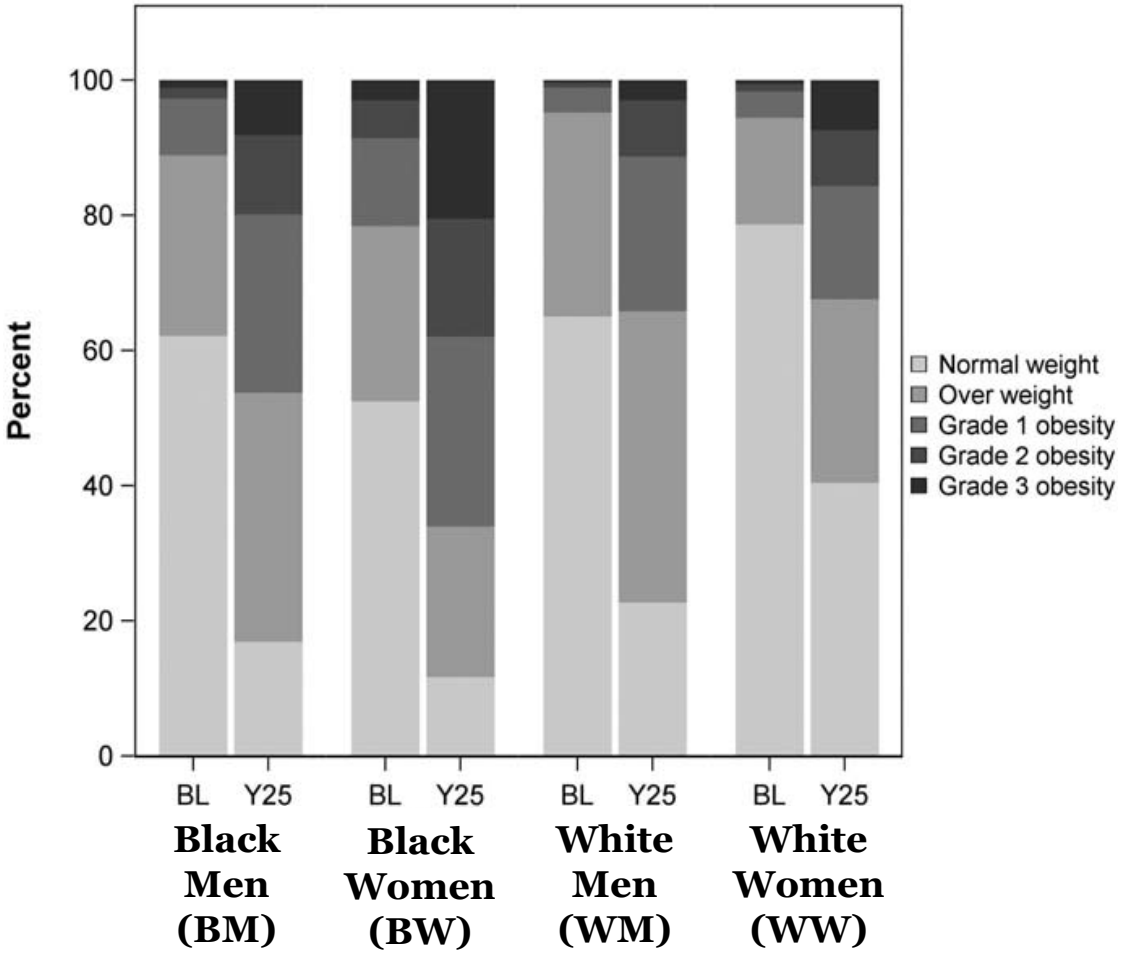
Longitudinal Studies of Weight Gain



Dutton et al., Obesity; 2016

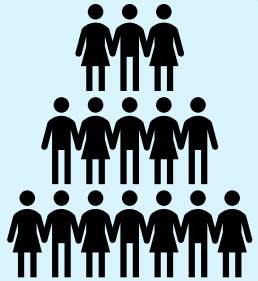
Longitudinal Studies of Weight Gain



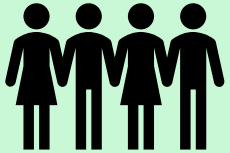


Dutton et al., Obesity; 2016

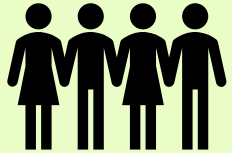
Levels of Obesity Prevention



Primordial
Reducing risk or onset of obesity at a population-level; focus on societal changes and national policy



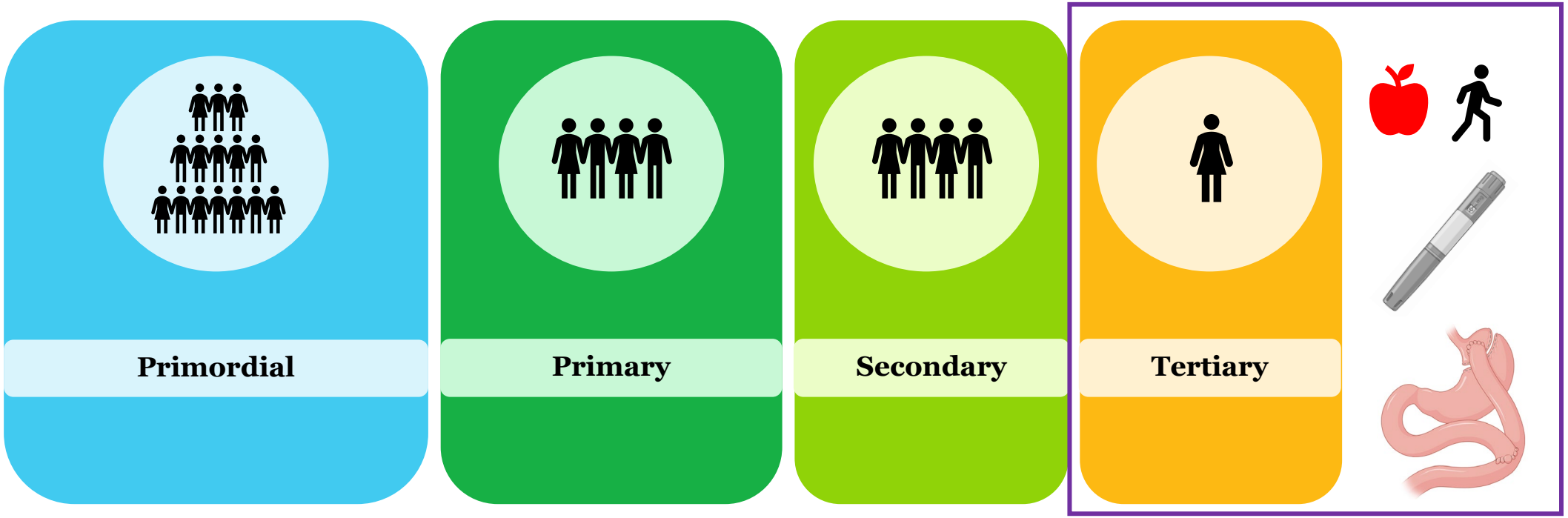
Primary
Reducing risk of weight gain among at-risk populations or environments



Secondary
Focuses on early disease detection through screening and prompt intervention

