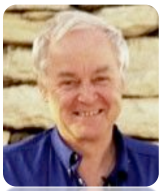
GPS HRN
The GLOBAL POSITIONING SYSTEMS in Health Research Network

NEWS UPDATE

September 2010

New perspectives: Can GPS data help us to monitor human carbon dioxide emission?



Prof Yves Schutz
University of Lausanne
Switzerland

Despite the immense potential of GPS in the field of human research and the exponential rate of scientific publications on GPS since the end of the 20th century, we should think about GPS applications that go beyond our specific research needs. We know, first, that the integration of GPS with other techniques remains the cornerstone of human research, and second, that we need to extract the maximum amount of information from GPS measurements and (re)think about the utilization of GPS data already collected for subsequent modelisation.

Integration of different techniques is not new for human GPS applications: accelerometers, inertial sensors and heart rate monitoring constitute ideal complementary techniques for better understanding the fine tuning of daily physical activity (PA). For example, investigators interested in free-living PA over several days have often used heavy water (D_2O^{18} isotopes) as the criterion standard for validating a number of accelerometers. Note that isotopes are stable and emit no radiation, a great advantage from an ethical point of view. This technique allows one to inconspicuously measure CO_2 production in man over several days from the differential turnover rates of water & CO_2. Carbon dioxide production is useful both to calculate energy expenditure (and to confront the later value to the PA profile based on GPS) as well as to quantify the human contribution to greenhouse gas (GHG). Sensing global and regional climate change using the satellites is already possible. In the context of harsher climate change targets, we need to ask ourselves whether our GPS technology may contribute to give useful information for preventing excess greenhouse gas.

Monitoring daily physical activity of humans on this planet by GPS should not remain a dream. As a result, the total energy requirement of various groups of populations can be estimated and monitored. As shown on the Figure below, by knowing the speed of displacement, the slope of terrain (objectively assessed by GPS), the body weight of the subject & assuming an average energy efficiency factor, simple modeling permit to calculate O_2 consumption, CO_2 production & the net energy expenditure related to the task performed, without using indirect **(cont.)**

Note from the editor

Hello everyone

This issue of the GPS-HRN newsletter opens with a thought-provoking article about monitoring CO_2 emissions from the Chair of the GPS-HRN, Prof Yves Schutz from the University of Lausanne. Assoc Prof Daniel Rodriguez from the University of North Carolina at Chapel Hill has also contributed an excellent article that discusses the identification of walking trips using GPS data. His research group is featured in the regular member profile section.

In other news, the organisers of the 2011 Active Living Research Conference have announced a concurrent oral session on GPS methods with a focus on youth. Additional GPS-related events will also be scheduled; these will hopefully include a GPS-HRN auxiliary meeting following the conference. Watch this space.

I would also like to draw your attention to the recently released book *Obesogenic Environments* edited by Dr Amelia Lake, Tim Townshend, and Dr Seraphim Alvanides. It features contributions from several of our members and is an excellent read (I have my copy already). More information (including a discount for GPS-HRN members) can be found on the News page of the GPS-HRN website (www.gps-hrn.org).

As always, if you come across any GPS-related news, updates, or recent publications, please don't hesitate to post them on the website.

