What is the Impact of Physical Inactivity on Non-Communicable Diseases Worldwide?

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"In view of the prevalence, global reach, and health effect of physical inactivity, the issue should be appropriately described as pandemic, with far-reaching health, economic, environmental, and social consequences."

Physical activity: "Worldwide, we estimated that physical inactivity causes 6–10% of the major non-communicable diseases...physical inactivity seems to have an effect similar to that of smoking or obesity."
Comment

1. Rethinking our approach to physical activity
   P.Dos, R.Horton

2. Physical activity: more of the same is not enough
   P.C. Hallal and others

3. Stressing harms of physical inactivity to promote exercise
   C.P. Wilk, X.Wu

4. Physical activity for people with disabilities
   J.H. Rimmer, A.C. Marques

5. Policies to promote physical activity in Brazil
   D.C. Melo, J.B. da Silva

Articles

9. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy
   H.M. Lee and others

Series

20. Global physical activity levels: surveillance progress, pitfalls, and prospects
    P.C. Hallal and others

31. Correlates of physical activity: why are some people physically active and others not?
    A.E. Bauman and others

45. Evidence-based intervention in physical activity: lessons from around the world
    C.W. Heth and others

55. The implications of megatrends in information and communication technology and transportation for changes in global physical activity
    M.Prett and others

67. The pandemic of physical inactivity: global action for public health
    H.W. Kohn 3rd and others
Most read in *The Lancet* journals in July 2012

1. **Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy**
     - Full text | PDF

2. **Global physical activity levels: surveillance progress, pitfalls, and prospects**
     - Full text | PDF

3. **Evidence-based intervention in physical activity: lessons from around the world**
     - Full text | PDF

4. **Rethinking our approach to physical activity**
     - Full text | PDF

5. **The pandemic of physical inactivity: global action for public health**
     - Full text | PDF
Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy
By: Lee, I-Min; Shiroma, Eric J.; Lobelo, Felipe; et al.
Group Author(s): Lancet Phys Activity Series Working
LANCET Volume: 380 Issue: 9898 Pages: 219-229 Published: JUL 21 2012

Global physical activity levels: surveillance progress, pitfalls, and prospects
By: Hallal, Pedro C.; Andersen, Lars Bo; Bull, Fiona C.; et al.
Group Author(s): Lancet Phys Activity Series Working
LANCET Volume: 380 Issue: 9898 Pages: 247-257 Published: JUL 21 2012

Correlates of physical activity: why are some people physically active and others not?
By: Bauman, Adrian E.; Reis, Rodrigo S.; Sallis, James F.; et al.
Group Author(s): Lancet Phys Activity Series Working
LANCET Volume: 380 Issue: 9898 Pages: 258-271 Published: JUL 21 2012

The pandemic of physical inactivity: global action for public health
By: Kohl, Harold W., III; Craig, Cora Lynn; Lambert, Estelle Victoria; et al.
Group Author(s): Lancet Phys Activity Series Working
LANCET Volume: 380 Issue: 9898 Pages: 294-305 Published: JUL 21 2012

Evidence-based intervention in physical activity: lessons from around the world
By: Heath, Gregory W.; Perra, Diana C.; Sarmiento, Olga L.; et al.
Group Author(s): Lancet Phys Activity Series Working
LANCET Volume: 380 Issue: 9898 Pages: 272-281 Published: JUL 21 2012

The implications of megatrends in information and communication technology and transportation for changes in global physical activity
By: Pratt, Michael; Sarmiento, Olga L.; Montes, Felipe; et al.
Group Author(s): Lancet Phys Activity Series Working
LANCET Volume: 380 Issue: 9898 Pages: 262-293 Published: JUL 21 2012
Topics Covered

- Estimation of public health burden
- Is this estimation science or art?
- What next?
Estimation of PH Burden
Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy

I-Min Lee, Eric J Shiroma, Felipe Lobelo, Pekka Puska, Steven N Blair, Peter T Katzmarzyk, for the Lancet Physical Activity Series Working Group*

Summary

Background Strong evidence shows that physical inactivity increases the risk of many adverse health conditions, including major non-communicable diseases such as coronary heart disease, type 2 diabetes, and breast and colon cancers, and shortens life expectancy. Because much of the world’s population is inactive, this link presents a major public health issue. We aimed to quantify the effect of physical inactivity on these major non-communicable diseases by estimating how much disease could be averted if inactive people were to become active and to estimate gain in life expectancy at the population level.