Tertiary
Strategies to lessen the impact of overweight/obesity through treatment

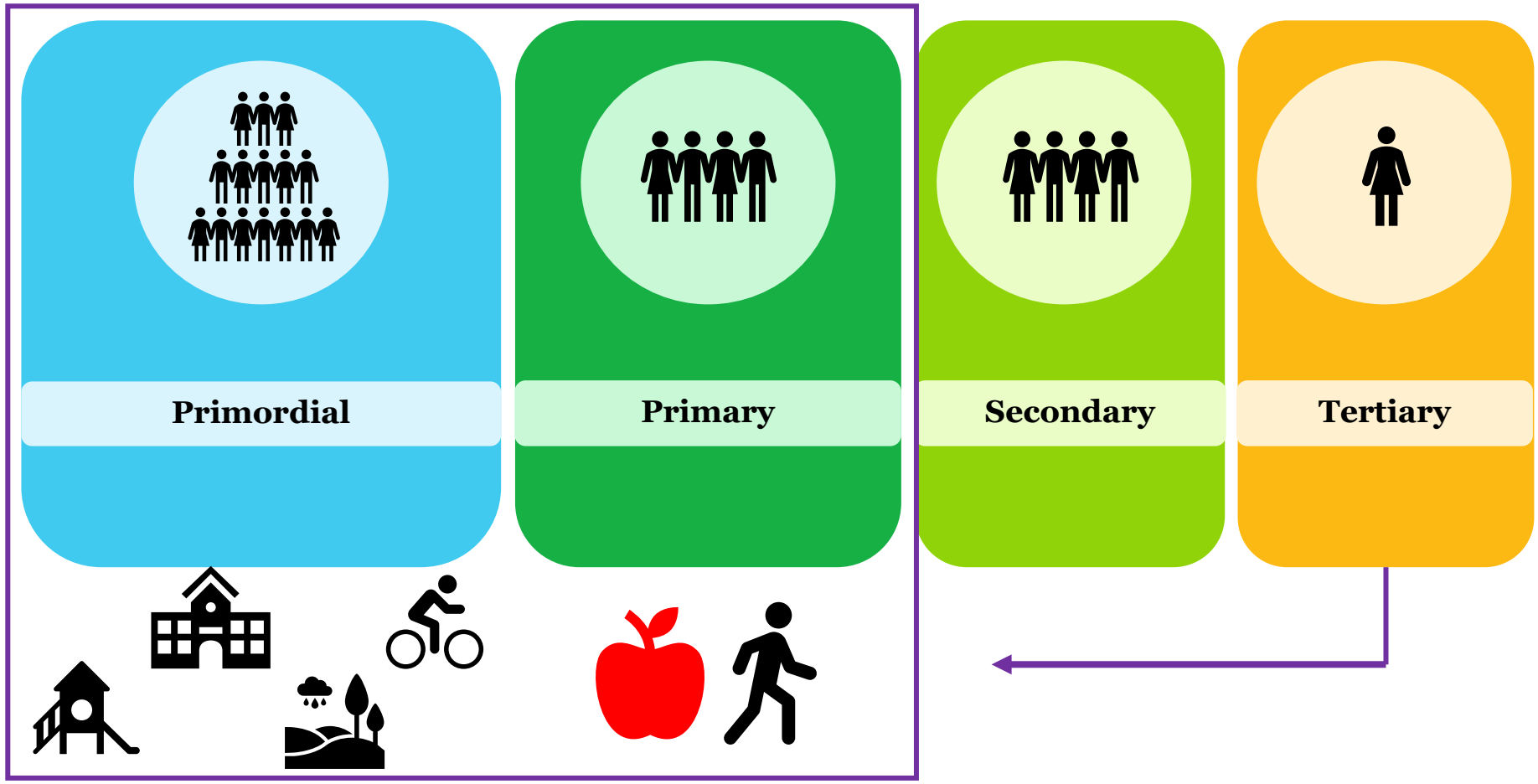
Shift from Tertiary to Primordial/Primary Prevention



- Effective strategies for weight loss exist
- Weight regain is common (~50% weight lost regained within first 2 years; 80% within 5 years*)

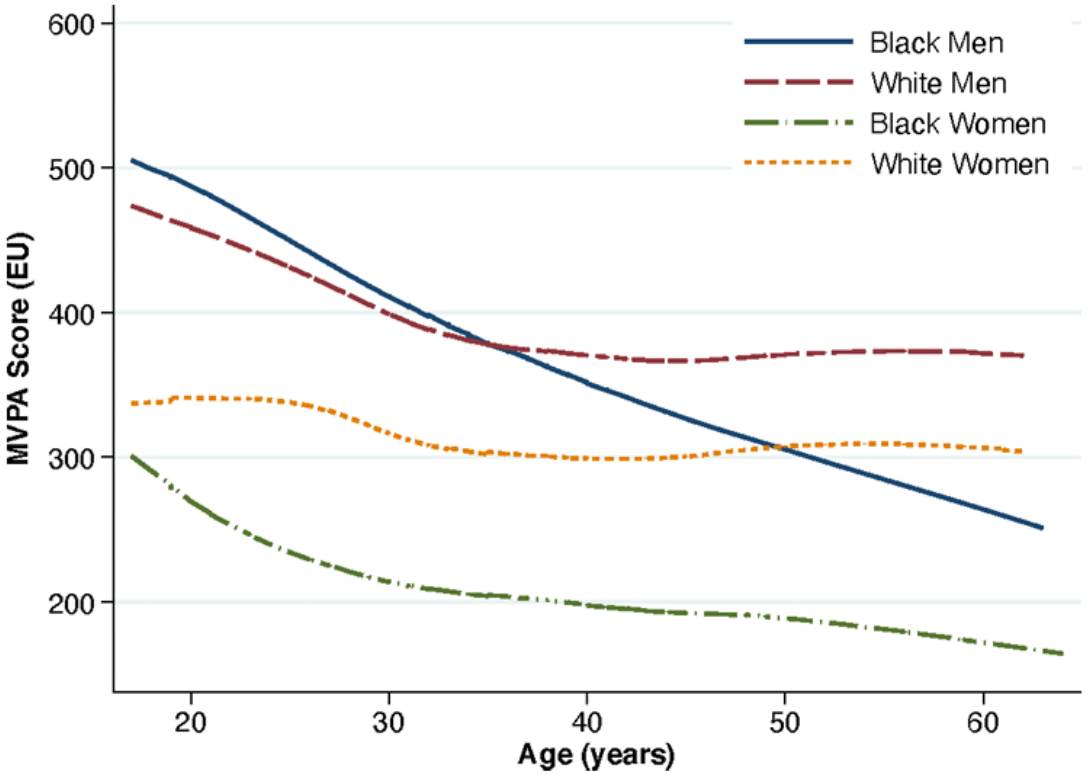
*Anderson et al., Am J Clin Nutr; 2001

Shift from Tertiary to Primordial/Primary Prevention



Longitudinal Studies of Physical Activity Change

- **Study.** Coronary Artery Risk Development in Young Adults (CARDIA)
- **Sample.** Black and White men and women aged 18-30 years at baseline (1985-86)
- **Follow-up.** 8 follow-up exams through Year 30 (2015-16)
- **Assessment.** CARDIA Physical Activity History
- **Analytic Approach.** Linear mixed models + pooled logistic regression models



Nagata et al., BJSM, 2021

Changes in Physical Activity Type

CARDIA

Early Adult to Midlife

LEISURE-TIME DOMAIN

	<25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Walking	80.2	81.7	80.9	77.0	74.1	75.5	76.6	75.2	75.0	78.3
Jogging or Running	62.1	55.0	44.9	35.5	31.7	30.6	27.4	20.6	14.9	13.8
Swimming	39.0	37.4	33.6	24.9	19.3	19.3	17.6	15.7	12.7	11.3
Bicycling	55.2	56.0	53.4	43.0	37.5	35.4	34.8	33.1	30.9	23.8
Racket Sports	27.4	26.7	20.4	12.1	8.9	7.4	6.5	5.5	6.0	7.9
Bowling or Golf	40.7	40.0	36.5	30.3	27.3	25.9	22.7	18.8	14.8	16.8
Exercise Class or Dancing	53.7	52.0	42.5	30.4	24.7	24.6	25.9	23.3	19.9	19.4
Home Activities or Strength Training	63.5	65.3	63.6	58.5	57.1	55.1	53.6	50.8	49.0	48.1
Calisthenics or Home Exercise	56.4	56.6	51.7	42.0	36.5	38.1	36.1	37.3	38.8	38.1
Other Moderate Sports	70.4	65.8	58.9	48.4	43.3	40.2	35.5	32.8	27.3	27.1
Other Vigorous Sports	53.1	49.0	42.6	32.5	24.9	20.2	15.9	11.1	10.1	7.2

Age

OCCUPATION DOMAIN

	<25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Vigorous Job Activites	52.0	50.9	49.1	42.6	39.5	39.5	38.2	35.3	32.1	32.4