All the best

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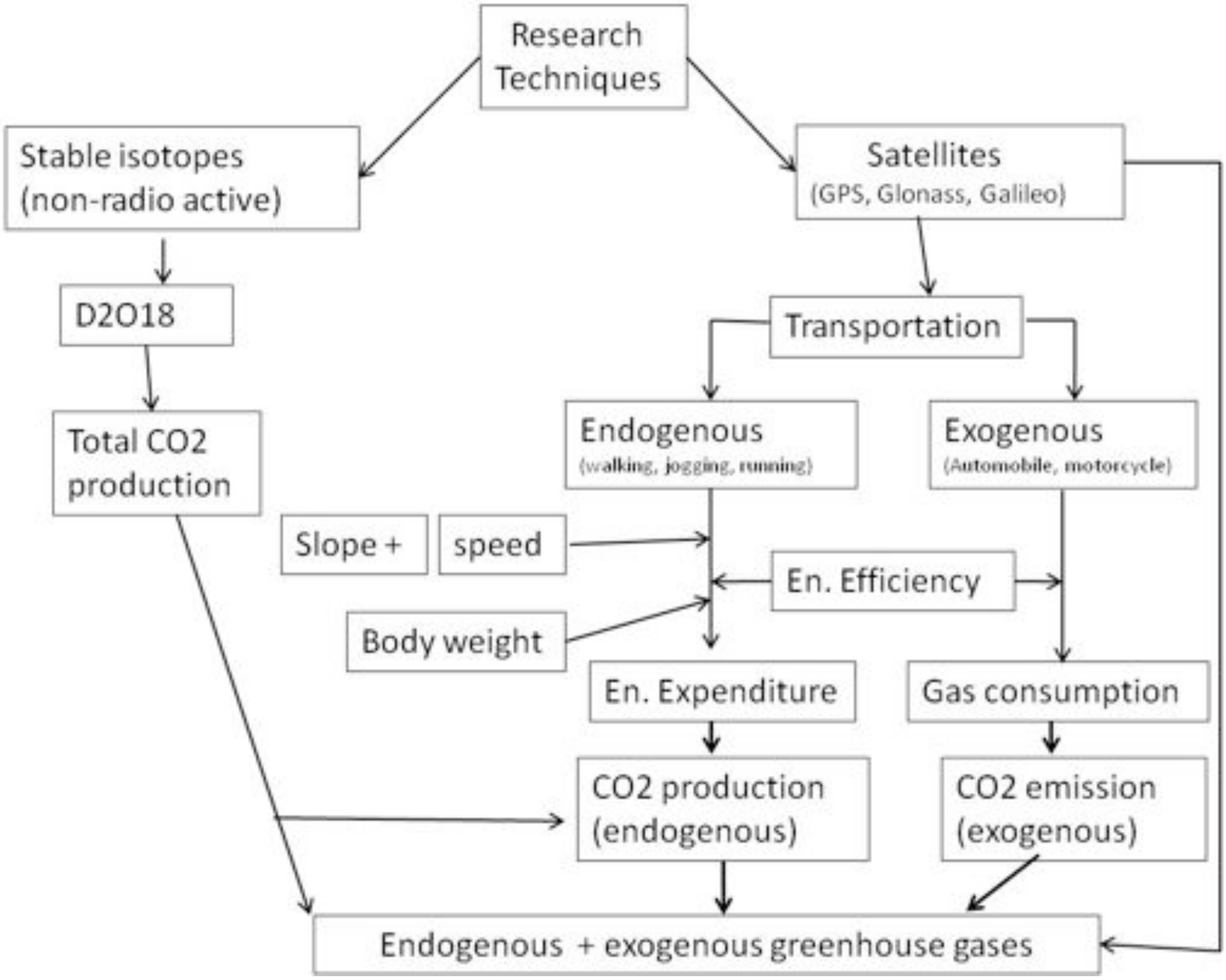
calorimetry (i.e., without face mask or mouthpiece to collect expired air).

Transportation remains a key feature of physical activity. As shown on the Figure, it can be defined as exogenous (car, motorbike, bus...) vs endogenous (walking, jogging, running...). Both processes produce CO_2, emitted from the car combustion engine or endogenously produced by humans in the general metabolism. To illustrate this issue, let's calculate the net energy cost of transportation between a car & a walking subject in terms of energy expended and CO_2 emission/production. An average women expending 2,000 kcal/d would consume 480 liters of O_2 and produce 400 liters of CO_2 over 24 hours.Note that CO_2 produced from enteric fermentation is not considered. Let's now compare the CO_2 emission of an average automobile (1,000 kg with one occupant, with an average emission of 180g CO_2 per km, with the endogenous CO_2 production of an average walking woman (60 kg), walking at a speed of 5 km/h (as measured by GPS). We find that the difference is enormous: 90 liters CO_2 per km in the vehicle vs 5-6 l/km in the human. However, when the results are expressed per kg object (respectively human) moved viz. as a net value (above resting), the difference in energetic cost of transportation between the two situations appears to be almost negligible in our example: 90 ml CO_2 emission per kg per km for the car vs 92 ml CO_2 production per kg in the woman. For the latter, it corresponds in terms of energy to roughly 0.5 kcal burned per kg body weight and per km walked.

This demonstration shows that the CO_2 produced by humans on the earth is not negligible. Let's note, to be honest, that the average distance performed by a car per day is way out as compared to the limited distance walked by an average subject.
Two conclusions may be drawn: first, the utilization of D_2O^{18}, as a complementary technique to GPS, has never been used for it's primary goal, which is the measurement of CO_2 production. Rather the data are usually transformed into in energy expenditure that involves much more error. Second, raw GPS data accumulated for a specific research purpose (say, distance walked and average speed) may still be well rediverted for other purposes, using pertinent simple modeling. In the example above, this may bring new insight into the concept that the total CO_2 produced by mankind, also contributes to greenhouse gas, and must be accounted for in the actual holistic ecological model of carbon footprint.