Methods For our analysis of burden of disease, we calculated population attributable fractions (PAFs) associated with physical inactivity using conservative assumptions for each of the major non-communicable diseases, by country, to estimate how much disease could be averted if physical inactivity were eliminated. We used life-table analysis to estimate gains in life expectancy of the population.

Findings Worldwide, we estimate that physical inactivity causes 6% (ranging from 3.2% in southeast Asia to 7.8% in the eastern Mediterranean region) of the burden of disease from coronary heart disease, 7% (3.9–9.6) of type 2 diabetes, 10% (5.6–14.1) of breast cancer, and 10% (5.7–13.8) of colon cancer. Inactivity causes 9% (range 5.1–12.5) of premature mortality, or more than 5.3 million of the 57 million deaths that occurred worldwide in 2008. If inactivity were not eliminated, but decreased instead by 10% or 25%, more than 533 000 and more than 1.3 million deaths, respectively, could be averted every year. We estimated that elimination of physical inactivity would increase the life expectancy of the world’s population by 0.68 (range 0.41–0.95) years.

Interpretation Physical inactivity has a major health effect worldwide. Decrease in or removal of this unhealthy behaviour could improve health substantially.

Funding None.
Health Benefits of Physical Activity

**Panel 1: Health benefits of physical activity in adults**

**Strong evidence of reduced rates of:**
- All-cause mortality
- Coronary heart disease
- High blood pressure
- Stroke
- Metabolic syndrome
- Type 2 diabetes
- Breast cancer
- Colon cancer
- Depression
- Falling

**Strong evidence of:**
- Increased cardiorespiratory and muscular fitness
- Healthier body mass and composition
- Improved bone health
- Increased functional health
- Improved cognitive function

Lee et al, Lancet 2012;380:219-29
31.1% inactive
Definition of “Inactive”

- “Inactive”: <30 min mod-intensity PA 5 d/wk, or <20 min vig-intensity PA 3 d/wk or equivalent combination of <600 MET-min/wk
- Consistent with current PA guidelines
- Data from WHO Global Health Observatory Data Repository
- 122 countries (89% of world’s population)
- Self-reported, using IPAQ or GPAQ
• Clearly, this is not a good situation!
• How can we quantify this problem in easy-to-understand measures for those involved in PH, including policy makers?
• This was goal of Lancet paper
Questions Asked

• What is the public health burden worldwide due to physical inactivity, resulting from major non-communicable diseases (NCDs)?

• Stated in another way: By removing inactivity, how much of these diseases may be eliminated, and how much gain in life expectancy may occur?
Tools Needed

- Population attributable fraction (PAF), which needs for calculation:
  - prevalence of inactivity
  - relative risk of outcome (RR)
- Life tables
Population Attributable Fraction

- PAF is simply the proportion of excess disease in the population attributable to inactivity:

\[
\text{PAF} = \frac{\text{Incidence Rate}_{\text{pop}} - \text{Incidence Rate}_{\text{active}}}{\text{Incidence Rate}_{\text{pop}}}
\]

- If we were to completely remove inactivity, this proportion of disease would be removed
Mathematically re-arranged, this becomes the common formula:

$$\text{PAF} = \frac{P_e (\text{RR}_{\text{unadj}} - 1)}{P_e (\text{RR}_{\text{unadj}} - 1) + 1} \times 100\%$$

