

Commentary

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Why combine diet and physical activity in the same international research society?

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Abstract

Research in diet and physical activity in the U.S. started in very different traditions, with behavioral science input being uneven in their development. Investigators and policy makers in Europe have recognized the complementarity of diet and physical activity and incorporated them both under the label Public Health Nutrition. Joining these disciplines internationally offers the opportunity to benefit all, since the problems addressed are human, not specific to any one country.

In regard to why combine diet and physical activity, at the biological level, there is reason to believe that diet and physical activity working in concert can remodel physiological structures and processes toward healthful ends. The diet and physical activity behaviors themselves vary in characteristics and are similar in others. The behavioral science components of these two disciplines face similar problems, and can learn from the advances made by the other, in the areas of measurement, correlates and intervention. By working together, knowledge will be enhanced from uncovering complementary and interactive relationships between diet and physical activity, and in relation to disease risks, that may result in designing more effective and efficient interventions and policies.

Since the behavioral sciences are at a disadvantage in comparison to the biological sciences in terms of scientific advances and thereby capturing the popular imagination for solutions to health problems, we must redouble our efforts to enhance funding for behavioral research in regard to diet and physical activity and to make the research advances necessary to prevent the medicalizing of essentially social and behavioral problems. Nutrition and physical activity should most effectively do this together.

Introduction

The International Society of Behavioral Nutrition and Physical Activity (ISBNPA) aspires to be truly international and combine the efforts, expertise and insights from the behavioral oriented professionals in two formerly disparate professional domains: diet (or nutrition) and physical activity (PA) (or exercise). Two issues are addressed: Why should this society be "International"?

and Why combine diet and physical activity? These issues are obviously addressed from the limited perspective of one person raised in one country.

Discussion

Why should this Society of Behavioral Nutrition and Physical Activity be International?

Eating and physical activity are behaviors in which all humans must engage everyday (or almost everyday) for survival. This fact has led to enormous diversity in these behaviors around our planet, as influenced by local geographic, meteorological and cultural factors [1]. Studying these influences across nations should lead to important insights into why and how we behave in these ways. Dramatic changes are occurring in these behaviors (e.g. the introduction of fast foods and automobiles in lower income countries) throughout the world, thereby providing even more opportunities for research into understanding diverse influences on diet and physical activity.

Progress in understanding the influences on diet and physical activity behavior appear to be most advanced in Europe [2,3]. Investigators in North America can learn much from their advances in behavior models. More money has been available in the U.S. for developing and evaluating intervention programs. Investigators elsewhere can learn from these advances.

Hunger, obesity, heart disease, cancer, diabetes and other health problems related to diet and physical activity are human problems, occurring in every country on Earth. Although the way in which these problems manifest in a particular country may vary by the nationally idiosyncratic combination of circumstances, the resulting health problems have the same devastating effects. The solutions also will likely be similar across countries, since many of the underlying causes are behavioral.

The U.S. has already entered the epidemic of obesity [4], and the causative factors getting here may not be ascertainable from historical documents. Other countries, alternatively, appear to be in a transition to such an epidemic [5]. Well-designed studies may elucidate the primary causative factors in those transitions, [6] which will facilitate more targeted policies in those countries, but also may promote insights into the etiology in the U.S. Some countries have initiated policies that appear to have stopped progression toward an obesity epidemic [7]. Perhaps principles from those programs can be applied elsewhere.

Industry provides many of the food products consumed and the artifacts that minimize physical activity (e.g. automobiles, televisions, computers). Most of these companies are parts of very large transnational conglomerates. Free trade policies across national boundaries have been advocated to enhance commerce and the generation of wealth, but with as yet unknown influences on diet, physical activity or health. Multinational studies would be best

positioned to understand how these companies' actions and free trade influence diet and physical activity. Policy to deal with the effects of industries actions are also likely best approached internationally. Effective such policies require the input of many disciplines, another strength of ISBNPA.