Using GPS to identify walking trips

Assoc Prof Daniel Rodriguez
University of North Carolina at Chapel Hill
USA

Outdoor behavioral patterns have long been an important subject among researchers in the fields of exercise science, transportation, parks and recreation, and planning. In particular, walking is recognized as not only a travel mode, but also an important leisure activity with positive health implications.

As research on walking has increased, the quality of collected data has gained currency as a focus of research. Accurate measurement of walking makes it easier to identify dose–response relationships between walking and health variables. However, direct observation and self-report methods such as surveys and diaries, while relatively easy to administer, inevitably engender reporting errors. Objective instruments such as pedometers and accelerometers increasingly are valued as a source of more accurate information on intensity and duration of walking behavior.

Portable Global Positioning System (GPS) technology provides an innovative means of adding contextual information to other measures of travel behavior. The unique ability of GPS units to provide data not available from other devices may yield a greater understanding of how various environmental attributes correlate with behavior. Studies with pre-defined pedestrian routes or activity schedules have demonstrated that the combination of GPS and accelerometer data can predict more than 90% of trip modes accurately, while GPS data alone may be sufficient to correctly classify 90% of physical activity (PA) bouts as walking or rest.

However, studies combining GPS and accelerometer data have not satisfactorily dealt with walking in free-living conditions. Beyond the focus on vehicle-based trips and use of algorithms with pre-defined pedestrian routes or activity schedules, limitations include complex time- and labor-intensive routines requiring proficiency with Geographic Information Systems (GIS).

Our research team at the University of North Carolina at Chapel Hill developed and tested algorithms to identify outdoor walking trips solely from portable GPS units in free-living conditions. For calibration, we determined the best algorithm from 35 person-days of data, using measures of agreement between diary-reported and GPS-identified trips (number, duration). To validate the method, we applied the best algorithm to 136 other person-days of diary and GPS data.

The preferred algorithm in the calibration phase resulted in 90% of trips identified from the GPS data being found in the diary, whereas 81% of trips reported in the diary appeared in the GPS data. This preferred algorithm used (1) a maximum 3-minute gap between points to define a trip, (2) five or more minutes of continuous GPS points, (3) speed ranging from 2.0 to 8.0 km/h, (4) at least 30m of displacement between the start and end points of a trip, and (5) merged walking trips when the time gap between trips was less than 3 minutes. Applied to the validation data, the algorithm found substantial agreement between the GPS data and the diary, with 86% of GPS-identified trips found in the diary and 77% of trips in the diary appearing in the GPS data. The algorithm successfully identified free-living walking trips lasting more than 5 minutes, suggesting that the ability to identify outdoor walking trips using GPS data improves with shorter recording intervals in the GPS units and more closely monitored compliance. The algorithm will be useful for those interested in walking activities and their contextual information by showing where, when, how long and how frequently walking trips occur. Improvements in GPS technology are likely to increase the ability to detect shorter-duration trips.