- $P_e$ – % inactive in the population
- $\text{RR}_{\text{unadj}}$ – crude RR, inactive vs. active (unadjusted for confounding factors)

Formula is invalid if there is confounding
When confounding (by age, smoking, etc.) exists, there is an alternate form of the PAF formula that can be validly used:

\[
PAF = P_d \frac{(RR_{adj} - 1) \times 100\%}{RR_{adj}}
\]

- \( P_d \) – % inactive among persons who eventually develop outcome (not among population)
- \( RR_{unadj} \) – adjusted RR, inactive vs. active

(These data – \( P_d \) – are not readily available, so common formula is often used)
Estimation of $P_d$

- We used an “adjustment factor” to calculate $P_d$
- This was calculated by obtaining the prevalence of inactivity among all persons in a cohort study, and among persons in the cohort study who went on to develop CHD (repeat for each outcome)
- Adjustment factor = \( \frac{\text{Prev among eventual CHD cases}}{\text{Prev among all}} \)
- $P_d = \text{adjustment factor} \times \text{prevalence of inactivity in population (from WHO)}$
Estimation of $P_d$

Adjustment factor calculated from these cohort studies:

- Aerobics Center Longitudinal Study
- Canada Fitness Survey Follow-up Study
- EPIC-InterAct Project
- EPIC-Norfolk Study
- FINRISK Survey
- Harvard Alumni Health Study
- Shanghai Women’s Health Study
- Scottish Health Survey
- Whitehall II Study
- Women’s Health Study
Estimation of $RR_{adj}$

- RRs were based on 2 level comparisons: inactive vs. active
- Conducted literature search to identify most recent meta-analyses for adjusted RR (CHD, T2D, colon ca)
- If not available, conducted meta-analyses using studies in most recent qualitative review (breast ca, all-cause mortality)
- We also conducted parallel meta-analyses to obtain unadjusted RR, for comparison
Estimation of Gain in Life Expectancy

Used life table analysis:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>nMx - age-specific death rate between ages x and x+n</th>
<th>nqx - probability of dying between ages x and x+n</th>
<th>lx - number of people left alive at age x</th>
<th>ndx - number of people dying between ages x and x+n</th>
<th>nLx - person-years lived between ages x and x+n</th>
<th>Tx - person-years lived above age x</th>
<th>expectation of life at age x</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>0.0053</td>
<td>0.00527</td>
<td>100000</td>
<td>527</td>
<td>99525</td>
<td>8105299</td>
<td>81.1</td>
</tr>
<tr>
<td>1-4</td>
<td>0.00021</td>
<td>0.00083</td>
<td>99473</td>
<td>82</td>
<td>397692</td>
<td>8005774</td>
<td>80.5</td>
</tr>
<tr>
<td>5-9</td>
<td>0.00011</td>
<td>0.00053</td>
<td>99390</td>
<td>53</td>
<td>496818</td>
<td>7608081</td>
<td>76.5</td>
</tr>
<tr>
<td>5 yr intervals ...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100+</td>
<td>0.42112</td>
<td>1</td>
<td>4325</td>
<td>4325</td>
<td>10269</td>
<td>10269</td>
<td>2.4</td>
</tr>
</tbody>
</table>

- Assumed death rates in age groups 40-80 y only are decreased by PAF for all-cause mortality (conservative approach)
- Most data on PA and mortality are from persons in this age group
Burden of Disease

~ 6-10% of major NCDs worldwide is attributable to physical inactivity

6% Coronary heart disease
7% Type 2 diabetes
10% Breast cancer
10% Colon cancer
9% Premature mortality