The proceedings of a European Public Health Nutrition conference addressed the complementary roles of diet and physical activity in understanding and ameliorating obesity and appetite, nutrient status, glucose-insulin dynamics, lipoprotein metabolism, blood pressure, osteoporosis, cancer, mood, mental health, youthful origins of adult disease and manpower needs [8]. Those of us outside of Europe can learn from their visionary combining of diet and physical activity in a discipline they call Public Health Nutrition [9,10]

The bottom line is that investigators in all countries can learn from the advances of those in other countries. Bringing investigators together under one roof should facilitate that learning. Furthermore, investigators from different countries with different perspectives provide for a more lively and interesting debate of ideas. Those pursuing research on AIDS realized the many benefits of focusing international attention on international problems [11]. We can learn from their example.

Finally, we can have more influence in international forums concerned with diet and physical activity, e.g. the World Health Organization (WHO), the Pan American Health Organization (PAHO), if we are working together.

Why should this International Society combine Behavioral Nutrition and Physical Activity?

The rationale for combining the disciplines of nutrition and physical activity will be addressed in seven categories: a brief history, biological complementarity, similarities in behaviors, cross disciplinary similarities and cross-fertilization in measurement, correlates and intervention, interrelationships between diet and physical activity, and joint policy relevance and survival.

Brief History of Two Disciplines

Physical activity and nutrition research came from different intellectual lineages. In the United States, physical activity research started in Departments of Physical Education in Schools of Education (explaining in part the early receptiveness to behavioral science). The American College of Sports Medicine was established in 1954 with its focus on physical activity and health [12]. The "exercise physiologist" as a health professional emerged in 1975 with the publication of Guidelines for Graded Exercise Testing and Prescription [13]. The exercise psychologist emerged in the 1980's in the American Psychological

Association. Alternatively, nutrition started in Schools of Agriculture (with its emphasis on biology and physiology) at the end of the 19th century. Behavioral and social science appears to have initially entered nutrition through the Agricultural Extension Service and their interest in nutrition education, to convert for the public's benefit the advances made in plant science and basic nutrition research. A better understanding of these historical lineages throughout the world could lead to better understanding our differences and minimizing barriers to effective collaboration in the future.

Biological Complementarity

The U.S. National Institutes of Health (NIH) recently held a conference "The Interaction of Physical Activity and Nutrition, Biological Remodeling and Plasticity" [14], which was designed to explore the linkages between diet and physical activity to physiological processes. Evidence of longer-term physiological change from modification of biological structures through complementary changes in diet and physical activity practices were reviewed in the areas of brain functioning, insulin and glucose regulation, arterial and arterial endothelium functioning, immunology and fetal origins of obesity. Diet and PA clearly have complementary and interactive effects on many physiological parameters to an extent that in addition to energy balance, we may need to consider lipid balance, glucose balance, or even metabolic balance. Interestingly, there were very few biological researchers who were combining diet and PA in their research, despite the substantial promise from doing so.

Research by my colleagues [15] emphasized the complementarity of diet and physical activity in regard to biological processes. Several dietary variables predicted a composite indicator of the metabolic syndrome, including alcohol, meat, and sweetened beverages, with fruit, juice and vegetable intake and several other dietary varia-

bles were marginally significantly predictive. When physical activity was added to the model, only total energy, alcohol and fruit and vegetables were predictive [15]. Thus, adding physical activity to a model changed the relationships of diet to metabolic syndrome. This suggests that diet and physical activity are interdependent and more epidemiologic research would benefit from including both diet and physical activity in their predictive models.

