New methods for advancing physical activity and food intake assessment for research and public health

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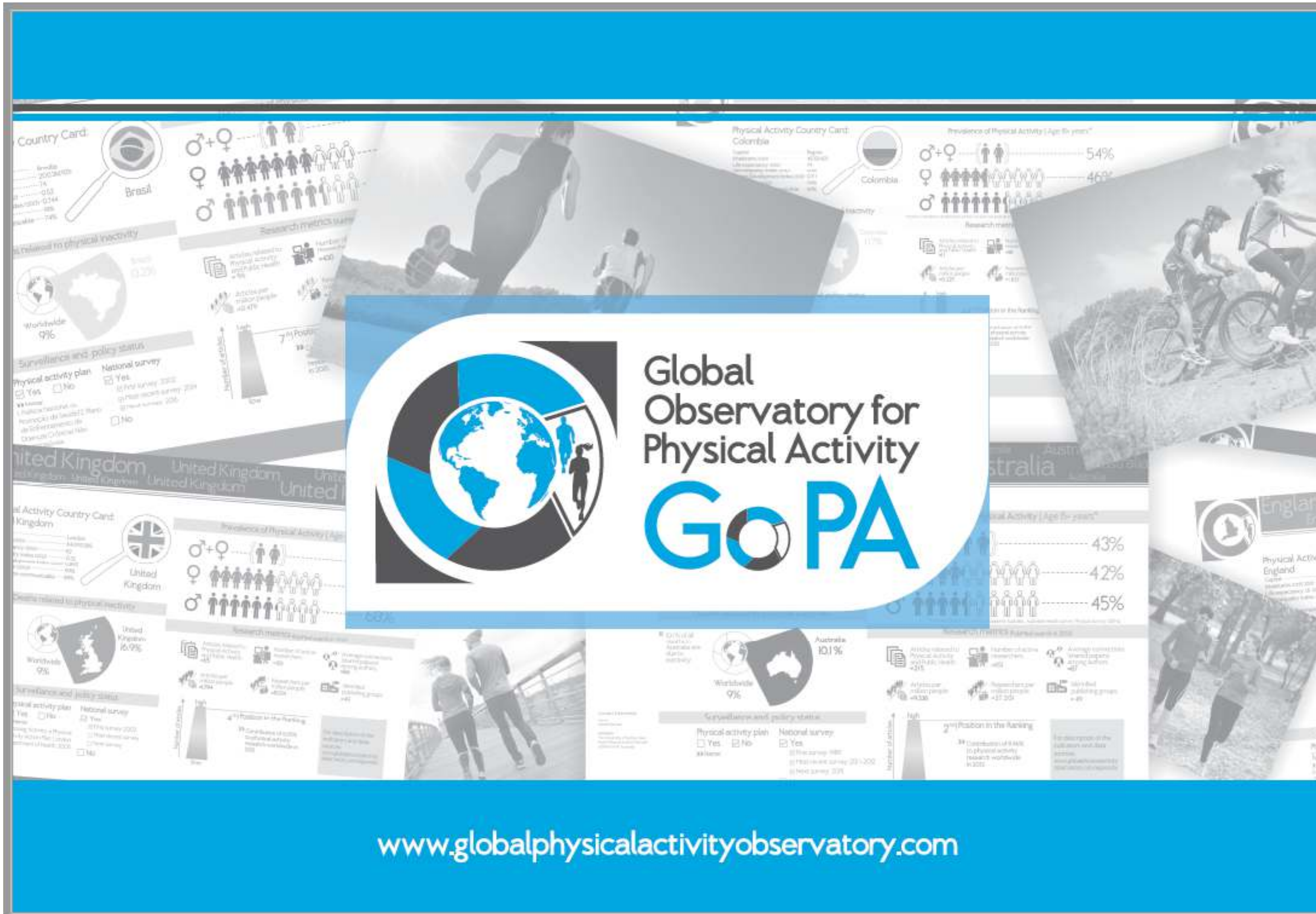
Monitoring physical activity research, policy, and surveillance worldwide



Background

- Rapidly advancing consumer and research technology for assessing diet and physical activity
- Tech Summit: Innovative Tools for Assessing Diet and Physical Activity for Health Promotion, November 2016
- Summary papers in progress focused on adults (McClung, Ptomey) older adults (Kerr), children (Spruijt-Metz)

Traditional dietary measures for field research

- Food records
- 24 hour recall
- Food Frequency Questionnaires (FFQ)
- Doubly labeled water
- Blood metabolomics
- Urinary nitrogen, sodium, potassium

New and emerging dietary measures for field research

- Photo-assisted dietary assessment
- Image-based dietary assessment
- Ecological momentary assessment (EMA)
- Automated 24 hour recall and FFQ
- UPC or grocery store purchase data
- Body worn monitors

Traditional physical activity measures for field research

- Questionnaires
- Diaries and logs
- Direct observation (e.g SOPARC, SOFIT)
- Step counters
- Accelerometers (i.e. Actigraph)
- Heart rate monitors
- Doubly labeled water

New and emerging physical activity measures for field research

- More advanced accelerometers (24 hour wear, different body locations, inclination)
- New analytic approaches based on pattern recognition and machine learning
- GPS
- Multi-sensor devices
- Ecological momentary assessment (EMA)
- Wearable cameras
- Consumer fitness wearables (Fitbit, Jawbone, Apple)
- Smart phone apps

Advantages of new technology

- Reduced reliance on self-report
- Reduced subject burden
- Greater objectivity
- Potential to collect and analyze massive amounts of detailed data
- Early studies of reliability and validity are generally favorable

