Physical Activity Influences on Cancer Risk and Survival

Christine Friedenreich, PhD
Senior Research Scientist, Population Health Research,
Alberta Health Services-Cancer Care

Adjunct Professor and ACF Weekend to End Women's Cancers
Breast Cancer Chair, University of Calgary

Alberta Health Services

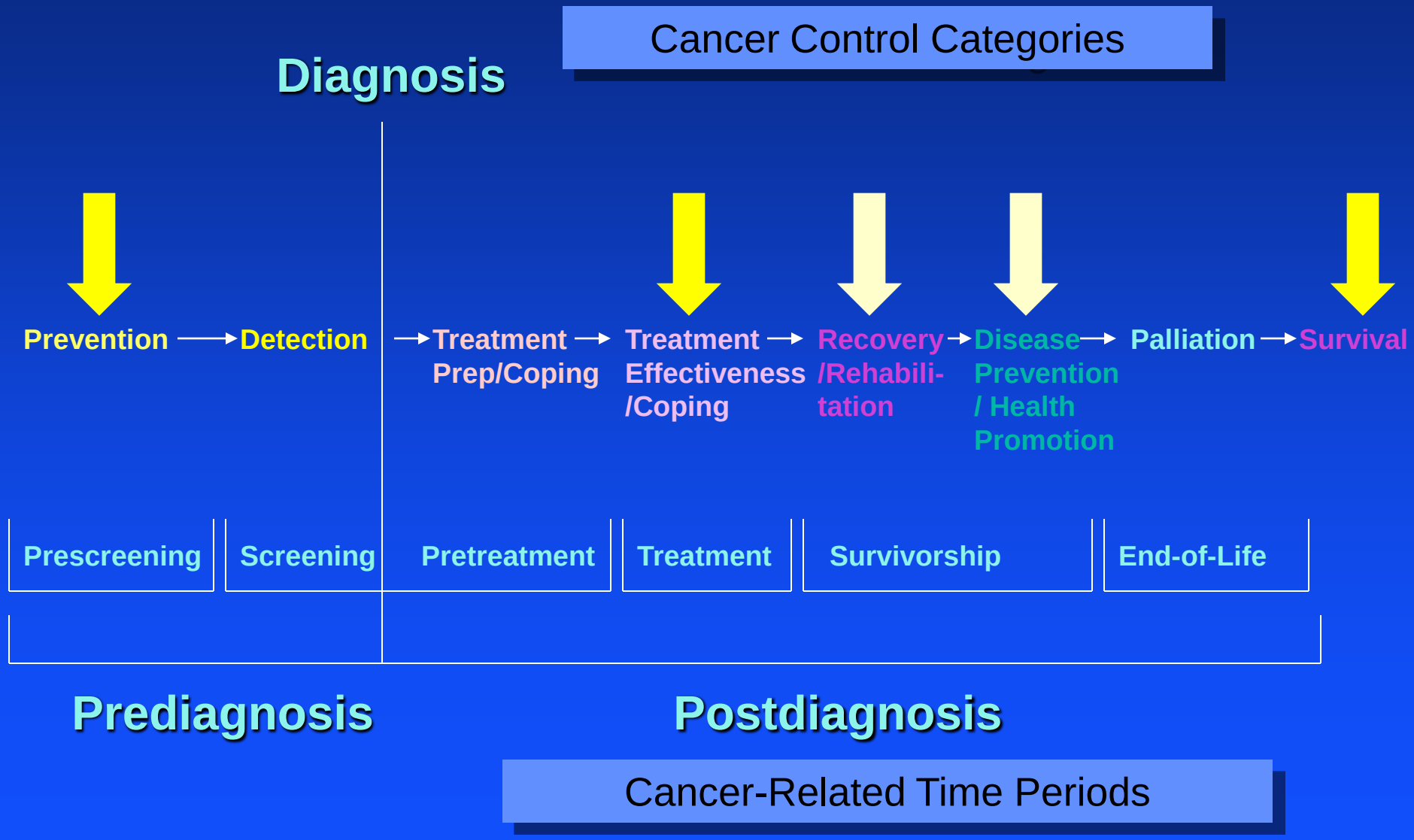
UNIVERSITY OF CALGARY

Overview

- Physical activity across the cancer continuum:
  - Prevention
  - Treatment
  - Rehabilitation
  - Survival
- Review of evidence from:
  - Observational studies
  - Randomized controlled exercise intervention trials
- Biologic mechanisms in physical activity and cancer control:
  - RCT evidence for cancer prevention, rehabilitation and survival
- Future research directions

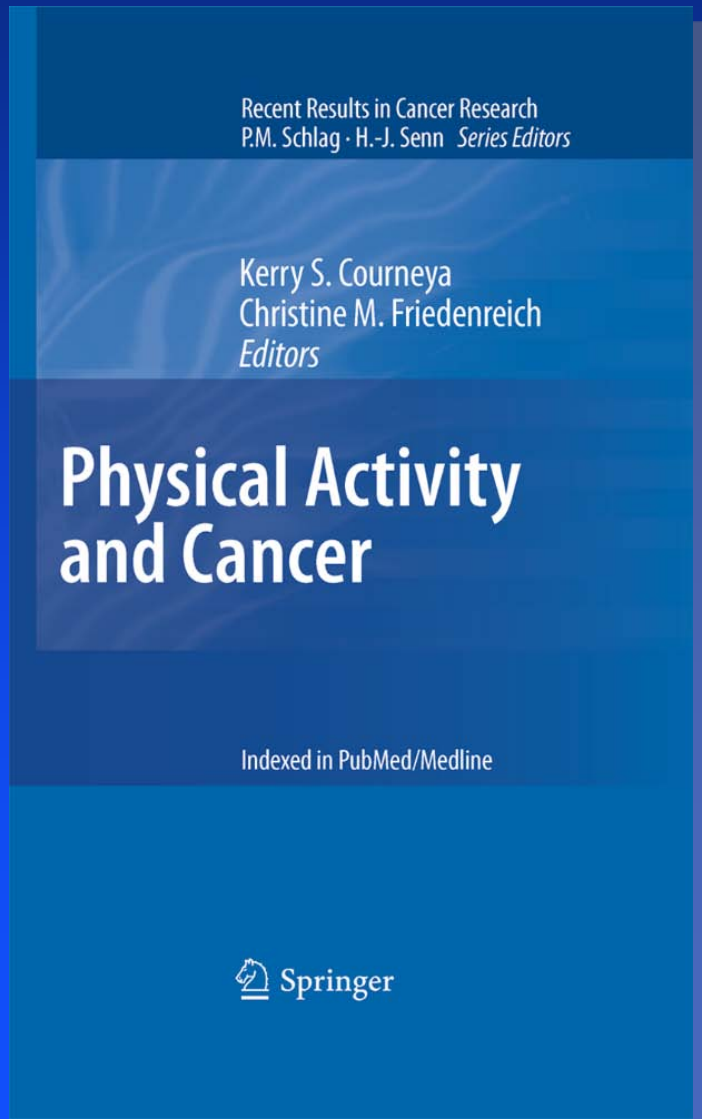
Physical Activity in Cancer Control Framework

Courneya & Friedenreich (2001, 2007)



Physical Activity and Cancer

Courneya and Friedenreich, editors



- Topics:
  - Physical Activity and Cancer Prevention
  - Physical Activity and Cancer Survivorship
  - Physical Activity and Cancer Special Topics

Recent Results in Cancer Research, Springer-Verlag, 2011

Level of Evidence on Physical Activity and Cancer Risk Reduction

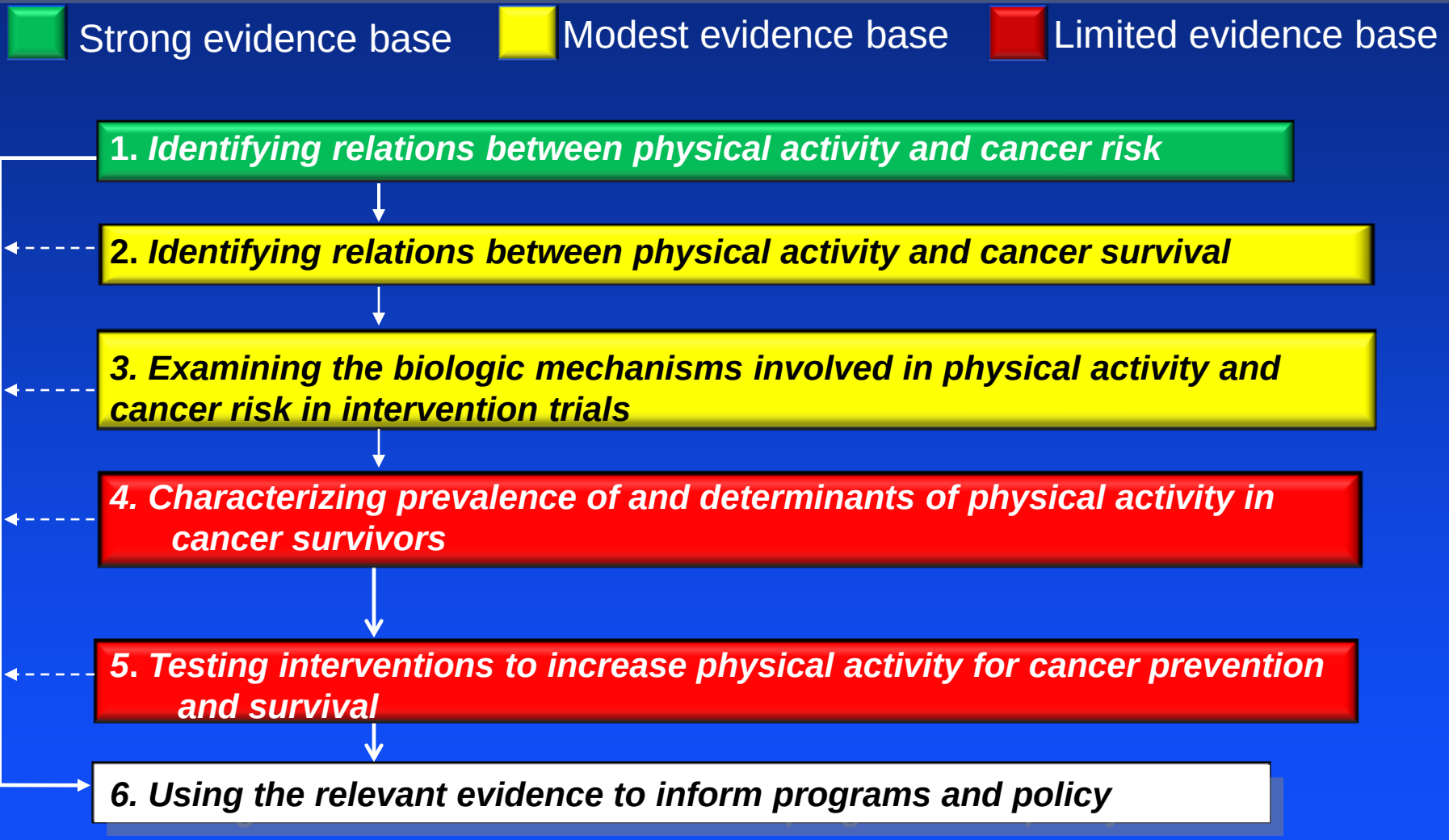
Convincing or Probable
Colon
Breast
Endometrial
Weaker evidence
Lung
Prostate
Ovarian

Insufficient or Null
Rectal *
Pancreatic
Gastric
Bladder
Testicular
Kidney
Hematologic cancers (non-Hodgkin lymphoma, Hodgkin lymphoma, leukemia, multiple myeloma)

** No association*

Friedenreich et al. *EJC*, 2010; 46:2593-2604

Physical Activity and Cancer Research: State of the Science



Adapted from Owen N et al. Amer J Prev Med 2011, 41, 189-196.

Physical Activity and Breast Cancer Risk

Lynch BM, Neilson HK, Friedenreich CM. Physical activity and breast cancer prevention.

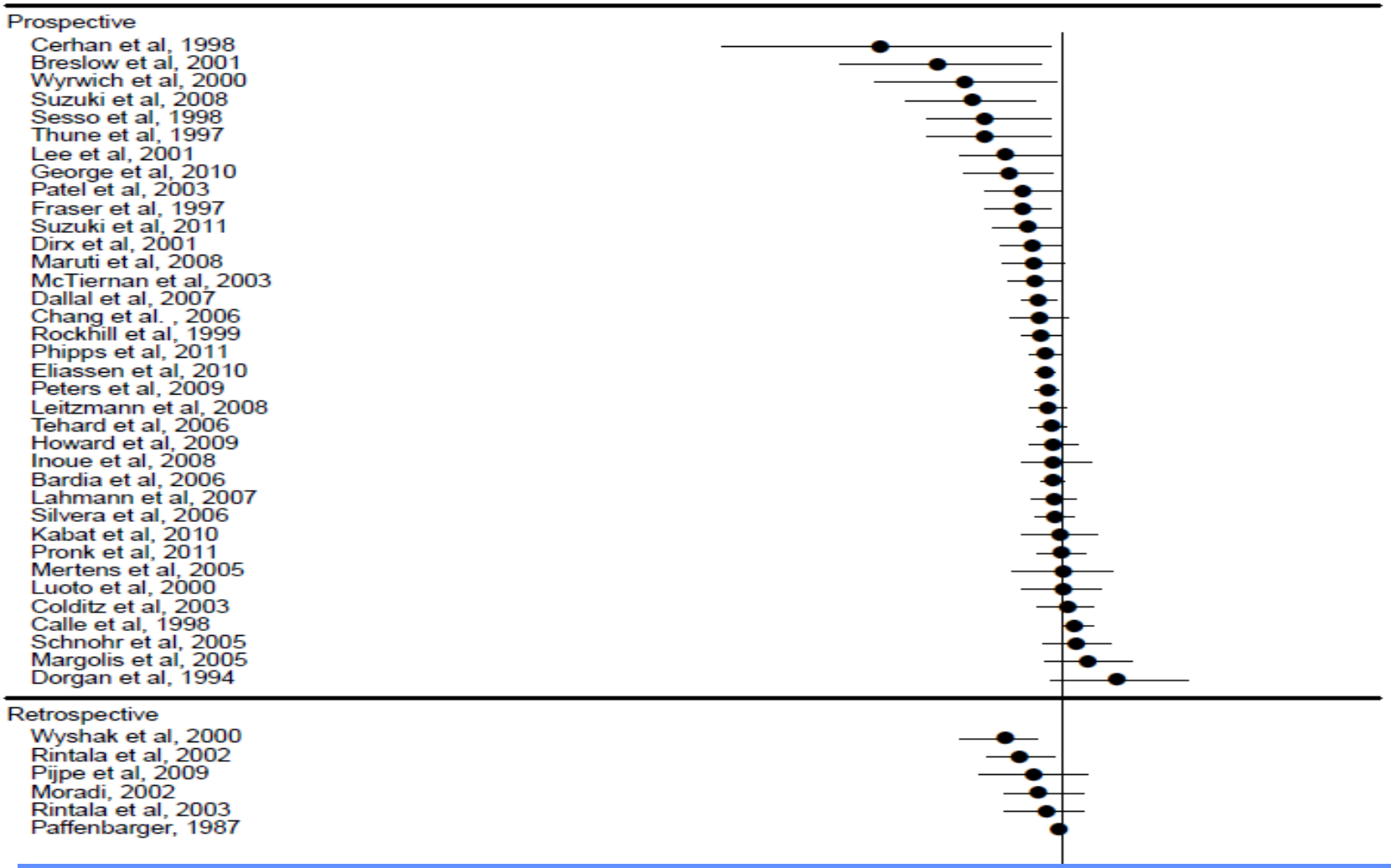
In Courneya KS and Friedenreich CM (eds). Physical Activity and Cancer. Recent Results in Cancer Research. Heidelberg:Springer-Verlag, 2011.

Summary of Evidence on Physical Activity and Breast Cancer Risk

- Consistent evidence *(66 out of 88 observed decreased risk):*
  - 19 studies show no effect
  - 66 studies show decreased risk
  - 3 studies find increased risks
- Fairly strong risk reductions *(25% decrease for highest vs. lowest activity levels, on average)*
  - 31% average risk reduction in case-control studies
  - 19% average risk reduction in cohort studies
- Clear dose-response with increasing activity and decreasing risk *(40 of 50 studies)*
- Biologic plausibility exists *(several possible mechanisms)*
- Temporality exists

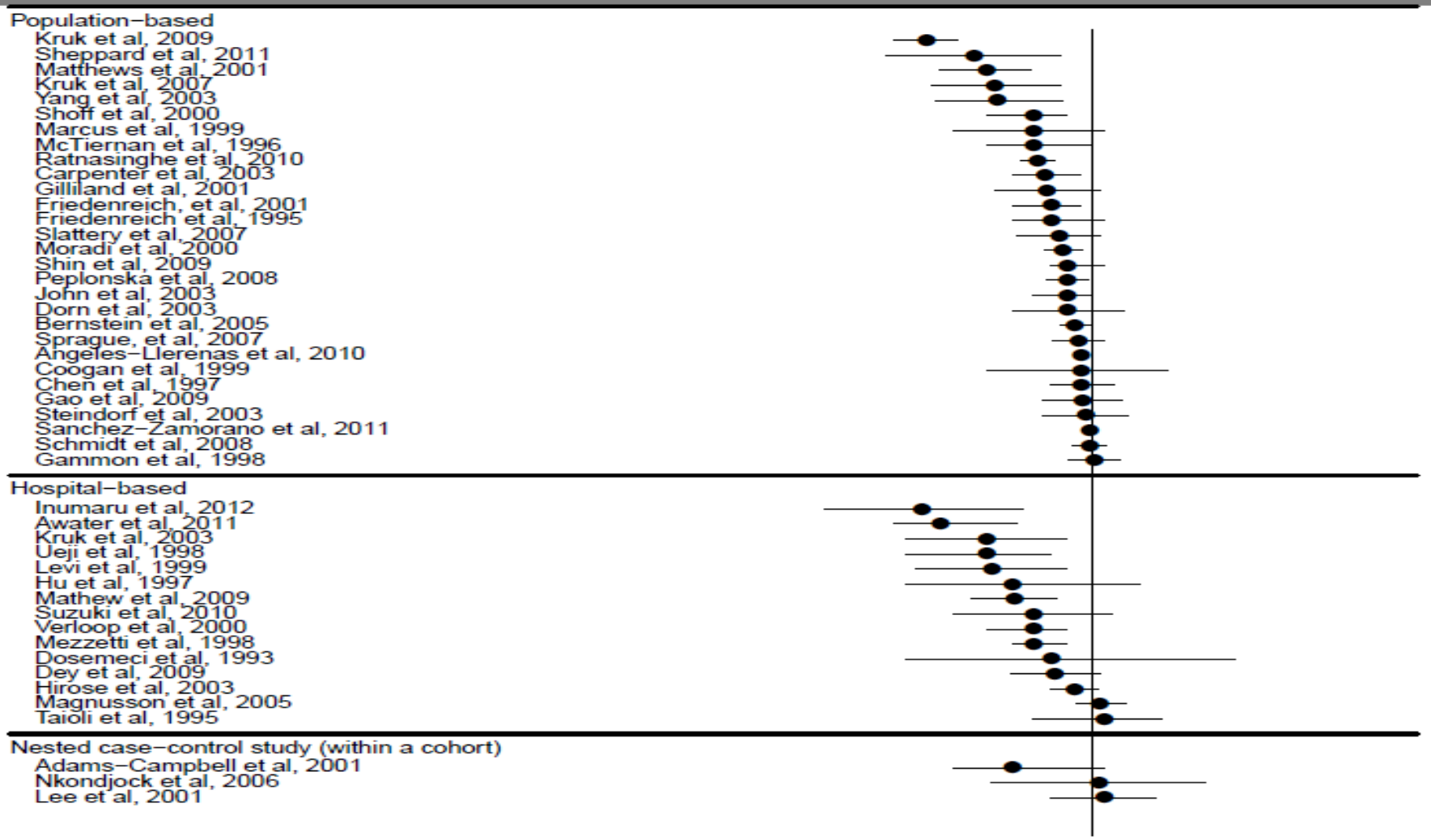
Lynch et al. in Courneya and Friedenreich, Physical Activity and Cancer. Heidelberg: Springer-Verlag, 2011

Physical Activity and Breast Cancer Risk: Cohort Studies



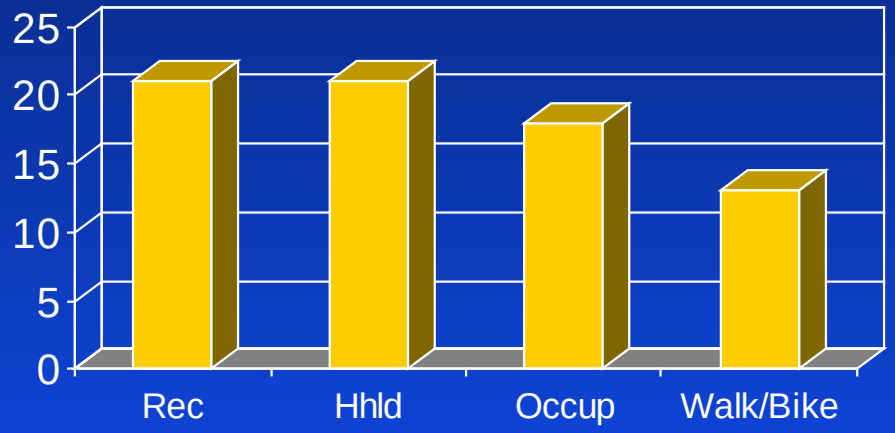
Statistically significant reduction in 16 of 42 cohort studies (38%)

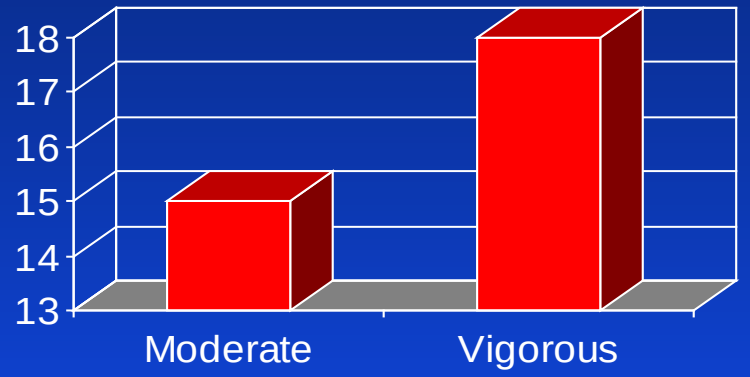
Physical Activity and Breast Cancer Risk: Case-control Studies

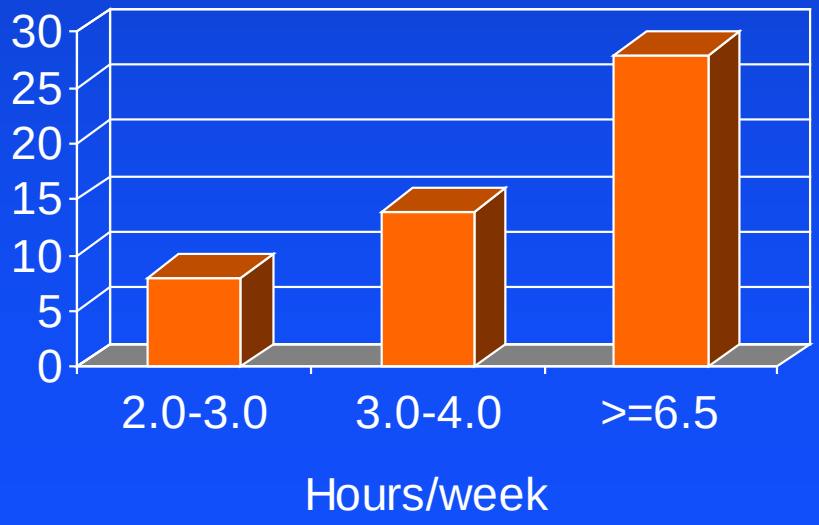


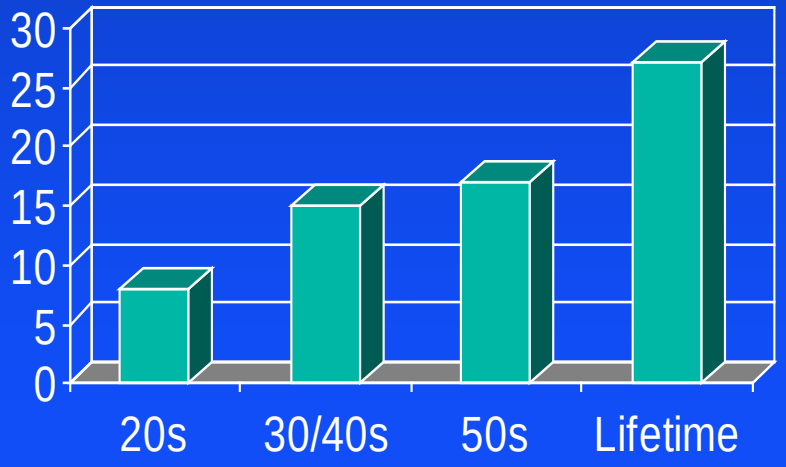
Statistically significant reduction in 22 of 47 case-control studies (46%)