Similarities and Differences in Behaviors

Behaviors tend to have at least eight defining characteristics: type of the behavior (e.g. walking, eating doughnuts), amount, duration, frequency, consistency over time (e.g. day to day variability), periodicity over time (e.g. seasonality), and location in time, place, and social milieu. Diet and physical activity tend to be different on some of these characteristics, but similar in regard to others. In regard to type, there are obvious differences in that one is an ingestive behavior which varies on food(s) or nutrients consumed, while the other is an energy expenditure behavior which varies by the many types of physical activity. But the disciplines are similar in regard to the huge diversity of types of behaviors in each category. In regard to amount, diet can be measured by physical quantities of foods (e.g. servings, gms), calories or specific nutrients; while physical activity can be measured by indicators of body movement, multiples of basic energy metabolism (METS), or energy expenditure (kcal), with each unit having a different purpose, and conversions being possible within and between disciplines. In regard to duration, meals or snacks can be short (seconds) or long (hours); while bouts of activity can be similarly variable. Both diet and physical activity have substantial day-to-day variability, which enhances dietary and PA diversity (a good thing), but impairs reliability of assessment [16,17]. Both behaviors have seasonal components [18], with both

Table 1: Types of measurement methods by type of behavior and time period.

Time Period	Diet	PA
24 hours	24 hr. recall (14) 24 hr. food recognition (15) Observation (19)	24 hr. recall (12) 24 hr. physical activity recognition (16) Observation (17-18)
Week	7-day food record (20) 7-day food frequency (21)	7-day activity recall (14)
Longer (months, years)	Food frequency (22-23)	Many activity inventories (14)
Technology Assisted for Variable Time Units	Food Intake Recording Software System (24) Camera (33-35)	Activitygram Accelerometer (30) Pedometer (29-30) Heart Rate Monitor (31-32)
Biomarkers for Variable Time Units	Doubly labeled water (25)	Serum nutrients (26, 28)

being due in large part to weather. However, the effects of weather on agricultural production, and thereby local food availability, have been mitigated by international transport across hemispheres which makes many foods almost ubiquitously available (at least in the U.S.), and the effects of weather on activity have similarly been mitigated by indoor activity equipment (e.g. treadmills, stair climbers, etc.) and fitness centers. In regard to location in time, meals and snacks tend not to occur at the same time as bouts of physical activity for the same individual (except for beverage intake usually to maintain hydration, or to add calories, during long duration activities). Meals, snacks and physical activity tend to be able to occur at almost any time of the day or night, with patterns varying by individual. In regard to location in place, dietary intake tends to more likely occur in eating places (e.g. kitchens, dining rooms, restaurants), while physical activity tends to occur in activity places (e.g. gyms, fitness centers, outside), but each behavior can and does occur in the other's usual locations. Finally, in regard to location in the social milieu, who's present at eating and physical activity will vary by gender, age and other characteristics of the person of interest. For some ages the social environment may be similar for diet and PA (e.g. very young children, advanced seniors), but not for others (e.g. middle aged office workers who exercise at a gym). Thus, there are many differences and similarities between the behaviors. Neither discipline has simultaneously assessed all these dimensions. Some of these dimensions may be useful in better understanding the influences of these behaviors on health outcomes, e.g. seasonal (time) variability, which is not usually captured in existing measures. Some may help better understand the behavior, e.g. just being outside (location) led children to being almost twice as active as being inside [18]. The complexities of each behavior have also led to difficulties in measuring each behavior. The similarities have predisposed to similar approaches to measurement and research on correlates and intervention. Bringing investigators from these two disciplines together should enable those making advances in some of these dimensions to enhance the efforts of those in the other discipline and vice versa. Investigators attempting to address influences on both diet and PA may need multiple dimensions to adequately address both. This should lead to advances in theory and methods on both sides.

Cross Disciplinary Similarities and Cross Fertilization in Measurement

Diet and PA face many of the same problems in measuring their respective behaviors and have developed similar measurement procedures. One domain can learn from the measurement advances made in the other. As recognized above, the complexity of the behaviors (types, durations, amounts, frequencies, locations, etc) leads to the difficulties in measuring them, but inattentiveness to the behav-

ior on the part of the reporter has also been noted in diet and PA, unless the behavior is highly unusual [19,20]. Additional errors are encountered in converting foods to nutrient intakes [21] and converting physical activities to MET values or energy expenditures.