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prevalence of inactivity in population (%)</th>
<th>Prevalence of inactivity in people eventually developing the outcome (%)</th>
<th>RR, unadjusted</th>
<th>RR, adjusted</th>
<th>PAF with unadjusted RR (%)</th>
<th>PAF with adjusted RR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary heart disease</td>
<td>35.2% (22.3-40.5)</td>
<td>42.2% (23.0-56.2)</td>
<td>1.33 (1.18-1.49)</td>
<td>1.16 (1.04-1.30)</td>
<td>10.4% (7.2-13.4)</td>
<td>5.8% (3.2-7.8)</td>
</tr>
<tr>
<td>Type 2 diabetes</td>
<td>35.2% (22.3-40.5)</td>
<td>43.2% (23.6-57.6)</td>
<td>1.63 (1.27-2.11)</td>
<td>1.20 (1.10-1.33)</td>
<td>18.1% (10.8-22.8)</td>
<td>7.2% (3.9-9.6)</td>
</tr>
<tr>
<td>Breast cancer*</td>
<td>38.8% (23.3-44.3)</td>
<td>40.7% (22.5-56.7)</td>
<td>1.34 (1.25-1.43)</td>
<td>1.33 (1.26-1.42)</td>
<td>11.6% (6.8-15.5)</td>
<td>10.1% (5.6-14.1)</td>
</tr>
<tr>
<td>Colon cancer</td>
<td>35.2% (22.3-40.5)</td>
<td>42.9% (23.4-57.1)</td>
<td>1.38 (1.31-1.45)</td>
<td>1.32 (1.23-1.39)</td>
<td>11.8% (6.8-15.1)</td>
<td>10.4% (5.7-13.8)</td>
</tr>
<tr>
<td>All-cause mortality</td>
<td>35.2% (22.3-40.5)</td>
<td>42.9% (23.4-57.1)</td>
<td>1.47 (1.38-1.57)</td>
<td>1.28 (1.21-1.36)</td>
<td>14.2% (8.3-18.0)</td>
<td>9.4% (5.1-12.5)</td>
</tr>
</tbody>
</table>
Potential Deaths Averted

- >5.3 M deaths/y worldwide (based on 2008 deaths) may be avoided by eliminating inactivity

<table>
<thead>
<tr>
<th>Countries, by Region</th>
<th>Potential Deaths Averted / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>638 000</td>
</tr>
<tr>
<td>Americas</td>
<td>679 000</td>
</tr>
<tr>
<td>E Mediterranean</td>
<td>525 000</td>
</tr>
<tr>
<td>Europe</td>
<td>812 000</td>
</tr>
<tr>
<td>S E Asia</td>
<td>739 000</td>
</tr>
<tr>
<td>W Pacific</td>
<td>1.5 M</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Countries, by Income</th>
<th>Potential Deaths Averted / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>409 000</td>
</tr>
<tr>
<td>Lower-middle</td>
<td>2.5 M</td>
</tr>
<tr>
<td>Upper-middle</td>
<td>811 000</td>
</tr>
<tr>
<td>Upper</td>
<td>1.0 M</td>
</tr>
</tbody>
</table>

- If physical inactivity were decreased by 25%, >1.3 M deaths/y worldwide may be avoided
- If physical inactivity were decreased by 10%, >533,000 deaths/y worldwide may be avoided
Potential Gain in Life Expectancy

World median = 0.68 y gain

NB: This is gain in POPULATION, not individual, life expectancy

(other studies show active PERSONS live some 2-4 years longer than inactive ones)
### Potential Gain in Life Expectancy

**Countries, by Region**

<table>
<thead>
<tr>
<th>Region</th>
<th>Potential Gain, Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>0.51</td>
</tr>
<tr>
<td>Latin America</td>
<td>0.82</td>
</tr>
<tr>
<td>N America</td>
<td>0.66</td>
</tr>
<tr>
<td>E Mediterranean</td>
<td>0.95</td>
</tr>
<tr>
<td>Europe</td>
<td>0.63</td>
</tr>
<tr>
<td>S E Asia</td>
<td>0.41</td>
</tr>
<tr>
<td>W Pacific</td>
<td>0.90</td>
</tr>
</tbody>
</table>