Challenges of new technology

- Analyzing and making sense of massive amounts of detailed data
- Certain technologies such as cameras and GPS are quite intrusive and pose serious ethical issues
- Rapid pace of technological change poses challenges for standardization essential to good research
- Blurring of the line between consumer and research technology
- Developing study designs and sampling frames appropriate for big data and new technology

Large-scale physical activity data reveal worldwide activity inequality

Tim Althoff[1], Rok Sosič[1], Jennifer L. Hicks[2], Abby C. King[3,4], Scott L. Delp[2,5] & Jure Leskovec[1,6]

To be able to curb the global pandemic of physical inactivity[1–7] and the associated 5.3 million deaths per year[2], we need to understand the basic principles that govern physical activity. However, there is a lack of large-scale measurements of physical activity patterns across free-living populations worldwide[1,6]. Here we leverage the wide usage of smartphones with built-in accelerometry to measure physical activity at the global scale. We study a dataset consisting of 68 million days of physical activity for 717,527 people, giving us a window into activity in 111 countries across the globe. We find inequality in how activity is distributed within countries and that this inequality is a better predictor of obesity prevalence in the population than average activity volume. Reduced activity in females contributes to a large portion of the observed activity inequality. Aspects of the built environment, such as the walkability of a city, are associated with a smaller gender gap in activity and lower activity inequality. In more walkable cities, activity is greater throughout the day and throughout the week, across age, gender, and body mass index (BMI) groups, with the greatest increases in activity found for females. Our findings have implications for global public health policy and urban planning and highlight the role of activity inequality and the built environment in improving physical activity and health.

Physical activity improves musculoskeletal health and function, prevents cognitive decline, reduces symptoms of depression and anxiety, and helps individuals to maintain a healthy weight[4,7]. Although prior surveillance and population studies have revealed that physical activity levels vary widely between countries[1], more information is needed about how activity levels vary within countries and the relationships between physical activity disparities, health outcomes (such as obesity levels), and modifiable factors such as the built environment. For example, while much is known about how both intrinsic factors (such as gender, age, and weight) and extrinsic factors (for example, public transportation density) are related to activity levels, evidence about how these factors interact (such as the influence of environmental factors on older or obese individuals) is more limited[8]. Understanding these interactions is important for developing public policy[9,10], planning cities[11], and designing behaviour-change interventions[12,13].

The majority of physical activity studies are based on information that is either self-reported, with attendant biases[14], or is measured via wearable sensors, but limited in the number of subjects, observation period, and geographic range[15]. Mobile phones are a powerful tool with which to study large-scale population dynamics and health on a global scale[12,16], revealing the basic patterns of human movement[17], mood rhythms[18], the dynamics of the spread of diseases such as malaria[19],

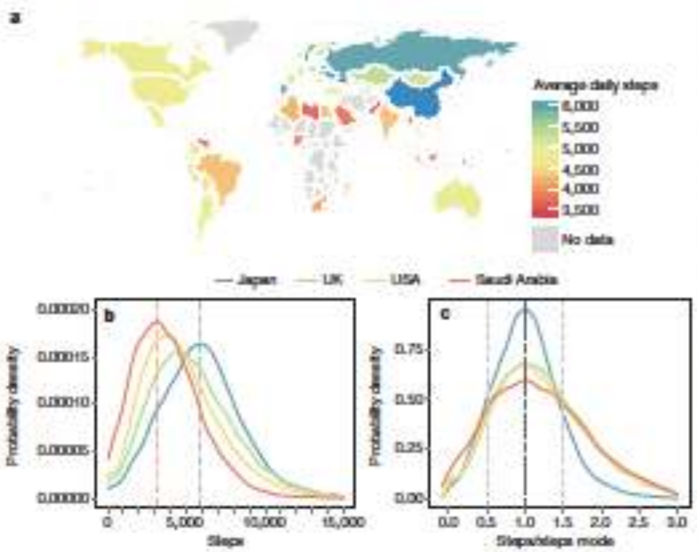


Figure 1 | Smartphone data from over 68 million days of activity by 717,527 individuals reveal variability in physical activity across the world. a, World map showing variation in activity (mean daily steps) between countries measured through smartphone data from 111 countries with at least 100 users. Cool colours correspond to high activity (for example, Japan in blue) and warm colours indicate low levels of activity (for example, Saudi Arabia in orange). b, Typical activity levels (distribution mode) differ between countries. Curves show distribution of steps across the population in four representative countries as a normalized probability density (high to low activity: Japan, UK, USA, Saudi Arabia). Vertical dashed lines indicate the mode of activity for Japan (blue) and Saudi Arabia (orange). c, The variance of activity around the population mode differs between countries. Curves show distribution of steps across the population relative to the population mode. In Japan, the activity of 76% of the population falls within 50% of the mode (that is, between the light grey dashed lines), whereas in Saudi Arabia this fraction is only 62%. The UK and USA lie between these two extremes for average activity level and variance. This map is based on CIA World Data Bank II data, publicly available through the R package mapdata (https://www.r-project.org/).

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Crucial Next Steps

- Developing consensus on assessment and analysis methodologies to enhance inter-disciplinary collaborations
- Establishing validity and reliability of new methods in adult, youth, and older adult populations
- Establishing an international working group to evaluate the huge influx of new apps and emerging technologies
- Development of novel biomarkers based on new technological capabilities to increase objectivity of measures
- Bridging between research and consumer wearable technology

Final Key Points

- New technologies are causing public health (population health) and individual health (clinical medicine) to converge
- The distinction between technology and strategies for assessment versus intervention is disappearing
- Researchers and clinicians no longer have exclusive access to or control of data
- The “digital divide” is disappearing as technology becomes more and more available to people and countries of all income levels