Breast Cancer Risk Reduction by Type, Dose and Timing of Activity

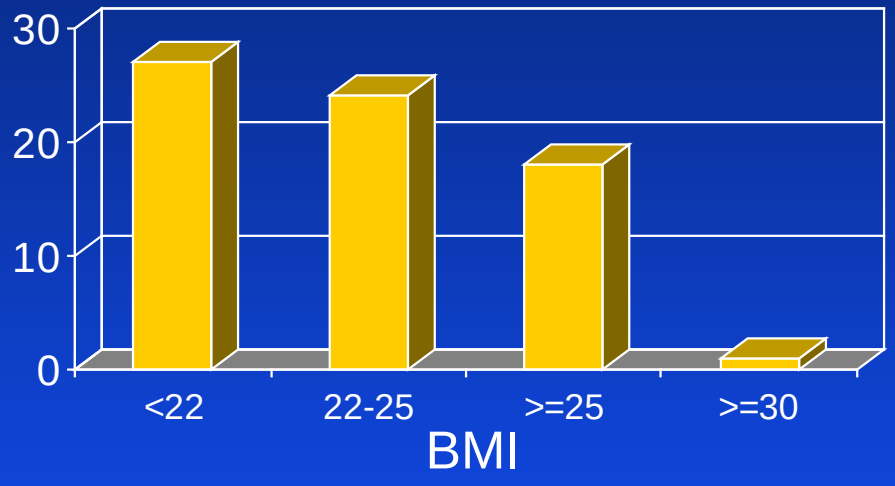


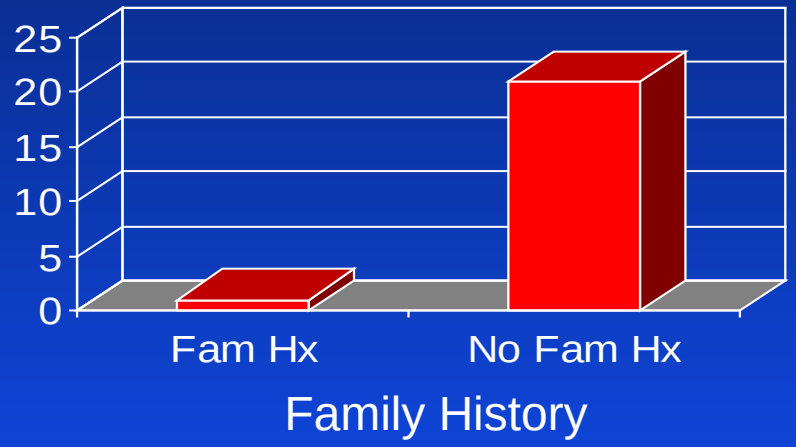


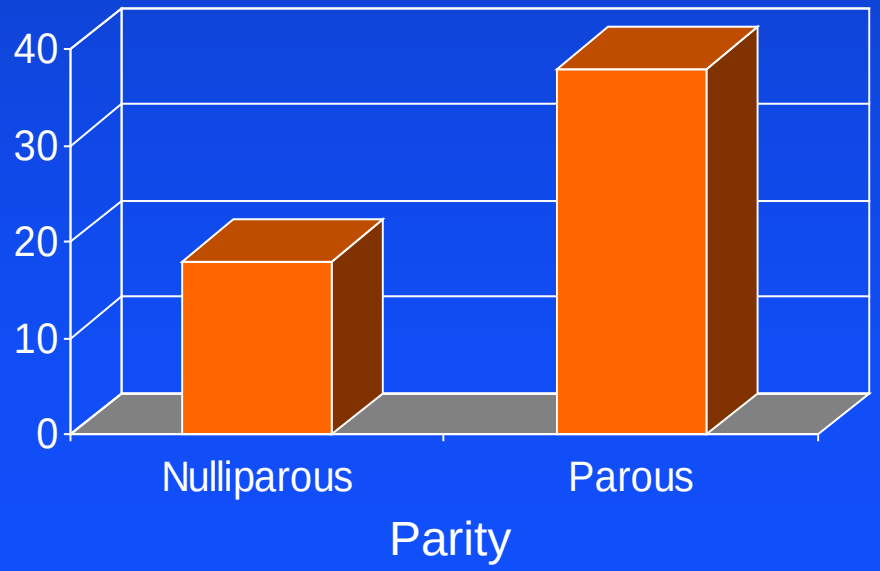


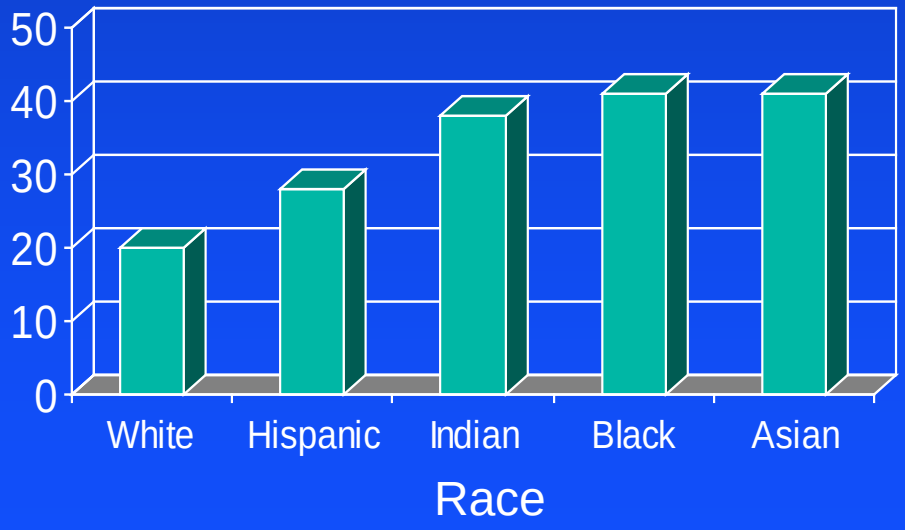


Population Subgroup Effects for Physical Activity and Breast Cancer







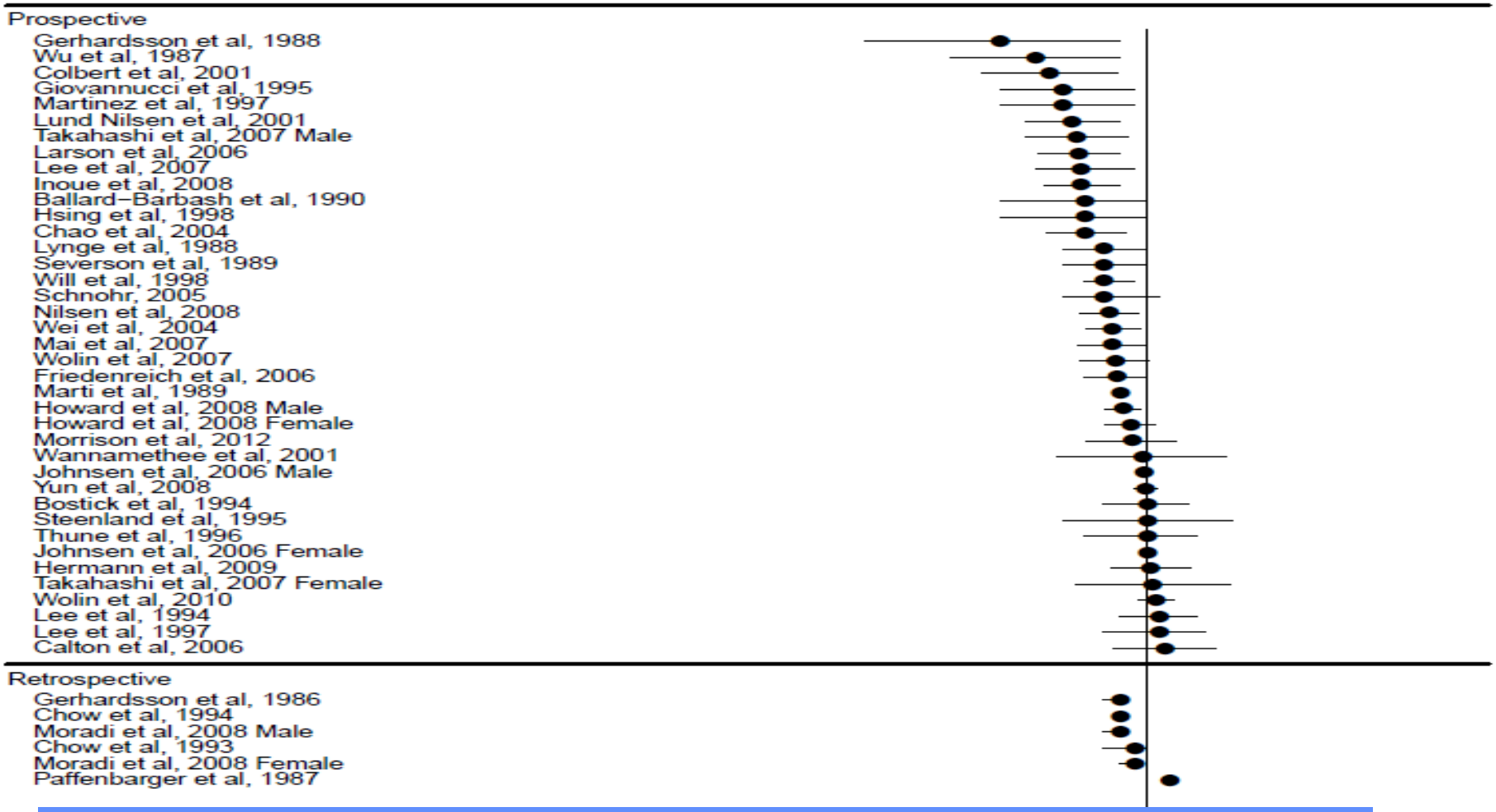


Physical Activity and Risk of Colon Cancer

Summary of Evidence on Physical Activity and Colon Cancer Risk

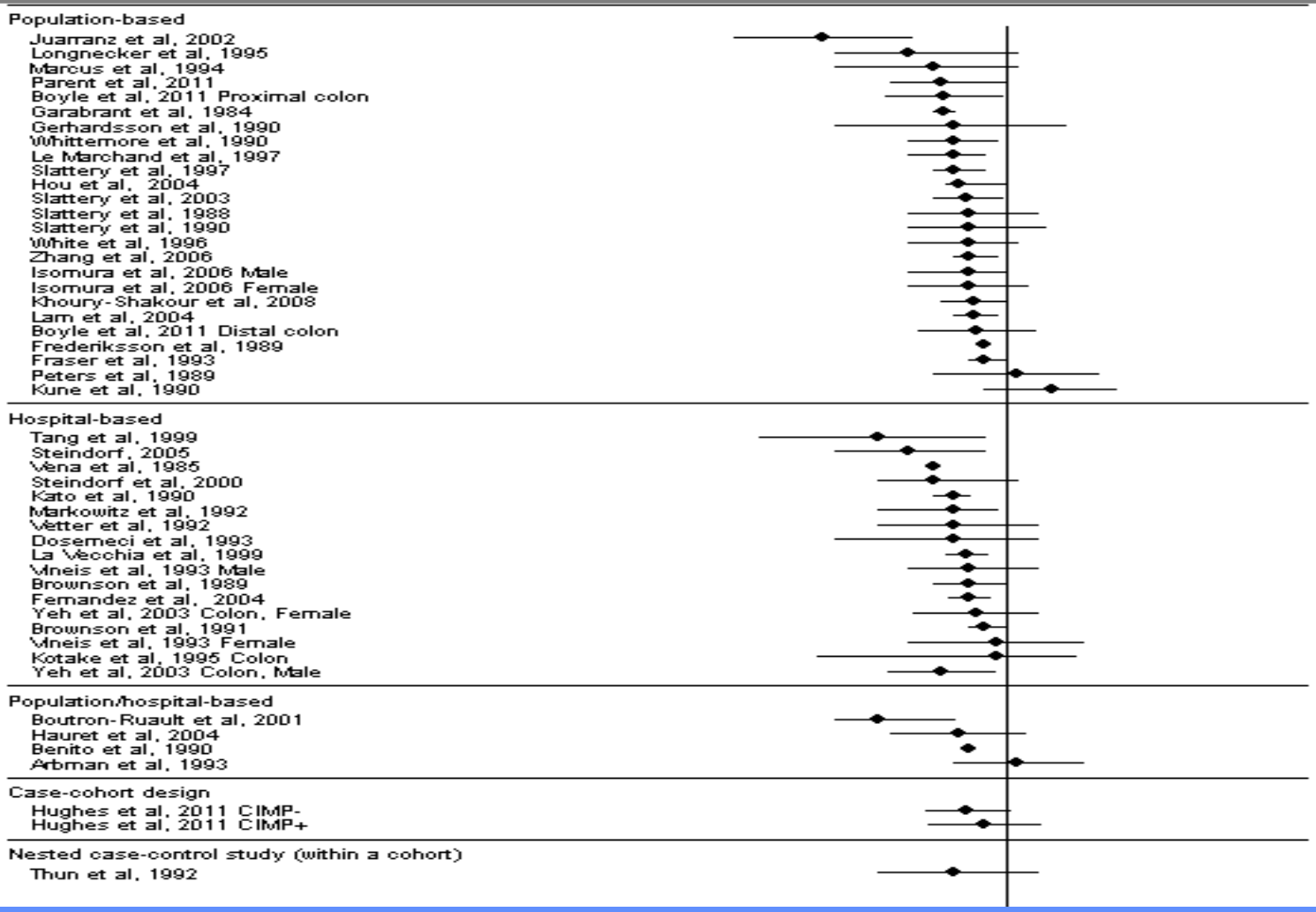
- Consistent evidence *(72 of 86 studies)*
  - 15 show no effect and no studies find increased risk
- Fairly strong risk reductions *(~30% decreases for highest vs. lowest activity levels)*
  - 27% average risk reduction in case-control studies
  - 20% average risk reduction in cohort studies
- Clear dose-response *(41 of 47 studies)*
- Biologic plausibility exists
- Temporality exists

Physical Activity and Colon Cancer Risk: Cohort Studies



Statistically significant risk reductions in 16 of 41 studies (39%)

Physical Activity and Colon Cancer Risk: Case-control Studies



Statistically significant risk reductions in 18 of 44 studies (41%)

Type, Dose and Timing of Activity: Colon Cancer

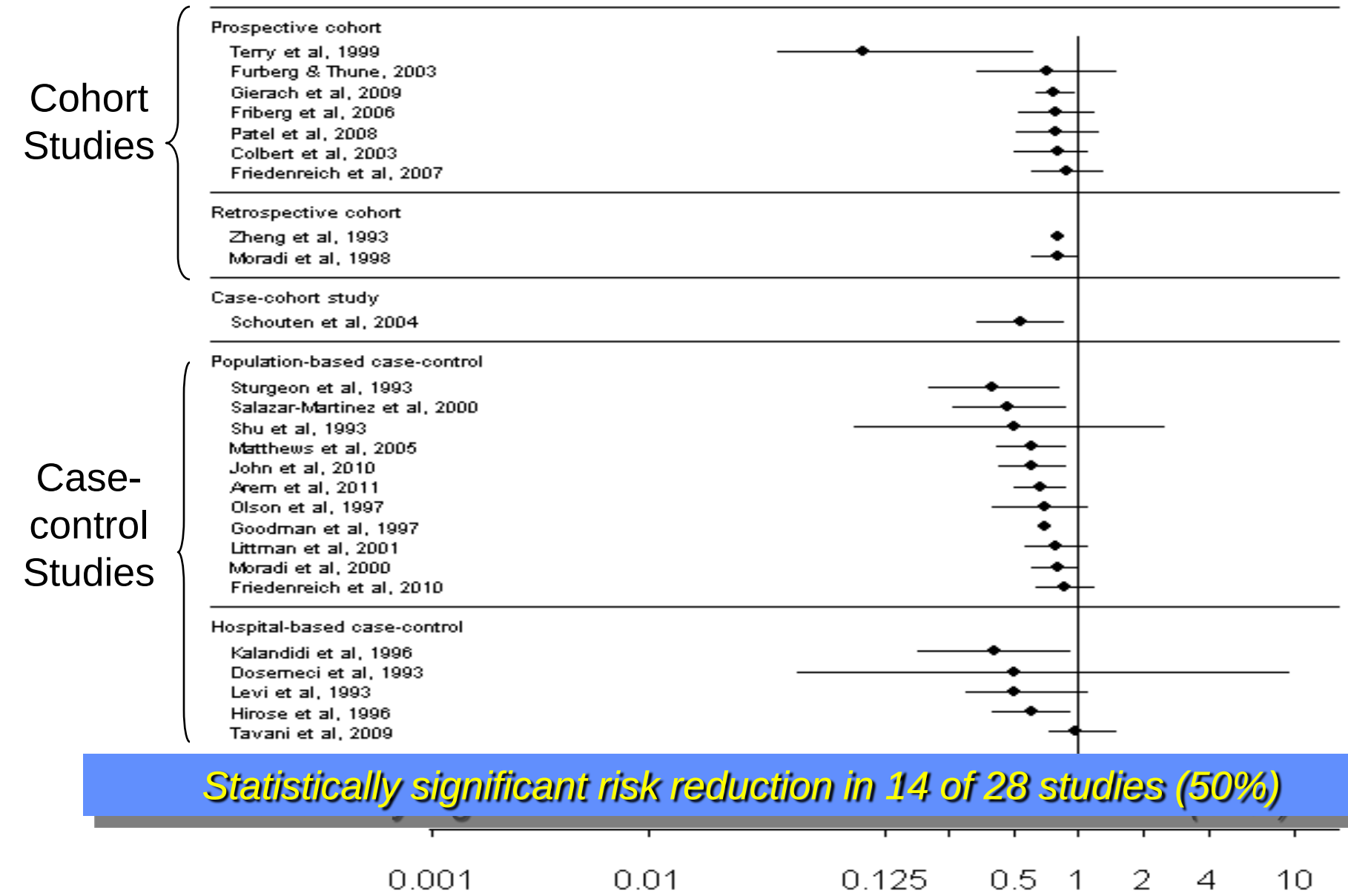
- Type of Activity
  - All types may be effective for lowering risk
    - e.g., occupational activity (22% decrease in risk), recreational (23%)
  - Sedentary behaviour may increase risk
- Intensity
  - Vigorous or moderate activity decrease risk
- Timing of activity
  - Inconsistent findings
- Population Sub-groups
  - Relatively constant effects across BMI categories
  - Association may vary by tumour sub-site
    - i.e., proximal or distal
  - Benefit for men and women
  - Unclear effects of race/ethnicity, dietary intake, HRT use

Physical Activity and Risk of Gynecologic Cancer

Summary of Evidence on Physical Activity and Endometrial Cancer Risk

- Consistent evidence *(23 of 28 studies)*
  - Nearly all of studies show risk reductions
- Fairly strong risk reductions *(30-35% decreases for highest vs. lowest activity levels)*
  - 25% average risk reduction in cohort studies
  - 37% average risk reduction in case-control studies
- Evidence of dose-response *(12 of 19 studies)*
- Biologic plausibility exists
- Sedentary behaviour emerging as possibly important

Physical Activity and Endometrial Cancer Risk

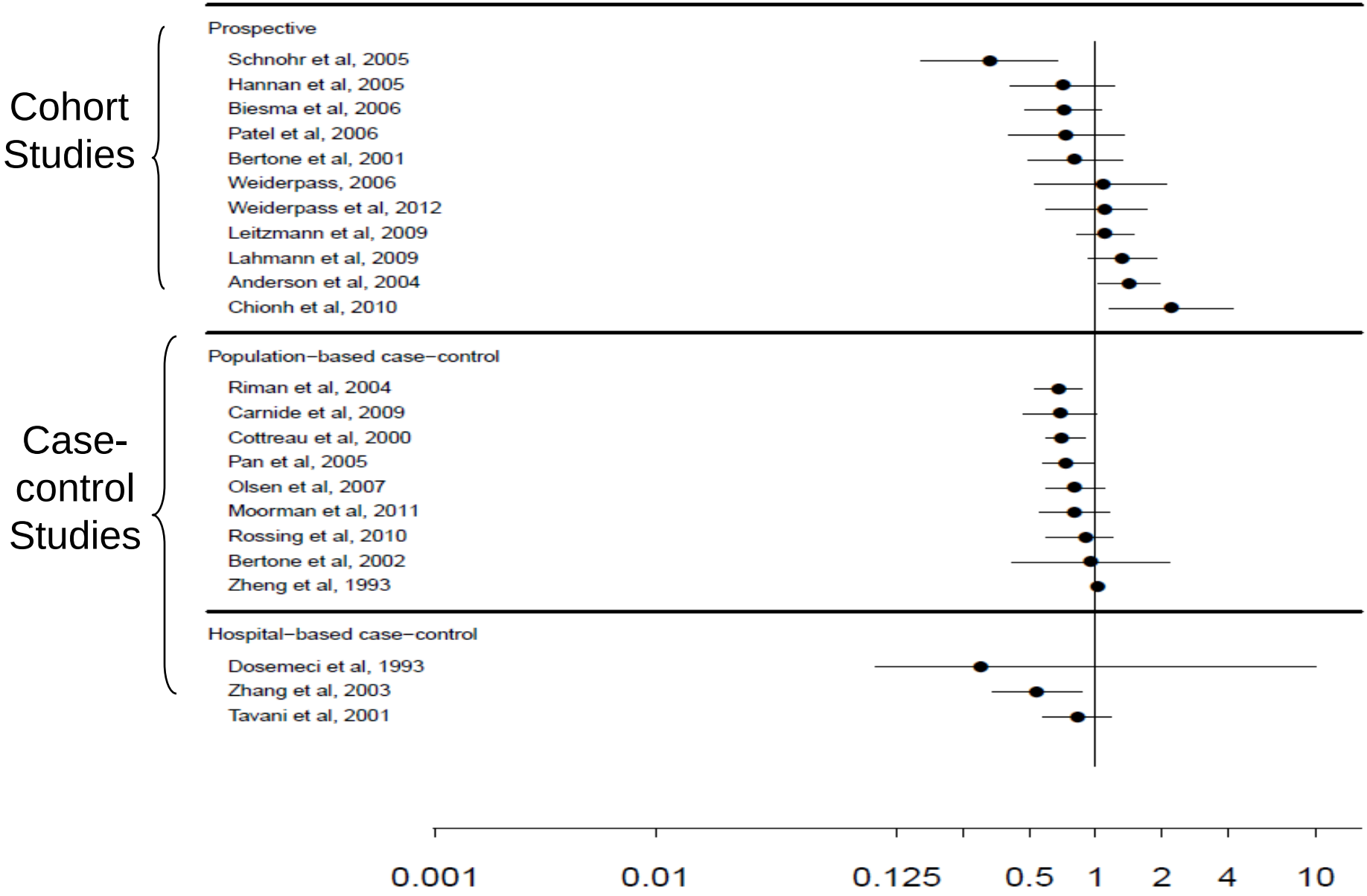


Statistically significant risk reduction in 14 of 28 studies (50%)

Summary of Evidence on Physical Activity and Ovarian Cancer Risk

- Moderately consistent evidence *(12 of 24 studies)*
  - 12 studies show risk reductions
  - 3 studies show increased risk (1 is statistically significant)
- Weak risk reductions *(<10% average decreases for highest vs. lowest activity levels)*
  - Average 10% increased risk in cohort studies
  - Average 25% decreased risk from case-control studies
- Some evidence of dose-response *(9 of 11 studies)*