**Countries, by Income**

<table>
<thead>
<tr>
<th>Income Level</th>
<th>Potential Gain, Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.37</td>
</tr>
<tr>
<td>Lower-middle</td>
<td>0.65</td>
</tr>
<tr>
<td>Upper-middle</td>
<td>0.80</td>
</tr>
<tr>
<td>Upper</td>
<td>0.68</td>
</tr>
</tbody>
</table>

(red represents extremes)
## Some Perspective

<table>
<thead>
<tr>
<th></th>
<th>Inactivity</th>
<th>Smoking</th>
<th>Obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAF</td>
<td>9%</td>
<td>9% (^a)</td>
<td>5% (^a)</td>
</tr>
<tr>
<td>Deaths attributed to risk factor (per y)</td>
<td>5M</td>
<td>5M (^{a b})</td>
<td>3M (^a)</td>
</tr>
<tr>
<td>Potential gain in LE with removal of factor</td>
<td>0.68 y from age 40 (122 countries)</td>
<td>1.1–2.2 y (^c) from age 50 (9 high-income countries)</td>
<td>0.7–1.1 y (^d) from birth (USA)</td>
</tr>
</tbody>
</table>

\(^a\) 2009 WHO Global Health Risks; \(^b\) Ezzati 2003; \(^c\) Crimmins 2011; \(^d\) Olshansky 2005
Individual vs. Population Perspective

Harm to the individual

Harm to the population

Wen et al, Lancet 2012;380:192-3
Estimates are Conservative

• Self-reported physical activity
• “adjustment factor” and RRs based on data mainly from N America and Europe
• Adjusted RRs may be over-adjusted
• Did not use range of RRs to reflect dose-response relationships
• Assumed physical activity to reduce mortality rates only for those 40–79 y

All would lead to conservative estimates
Estimation of PH Burden: Science or Art???

Lancet Physical Activity Series estimate of deaths attributable to inactivity: 5.3 M

Global Burden of Disease estimate of deaths attributable to inactivity: 3.2 M

Where are the missing 2 M???
Health in Arab world

People in Arab countries live longer but face more chronic illness.

Search GBD data

Example Search: Ghana malaria females under 5 death 1990

The GBD Approach

Country Profiles

Data Visualizations

New US$100,000 Prize

The Rolex Prize rewards bold action to improve population health through disease burden evidence. Nominations close March 31, 2014.

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Jobs

IHME is a dynamic, organization with a work environment that is innovative, creative, and highly collaborative. Our vibrant intellectual community is made up of a diverse group of academic faculty, researchers, and staff from around the world drawn to our goal of improving the health of the world's populations. As part of the University of Washington, IHME combines the academic excellence of a university research institute with the independence and entrepreneurial spirit of a non-governmental organization (NGO).

Faculty Openings

- Assistant Professor of Global Health
- Lecturer of Global Health
- Professor

Staff Openings

- Documentation Specialist
- Product Owner, Data Visualizations
- Project Coordinator, Director's Office
- Project Officer, Mesoamerica Project
- Senior Developer
- System Administrator
- Taxonomist
Lancet Physical Activity Series (LPAS) working group

No formal funding
Data Needed for Estimation of PH Burden of Inactivity on Deaths

- How much inactivity is there? (estimation of prevalence of inactivity)
- How bad is inactivity for mortality? (estimation of RR of mortality)
Prevalence of Inactivity: LPAS

- Basic definition: inactive vs. active

- Used empirical data, IPAQ/GPAQ, from 122 countries worldwide

- Used current PA guidelines, which require at least 150 min/wk of moderate-intensity PA, equivalent to 600 MET-min/wk