HOUSEHOLD DOMAIN

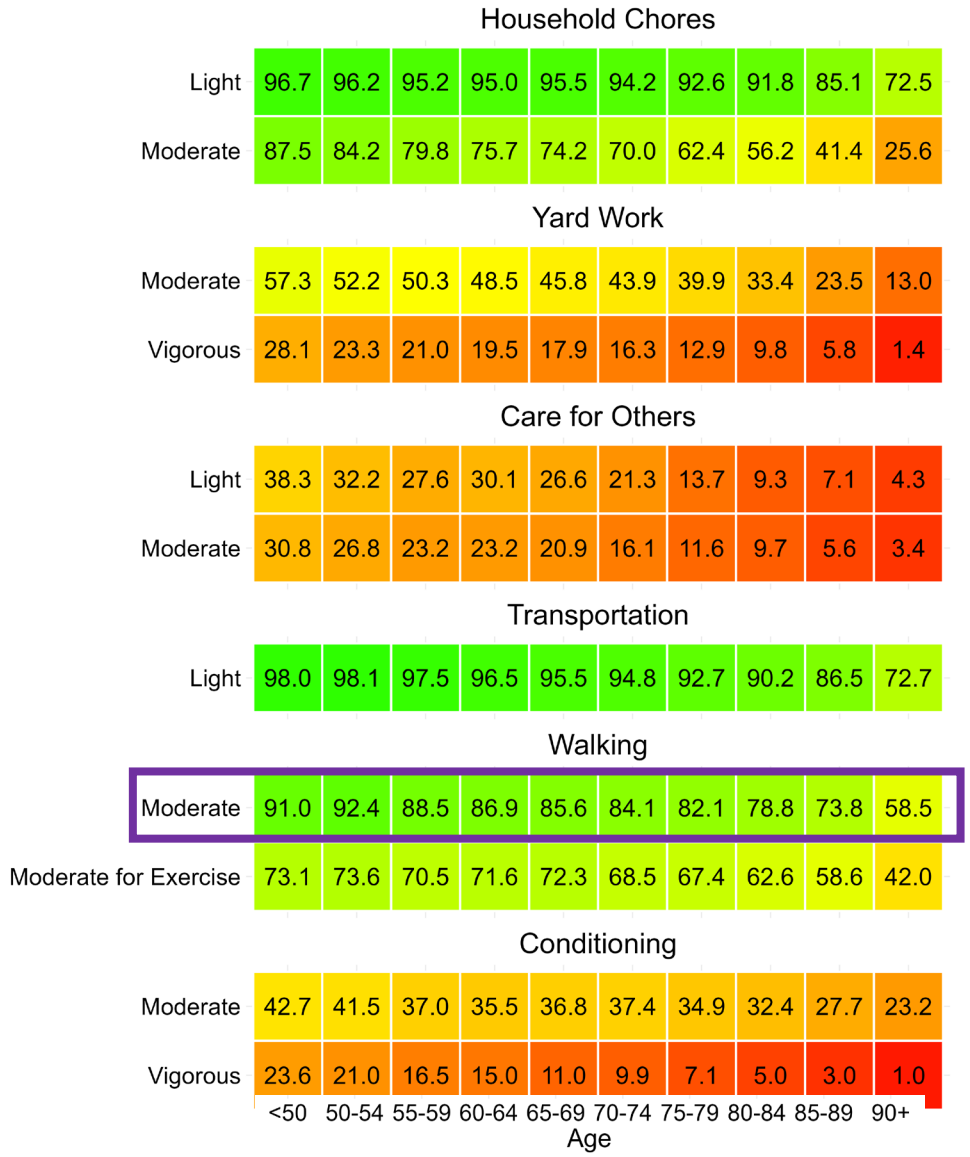
	<25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Home Maintenance or Gardening	53.2	59.3	67.1	66.3	66.6	65.7	65.0	63.4	63.6	66.5