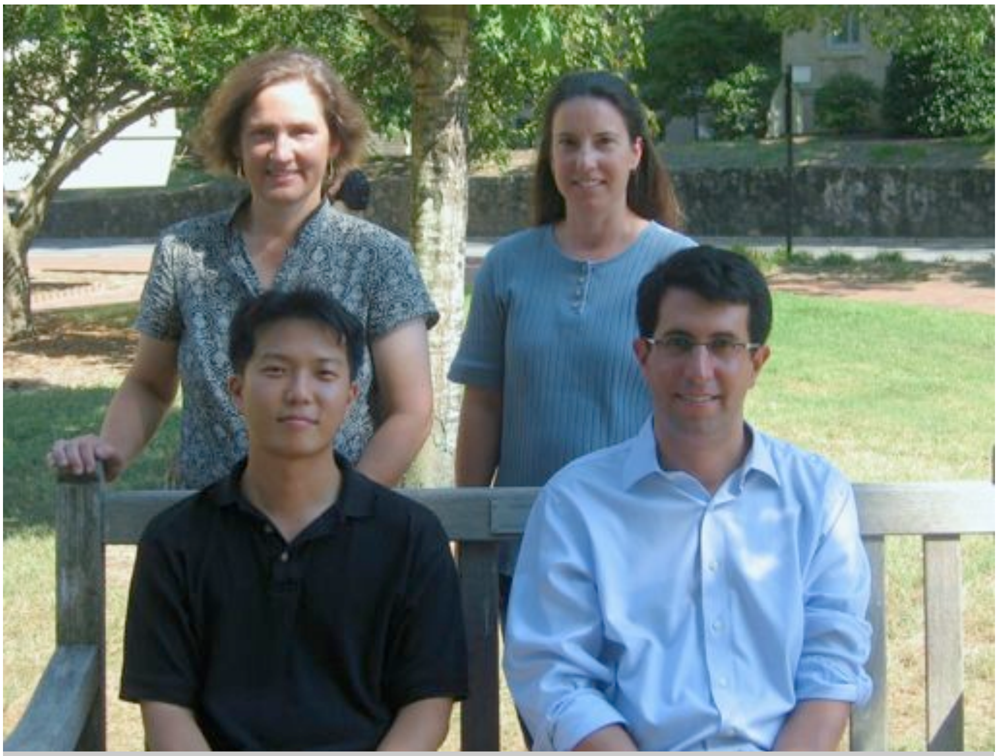
The algorithm might be improved in several ways. Relaxing the speed range would reduce the number of cases where diary-reported trips are not identified by GPS, although the reverse (GPS-derived trips not reported in the diary) would increase. Our results and previous studies suggest it may be preferable to use accelerometers with a pedometer function concurrently, obviating the cutoff point of the speed criterion and increasing accuracy in identifying type of activity.

We are working on further research determining whether detection of walking can be improved by having participants wear an accelerometer in addition. Using a convenience sample of high school girls (N=51; 26 participants in California and 25 in Minnesota) in 2007, we fitted participants with both a GPS unit and an accelerometer, and recorded their travel for six days. We examined agreement in the number of walking trips with Kappa statistics, and agreement in locations visited by walking with GIS. We found moderate agreement between the number of walking trips as recorded by the GPS/accelerometer combination and those reported in the diary. Comparison of reported locations reached by walking and GPS data suggest that locations and establishment names reported in the travel diary are accurate. Use of GPS and accelerometers is promising for understanding the influence of contextual factors on behavior and should be replicated with larger samples. Other strategies to improve detection of walking using GPS include reducing the recording interval on the GPS units, and checking respondents' compliance with the protocol.

Preparation of this article was funded by the Robert Wood Johnson Foundation through its national program Active Living Research (ALR) and by NIH/NHLBI grant # R01HL71244.

Member profile

Using GPS to investigate active environments at UNC—Chapel Hill, USA



Clockwise from top left: Dr Elizabeth Shay, Assoc Prof Kelly Evenson, Assoc Prof Daniel Rodriguez, Gi-Hyoug Cho.

Merging objective and self-reported measures of travel behavior is a common theme running through a series of research projects at the University of North Carolina at Chapel Hill (UNC-CH). A multi-disciplinary team has demonstrated the viability and validity of combining portable Geographic Positioning System (GPS) and accelerometry (used to measure physical activity) data with self-report measures to investigate travel behavior and physical activity (such as walking and bicycling), and how they correlate with contextual variables of the natural and built environments. In the past decade, this diverse but well-coordinated group has published research papers and reports relating to physical activity, active travel, and their environmental correlates, and presented the work at conferences and workshops. Funding for the work has come from a variety of sources, including Robert Wood Johnson Active Living Research and the National Institutes of Health.

Dr. Daniel Rodriguez and Gi-Hyoug Cho (City and Regional Planning), Dr. Kelly Evenson (Epidemiology), and Dr. Elizabeth Shay (Institute for the Environment) with other collaborators at UNC-CH and at other institutions, have generated methodological advances in coordinating and implementing GPS and accelerometry to advance the use of objective measures of walking in free-living conditions. They also developed and tested innovative measures of the built environment for use as variables in models of travel mode choice, trip generation, physical activity outcomes such as bouts and minutes of moderate and vigorous physical activity (MVPA), and indicators of sedentary behaviors.

Another methodological innovation to emerge from this team is the Spatial Activity Data Processor (SADP, authored by Tracy Hadden Loh), which cleans GPS data files collected with Garmin Foretrex and Qstarz GPS units, analyzes text files from accelerometers, and merges the GPS and accelerometer data into a single data file, identifying and summarizing the results in easy-to-use text files. The program runs for both single and multiple batches of data and was written in Java, so it's compatible with most computers available today. This tool is available at no cost to interested researchers, by contacting Dr. Rodriguez at danrod@unc.edu.