- Inactive = <600 MET-min/wk
Prevalence of Inactivity: GBD

- More sophisticated: dose-response with 4 levels of PA
- Source of data for estimation unclear: “done with statistical models” using “population surveys”
- 4 levels: <600, 600-3999, 4000-7999, and 8000+ MET-min/wk
- 8000 MET-min/wk is equivalent to ~38 h/wk of walking!
Relative Risk of Mortality: LPAS

• Recall: prevalence of PA defined using IPAQ/GPAQ with 2 levels: inactive (<600 MET-min/wk) vs. active

• Used data from 32 studies in the most recently published meta-analysis for estimating RR of inactive vs. active, as defined above
Physical Activity and All-cause Mortality: An Updated Meta-analysis with Different Intensity Categories

Authors
H. Lollgen1, A. Bockenhoff2, G. Knapp3

Affiliations
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2 Institute of Medical Informatics, University of Essen/Duisburg, Essen, Germany
3 Technological University Dortmund, Faculty of Statistics, Dortmund, Germany

Abstract
In a meta-analysis we investigated the effect of physical activity with different intensity categories on all-cause mortality. Many studies have reported positive effects of regular physical activity on primary prevention. This recent meta-analysis analyzed all-cause mortality with special reference to intensity categories. A computerized systematic literature search was performed in EMBASE, PUBMED, and MEDLINE databases (1990–2006) for prospective cohort studies on physical leisure activity. Thirty-eight studies were identified and evaluated. The presentation refers to studies with 3 or 4 different intensities.

For studies with three activity categories (mildly, moderately, and highly active) and multivariate-adjusted models, highly active men had a 22% lower risk of all-cause mortality (RR=0.78; 95% CI: 0.72 to 0.84) compared to mildly active men. For women, the relative risk was 0.69 (95% CI: 0.53 to 0.90). We observed similar results in moderately active persons compared to mildly active individuals (RR=0.81 for men and RR=0.76 for women). This association of activity to all-cause mortality was similar and significant in older subjects. Regular physical activity over longer time is strongly associated with a reduction in all-cause mortality in active subjects compared to sedentary persons. There is a dose-response relation with more intensive activity.
Webfigure 5: Meta-analyses to obtain the unadjusted and adjusted relative risk of all-cause mortality associated with physical inactivity

Adjusted relative risks:

This meta-analysis pooled multivariable-adjusted RRs from 32 studies. The pooled adjusted relative risk (95% confidence interval) associated with physical activity was 1.28 (1.31–1.36).
Relative Risk of Mortality: GBD

- Recall: prevalence of PA defined using “statistical models” with 4 levels: <600, 600-3999, 4000-7999, and 8000+ MET-min/wk
- Used data from 2 US studies (Nurses’ Health Study and American Cancer Society CPS II Study) for estimating RR’s of: no MVPA, <600, 600-1599 and 1600 MET-min/wk
- These two sets of PA categories do NOT correspond
The Preventable Causes of Death in the United States: Comparative Risk Assessment of Dietary, Lifestyle, and Metabolic Risk Factors

Goodarz Danaei1,2, Eric L. Ding1, Dariush Mozaffarian1,3, Ben Taylor4,5, Jürgen Rehm4,5,6, Christopher J. L. Murray7, Majid Ezzati1,2*

1 Harvard School of Public Health, Boston, Massachusetts, United States of America, 2 Initiative for Global Health, Harvard University, Cambridge, Massachusetts, United States of America, 3 Harvard Medical School, Boston, Massachusetts, United States of America, 4 Centre for Addiction and Mental Health, University of Toronto, Toronto, Canada, 5 Public Health Sciences, University of Toronto, Toronto, Canada, 6 Clinical Psychology and Psychotherapy, Technische Universität Dresden, Dresden, Germany, 7 Institute for Health Metrics and Evaluation, The University of Washington, Seattle, Washington, United States of America

Abstract

Background: Knowledge of the number of deaths caused by risk factors is needed for health policy and priority setting. Our aim was to estimate the mortality effects of the following 12 modifiable dietary, lifestyle, and metabolic risk factors in the United States (US) using consistent and comparable methods: high blood glucose, low-density lipoprotein (LDL) cholesterol, and blood pressure; overweight-obesity; high dietary trans fatty acids and salt; low dietary polyunsaturated fatty acids, omega-3 fatty acids (seafood), and fruits and vegetables; physical inactivity; alcohol use; and tobacco smoking.