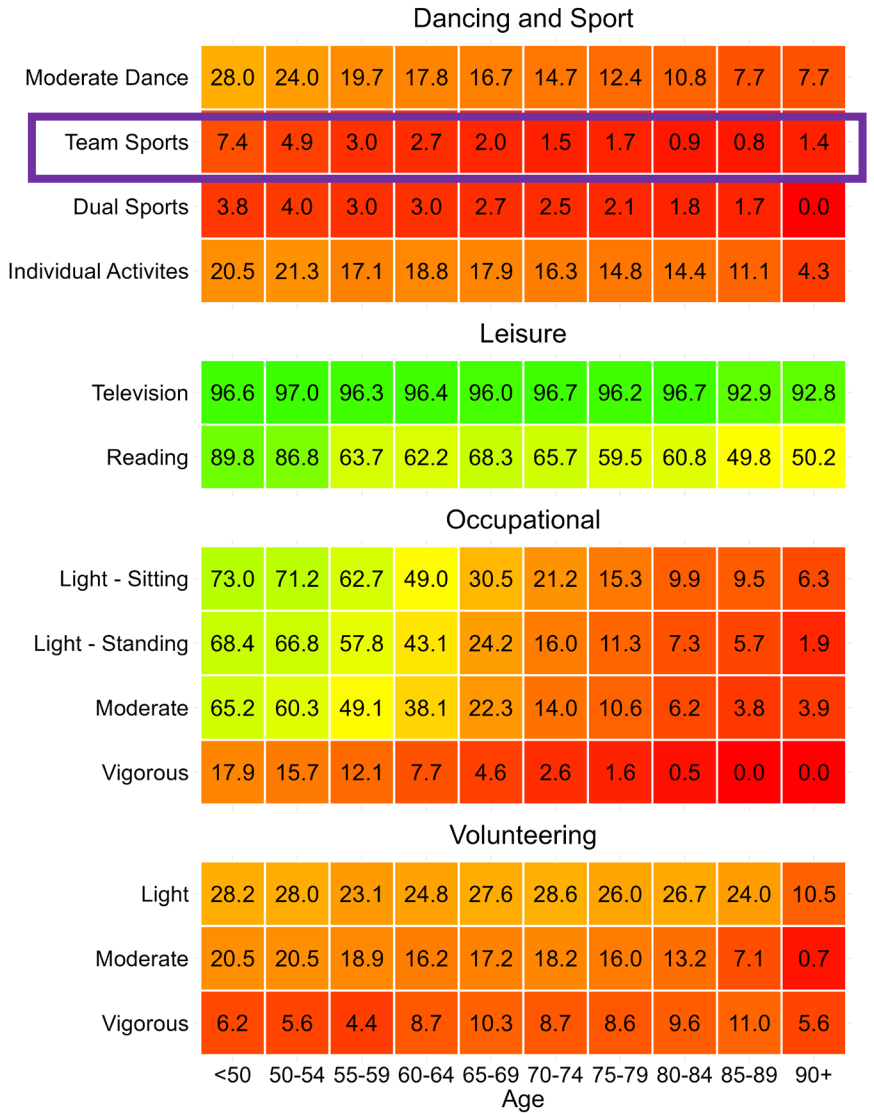
Age

High Endorsement

Low Endorsement

Hornikel et al., in progress





MESA

Midlife to Older Adult

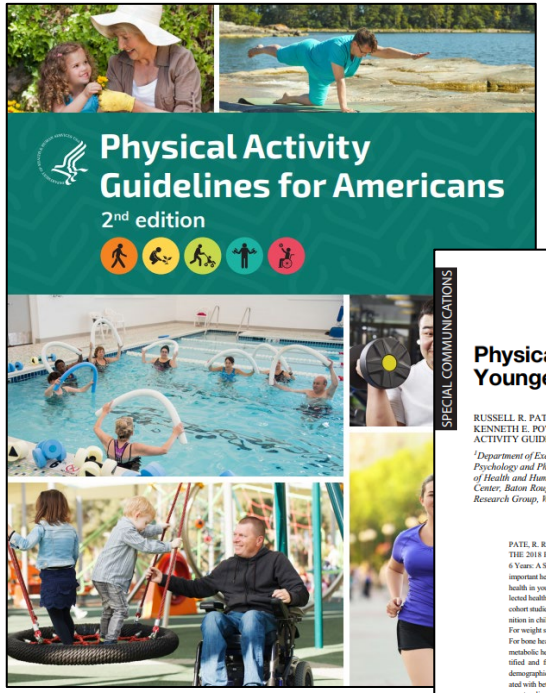
High Endorsement

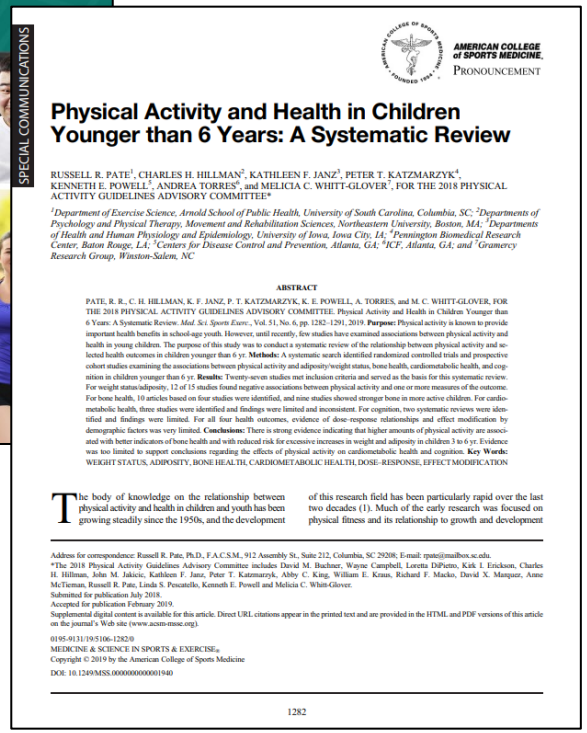
Low Endorsement

Hornikel et al., in progress

What Do We Know? Primary Prevention

- **Children 3-6 years.**
  - **Strong evidence** to support an association between greater amounts of PA and reduced risk of excessive ↑ body weight and adiposity
  - **Insufficient evidence** on dose-response and potential moderating "effects" of age, sex, social constructs (e.g., race/ethnicity, sociodemographic status) or initial weight status
- **Children & Adolescents.**
  - **Strong evidence** to support an association between greater amounts of PA and smaller increases in weight and adiposity
  - **Insufficient evidence** on dose-response and potential moderating "effects" of age, sex, social constructs (e.g., race/ethnicity, sociodemographic status) or initial weight status





SPECIAL COMMUNICATIONS

AMERICAN COLLEGE of SPORTS MEDICINE
PRONOUNCEMENT

Physical Activity and Health in Children Younger than 6 Years: A Systematic Review

RUSSELL R. PATE[1], CHARLES H. HILLMAN[2], KATHLEEN F. JANZ[3], PETER T. KATZMARZYK[4], KENNETH E. POWELL[5], ANDREA TORRES[6], and MELICIA C. WHITT-GLOVER[7], FOR THE 2018 PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE*

[1]Department of Exercise Science, Arnold School of Public Health, University of South Carolina, Columbia, SC; [2]Departments of Psychology and Physical Therapy, Movement and Rehabilitation Sciences, Northeastern University, Boston, MA; [3]Departments of Health and Human Physiology and Epidemiology, University of Iowa, Iowa City, IA; [4]Pennington Biomedical Research Center, Baton Rouge, LA; [5]Centers for Disease Control and Prevention, Atlanta, GA; [6]ICF, Atlanta, GA; and [7]Gramercy Research Group, Winston-Salem, NC

ABSTRACT

PATE, R. R., C. H. HILLMAN, K. F. JANZ, P. T. KATZMARZYK, K. E. POWELL, A. TORRES, and M. C. WHITT-GLOVER, FOR THE 2018 PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE. Physical Activity and Health in Children Younger than 6 Years: A Systematic Review. *Med. Sci. Sports Exerc.*, Vol. 51, No. 6, pp. 1282–1291, 2019. **Purpose:** Physical activity is known to provide important health benefits in school-age youth. However, until recently, few studies have examined associations between physical activity and health in young children. The purpose of this study was to conduct a systematic review of the relationship between physical activity and selected health outcomes in children younger than 6 yr. **Methods:** A systematic search identified randomized controlled trials and prospective cohort studies examining the associations between physical activity and adiposity/weight status, bone health, cardiometabolic health, and cognition in children younger than 6 yr. **Results:** Twenty-seven studies met inclusion criteria and served as the basis for this systematic review. For weight status/adiposity, 12 of 15 studies found negative associations between physical activity and one or more measures of the outcome. For bone health, 10 articles based on four studies were identified, and nine studies showed stronger bone in more active children. For cardiometabolic health, three studies were identified and findings were limited and inconsistent. For cognition, two systematic reviews were identified and findings were limited. For all four health outcomes, evidence of dose-response relationships and effect modification by demographic factors was very limited. **Conclusions:** There is strong evidence indicating that higher amounts of physical activity are associated with better indicators of bone health and with reduced risk for excessive increases in weight and adiposity in children 3 to 6 yr. Evidence was too limited to support conclusions regarding the effects of physical activity on cardiometabolic health and cognition. **Key Words:** WEIGHT STATUS, ADIPOSITY, BONE HEALTH, CARDIOMETABOLIC HEALTH, DOSE–RESPONSE, EFFECT MODIFICATION

The body of knowledge on the relationship between physical activity and health in children and youth has been growing steadily since the 1950s, and the development of this research field has been particularly rapid over the last two decades (1). Much of the early research was focused on physical fitness and its relationship to growth and development

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*The 2018 Physical Activity Guidelines Advisory Committee includes David M. Buchner, Wayne Campbell, Loretta DiPietro, Kirk I. Erickson, Charles H. Hillman, John M. Jakicic, Kathleen F. Janz, Peter T. Katzmarzyk, Abby C. King, William E. Kraus, Richard F. Macko, David X. Marquez, Anne McTiernan, Russell R. Pate, Linda S. Pescatello, Kenneth E. Powell and Melicia C. Whitt-Glover.
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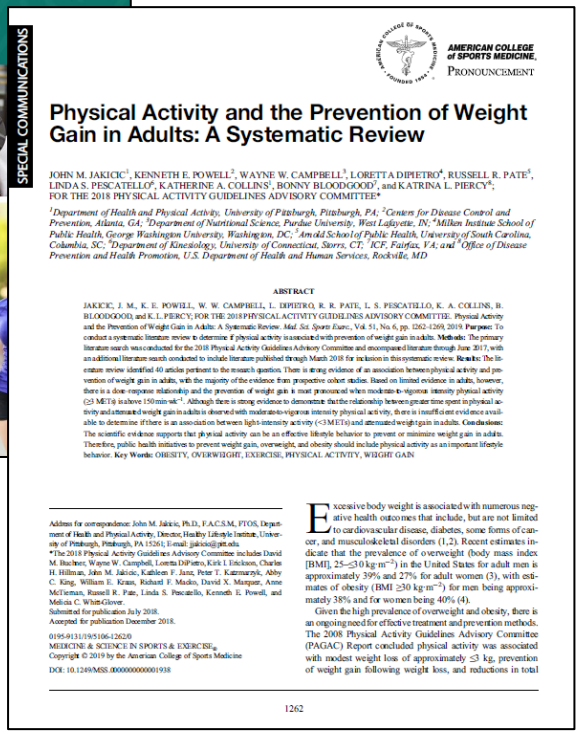
U.S. DHHS, 2018 & Pate et al., 2019

What Do We Know? Primary Prevention

- **Adults.**
  - **Strong evidence** to support an association between greater amounts of PA and attenuated weight gain. Most pronounced when MVPA ≥ 150 min·wk^{-1}
  - **Moderate evidence.** Association does not vary by sex
  - **Limited evidence** on the dose-response association AND potential moderating "effect" of age
  - **No evidence** on if the association varies by social constructs (e.g., race/ethnicity, sociodemographic status) or initial weight status


SPECIAL COMMUNICATIONS

AMERICAN COLLEGE of SPORTS MEDICINE
PRONOUNCEMENT

Physical Activity and the Prevention of Weight Gain in Adults: A Systematic Review

JOHN M. JAKICIC[1], KENNETH E. POWELL[2], WAYNE W. CAMPBELL[3], LORETTA DIPIETRO[4], RUSSELL R. PATE[5], LINDA S. PESCATELLO[6], KATHERINE A. COLLINS[1], BONNY BLOODGOOD[7], and KATRINA L. PIERCY[8], FOR THE 2018 PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE*