Physical Activity and Ovarian Cancer Studies

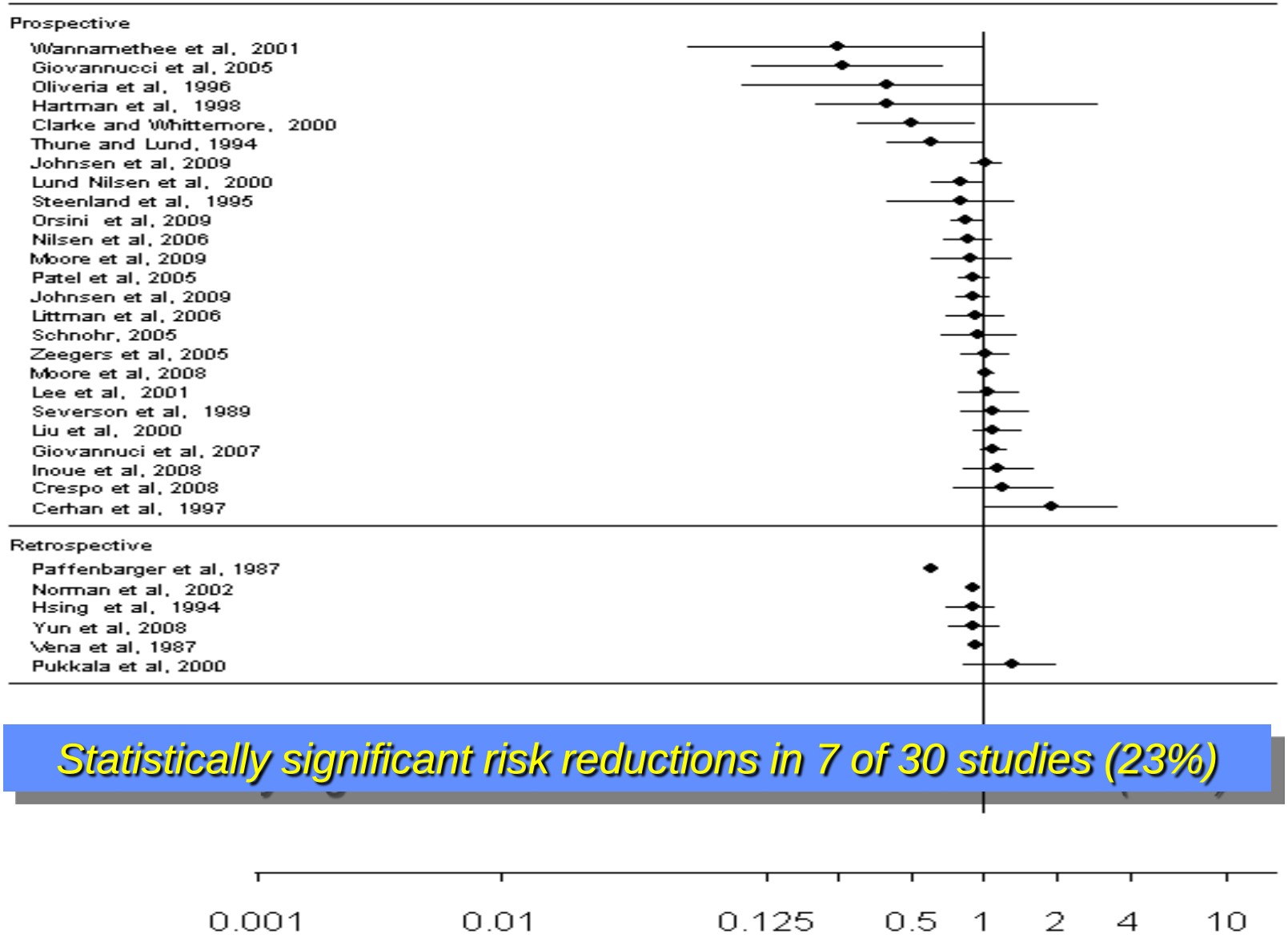


Physical Activity and Risk of Prostate Cancer

Summary of Evidence on Physical Activity and Prostate Cancer Risk

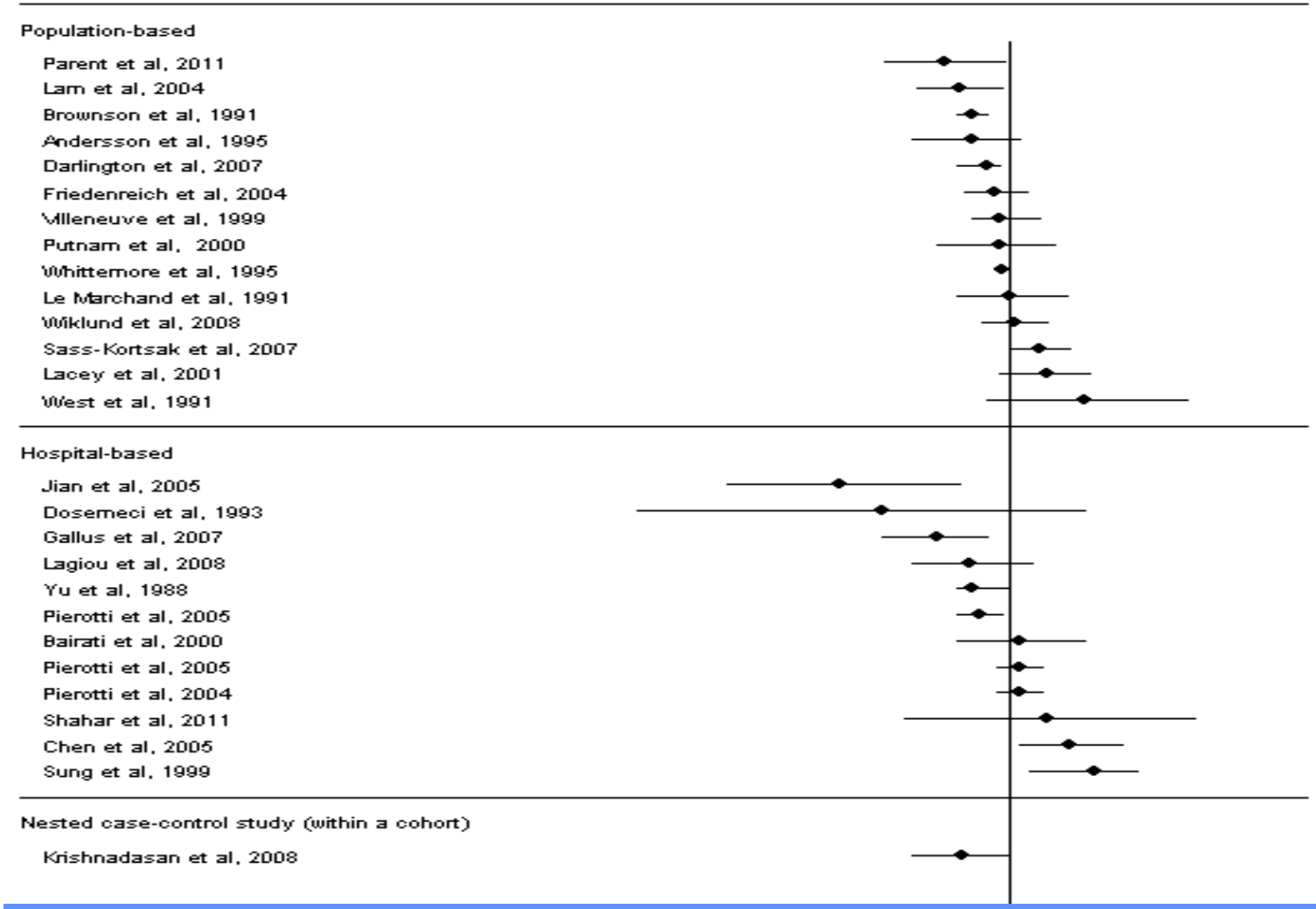
- Less consistent evidence *(26 of 56 studies)*
  - 25 studies find no effect
  - 26 studies find decreased risk
  - 5 studies find increased risk
- Weak risk reductions *(10% decreases for highest vs. lowest activity levels)*
- Evidence of dose-response *(12 of 18 studies)*
  - about half of the studies that examined these trends
- Some biologic plausibility exists

Physical Activity and Prostate Cancer: Cohort Studies



Statistically significant risk reductions in 7 of 30 studies (23%)

Physical Activity and Prostate Cancer: Case-control Studies



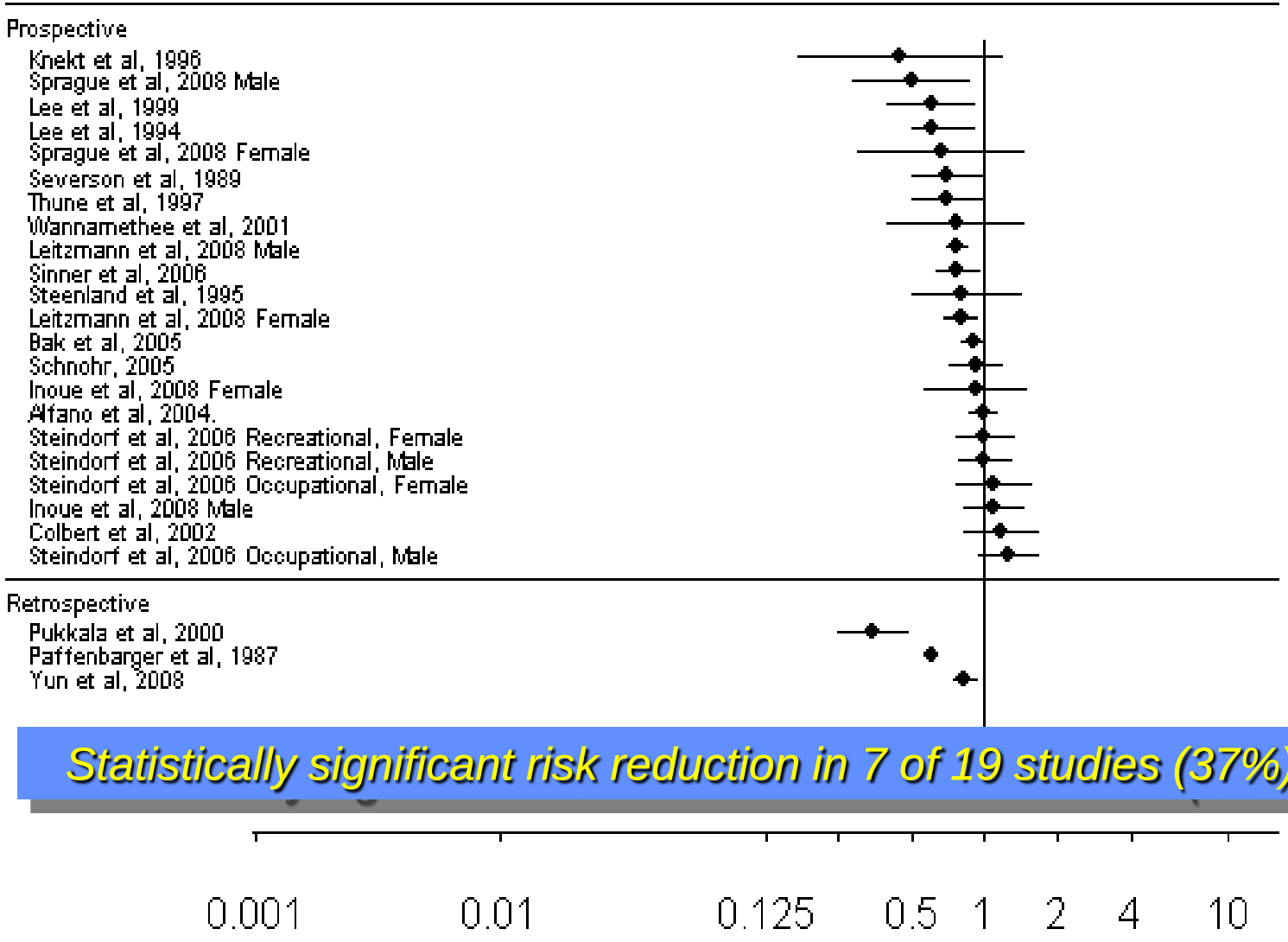
Statistically significant risk reductions in 8 of 26 studies (30%)

Physical Activity and Risk of Lung Cancer

Summary of Evidence on Physical Activity and Lung Cancer Risk

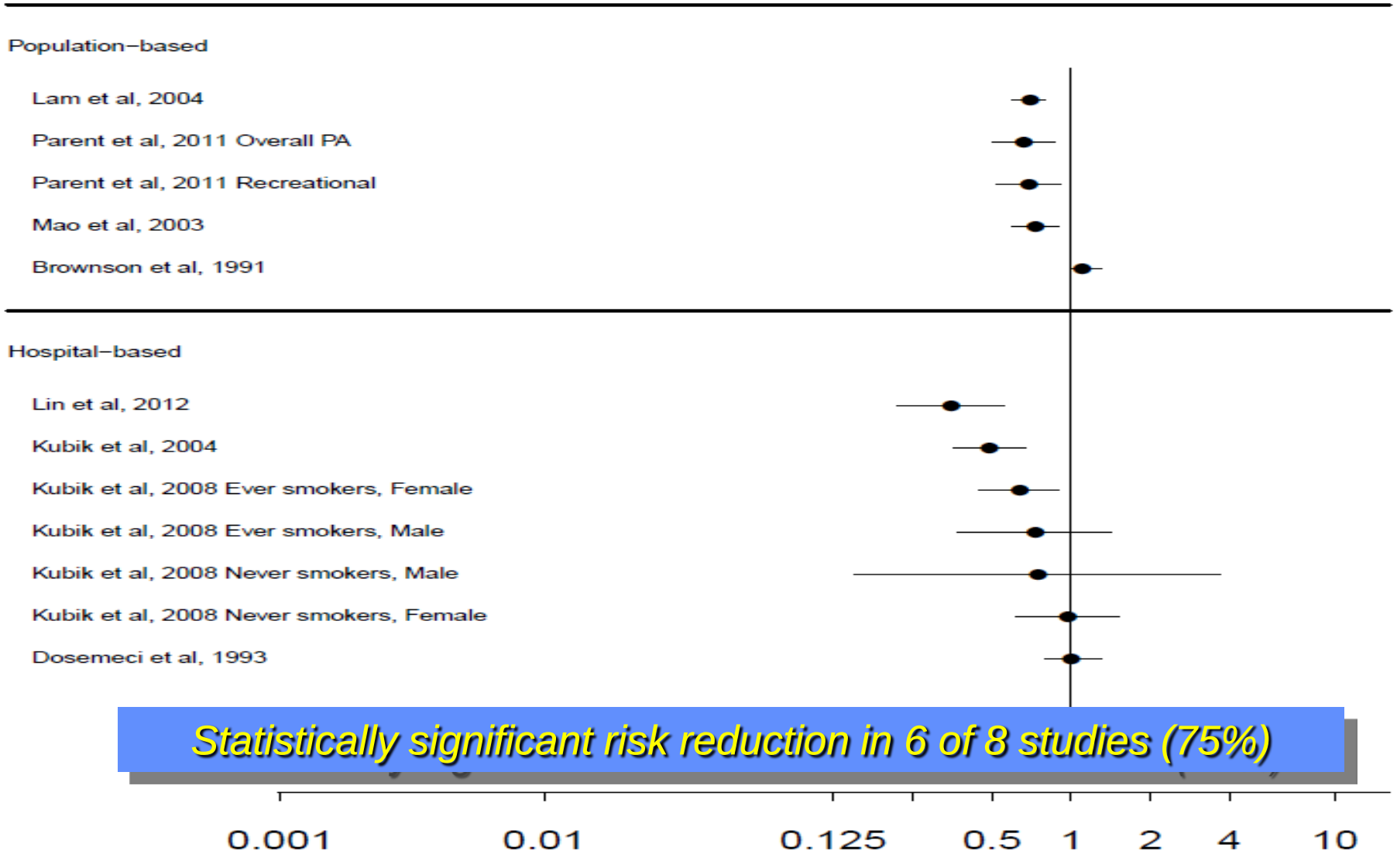
- Consistent evidence *(20 of 28 studies)*
  - 7 show no effect
  - 20 show decreased risks
- Fairly strong risk reductions *(25% decreases for highest vs. lowest activity levels)*
- Evidence of dose-response *(9 of 11 studies)*
  - about half of the studies that examined these trends
- Weaker evidence for biologic plausibility exists
- Effect of smoking needs to be considered

Physical Activity and Lung Cancer: Cohort Studies



Statistically significant risk reduction in 7 of 19 studies (37%)

Physical Activity and Lung Cancer: Case-Control Studies



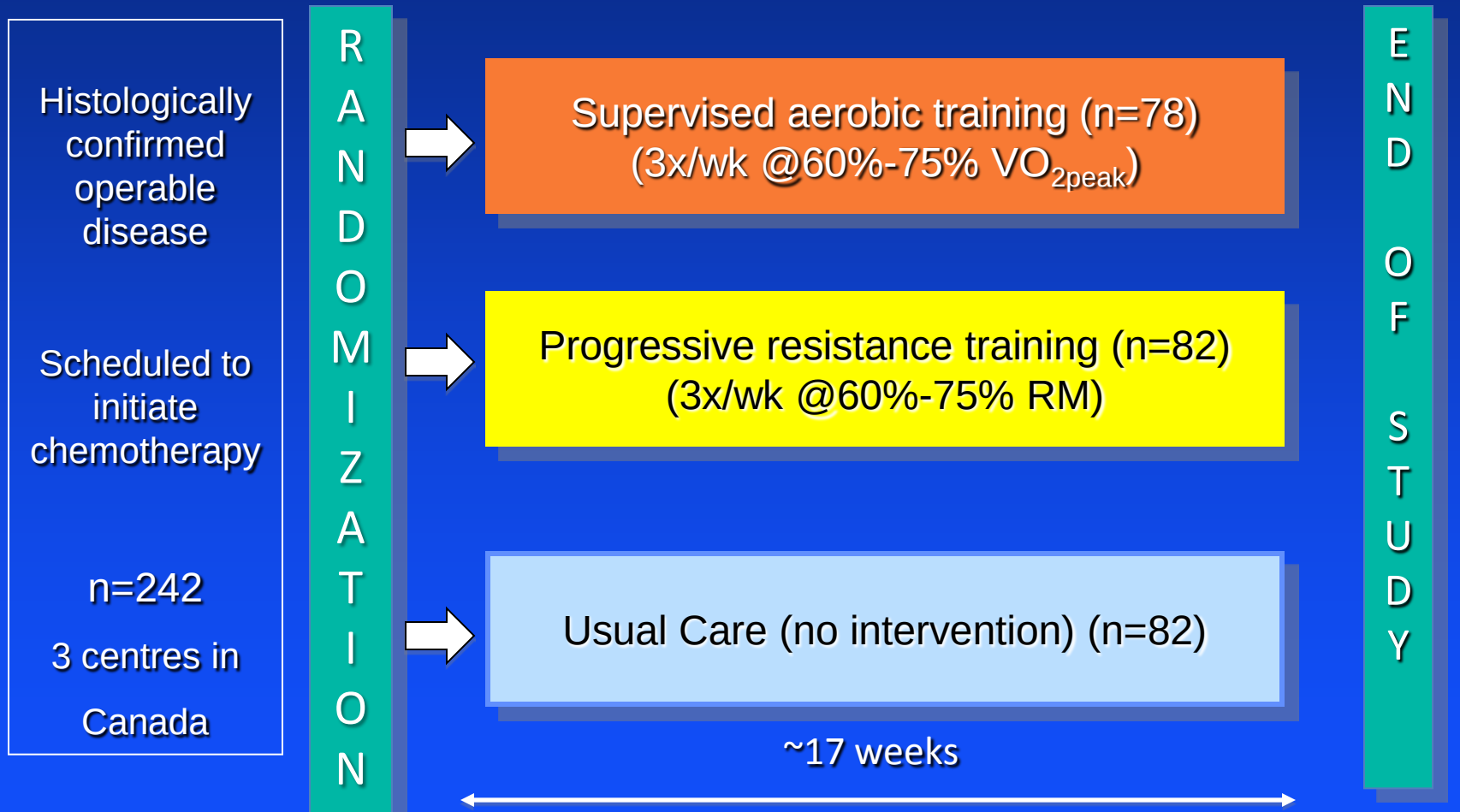
Statistically significant risk reduction in 6 of 8 studies (75%)

Summary of Evidence on Physical Activity and Cancer Risk by Site

Cancer Site	Number of Studies	Studies found reduced risk	Consistency of evidence	Magnitude of risk reduction	Dose-response effect
Colon	86	72	Yes	30%	Yes
Breast	88	66	Yes	25%	Yes
Endometrial	28	23	Yes	30-35%	Yes
Lung	28	20	Some	25%	Some
Prostate	56	26	No	10%	Limited
Ovarian	24	12	No	<10%	Limited
All Others	Insufficient or Null				

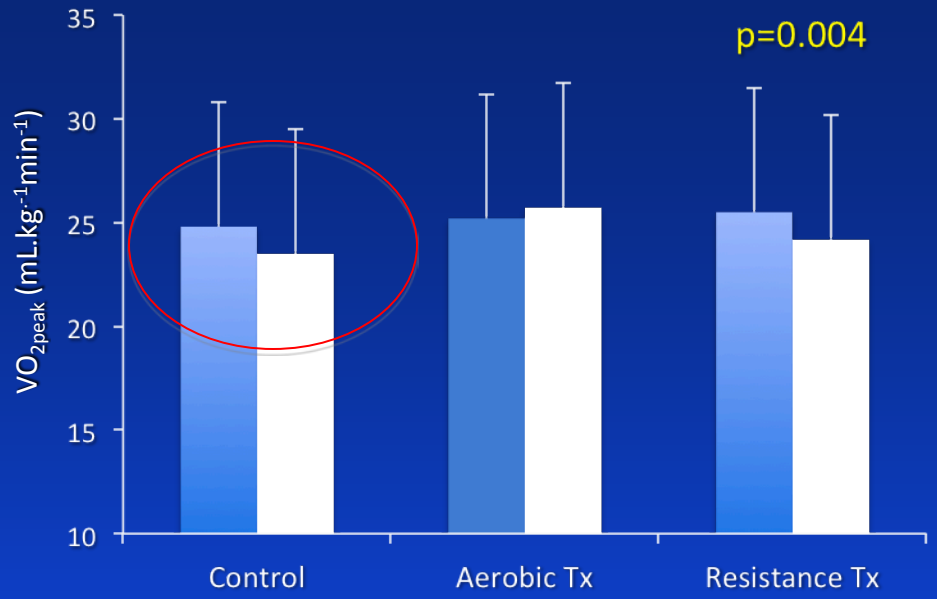
Physical Activity During Cancer Treatment

Supervised Trial of Aerobic vs Resistance Training (START Trial)