Methods and Findings: We used data on risk factor exposures in the US population from nationally representative health surveys and disease-specific mortality statistics from the National Center for Health Statistics. We obtained the etiological effects of risk factors on disease-specific mortality, by age, from systematic reviews and meta-analyses of epidemiological studies that had adjusted (i) for major potential confounders, and (ii) where possible for regression dilution bias. We estimated the number of disease-specific deaths attributable to all non-optimal levels of each risk factor exposure, by age and sex. In 2005, tobacco smoking and high blood pressure were responsible for an estimated 467,000 (95% confidence interval [CI] 436,000–500,000) and 395,000 (372,000–414,000) deaths, accounting for about one in five or six deaths in US adults. Overweight-obesity (216,000; 188,000–237,000) and physical inactivity (191,000; 164,000–222,000) were each responsible for nearly 1 in 10 deaths. High dietary salt (102,000; 97,000–107,000), low dietary omega-3 fatty acids (84,000; 72,000–96,000), and high dietary trans fatty acids (82,000; 63,000–97,000) were the dietary risks with the largest mortality effects. Although 26,000 (23,000–40,000) deaths from ischemic heart disease, ischemic stroke, and diabetes were averted by current alcohol use, they were outweighed by 90,000 (88,000–94,000) deaths from other cardiovascular diseases, cancers, liver cirrhosis, pancreatitis, alcohol use disorders, road traffic and other injuries, and violence.

Conclusions: Smoking and high blood pressure, which both have effective interventions, are responsible for the largest number of deaths in the US. Other dietary, lifestyle, and metabolic risk factors for chronic diseases also cause a substantial number of deaths in the US.
Annual deaths attributable to physical inactivity: whether the missing 2 million?

The Global Burden of Disease (GBD) 2010 team (Dec 15, p 2224) estimate that 3.2 million deaths per year are attributable to inactivity. Yet in The Lancet’s Physical Activity Series (LPAS), we estimated 5.3 million such deaths: 5 Why the substantial difference?

There are two key methodological differences between the studies. First, LPAS used data from standardised surveys to estimate the level of inactivity in adults in 122 countries, defining inactive people as those not meeting current guidelines—i.e., 150 min of moderate-intensity physical activity (about 600 metabolic equivalent [MET] min) per week. All others were regarded as active. GBD did not give details on countries that provided inactivity data, but defined four categories: 0, 600-3999, 4000-7999, and ≥8000 MET min per week. It is unclear how these levels were constructed, since ≥8000 MET min per week is equivalent to about 38 h per week of brisk walking.

Second, LPAS estimated the relative risk of mortality in inactive, compared with active, adults by use of available data worldwide, whereas GBD estimated relative risks associated with 0, 600-3999, and 4000-7999 relative risks. LPAS used one that accounts for confounding of relative risks by other health habits. Further, LPAS used 2008 data for deaths (57 million worldwide); GBD used 2010 data (53 million).

Finally, GBD noted that the LPAS estimation might be high since we did not exclude children. This is correct: had we included only those aged 15 years and older, the estimate would have been slightly lower at 4.8 million deaths caused. However, all other assumptions used for LPAS estimates were conservative.

Should disease burden estimations then be deemed worthless? By no means! We echo the imperative for “attention [to be] paid to achieving scientific consensus [that] would greatly improve future assessments.” Let the discourse begin!

We declare that we have no conflicts of interest.