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ABSTRACT

JAKICIC, J. M., K. E. POWELL, W. W. CAMPBELL, L. DIPIETRO, R. R. PATE, L. S. PESCATELLO, K. A. COLLINS, B. BLOODGOOD, and K. L. PIERCY; FOR THE 2018 PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE. Physical Activity and the Prevention of Weight Gain in Adults: A Systematic Review. *Med. Sci. Sports Exerc.*, Vol. 51, No. 6, pp. 1262–1269, 2019. **Purpose:** To conduct a systematic literature review to determine if physical activity is associated with prevention of weight gain in adults. **Methods:** The primary literature search was conducted for the 2018 Physical Activity Guidelines Advisory Committee and encompassed literature through June 2017, with an additional literature search conducted to include literature published through March 2018 for inclusion in this systematic review. **Results:** The literature review identified 40 articles pertinent to the research question. There is strong evidence of an association between physical activity and prevention of weight gain in adults, with the majority of the evidence from prospective cohort studies. Based on limited evidence in adults, however, there is a dose–response relationship and the prevention of weight gain is most pronounced when moderate-to-vigorous intensity physical activity (≥3 METs) is above 150 min·wk^{-1}. Although there is strong evidence to demonstrate that the relationship between greater time spent in physical activity and attenuated weight gain in adults is observed with moderate-to-vigorous intensity physical activity, there is insufficient evidence available to determine if there is an association between light-intensity activity (<3 METs) and attenuated weight gain in adults. **Conclusions:** The scientific evidence supports that physical activity can be an effective lifestyle behavior to prevent or minimize weight gain in adults. Therefore, public health initiatives to prevent weight gain, overweight, and obesity should include physical activity as an important lifestyle behavior. **Key Words:** OBESITY, OVERWEIGHT, EXERCISE, PHYSICAL ACTIVITY, WEIGHT GAIN

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*The 2018 Physical Activity Guidelines Advisory Committee includes David M. Buchner, Wayne W. Campbell, Loretta DiPietro, Kirk I. Erickson, Charles H. Hillman, John M. Jakicic, Kathleen F. Janz, Peter T. Katzmarzyk, Abby C. King, William E. Kraus, Richard F. Macko, David X. Marquez, Anne McTiernan, Russell R. Pate, Linda S. Pescatello, Kenneth E. Powell, and Melicia C. Whitt-Glover.
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Excessive body weight is associated with numerous negative health outcomes that include, but are not limited to cardiovascular disease, diabetes, some forms of cancer, and musculoskeletal disorders (1,2). Recent estimates indicate that the prevalence of overweight (body mass index [BMI], 25–≤30 kg·m^{-2}) in the United States for adult men is approximately 39% and 27% for adult women (3), with estimates of obesity (BMI ≥30 kg·m^{-2}) for men being approximately 38% and for women being 40% (4).

Given the high prevalence of overweight and obesity, there is an ongoing need for effective treatment and prevention methods. The 2008 Physical Activity Guidelines Advisory Committee (PAGAC) Report concluded physical activity was associated with modest weight loss of approximately ≤3 kg, prevention of weight gain following weight loss, and reductions in total

U.S. DHHS, 2018 & Jakicic et al., 2019

Disconnect between Physical Activity and Weight Recommendations?

Weight	 **Weight Gain** Underweight: 28-40 lbs Normal: 25-35 lbs Overweight:15 to 25 lbs Obese: 11 to 20 lbs	 **Weight Gain** Birth to 6 mo: 2x birth weight Birth to 12 mo: 3x birth weight	 **Weight Status (2-19 y)** Underweight: <5th %ile Normal: 5 to <85th %ile Overweight: 85 to <95th %ile Obese: ≥95th %ile	 **Weight Status (≥20 y)** Underweight: <18.5 kg/m² Normal: 18.5-<25 kg/m² Overweight: 25-<30 kg/m² Obese: ≥30 kg/m²	 **Weight Status (≥20 y)** Underweight: <18.5 kg/m² Normal: 18.5-<25 kg/m² Overweight: 25-<30 kg/m² Obese: ≥30 kg/m²
Physical Activity (PA)	≥150 min·wk^{-1} moderate intensity PA* **includes resistance training*	Activity several times a day in a variety of ways, particularly interactive floor play	**1-2 years:** ≥180 min·d^{-1} any intensity PA **2-4 years:** ≥180 min·d^{-1} any intensity PA, of which 60 min·d^{-1} is moderate intensity **5-17 years:** ≥60 min·d^{-1} of moderate to vigorous PA + muscle & bone strengthening	≥150 min·wk^{-1} moderate intensity PA or ≥75 min·wk^{-1} vigorous intensity PA or Equivalent combination of MVPA 2 times·wk^{-1} of muscle strengthening	≥150 min·wk^{-1} moderate intensity PA or ≥75 min·wk^{-1} vigorous intensity PA or Equivalent combination of MVPA 2 times·wk^{-1} of muscle strengthening + balance

What Are the Research Gaps? Primary Prevention

- **Timing.** Critical Windows vs. Cumulative vs. Most Proximal
  - Influence of life events and transitions
  - Concurrent changes
- **Activity Dose.**
  - Individual-level characteristics
  - MVPA vs. Healthy 24-hours or waking hours
  - Potential heterogeneity by age, social construct, initial weight (or body composition) status, health status, etc.
- **Gaps in Life course.** In utero (dyadic associations) to very early childhood

Timing: Life Course Epidemiology Framework

- Evidence primarily established via methodological or statistical approaches that consider:
  - Concurrent exposure/outcome measures
  - Single exposure estimate
  - Follow-up over short periods of time
- Evidence supports both physical activity and weight/adiposity are dynamic over-time
- Evidence also supports a synergist relationship

In utero | Early Childhood | Childhood | Adolescence | Early Adulthood | Middle Adulthood | Older Adulthood

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Human Kinetics
COMMENTARY

Relevance of Life Course Epidemiology for Research on Physical Activity and Sedentary Behavior

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The importance of physical activity for health, well-being, and the economy is well established.[1] However, much assumed knowledge in this field is based on methods that empirically fail to consider that life circumstances, including physical activity and sedentary behavior, constantly change across the lifespan. To date, most epidemiological research on determinants and health consequences of physical activity and sedentary behavior has relied on the premise that behaviors (eg, physical activity) and social conditions (eg, socioeconomic position) assessed in one time point represent an individual's behavior or condition over the years. With the increased availability of historical data, it is becoming apparent that assumptions about the causes and consequences of physical activity and sedentary behavior may have been overly simplistic. This commentary intends to reinforce the broad appeal of the life course perspective and raise discussions on how physical activity and sedentary behavior research could benefit from complementary approaches and methods of life course epidemiology.

Life course epidemiology was first defined in 1997 as "the study of long-term biological, behavioural, and psychosocial processes that link adult health and disease risk to physical or social exposures acting during gestation, childhood, adolescence, earlier in adult life, or across generations".[2] However, despite growing interest in using life course epidemiology models to explore causal pathways between risk factors and development of diseases in adulthood,[3] the use of life course models in physical activity research is still limited to few studies. This is demonstrated by a rapid search on PubMed for studies that include broad terms for physical activity and life course in the title or abstract (Figure 1).

Many Life Stories in One Time Point

Although maintaining physical activity and sedentary behavior at recommended levels over time is thought to be essential for good health, physical activity levels change continually across the lifespan. For example, it may be the case that the current low levels of physical activity and high sedentary faced by many readers of this journal is a poor representation of their physical activity levels during childhood and adolescence (as it is the case of the author). In fact, the current state of knowledge still does not allow us to comprehend the extent to which the physical activity accumulated in specific periods of the lifespan may trigger health benefits later in life or whether the benefits of high levels of physical activity accumulated during a life stage are "washed out" when life constraints lead to periods of inactivity.