In addition to these methodological gains, the research has generated fresh empirical findings. The team's work in Montgomery County, MD found a positive association between physical activity and residence in an urban neighborhood, whether self-reported or measured as objective counts of minutes and steps. This study demonstrated the importance of understanding the physical environmental context within which individuals choose to engage in physical activity.

Accelerometry and portable GPS technology also were applied in a longitudinal observational study of youth travel (trips and modes), environment, physical activity, and diet known as the Trial of Activity in Adolescent Girls 2 (TAAG2). Approximately 300 high school participants at two sites (San Diego, CA and Minneapolis, MN) carried both GPS and accelerometer units and kept a location log (Neighborhood Places Log). The GPS and physical activity data were merged and compared with diary entries. The multi-year study first validated new measures and reliability-tested instruments before moving on to the implementation and subsequent data analysis stage. Among others, the GPS and accelerometer combination enabled the analysis of walking routes that girls took relative to other routes they could have taken. To date, such analyses for pedestrians were possible only with self-reported data. The TAAG2 study illustrates the power of combining data on the physical and social environment, physical activity, and diet to better understand how and where youth are active, how they travel among major destinations (home, school, and other places), and how these patterns might change as adolescent girls reach key milestones, such as driving age.

The combination of objective and self-report data also was used in the Systematic Observations of Play and Recreation in Communities (SOPARC) Study, which combines 1) scans of physical activity occurring in recreational areas (e.g., facilities such as tennis courts) and associated attributes (e.g., availability, usability), with outcome variables including number of participants, their observed socio-demographic characteristics, and physical activity type and levels, and 2) self-reported and objectively measured park use and physical activity in several hundred individuals fitted with GPS and accelerometry units over a 3-week period. This project is being implemented in five U.S. locations and will wrap up data collection in fall 2010.

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Technology update: QStarz announces two new portable GPS receivers

QStarz BT-Q818XT

Key features (from QStarz website):

- 10Hz update rate: Update GPS satellite data per 0.1 second
- 66-Channel Performance for fast acquisition and reacquisition
- Super high sensitivity -165dBm adopting latest MTK II chipset
- Lower power consumption up to 42hrs navigation time
- Fast position fix: cold start 35 s, warm start 33s, hot start 1s
- • G-Mouse + Bluetooth in one: wired and wireless GPS receiver

QStarz QTracker

Key features (from navigadget website):

- Real time tracking: SIM card installed into the device that, when called, sends a text message back with a link to Google Maps
- Sends text when the battery is low
- Runs on GSM frequencies 850/900/1800/1900 MHz
- MTK II chipset capable of tracking 66 satellites
- Charges via mini USB in 3 hours
- Powers off automatically to save battery life

Recent GPS Publications

ORIGINAL ARTICLES

Gi-Hyoug Cho, Daniel A Rodriguez & Kelly R Evenson

Identifying Walking Trips Using GPS Data

Medicine and Science in Sport and Exercise, 2010, (published ahead of print).

Ben W Wheeler, Ashley R Cooper, Angie S Page & Russell Jago

Greenspace and children's physical activity: a GPS/GIS analysis of the PEACH project

Preventive Medicine, 2010, 51(2), 148-152.

BOOK

Amelia A Lake, Tim G Townshend & Seraphim Alvanides (ed.)

Obesogenic Environments: Complexities, Perceptions and Objective Measures

West Sussex: Wiley-Blackwell

ISBN 978-1-4051-8263-8

IPEN
INTERNATIONAL PHYSICAL ACTIVITY AND THE ENVIRONMENT NETWORK

IPEN was launched by Professor Jim Sallis (USA), Dr Ilse DeBourdeaudhuij (Belgium) and Professor Neville Owen (Australia) at the International Congress of Behavioral Medicine in Mainz Germany in August 2004.

Physical activity habits are determined by multiple levels of influence – personal, family, social, environmental, economic and other factors. Ecological models of health behaviour have been used to synthesize research at these different levels, and to focus attention on relationships of particular physical activities with specific attributes of physical environments, including the built environment.

While physical activity environments will vary within countries, the greatest and most informative sources of variation in the relationships of environmental attributes with physical activity are likely to be between countries. The IPEN initiative seeks to stimulate, inform, and support systematic and rigorous studies of physical activity and the environment, in as many countries as possible.

Please contact Jacqueline Kerr (jkerr@ucsd.edu) or Nicole Bracy (nbracy@projects.sdsu.edu) if you would like more information.

www.ipenproject.org

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