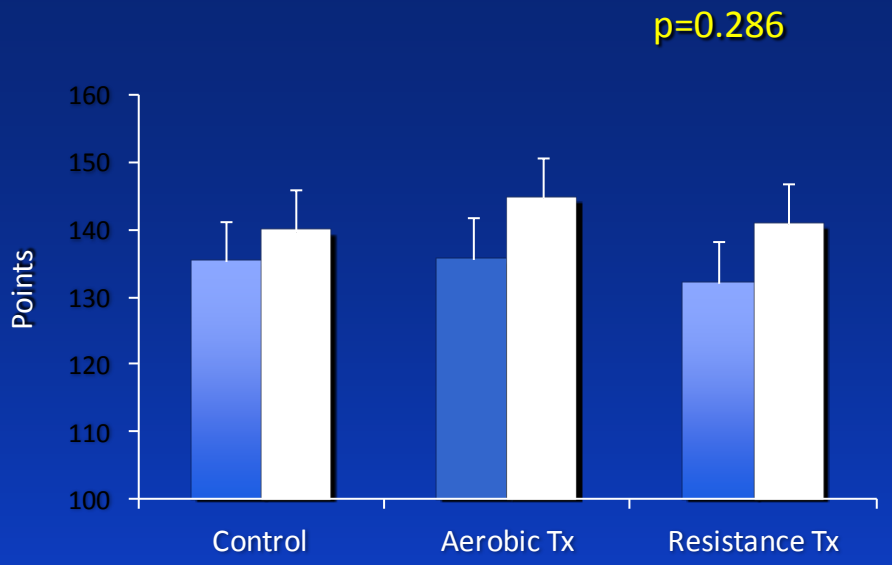


Courneya KS et al. *J Clin Oncol* 2007;25:4396-4404

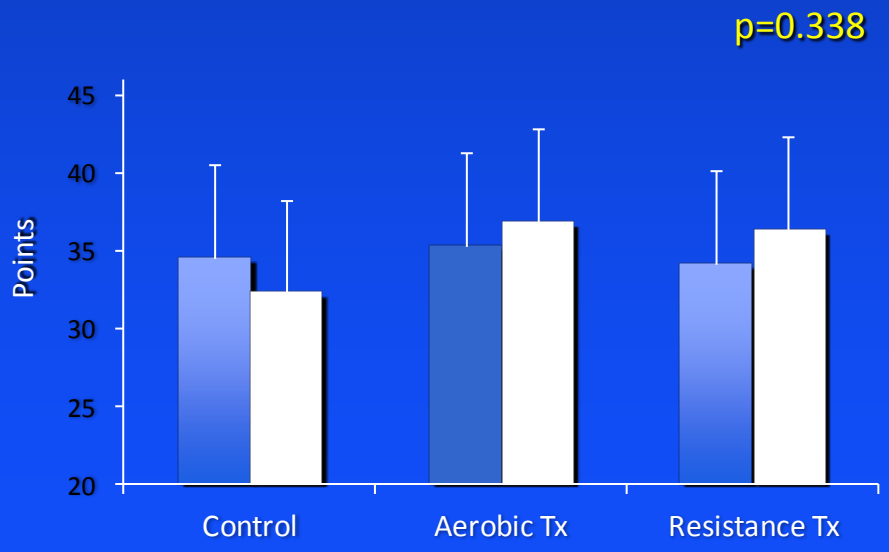
Aerobic capacity



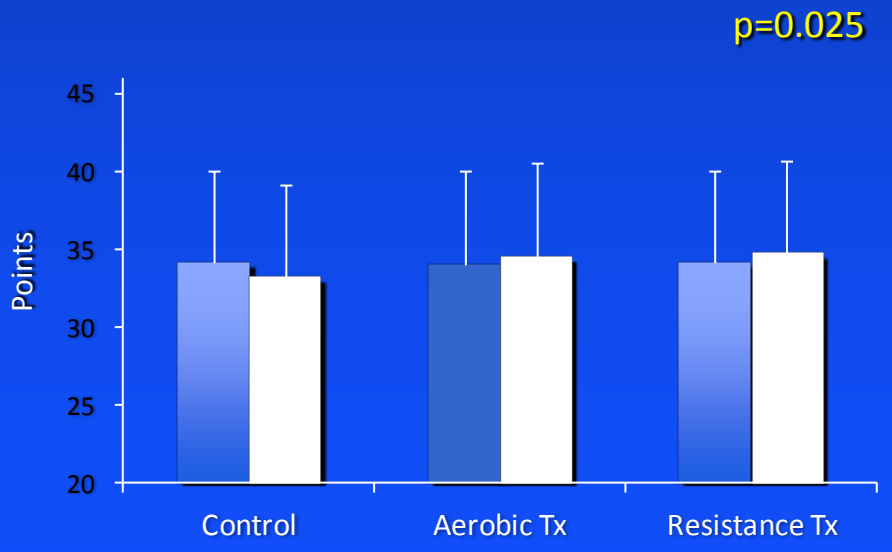
QOL



Fatigue



Self-esteem



Courneya et al. *J Clin Oncol*, 2007

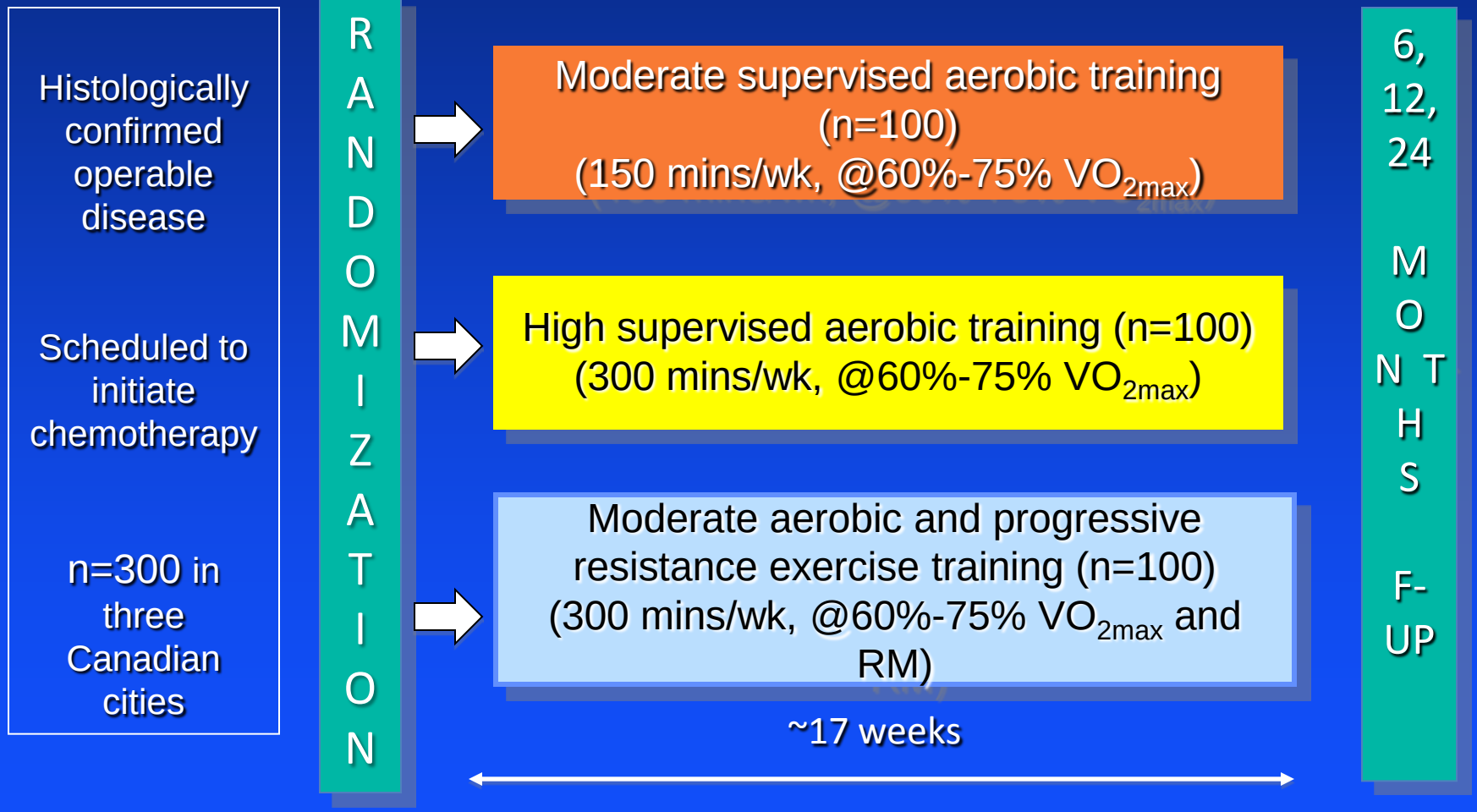
Adapted from Jones, AICR, 2011

Main Results from START Trial

- Aerobic exercise (AET) was better than usual care (UC) for:
  - Self-esteem
  - Aerobic fitness
  - Percent body fat
  - Fat mass
- Resistance exercise (RET) was better than usual care for:
  - Self-esteem
  - Lower body strength
  - Upper body strength
  - Lean body mass
  - Chemotherapy completion rate
- Improved quality of life, fatigue, depression and anxiety in exercise groups as compared to usual care (*non-statistically significant improvements*)

Courneya et al. *JCO*, 2007; 25:4396-4404

Combined Aerobic and Resistance Exercise Trial (CARE Trial)



Randomized Controlled Trials of Physical Activity in Cancer Survivors

Summary of Effects of Exercise on Physical Characteristics By Cancer Phase

Characteristic	Treatment		Survivorship	
	Effect	*P*-value	Effect	*P*-value
PA level	↑	0.70	↑↑	0.0001
Aerobic fitness	↑	0.03	↑	0.03
Upper body strength	↑↑	0.006	↑↑	0.0001
Lower body strength	↑↑	0.006	↑	0.02
Body weight	↓	0.05	↓↓	0.004
% body fat	↓	0.04	↓↓	0.006

Speck et al., *J Cancer Survivorship* 2010;4:87-100

Summary of Effects of Exercise on Patient Reported Outcomes By Cancer Phase

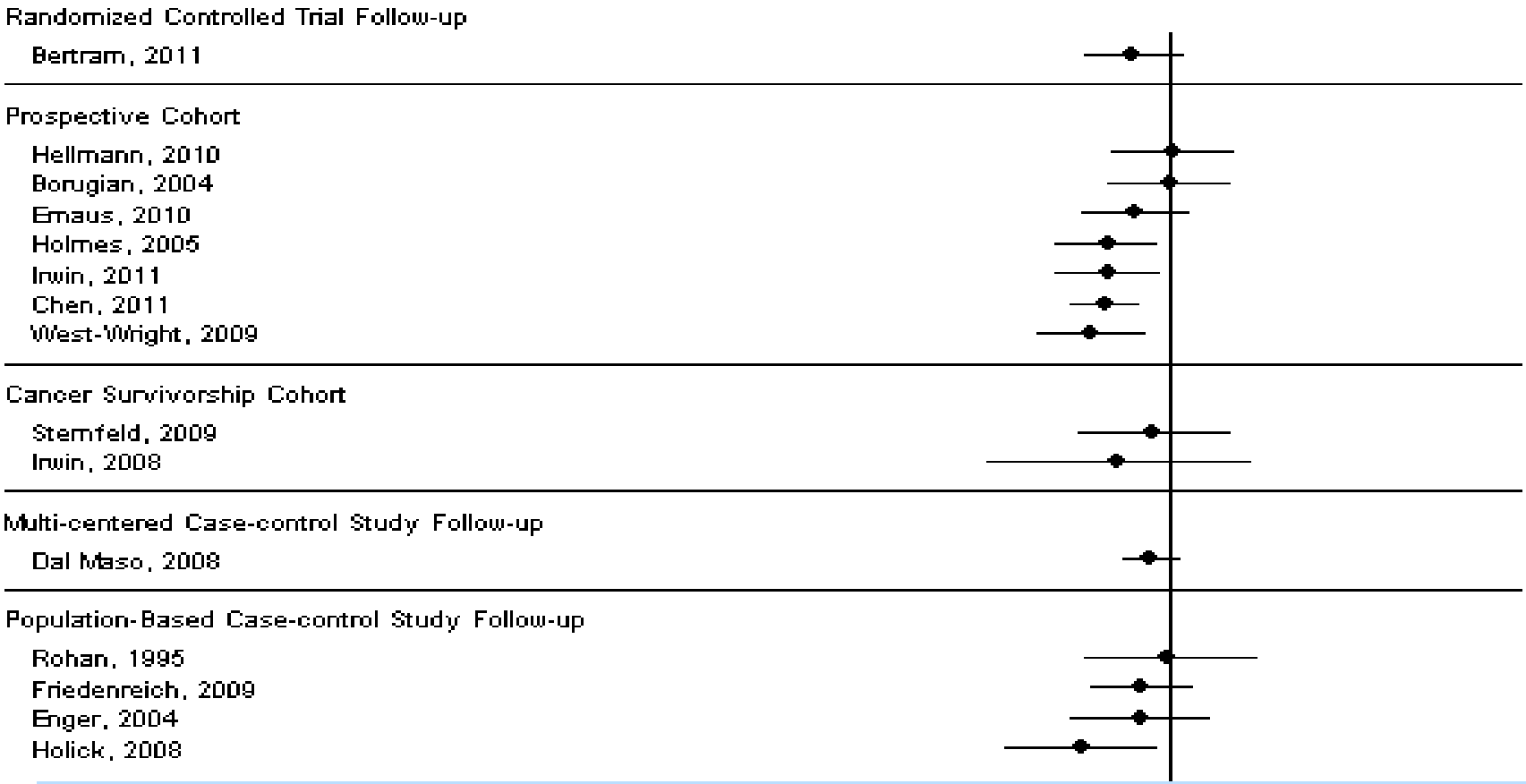
Characteristic	Treatment		Survivorship	
	Effect	*P*-value	Effect	*P*-value
Fatigue	↓	0.75	↓↓	0.003
Quality of life	↑	0.11	↑	0.03
Physical function	↑↑	0.04	↑	0.25
Depression	Null	0.70	↓	0.10
Anxiety	↓	0.02	↓↓	0.07

Speck et al., *J Cancer Survivorship* 2010;4:87-100

Observational Studies on Physical Activity and Breast Cancer Survival

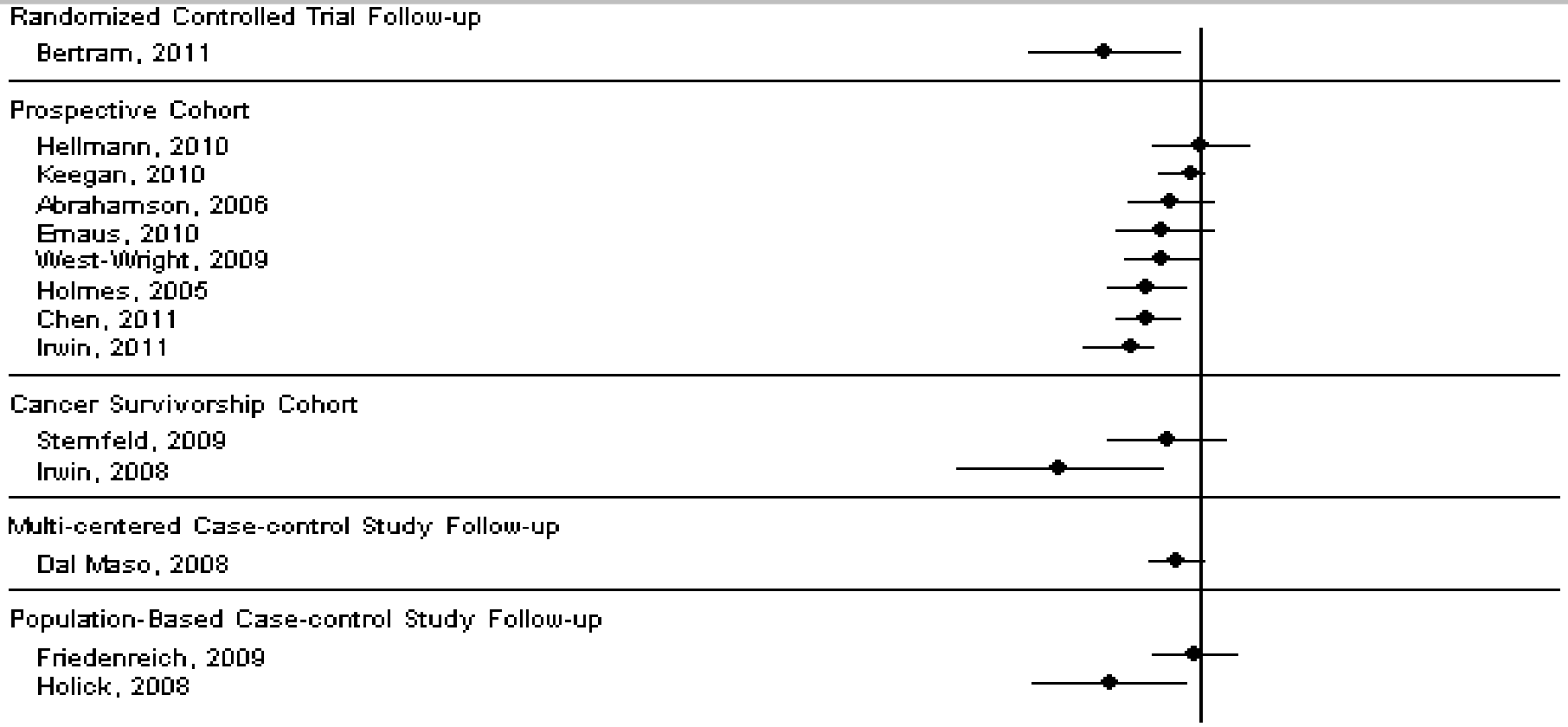
Ballard-Barbash et al. JNCI 2012; 104: 815-840

Physical Activity and Breast Cancer Mortality: Observational Studies



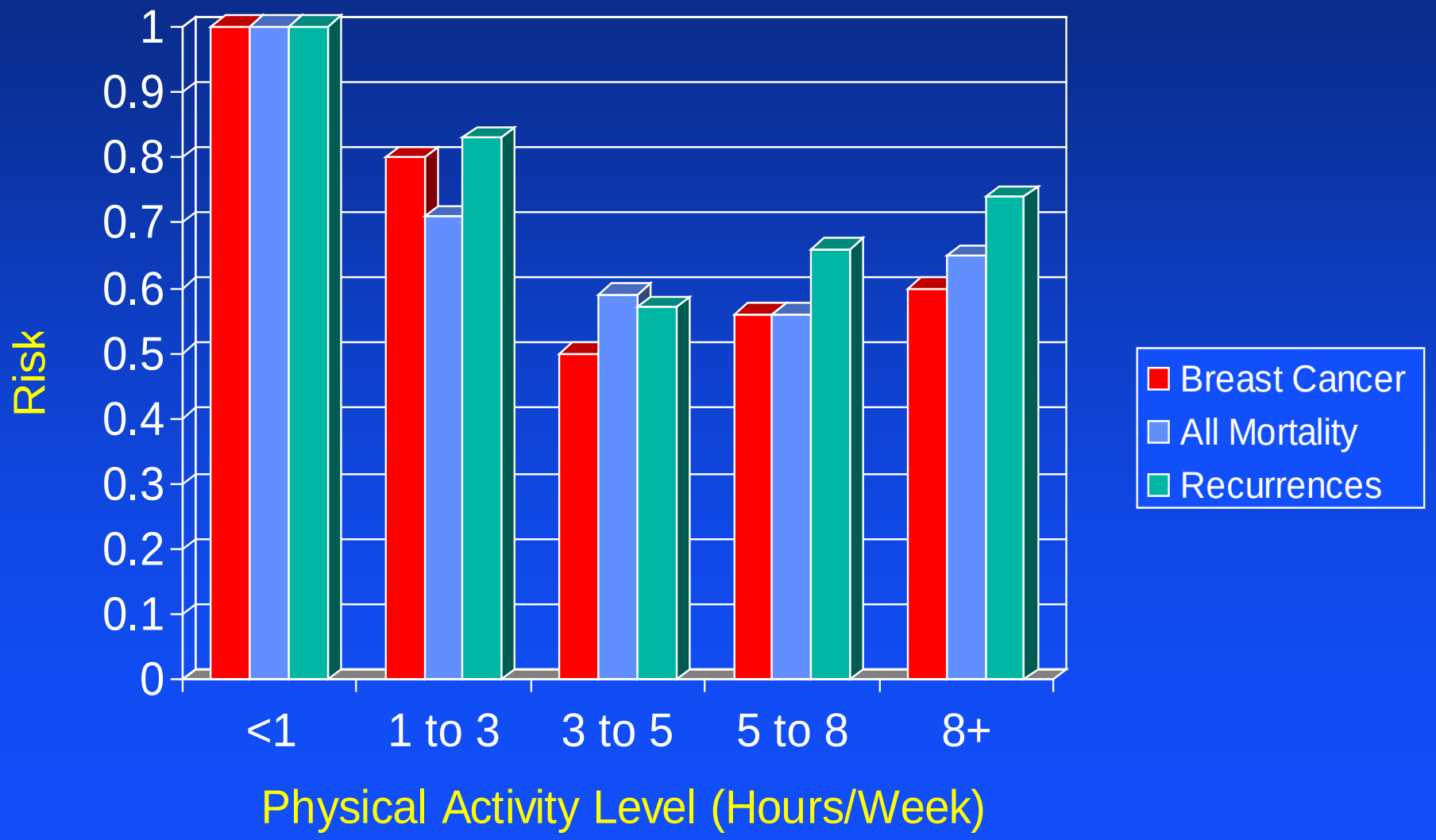
Average risk reduction is 25% ranging from 0-50% for active vs least active

Physical Activity and Breast Cancer Observational Studies: All Cause Mortality



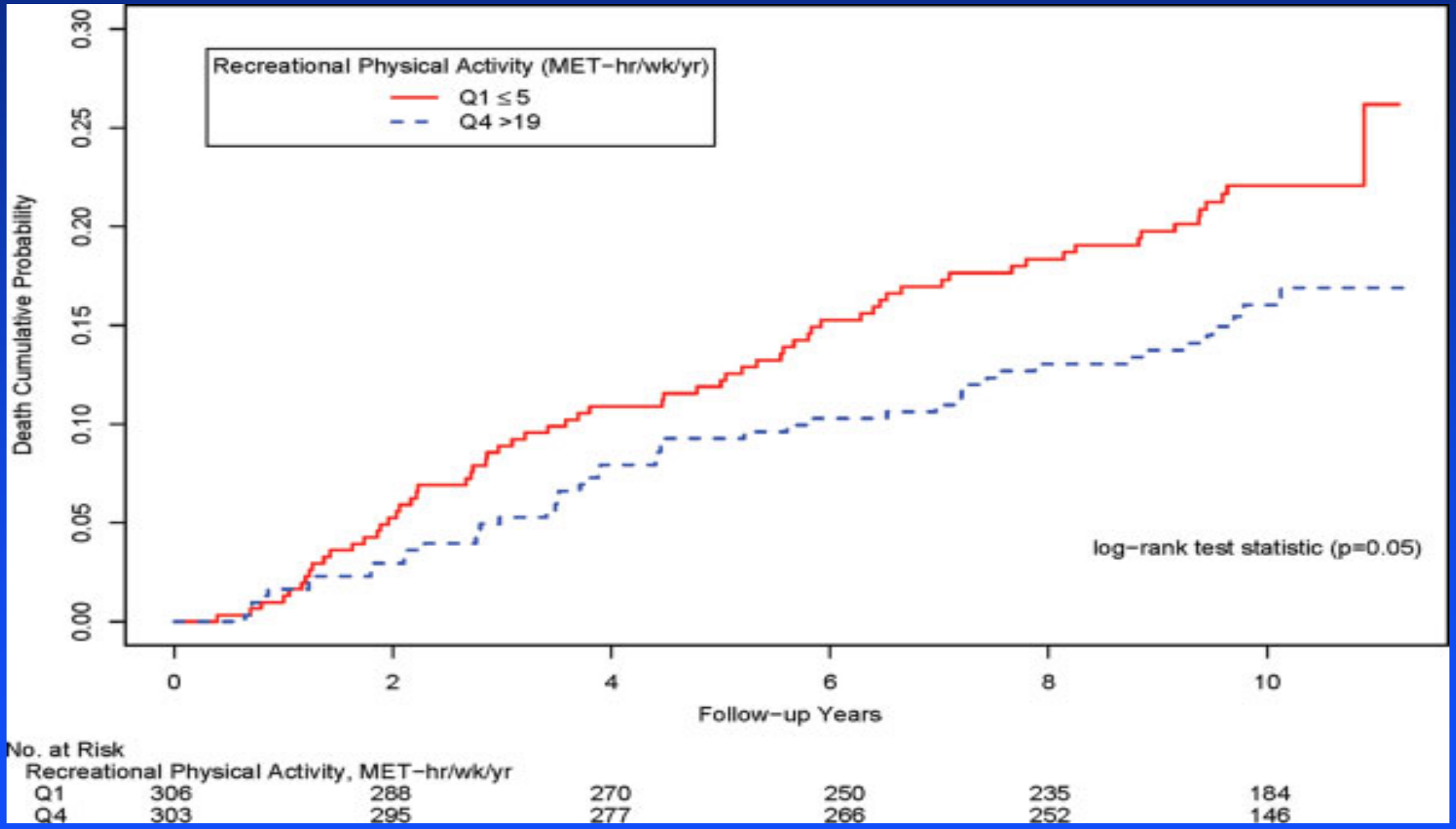
Average risk reduction is 29% ranging from 0-67% for active vs least active