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Physical activity research can benefit from several conceptual models that focus on the nature and determinants of life transitions, timing, links to events in other life stages, and respective consequences for human health and development.[2] Conceptual models such as critical/sensitive period models, accumulation, chains of risk models, and trajectories[3] can be modeled to address different aspects of the individual's life history related to physical activity, thus accounting for the variety of life stories that remain hidden when physical activity and sedentary behavior are considered only in a single time point.

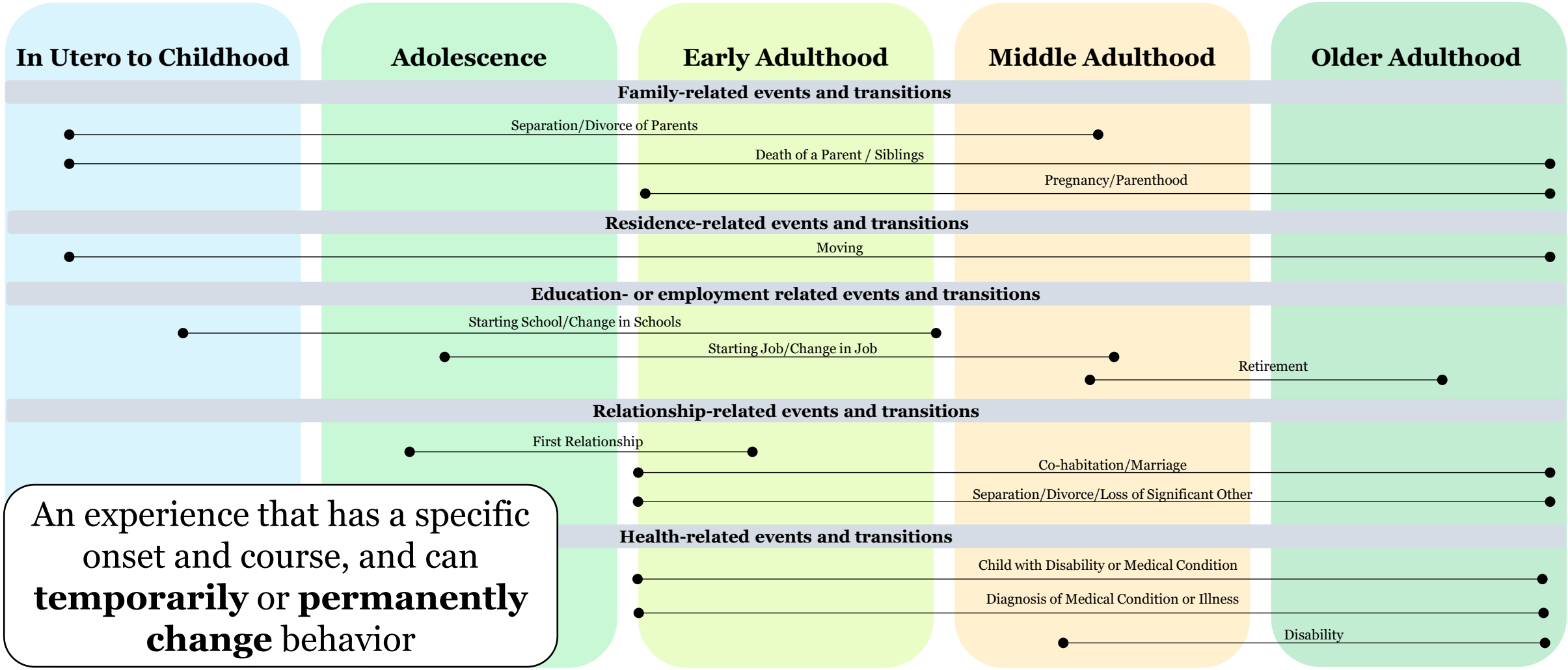
For example, the accumulation hypothesis assumes that cumulative exposures during the life course increase the risk of disease regardless of the timing.[3] Modeling this hypothesis in physical activity means exploring the extent to which growing a "physical activity bank savings" throughout the lifespan is important for preventing diseases. In addition, if the accumulation of physical activity is important irrespective of timing, public health messages could be tailored to consider the broad saga of an individual's physical activity. Furthermore, this could also mean that periods of inactivity imposed by life constraints may not be as deleterious to health as thought, as long as an individual has enough savings in their physical activity bank or compensates for the negative balance in the near future.

Critical and sensitive period models focus on the timing of exposure.[3] Critical and sensitive periods can be used to explore how biological and social transitions during life stages may have more impact on behavior adoption and risk of disease than other times. These life course models are well placed to explore how physical activity during specific trimesters of gestation impacts early development or to investigate in which time-window during childhood and adolescence enhancing participation in physical activity would have the most substantial effect on the maintenance of physical activity during adulthood.

Another approach still to be further explored in the field of physical activity is the modeling of physical activity trajectories. Recent studies have modeled trajectories of physical activity using a variety of methods[4,5] and investigated whether the risk/protective effect associated with physical activity is different between those who have always been active and those who were always inactive or became inactive. Overall, the findings from these studies have suggested that individuals who were inactive in a period of life but became physically active during mid-age had better health outcomes than those who were always inactive.[4,5]

A life course framework is also a powerful tool for better understanding the determinants and social inequalities in physical activity, hence providing important insights into how social inequalities impact the etiology of chronic disease conditions. This has been demonstrated in previous studies that found childhood socioeconomic position may have a lasting impact on physical

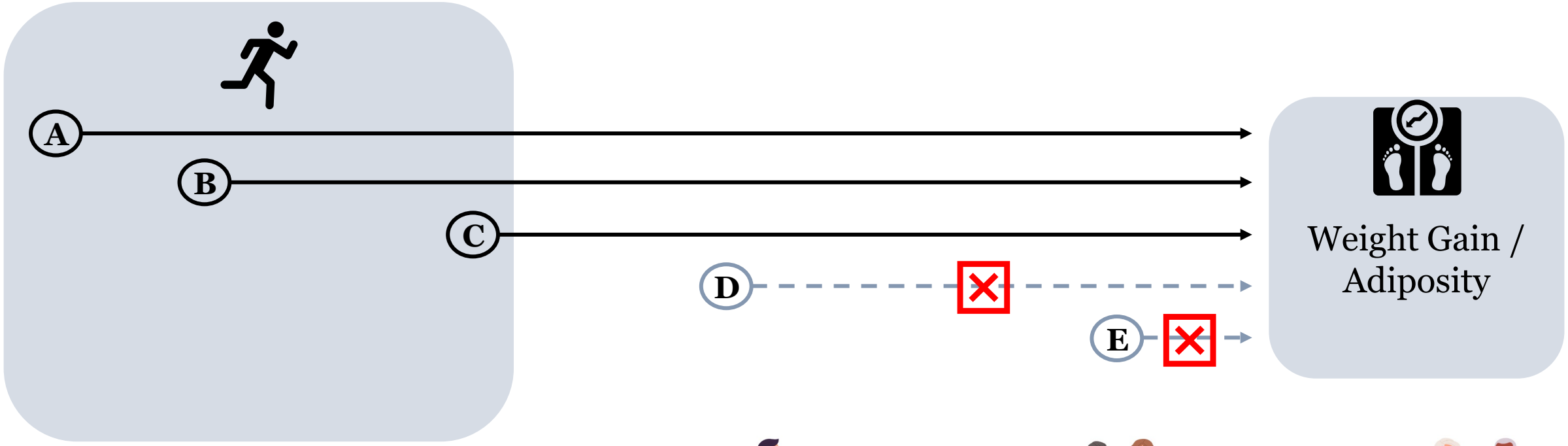
Life Events & Transitions by Life Epoch



An experience that has a specific onset and course, and can **temporarily** or **permanently change** behavior