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• LPAS stands by its estimates of ~5 M deaths worldwide each year due to inactivity
• But, we agree that estimation of burden of disease is an inexact science that can be improved
What Next?

Some Ideas for Future Work
Data Needed for Estimation of PH Burden

- How much inactivity is there?  
  (estimation of prevalence of inactivity)

- How bad is inactivity for mortality?  
  (estimation of RR of mortality)

(can ask same question for other health endpoints)
How Much Inactivity is There?

- Better worldwide coverage of PA levels
- Trends over time in PA levels, especially in low-, middle-income countries
- Country- or region-specific data
- Finer categorization (not just 2 levels)
Time Trends in Physical Activity/ Inactivity, VIGITEL Survey

- Leisure-time physical activity
- Transportation physical activity
- Television viewing time

Mielke, Hallal, Malta, Lee; in progress
### PH Burden, by Region and State, Brazil

<table>
<thead>
<tr>
<th>Region</th>
<th>CVD</th>
<th>Type 2 Diabetes</th>
<th>Breast Cancer</th>
<th>Colon Cancer</th>
<th>All-Cause Mortality</th>
<th>Life Expectancy</th>
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<td></td>
<td>PAF</td>
<td>95%CI</td>
<td>PAF</td>
<td>95%CI</td>
<td>PAF</td>
<td>95%CI</td>
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<tr>
<td>All of Brazil</td>
<td>3.29</td>
<td>(1.21-5.44)</td>
<td>4.28</td>
<td>(2.08-6.34)</td>
<td>5.18</td>
<td>(2.41-8.09)</td>
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<td>(1.11-4.96)</td>
<td>3.71</td>
<td>(1.82-5.82)</td>
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<td>(1.94-4.39)</td>
<td>3.5</td>
<td>(1.60-5.15)</td>
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<td>(2.23-7.76)</td>
</tr>
</tbody>
</table>

Rezende, Rabacow, Visconti, Luiz, Matsudo, Lee; JPAH, in press
Years of Life Gained with Different Levels of Physical Activity

How much is enough?

- Walking:
  - 200 minutes/week (28.6 minutes/day)
  - 400 minutes/week (57.2 minutes/day)
  - 600 minutes/week (85.7 minutes/day)

- Running:
  - 100 minutes/week (14.2 minutes/day)
  - 200 minutes/week (28.6 minutes/day)
  - 300 minutes/week (42.8 minutes/day)

Pooled data from >650,000 persons

Moore et al, PLOS Medicine 2012;9:e1001335
How Bad is Inactivity?

• Incorporate dose-response, instead of just dichotomous inactive vs. active

• Currently, data primarily based on US and European studies; need data from low- and middle-income countries

• Sedentary behavior: consider this independently?
Physical Activity and All-Cause Mortality
Dose-Response Relation

Moore et al, PLOS Medicine 2012;9:e1001335
Physical Activity and CHD Dose-Response Relation

Sattelmair et al, Circulation 2011; 124:789-95
Physical Activity and Breast Cancer Dose-Response Relation

Fig. 3 The dose-response analysis between breast cancer risk and moderate plus vigorous recreational activity with restricted cubic splines in a multivariate random-effects dose-response model. The solid line and the long dash line represent the estimated relative risk and its 95% confidence interval. Short dash line represents the linear relationship.

PA guidelines
Physical Activity, Sedentary Behavior and All-Cause Mortality

Most active, but most TV

Least active, but least TV

Moderate-vigorous physical activity (hrs/week)

Hazard Ratio

Television viewing (hrs/day)

< 1  1 to 2  3 to 4  5 to 6  ≥ 7

Conclusions

- Physical inactivity has a major adverse effect on the world’s health.
- Its effect is similar in magnitude to those from established risk factors such as smoking or obesity.
- Decreasing inactivity can substantially improve the world’s health.
- Continued surveillance and research worldwide are needed to monitor efforts to reduce physical inactivity.