Risk of Breast Cancer Recurrence and Mortality by Physical Activity Level



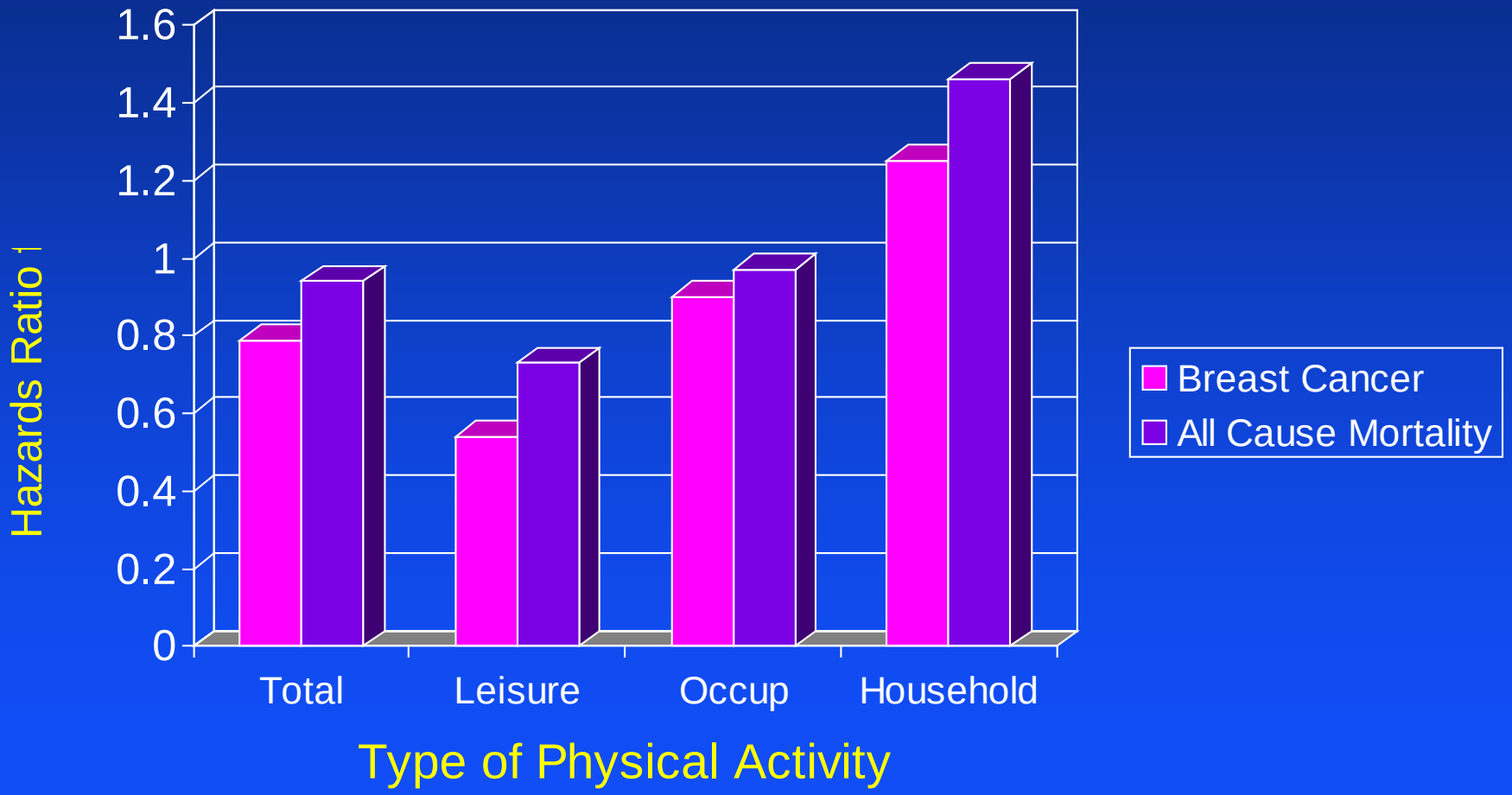
Holmes et al. *JAMA* 2005; 293:2479-86

Alberta Cohort Study of Lifetime PA and Breast Cancer Survival



Friedenreich et al., *Int J Ca* 2009; 124:1954-62

Alberta Cohort Study of Lifetime PA and Breast Cancer Survival



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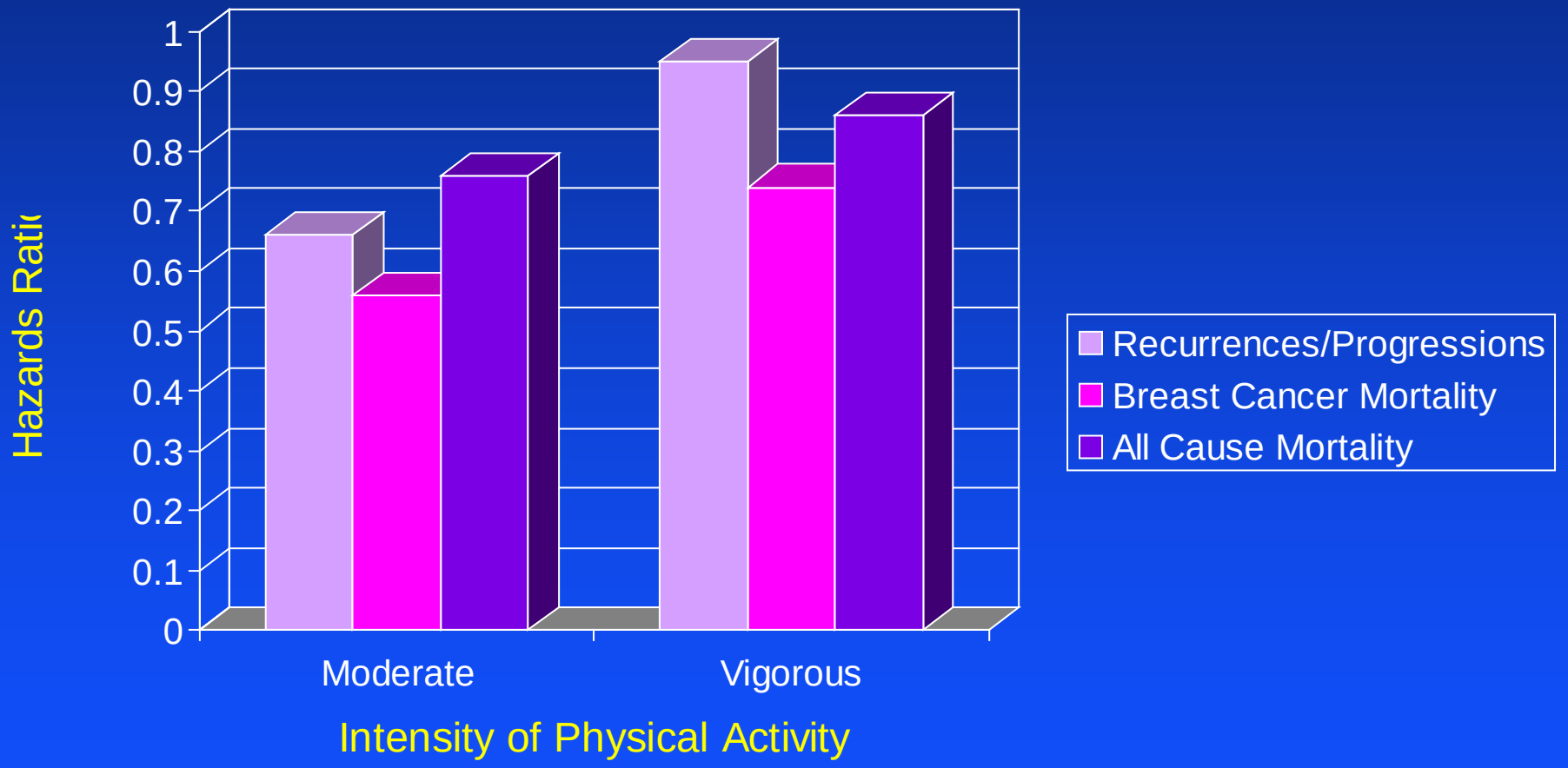
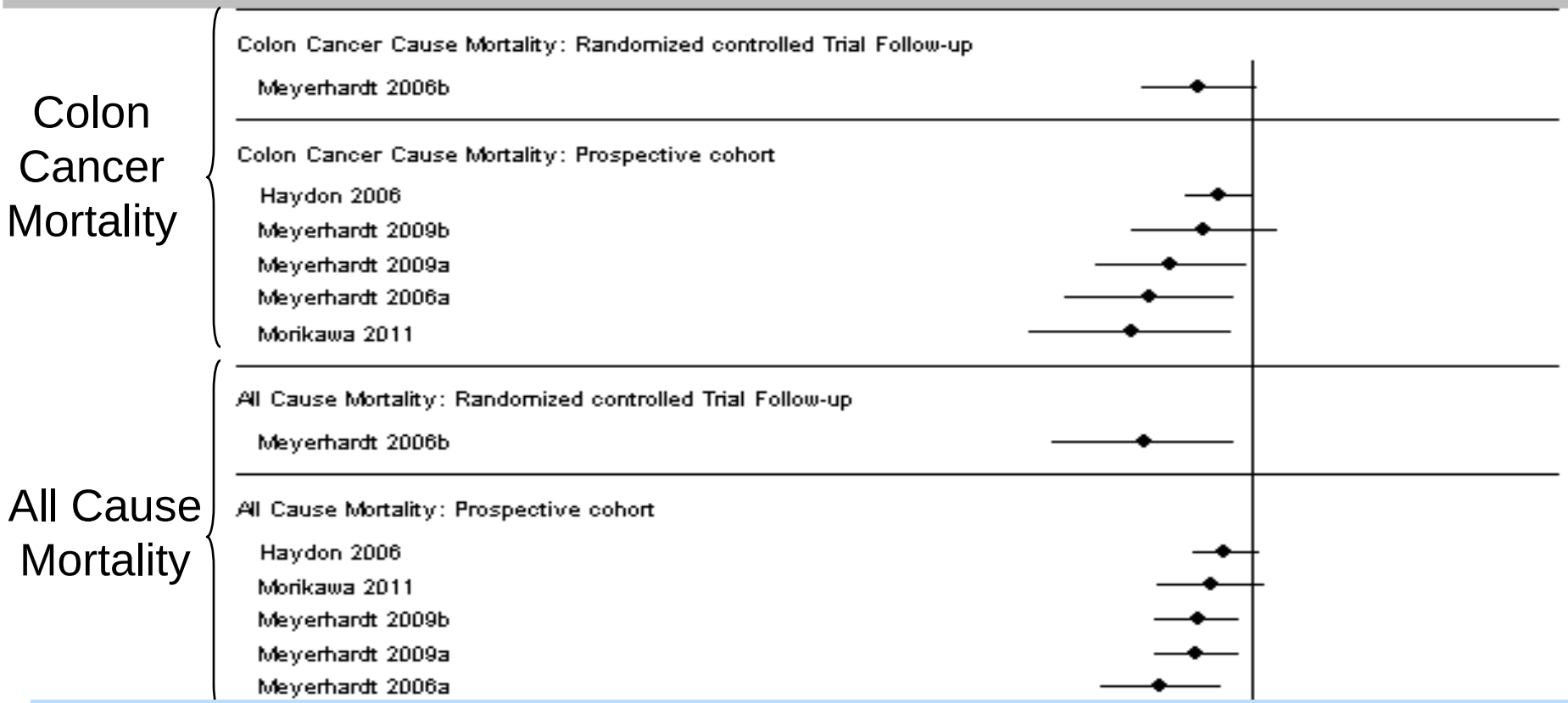


Friedenreich et al., *Int J Ca* 2009; 124:1954-62

Observational Studies on Physical Activity and Colon Cancer Cancer Survival

Physical Activity and Colon Cancer Mortality and All Cause Mortality: Observational Studies



Average risk reduction is 48% (27-67%) for colon cancer mortality and 44% (23-63%) for all cause mortality for most vs. least active

Nurses Health Study: Survival After Colorectal Cancer by Level of Post-diagnosis Physical Activity

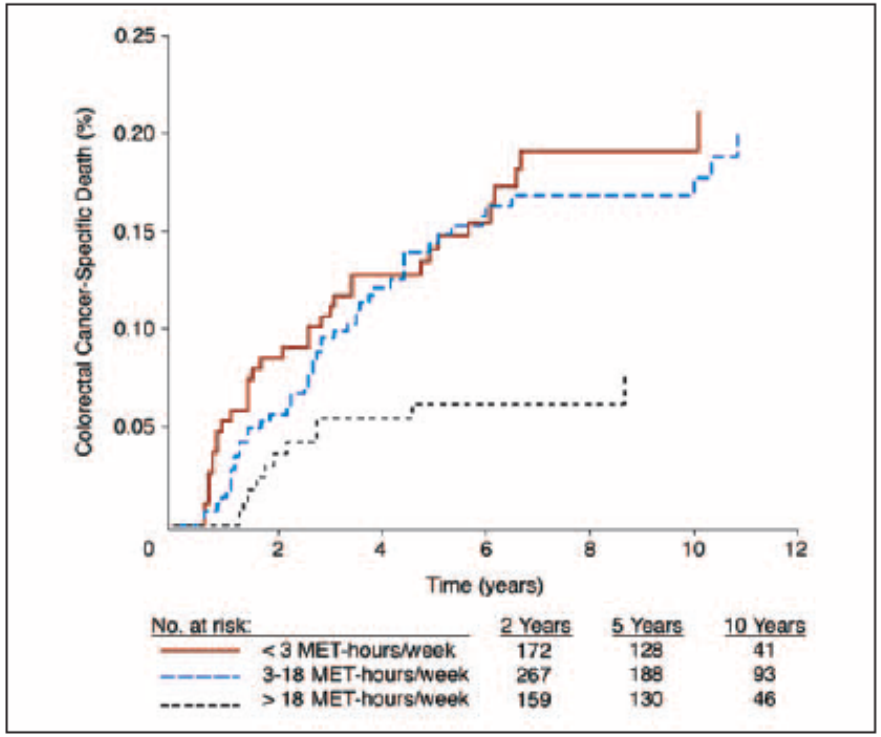


Fig 1. Cumulative incidence curve of colorectal cancer–specific deaths by level of postdiagnosis physical activity. MET, metabolic equivalent task.

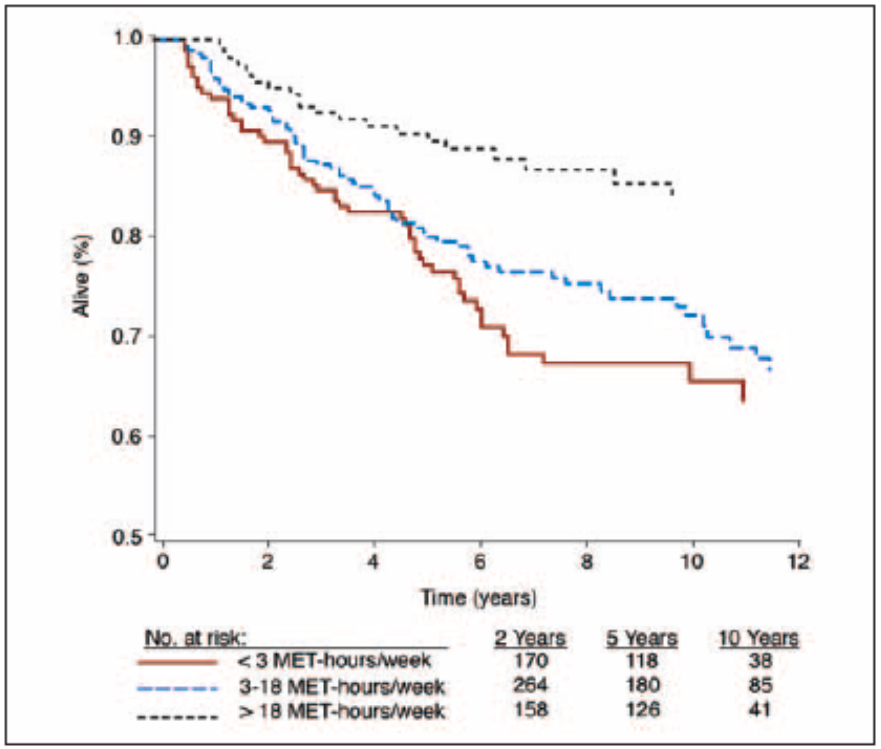
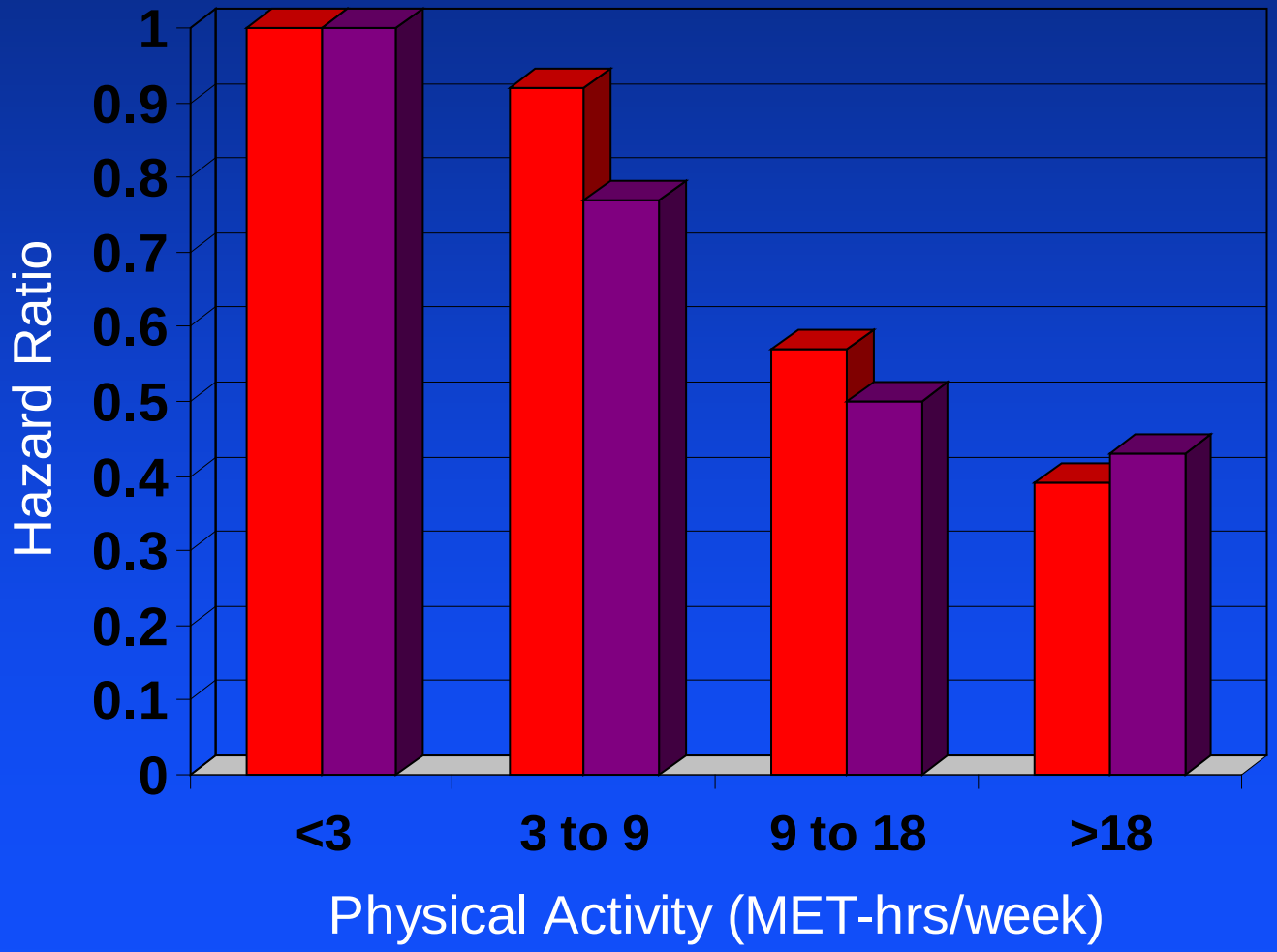


Fig 2. Kaplan and Meier curve of overall survival by level of postdiagnosis physical activity. MET, metabolic equivalent task.

Cumulative incidence and Kaplan-Meier survival curves

Meyerhardt et al. *JCO* 2006; 24:3527-34

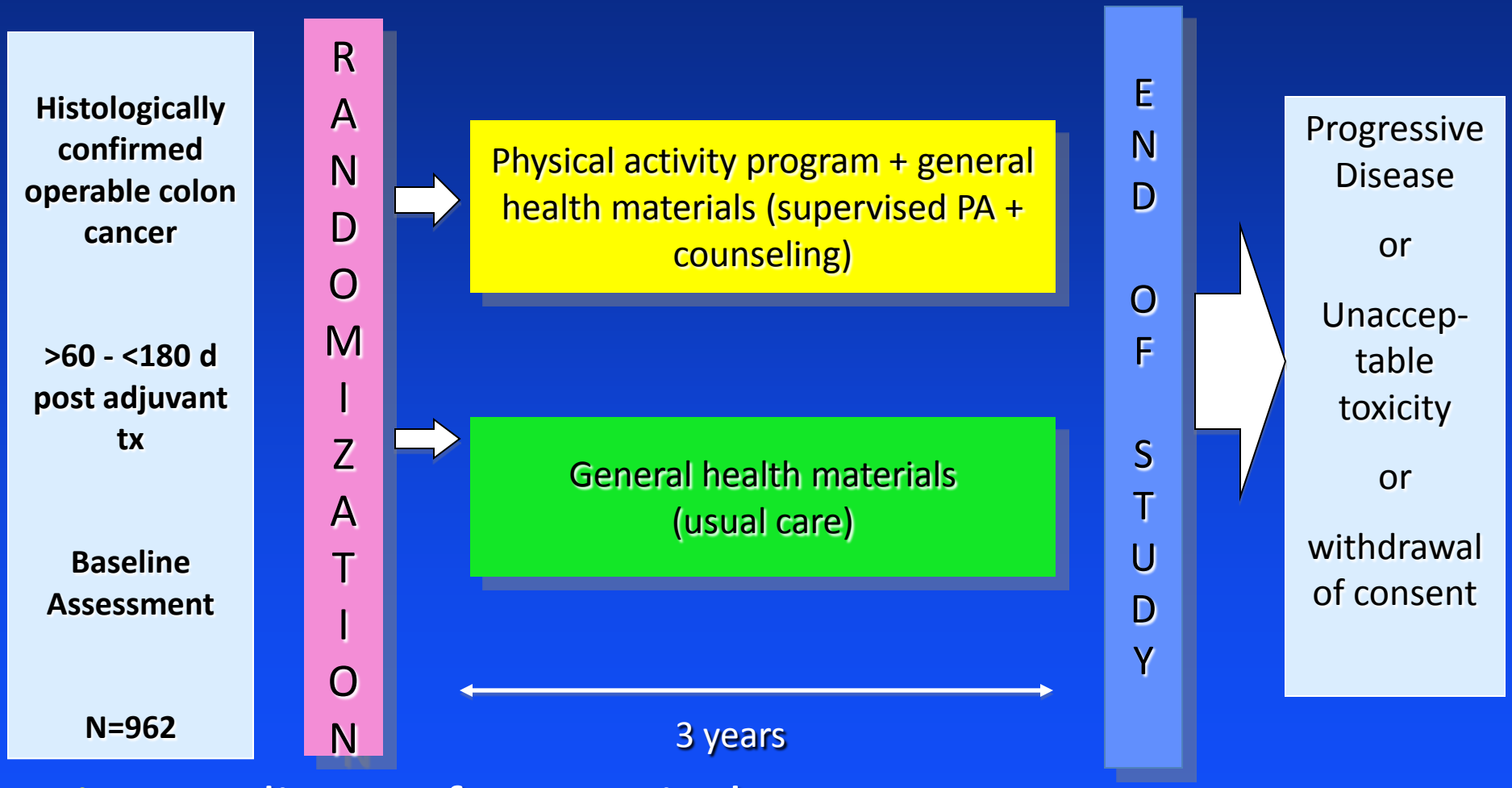
Multivariate-Adjusted Hazard Ratios of CRC Specific and Overall Mortality (n=554)