Adapted from Gropper et al., PLoS One; 2020

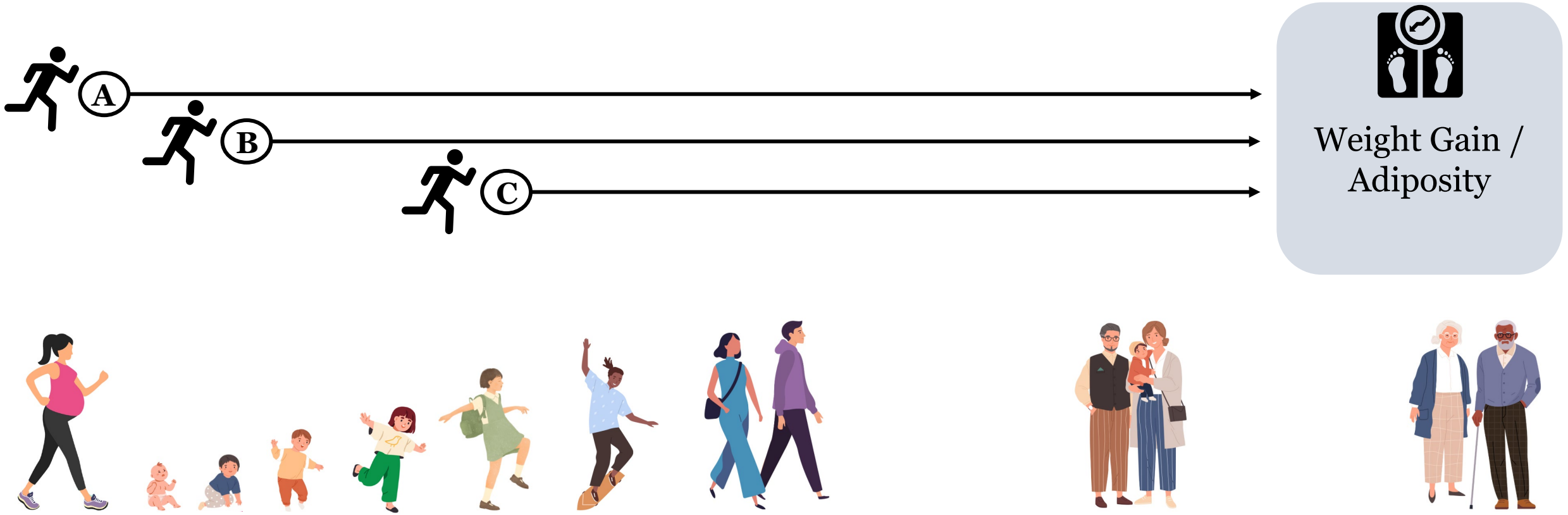
Physical Activity Timing: Sensitive Period Model



In utero | Early Childhood | Childhood | Adolescence | Early Adulthood | Middle Adulthood | Older Adulthood

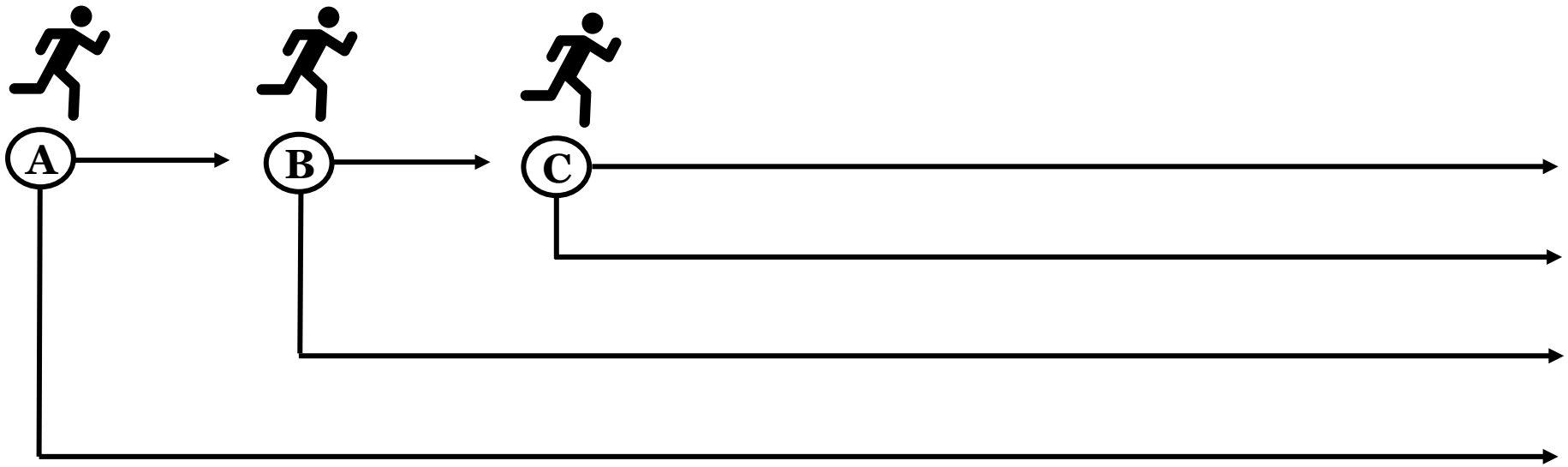
Adapted from Wagner et al., The Lancet Public Health; 2024

Physical Activity Timing: Cumulative Model



Adapted from Wagner et al., The Lancet Public Health; 2024

Physical Activity Timing: Pathway Model

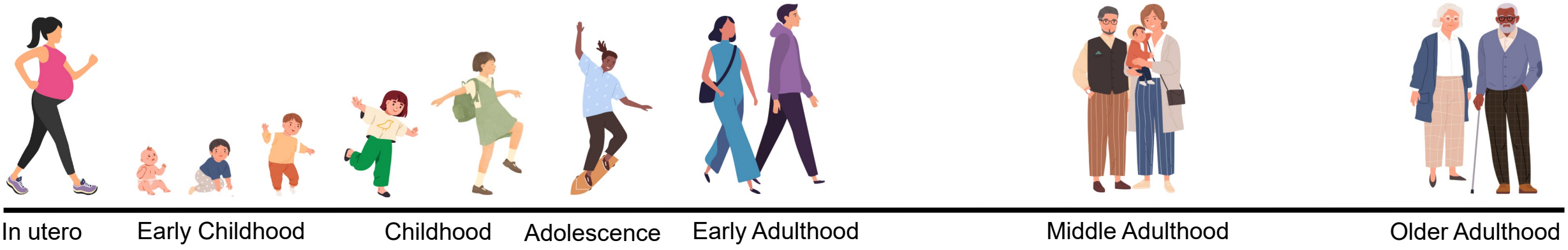


Weight Gain / Adiposity

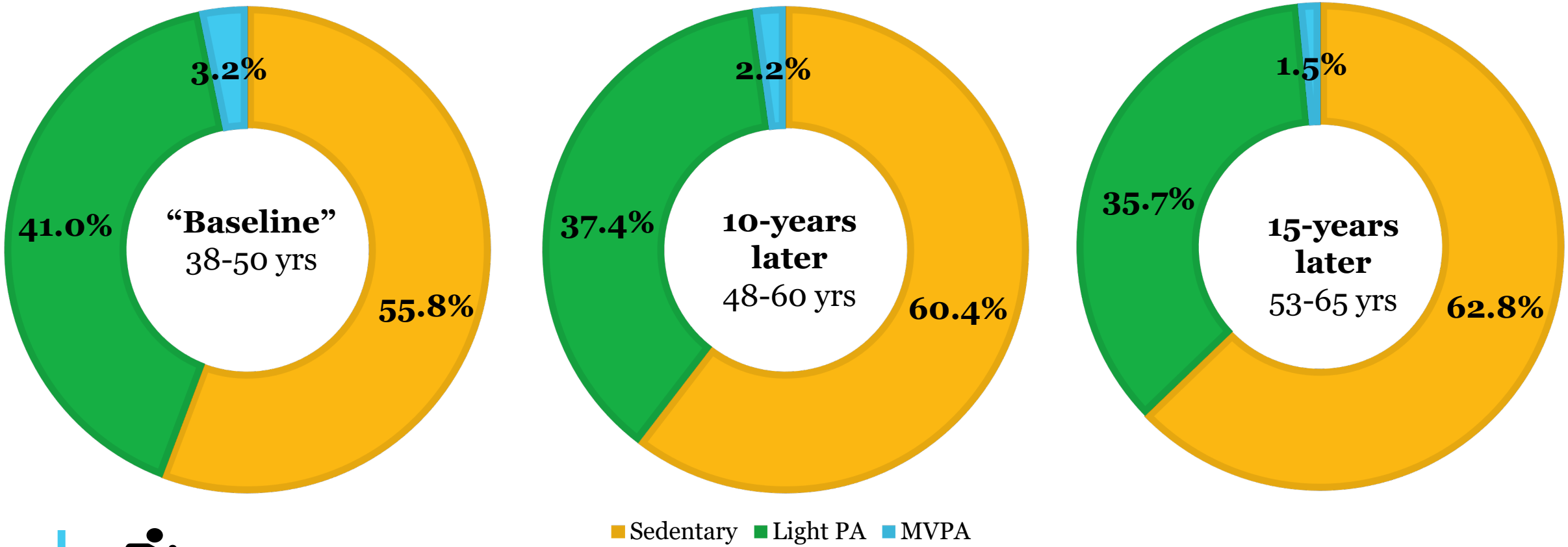
Adapted from Wagner et al., The Lancet Public Health; 2024

Physical Activity Dose

- Possible disconnect between aerobic physical activity guidelines for general health benefit vs. prevention of weight gain
- Studies support a dose ≥ 150 minutes per week of at least moderate intensity activity
  - Primarily based on questionnaire data
  - Potential heterogeneity by individual level characteristics, e.g., sex, age, social construct, and weight status has been largely unexplored



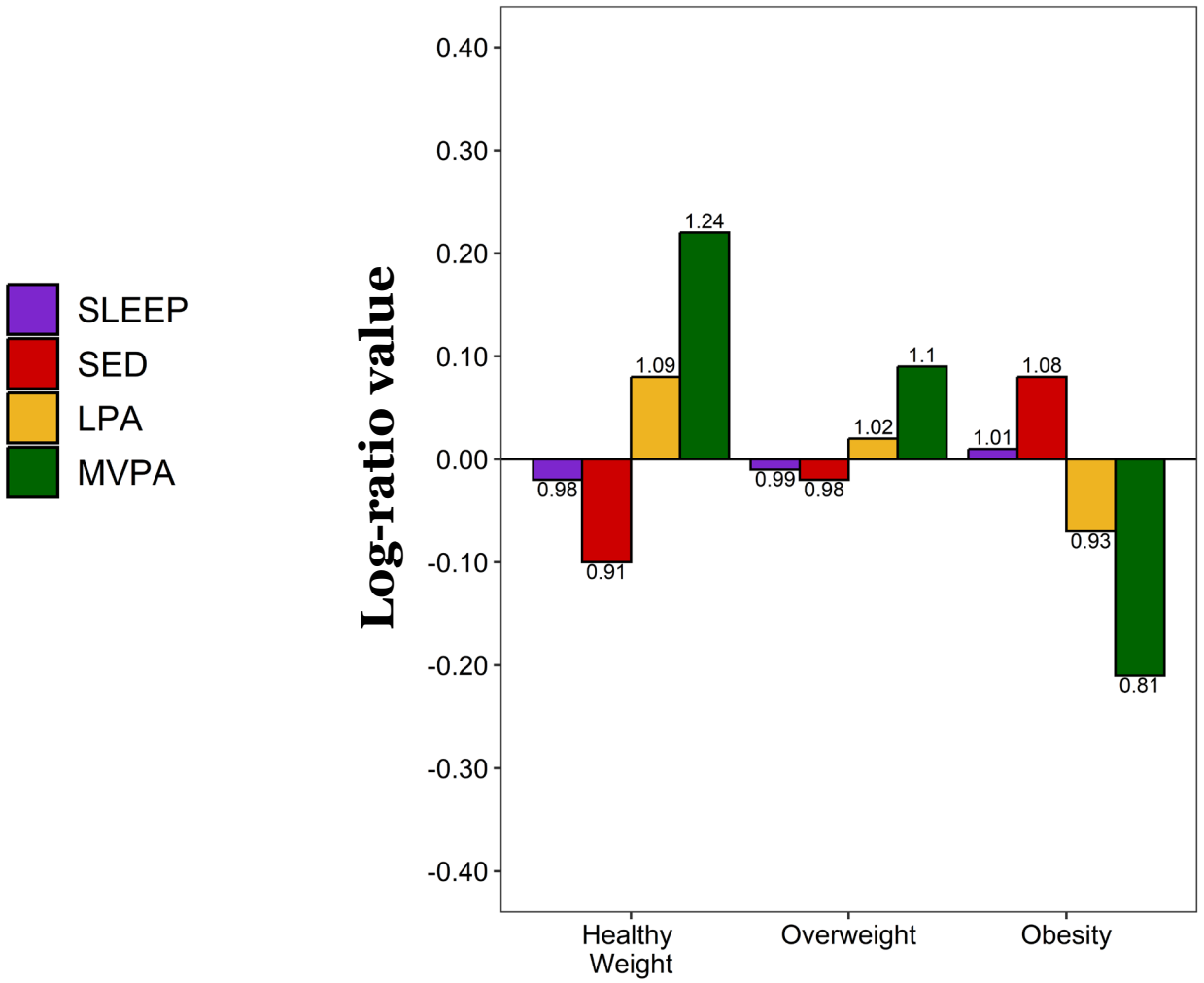
Longitudinal Studies of Accelerometry



From Y20 to Y30 to Y35: 33 daily minutes to 22 daily minutes to 15 daily minutes

From Y20 to Y30 to Y35: 9.5 daily hours to 10.25 daily hours to 10.7 daily hours

24-hour Compositions by Weight Status



Average Composition.

Sleep. 34.6%

Sedentary. 31.4%

Light Intensity. 30.5%

Moderate or Vigorous Intensity. 3.5%

Swan Study of Women's Health Across the Nation

Dooley et al., In Review

Understudied Periods: In Utero to <3 years

- In addition to maternal benefits, evidence suggests that physical activity during pregnancy has benefits to the child
  - Reduces risk for small- and large- for gestational age (LGA) birthweight
  - Reduces adiposity at birth
- LGA birth weight, adiposity at birth, and rapid growth during infancy have been associated with higher risk of childhood obesity
- Badon et al. found that reallocation of 10 min·d^{-1} from sleep, sedentary or light intensity PA to MVPA in:
  - **early pregnancy** was associated with a lower risk of LGA birthweight and rapid infant growth
  - **late pregnancy** was associated with a lower risk of LGA birthweight

Badon et al., 2025, MSSE

Understudied Periods: <3 years

- Significant prevalence of children <3 years have high weight to length ratios
- Evidence linking physical inactivity to adiposity in children <3 years is very limited
  - Age group omitted from the 2018 Physical Activity Guidelines for Americans
- Knowledge Gap due to lack of valid instruments to assess physical activity
- Rapid period of motor development
  - Expected movement patterns dependent on achievement of developmental milestones with high variability by child

Pate et al., 2020; BMC Public Health & Pate et al., 2025, JPeds

Physical Activity Timing

ENRICH →

Adolescent Brain Cognitive Development® →

Add Health →

CARDIA →

ARIC →

MESA

JACKSON HEART STUDY →

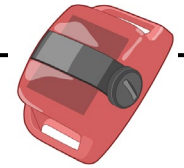
Swan Study of Women's Health Across the Nation →

DPP → DPPOS →

*Limited Data Available

In utero | Early Childhood | Childhood | Adolescence | Early Adulthood | Middle Adulthood | Older Adulthood

Physical Activity Dose



24-hours

ENRICH

Adolescent Brain Cognitive Development

Add Health
The National Longitudinal Study of Adolescent to Adult Health

CARDIA

ARIC

MESA

JACKSON HEART STUDY

Swan
Study of Women's Health Across the Nation

DP
Diabetes Prevention Program

DPPOS

In utero | Early Childhood | Childhood | Adolescence | Early Adulthood | Middle Adulthood | Older Adulthood

Conclusions & Recommendations

- Physical inactivity is related to unhealthy weight gain across the life course
- Observational studies with repeated assessment of physical activity and weight across several decades can play a key role in addressing novel questions related to physical activity **timing** and **dose**, particularly with investment in long-term funding and device-based assessment
- Additional investment in studies that follow pregnant persons and their offspring through very early childhood is needed

Thank You

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Scoring and Classifying Outcomes for Research in Exercise and Sleep

Several images created in https://BioRender.com