P-trend=0.008 for CRC deaths and 0.003 for overall deaths

Meyerhardt et al. *JCO* 2006; 24:3527-34

Colon Health and Life-Long Exercise Change (CHALLENGE) Trial



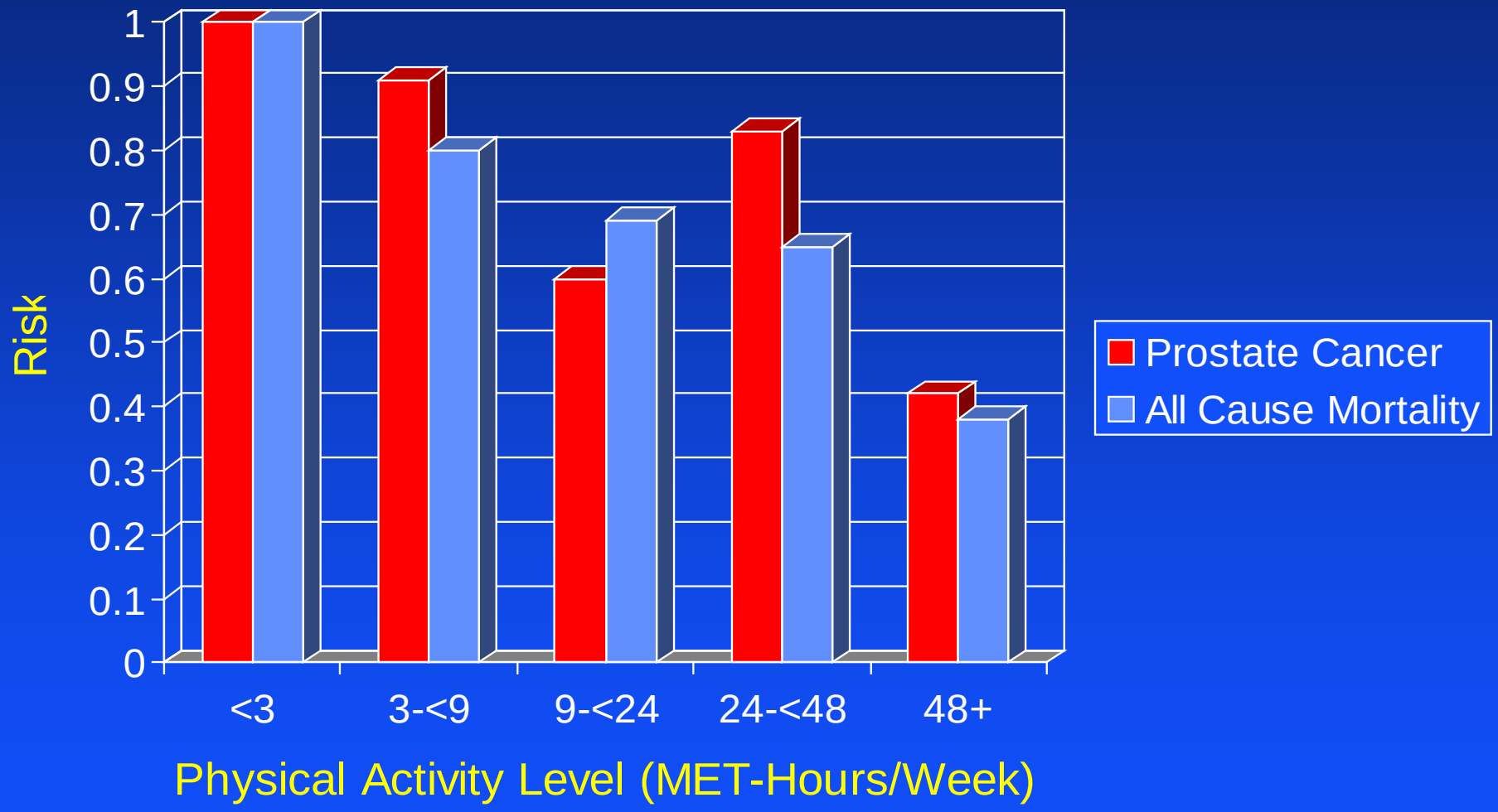
Primary: disease-free survival

Secondary: PROs, functional capacity, etc.

Courneya et al. *Curr Oncol*, 2008;15:262-70

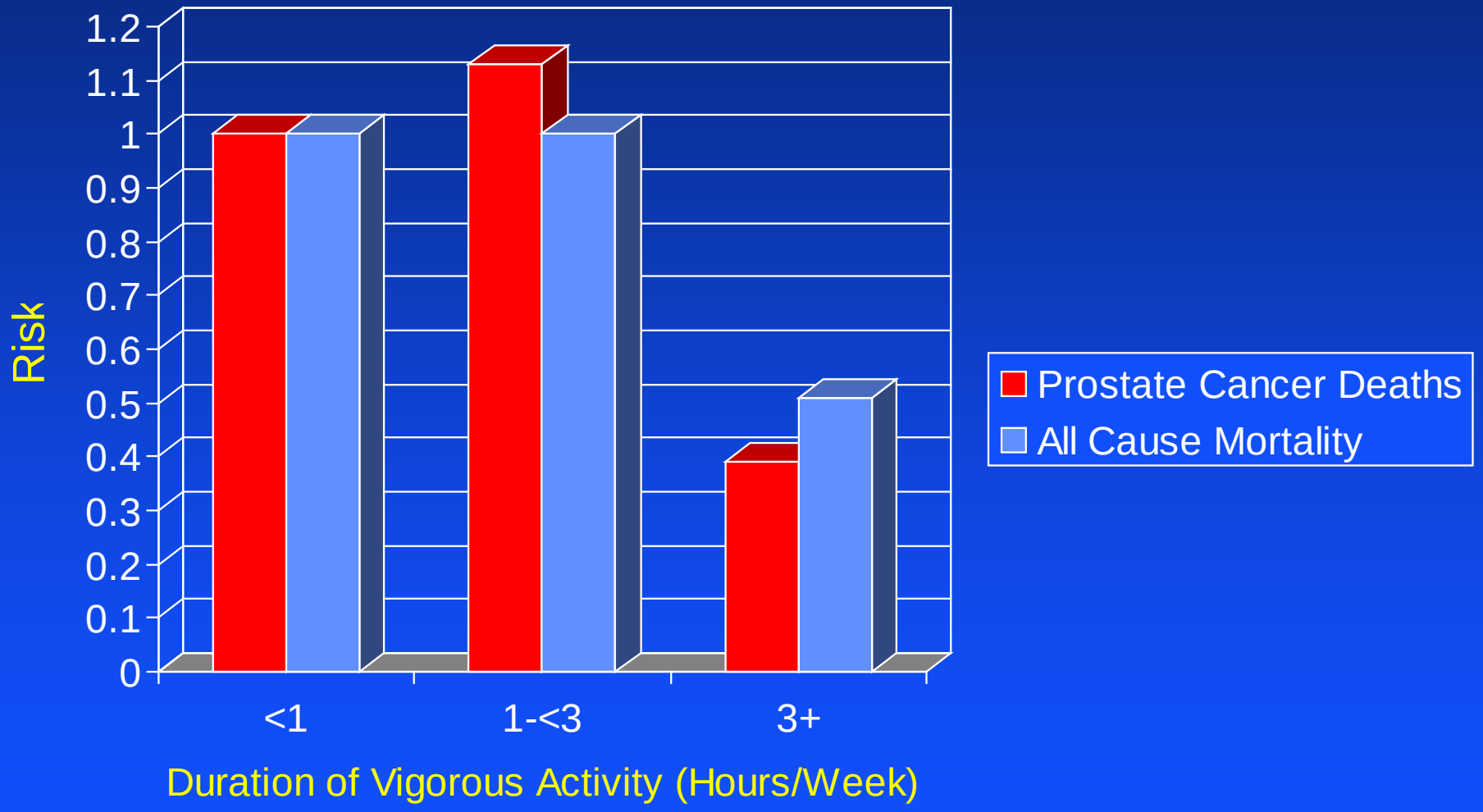
Physical Activity and Prostate Cancer Survival

Risk of Prostate Cancer Mortality by Post-diagnosis PA



Kenfield et al. *JCO* 2011;29:726-32

Risk of Prostate Cancer and All Cause Mortality by Vigorous Post-diagnosis Physical Activity



Kenfield et al. *JCO* 2011; 29:726-32.

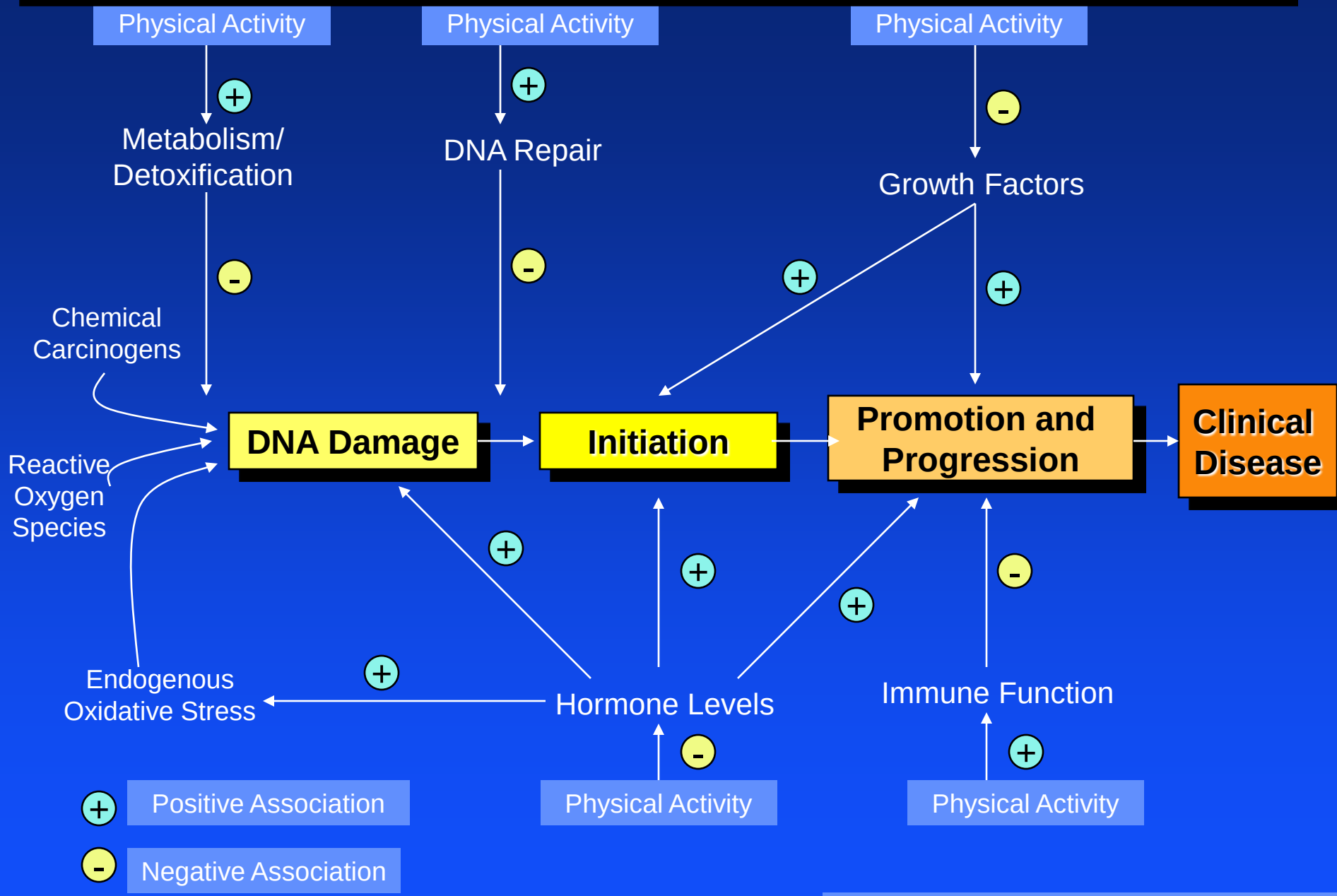
Summary of Evidence on Physical Activity and Cancer Mortality by Site

Cancer Site	Number of studies	Magnitude of reduction in cancer specific mortality	Magnitude of reduction in all cause mortality	Dose-response effect
Breast	17	25%	30%	Some
Colon	6	45-50%	40-45%	Some
Prostate	1	60%	45%	NA
Ovarian	2	10%*	10%	NA
Glioma	1	NR	55%	NA

* Increased risk

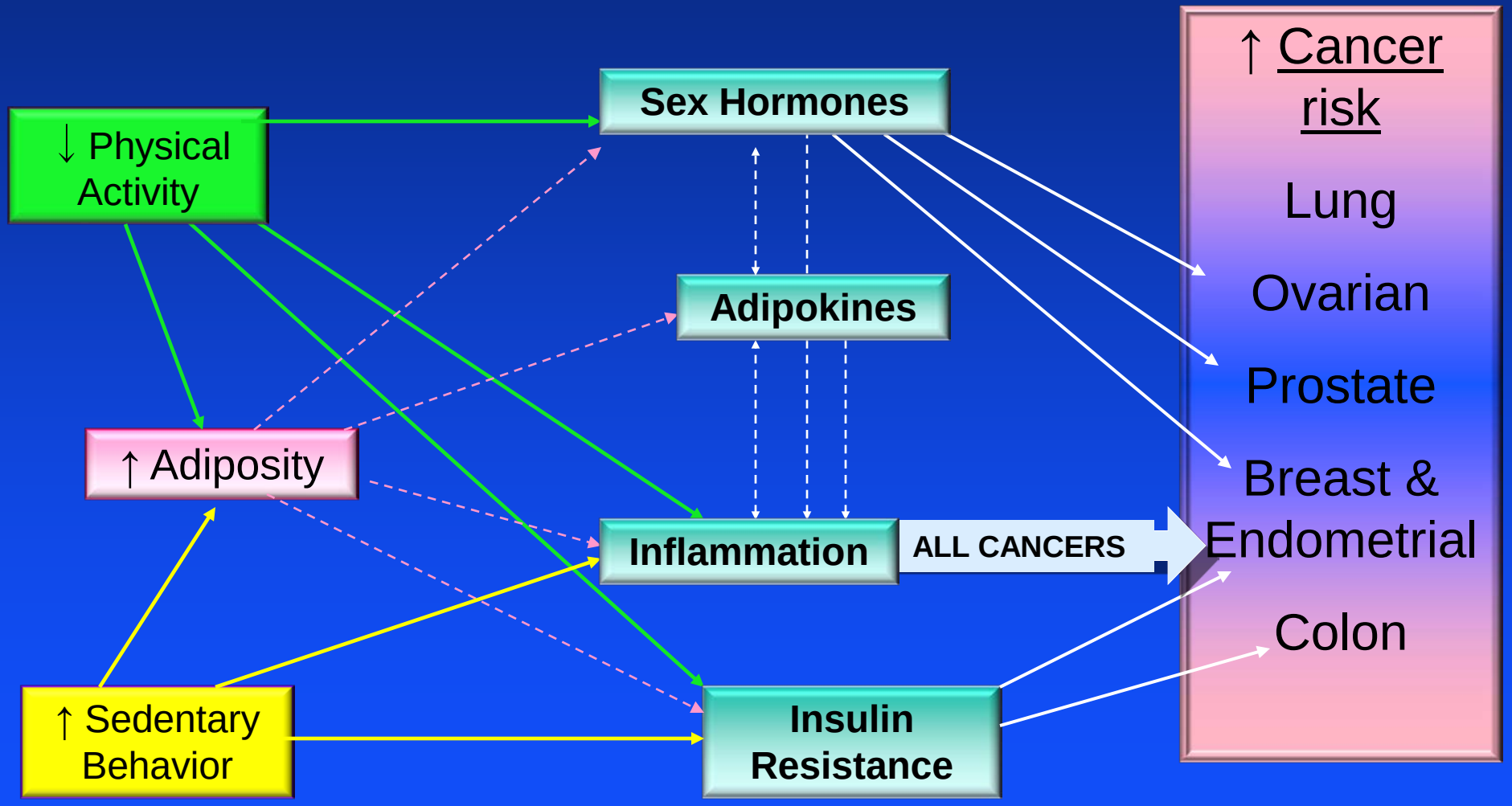
Physical Activity and Cancer Risk: Biologic Mechanisms

How physical activity could interact with carcinogenesis



Adapted from Rundle A. CEBP 2005;14:227-36

Hypothesized Biologic Mechanisms Between Physical Inactivity, Sedentary Behaviour and Cancer Risk



Friedenreich CM, Lynch BM, Langley A. in press

Biologic Mechanisms: Emerging Evidence of Effect of PA

Mechanism	Possible effect of Physical Activity	Cancer Sites
Vitamin D	• Associated with higher 25-hydroxyvitamin D blood levels	Colon, Breast
Insulin-like growth factors	• Might ↓ IGF-1 and ↑ IGFBP-3	Colon, Premenopausal breast, Endometrium, Ovaries, Prostate, Lung
Immune function	• May improve innate and acquired immune responses to recognize and eliminate cancer cells • Effects of long-term, moderate intensity PA on humans at risk not well understood	Most cancers
Oxidative stress, anti-oxidant defense and DNA repair	• May reduce oxidative stress, increase anti-oxidant enzymes (e.g. superoxide dismutase), and/or enhance DNA repair	Most cancers
Prostaglandins	• May inhibit synthesis of prostaglandins	Colon
Gastrointestinal transit time	• ↑ Gut motility and may ↓ transit time → less interaction between mucosa and carcinogens but changes may not be large enough to alter risk	Colon
Pulmonary function	• ↓ Concentration of carcinogens in lung and ↓ exposure time of carcinogens to lung tissue	Lung

Randomized Controlled Exercise Intervention Trials for Breast Cancer Prevention

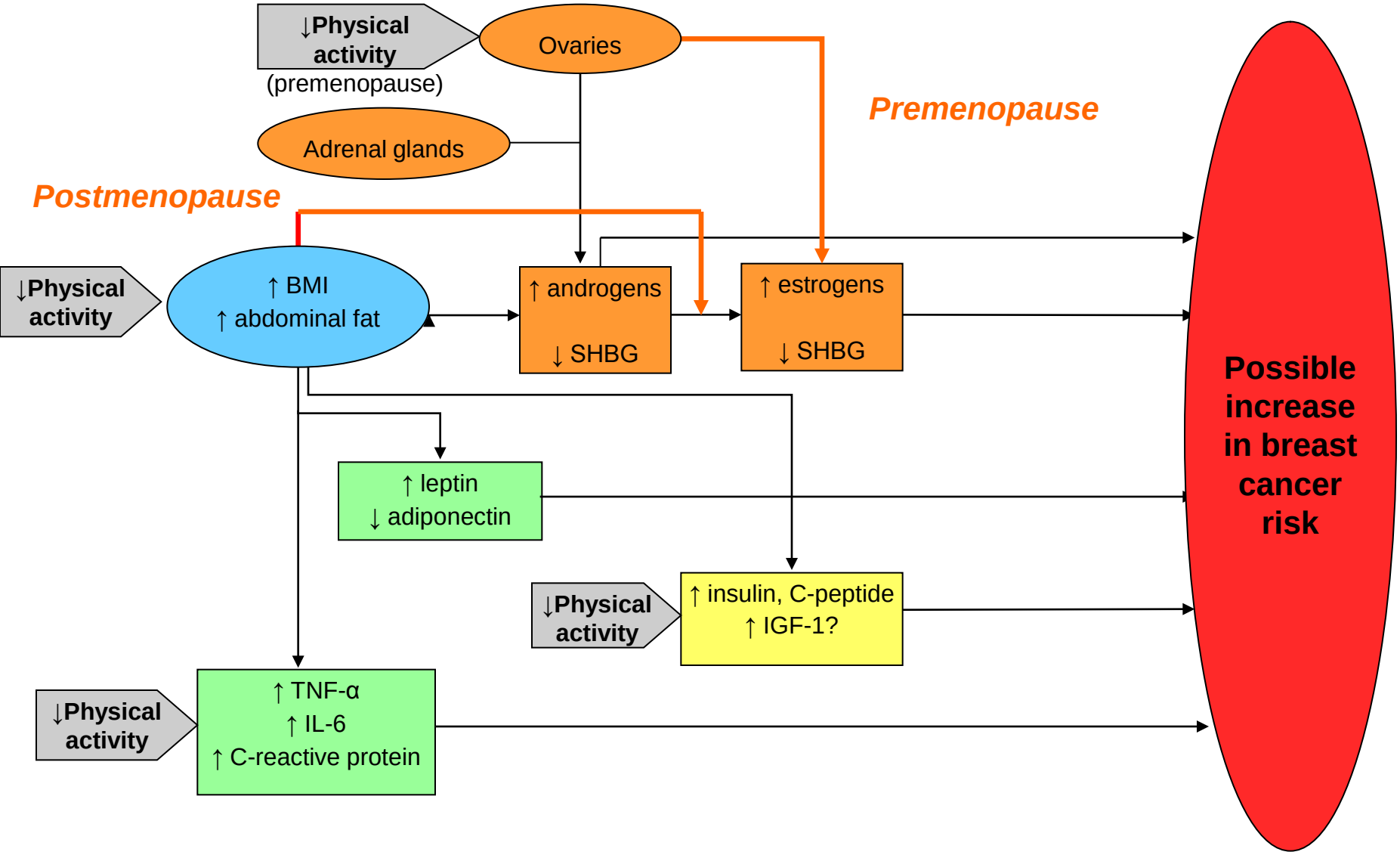
- Three year-long RCTs conducted to date on aerobic exercise and breast cancer biomarkers among postmenopausal, inactive, 50-75 yr old healthy women:
  - McTiernan et al. (*Physical Activity for Total Health Trial*) (N=173)
  - Monninkhof et al. (*Sex Hormones and Physical Exercise Trial*) (N=189)
  - Friedenreich et al. (*Alberta Physical Activity and Breast Cancer Prevention Trial*) (N=320)

ALPHA Trial: Design

- **Study design:** Two-armed, two-centered RCT
- **Intervention:** Year-long, 5 days/week, 45 mins/session (3 supervised, 2 unsupervised), aerobic exercise only, no change in diet
- **Eligibility criteria:** Postmenopausal, 50-74 yrs, no previous cancer, healthy, BMI=22-40, no HRT use, non-smoker, non-excessive alcohol, inactive
- **Control:** No change in exercise or diet
- **Sample size:** 320
- **Outcomes:** Sex hormones, adiposity, insulin resistance, inflammation, mammographic density

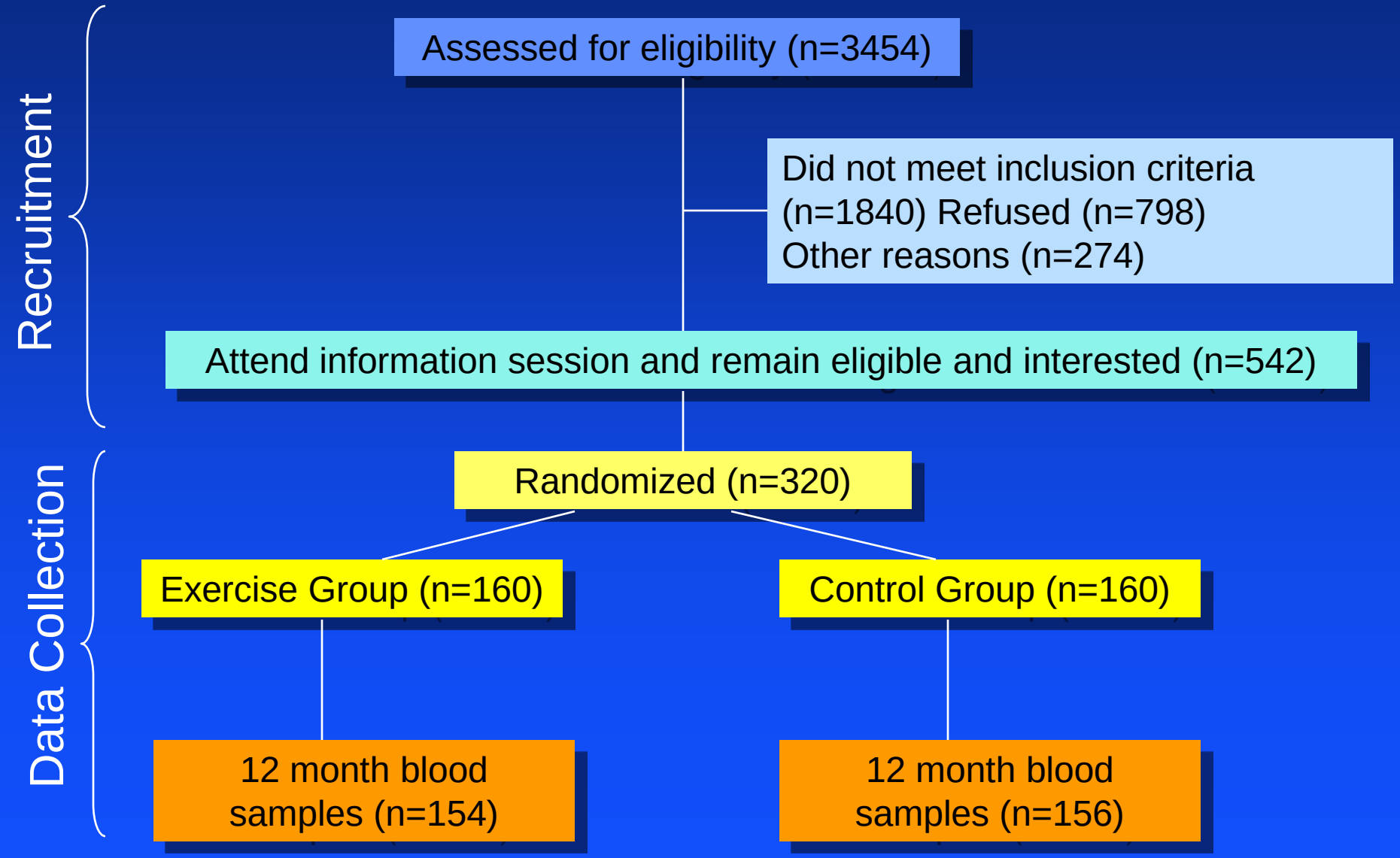
ALPHA Trial

Hypothesized Biologic Mechanisms Between Physical Activity and Breast Cancer

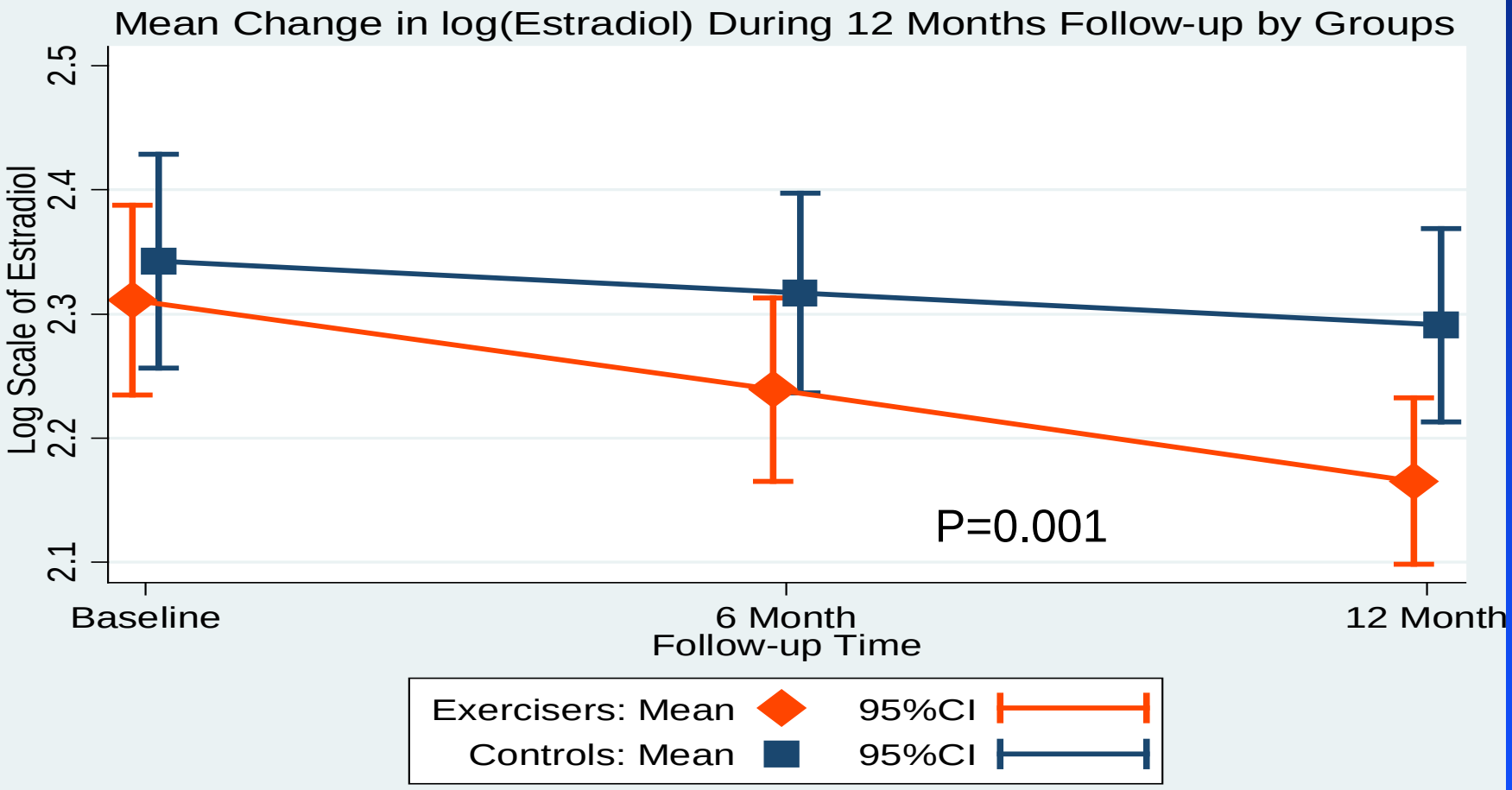


Friedenreich CM, Neilson HK, Lynch BM. *Eur J Cancer*. 2010; 46:2593-2604

ALPHA Trial: Flow Chart

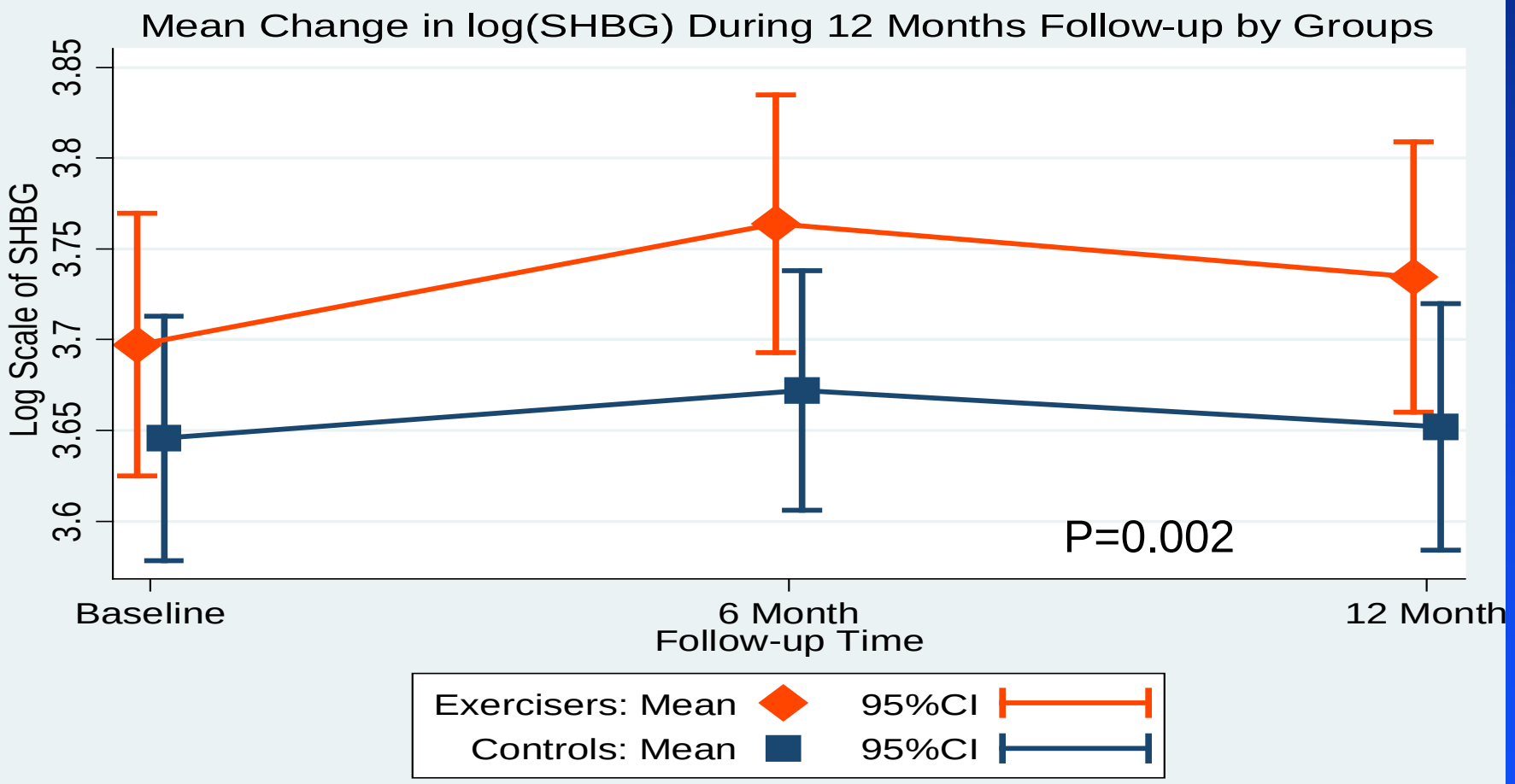


Impact of Exercise Intervention on Endogenous Estrogens: Estradiol



Friedenreich et al., *JCO*, 2010; 28:1458-66

Impact of Exercise Intervention on Sex Hormone Binding Globulin



Friedenreich et al., *JCO*, 2010; 28:1458-66

Impact of Exercise Intervention on Adiposity Outcomes

Change from Baseline	Exercisers	Controls	Difference	*p*-value
Weight (kg)	-2.3	-0.5	-1.8	<.001
Body mass index (kg/m^2)	-0.9	-0.2	-0.7	<.001
Waist circumference (cm)	-2.2	0.1	-2.3	<.001
Abdominal fat area (cm^2)	-48.5	-9.6	-38.9	<.001
Intra-abdominal fat area (cm^2)	-16.5	-1.6	-14.9	<.001

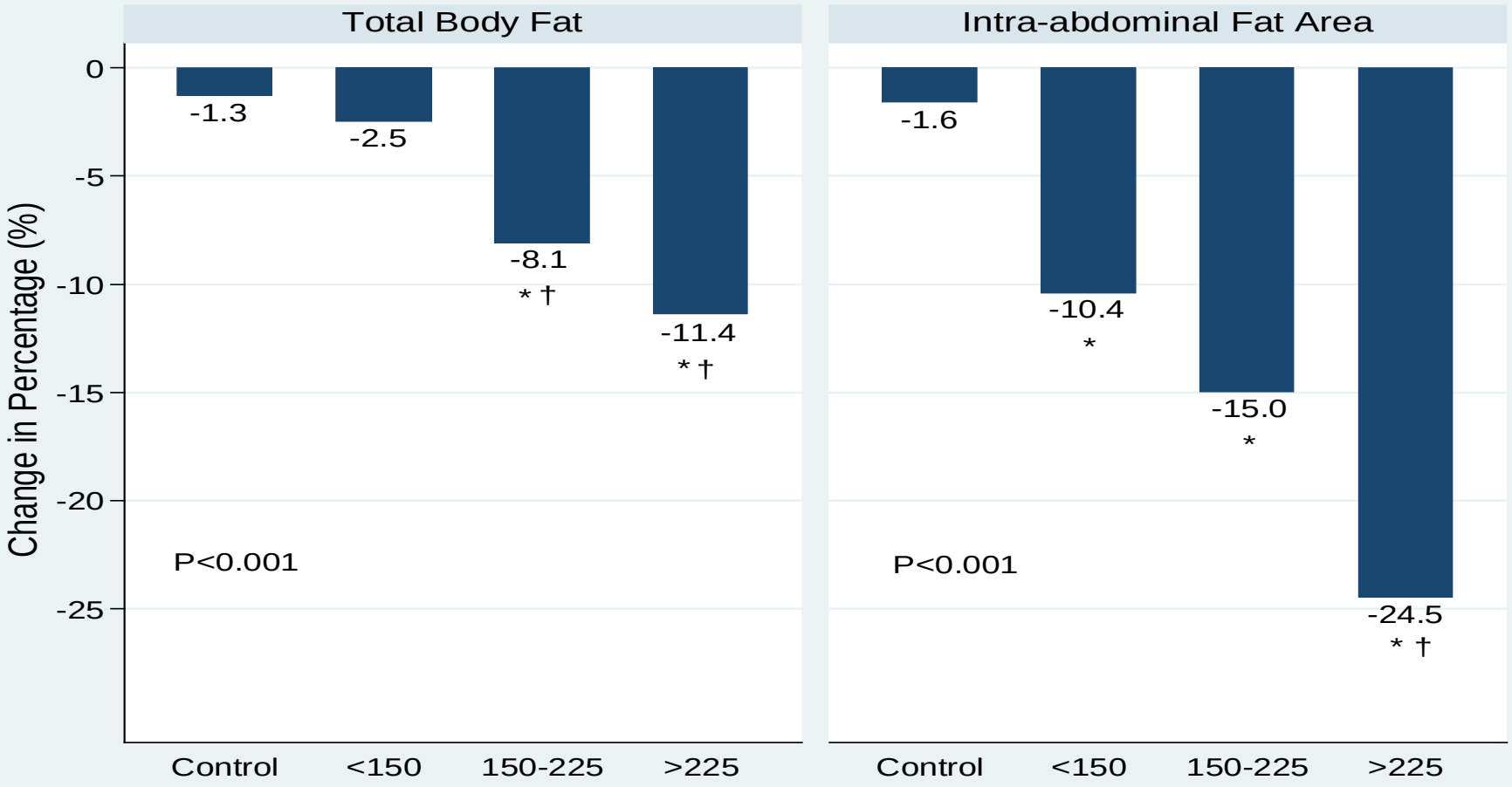
Friedenreich et al., *Int J Obes* 2010; 35:427-35

Impact of Exercise Intervention on Adiposity Outcomes

Change from Baseline	Exercisers	Controls	Difference	*p*-value
Subcutaneous fat area (cm^2)	-32.0	-7.9	-24.1	<.001
Percent body fat	-2.0	-0.2	-1.8	<.001
Fat mass (kg)	-2.4	-0.4	-2.0	<.001
Lean muscle mass (kg)	-0.0	-0.1	0.1	0.564

Friedenreich et al., *Int J Obes* 2010; 35:427-35

Percent Change of Total Body Fat and Intra-abdominal Fat Change by Average Weekly Duration of Exercise



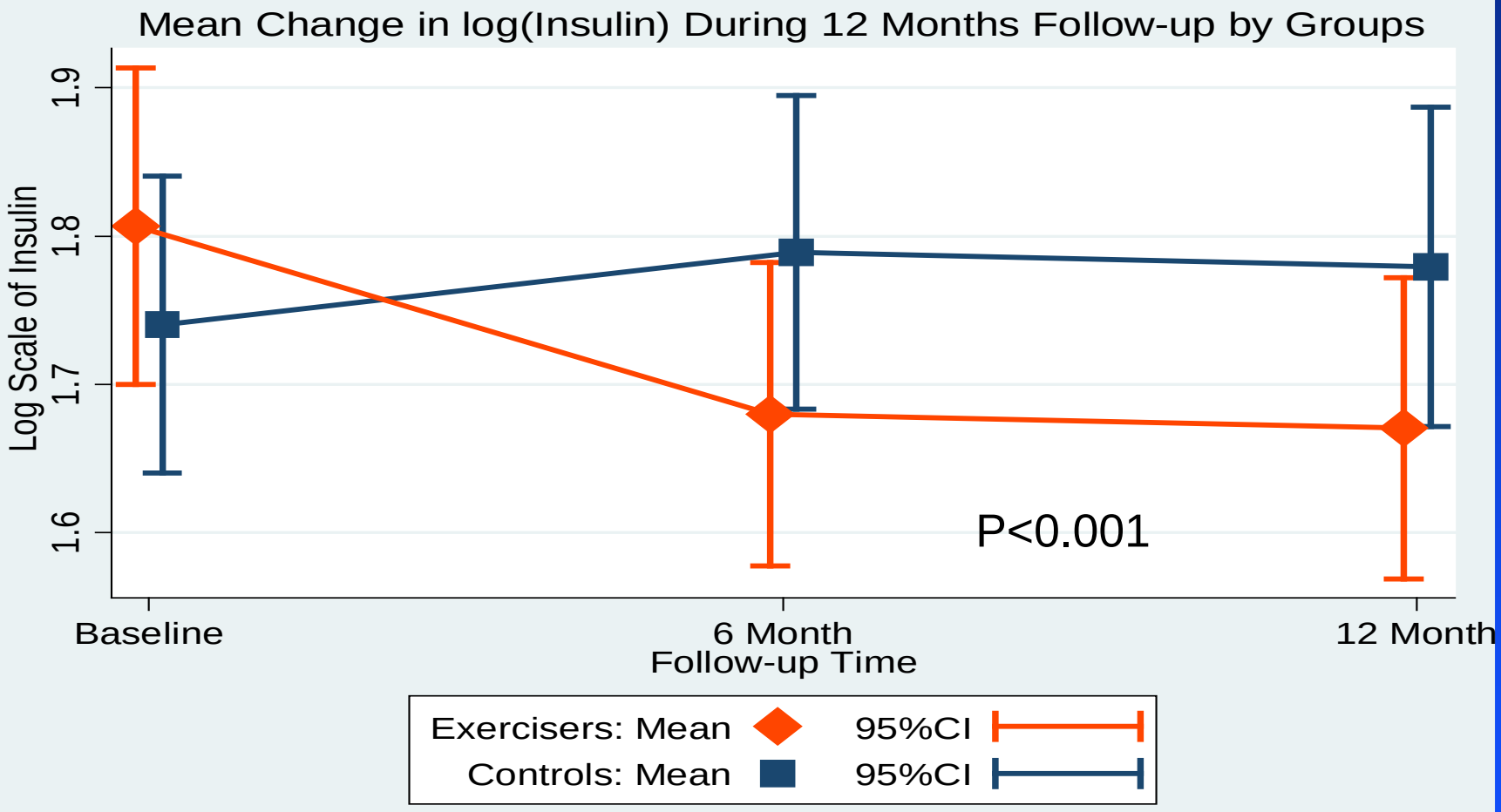
*** Significant difference compared with control group (*P*<0.05).**
† Significant difference compared with low-active group (*P*<0.05).

Friedenreich et al., *Int J Obes* 2010; 35:427-35

Insulin Resistance Outcomes

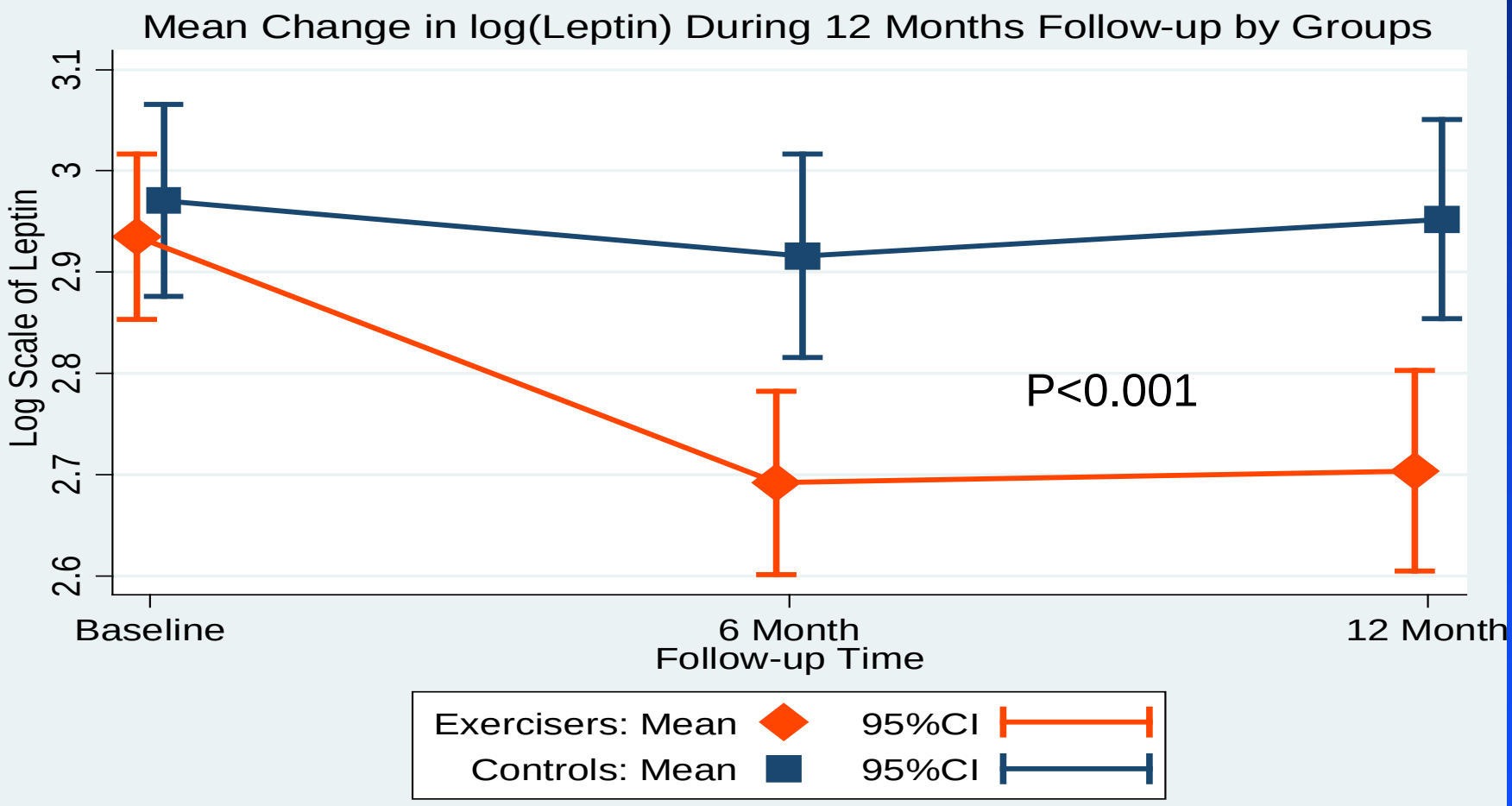
Friedenreich et al., Endocrine-Related Cancer, 2011;18:357-69

Impact of Exercise Intervention on Insulin



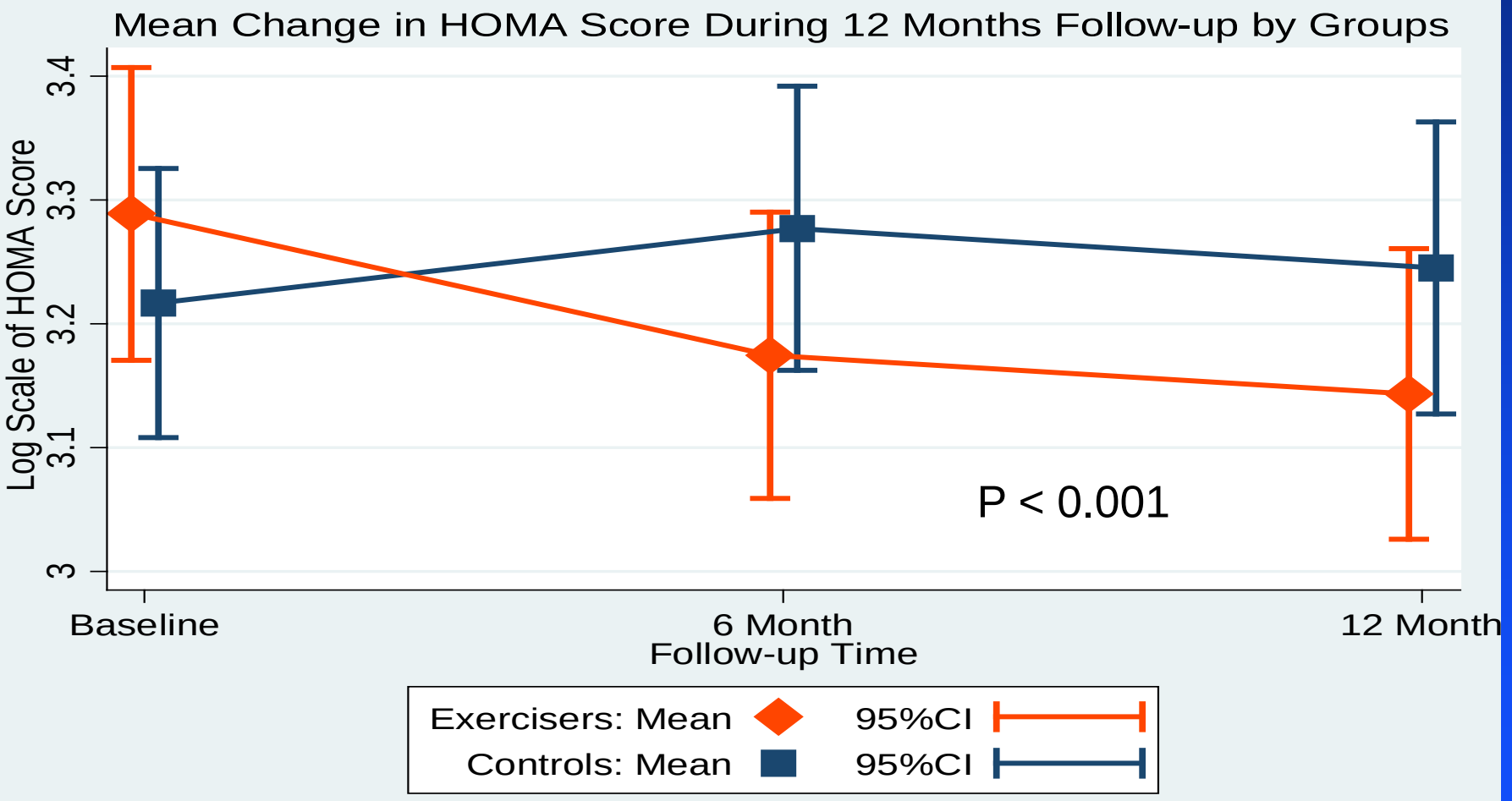
Friedenreich et al., *Endocrine Related Cancer* 2011;18:357-69

Impact of Exercise Intervention on Leptin

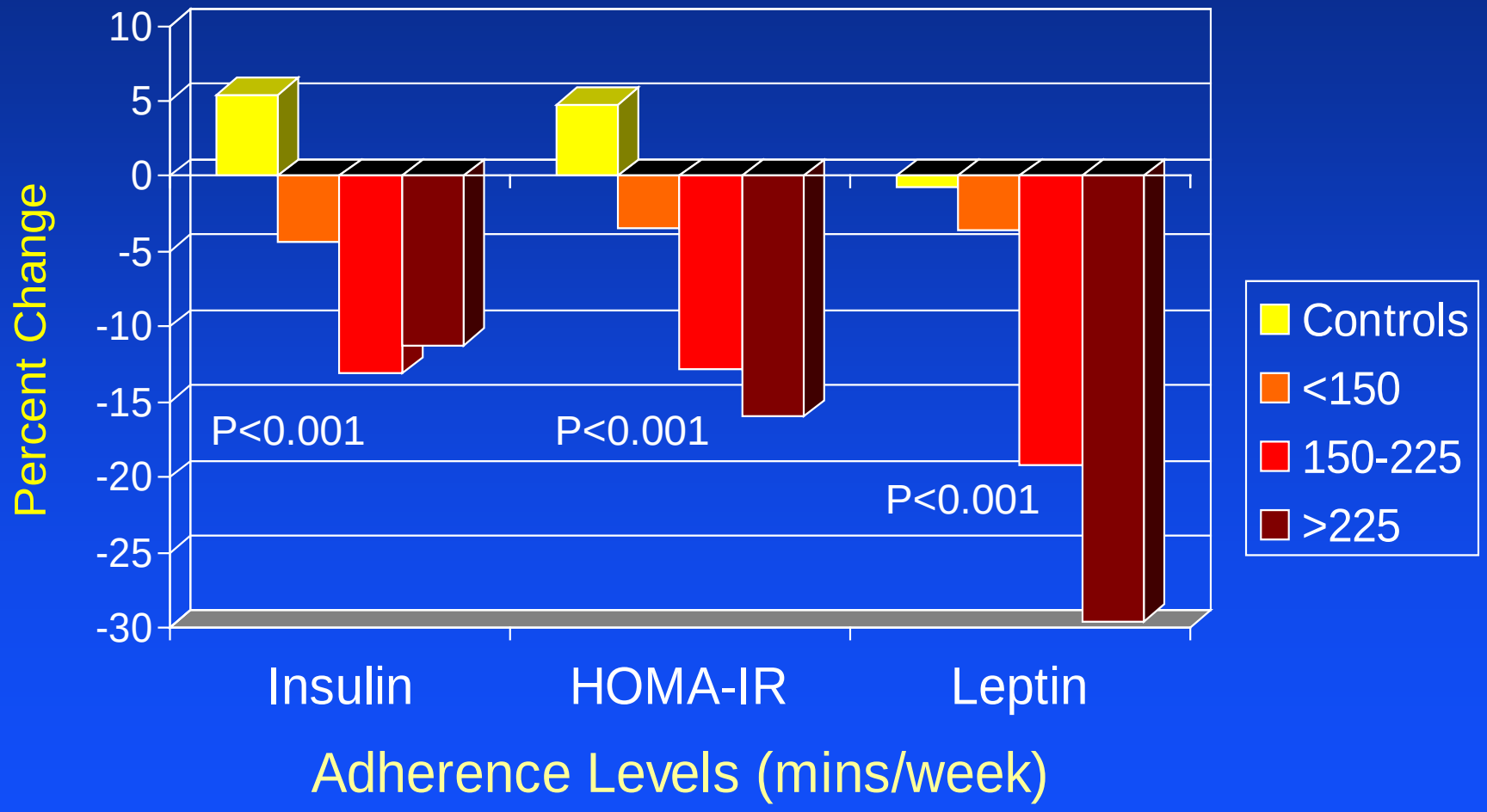


Friedenreich et al., *Endocrine Related Cancer* 2011;18:357-69

Impact of Exercise Intervention on Insulin Resistance (HOMA)



Percent Change in Insulin Biomarkers by Adherence Levels

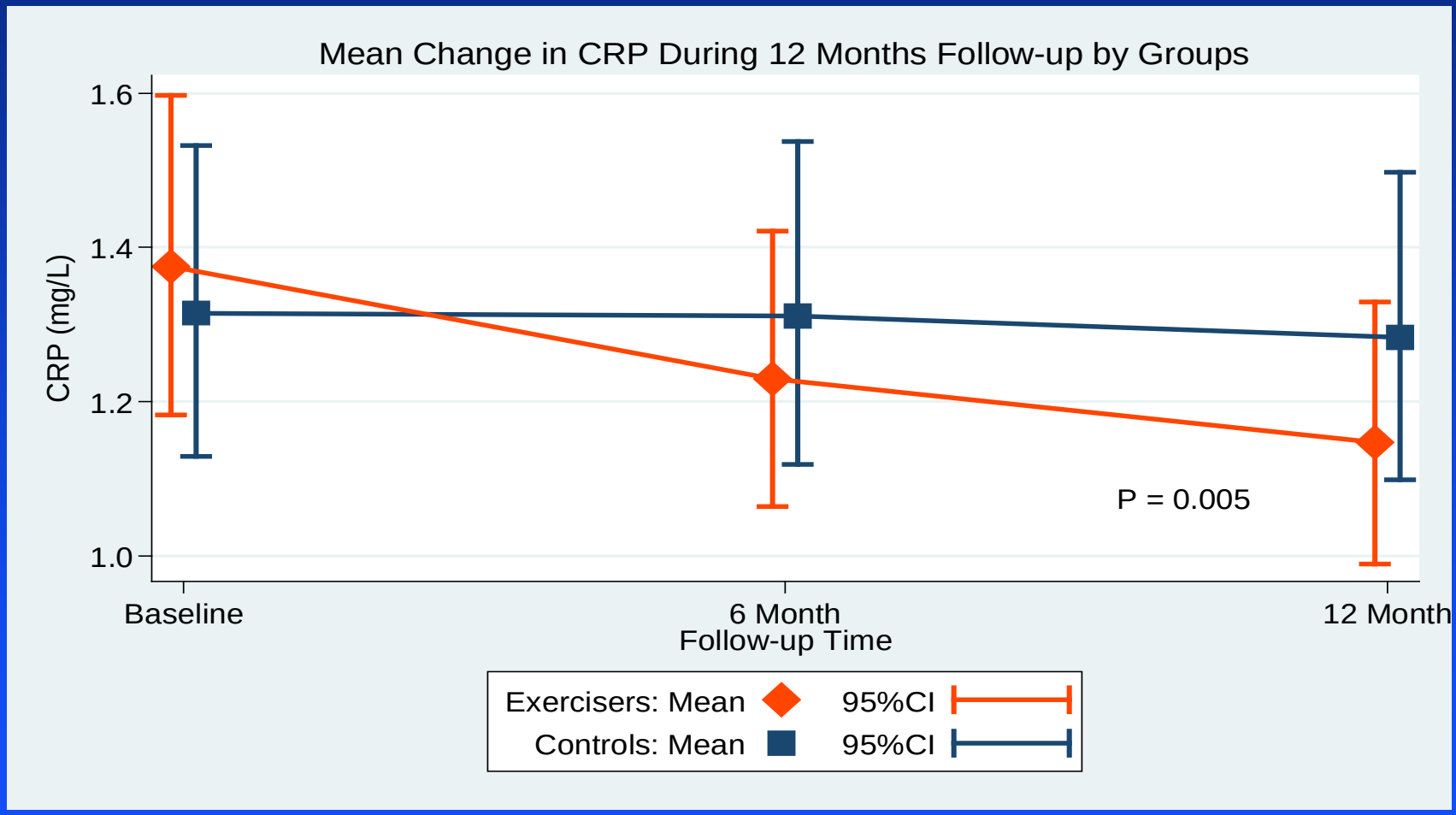


Friedenreich et al., *Endocrine Related Cancer* 2011;18:357-69

Inflammatory Marker Outcomes

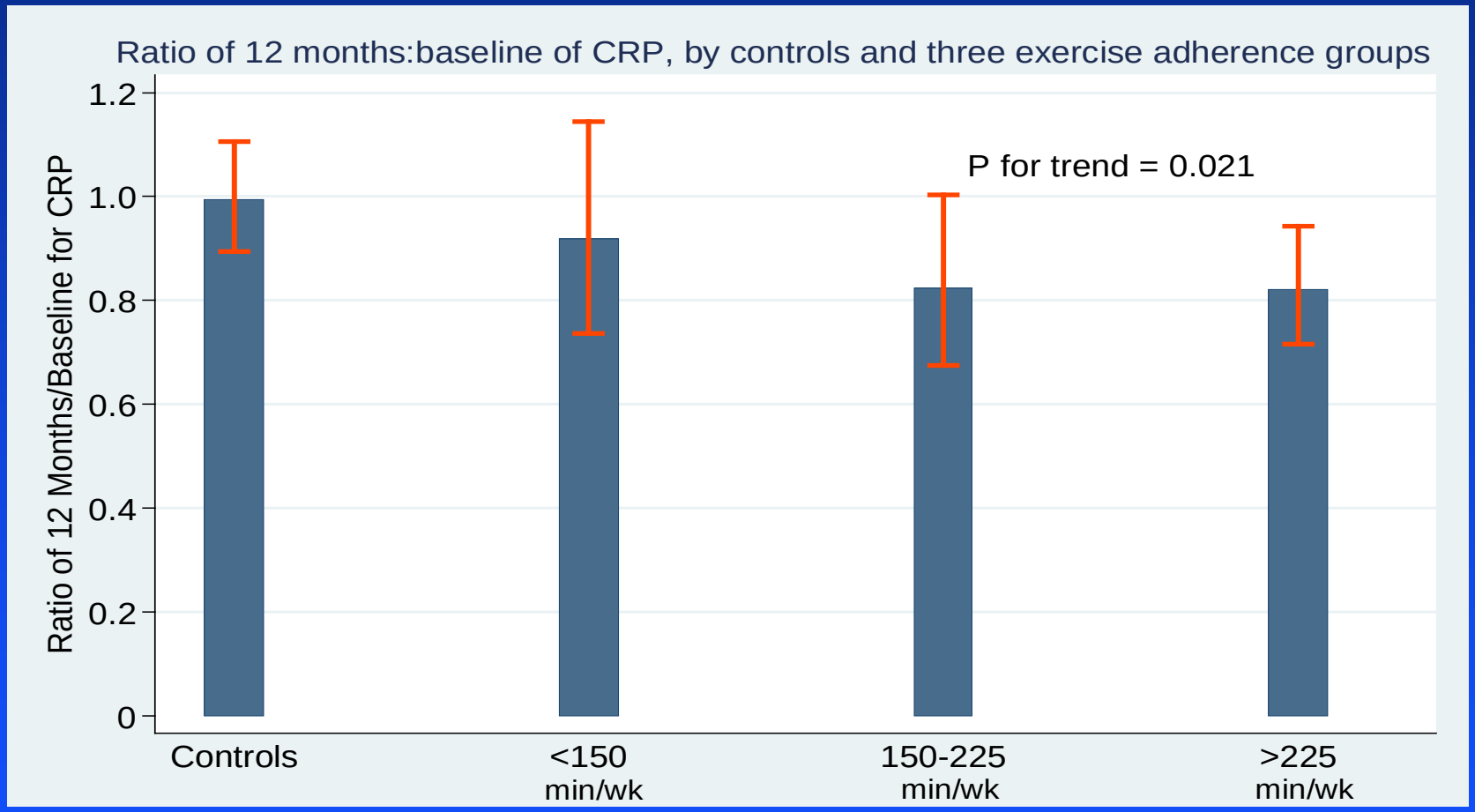
Friedenreich et al., *Cancer Prev Research* 2011;4 (epub)

Impact of Exercise Intervention on C-reactive Protein



Friedenreich CM et al. *Cancer Prev Research* 2011

Percent Change of C-reactive Protein by Average Weekly Duration of Exercise



Friedenreich CM et al. *Cancer Prev Research* 2011;4

Main Findings on Exercise and Breast Cancer Biomarkers

Endpoint	PATH Trial	SHAPE Trial	ALPHA Trial
Sex hormones	↓estrone and estradiol restricted to women who lost >2% body fat	No effect on estrogens or androgens	↓estradiol and ↑SHBG
Obesity	↓ all adiposity measures	↓ body fat but no effect on weight, BMI or hip circumference	↓all adiposity measures
Insulin resistance	↓insulin, leptin, HOMA score	Not reported	↓ insulin, HOMA-IR, leptin, adiponectin/leptin ratio
Inflammation	↓C-reactive protein	Not reported	↓ C-reactive protein
Publications	Irwin 2003; McTiernan 2004; Frank 2005; Campbell 2009	Monninkhof 2009; Velthuis, 2009	Friedenreich 2010a; Friedenreich 2010b, Friedenreich 2011

Funded by ACF and CCSRI

Breast Cancer and Exercise Trial in Alberta: Study Design

Recruit 400 postmenopausal healthy women 50-74 years

Randomize

High volume exercise group
(5 days/wk x 60 mins/session @ 70-80% max HRR)

Moderate volume exercise group
(5 days/wk x 30 mins/session @ 70-80% max HRR)

Compare high vs. moderate exercise groups on endogenous sex hormones, obesity and inflammatory markers, insulin, glucose

Follow-up at 24 months: examine exercise maintenance and long term effect on biomarkers

beta trial

Study Participants and Staff

Alberta **M**oving **Be**yond B**r**east Cancer (AMBER) Cohort Study

Alberta Moving Beyond Breast Cancer Cohort (AMBER) Study

Study Time Line and Design

Courneya KS, Friedenreich CM (co-PIs), CIHR 2011-16

2012-2017

2017-2022

Enroll 1500 incident Stage I-IIIb breast cancer cases

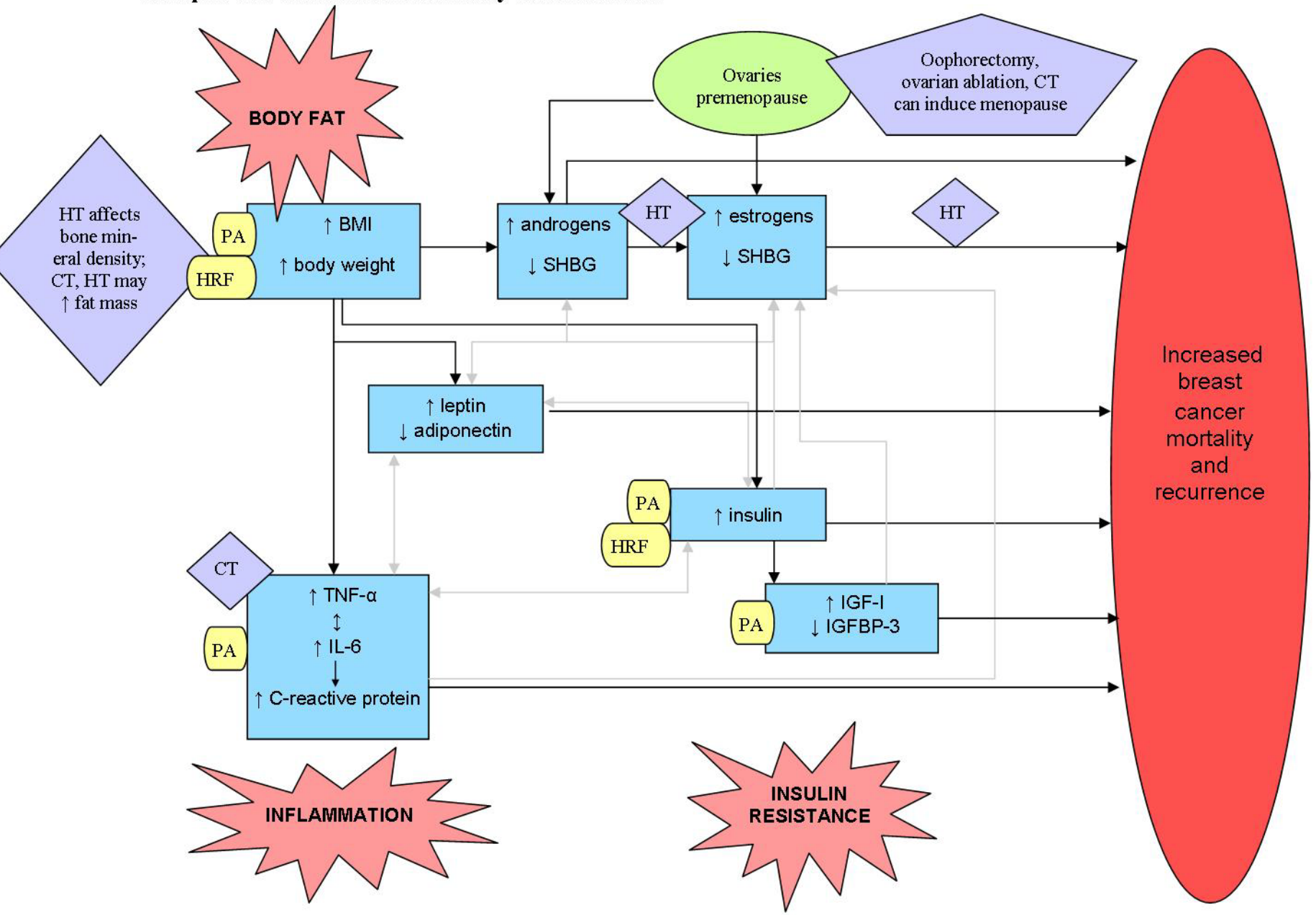
Measure physical activity, health-related fitness, determinants of PA, patient-related outcomes, biomarkers, lymphedema

How can physical activity and health related fitness be used to inform clinical recommendations for improving patient-related outcomes and survival in breast cancer survivors?

Repeat baseline measurements at 1, 3 and 5 years post-diagnosis

Follow-up for mortality outcomes (disease-specific and all cause)

Figure 6. Hypothesized biologic model relating proposed biomarkers to long-term physical activity, health-related fitness, breast cancer therapies and breast cancer mortality and recurrence



CT- chemotherapy; HRF- health-related fitness; HT- hormone therapy; PA - physical activity

Lifestyle and Breast Cancer Risk: Current State of the Scientific Inquiry

- NCI Workshop on Feasibility of Physical Activity and Weight Control Trial to Prevent Breast Cancer, March, 2006
- **Background:**
  - Diabetes Prevention Program (DPP)
  - Dietary Approaches to Prevent Hypertension (DASH)
  - Look Action for Health in Diabetes (Look AHEAD)
- **Recommended study design:**
  - Primary endpoint: breast cancer
  - Inclusion criteria: age 45-75, postmenopausal, Gail score>1.7
  - Exclusion criteria: invasive breast cancer, DCIS, use of SERMs
  - Intervention: calorie-controlled diet and 150-225 mins/wk of moderate intensity activity, 5 days or more per week
  - Trial goal: 10% weight loss if BMI >25 kg/m^2, overall 5-7% avg wt loss
  - Sample size: Estimated breast cancer risk reduction with increased physical activity would be 18% and for weight control 12% with an additive effect with the two components for a 30% reduction in risk

Sample Size for RCT of PA and Weight Control for Primary Prevention of Breast Cancer

Table 4. Sample size estimations for a primary prevention trial of invasive and noninvasive breast cancer to evaluate physical activity and weight control

Hazard ratio (control vs treatment 5-year disease-free interval rate)	Power, %	Minimum follow-up of 5 years		Minimum follow-up of 3 years	
		Length of accrual, y	No. of patients	Length of accrual, y	No. of patients
0.75 (97.8 vs 98.4)	90	5.1	20 638	6.2	25 052
	85	4.5	18 262	5.6	22 468
	80	4.1	16 350	5.1	20 442
0.80 (97.8 vs 98.3)	90	7.3	29 190	8.5	34 174
	85	6.5	25 974	7.6	30 774
	80	5.8	23 472	7.0	28 108
0.85 (97.8 vs 98.1)	90	11.3	45 246	12.7	50 874
	85	10.1	40 502	11.4	45 976
	80	9.2	36 807	10.5	42 146

Ballard-Barbash et al. JNCI 2009;

- For a 20% risk reduction, power of 85-90% and 5 year follow-up would need 26,000-30,000 women
- No trial currently planned

Future Research Directions

- Investigate sedentary behaviour and light intensity activity as risk factors for cancers
- Improve PA measurements including objective assessments
- More precision on type, dose, timing of activity in relation to risk and survival
- Examine effect modification by other factors
- Conduct prospective observational studies of new biomarkers
- Need more mechanistic RCTs that evaluate different doses and types of PA
- Need more research on PA and survival at other cancer sites
- Ultimate objective: provide more quantitative data to enhance public health recommendations regarding PA type, dose, timing for cancer risk reduction and improved survival

Conclusion

- Strong, consistent evidence worldwide that PA reduces colon, breast, endometrial cancer risks and possibly also prostate, lung and ovarian cancers by 10-30% with a dose-response effect and some sub-group effects
  - Several plausible biologic mechanisms exist
  - RCTs are finding support for these mechanisms
- PA also improves survival after breast, colon and prostate cancers by 30% or more

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  - CIHR
  - Canadian Breast Cancer Research Alliance
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- Trainees: Dr. Christy Woolcott, Ame-Lia Tamburrini, Rita Biel, Dr. Brigid Lynch, Dr. Fabiola Aparicio-Ting, Dr. Shannon Conroy
- Staff: Department of Population Health Research, Alberta Health Services-Cancer Care