The methods devised to measure these behaviors have been highly similar (Table 1). For measuring behavior for a 24-hour period, both fields devised 24-hour recalls [20,22], recognition forms [23,24], and observation methods [25-27]. For measuring behavior over a week, nutrition employs 7-day food records [28] or 7-day food frequency questionnaires [29], while physical activity devised the 7-day activity recall [20]. For longer periods (months, years, "usual"), there are a variety of food frequency questionnaires [30,31], and corresponding quite varied activity assessment questionnaires [20]. Both fields have generated computer based assessment programs for the previous day, or multiple days e.g. the Cooper Clinic's Activitygram and the Food Intake Recording Software System, [32]. Both fields have used biomarkers, e.g. doubly labeled water to assess energy expenditure [33], and serum nutrient markers of dietary intake [34]. Interestingly, while doubly labeled water is a precise measure of total energy expenditure it may not be accurate for estimating activity related energy expenditure because estimates of the other components of energy expenditure (which must be subtracted from total energy expenditure to get activity energy expenditure) are fraught with error [35]. Similarly, serum nutrient values are generally poor indicators of dietary intake because of variability in concentrations of nutrients in foods, bioavailability of these nutrients, differences in nutrient metabolism, hydration and other factors [36].

The physical activity domain has benefited enormously from instruments that record body movements, e.g. pedometers [37] and accelerometers [38], or physiological responses to those movements, e.g. heart rate monitors [39,40], which are not subject to self-report errors. The nutrition domain may learn to use technology solutions, as well. For example, cameras with pictures of foods before and after a meal, and telephone messages of the foods in pictures, all linked by satellite technology provide some hope of technology solutions to dietary assessment [41-43]. Similarly, grocery stores and even schools collect vast quantities of point of service purchase (POSP) data tied to consumer identification cards and numbers. The nutrition domain needs to systematize the collection of these data and develop methods to mine it for objective data collection purposes.

The physical activity domain has developed non-invasive biomarkers of physical activity, e.g. cardiovascular fitness, which work reasonably well among adults [44], but

perhaps not children [45]. Non-invasive biomarkers may be possible in nutrition as well, e.g. smart infrared transcutaneous sensing of serum nutrients [46-48].

Both the diet and physical activity domains would also benefit from improved measurement of the psychosocial variables of interest [49]. There have been problems of large numbers of items needed to measure scales, low reliability of scales used and an inability to equate instruments across studies. Item response theory (IRT) offers stronger statistical models underlying the measures, computerized assessment requiring fewer items, item banking offering more hope of greater consistency across studies, and methods for equating measures across studies [50].

Cross Disciplinary Similarities and Cross Fertilization in Correlates

For the most part, physical activity and nutrition investigators have studied the same kinds of correlates, i.e. demographics, physical environment, social environment, and psychosocial variables [49,51-54]. Most of the psychosocial variable models have experienced low levels of predictiveness of diet [51] and physical activity [52], although research in the Theory of Planned Behavior tradition has been very innovative and offers promise of exceeding low levels of predictiveness [55].

Much of the literature on correlates reads as if the investigators assessed their favorite variables and ran some correlations and regressions to see what was related. A small group of investigators of correlates of physical activity [56,57] and of diet [2,3] have taken a more theory testing approach in which specific innovative hypotheses were specified (in advance of data collection) and the studies designed specifically to test these hypotheses. This conceptual approach makes much more interesting science and has led to more predictive models, which in turn holds more promise for designing more effective interventions [51,52].

There has been recent interest in physical environmental correlates of physical activity including availability of resources and facilities in the home and neighborhood, and the ways in which neighborhoods are structured [58]. The nutrition domain could learn from this by more carefully analyzing factors influencing locations of food stores [59], variability in the availability and quality of foods in these stores [60], and variability in the foods available in the homes [61].

Within the nutrition domain, there has been substantial interest in biological influences on dietary behavior, e.g. the genetically determined sensitivity to the bitter tastes found in some vegetables may be negatively associated with the intake of those foods [62]; high levels of circulat-

ing leptin appear to discourage dietary intake [63], although there appears to be an imperfection in that regulatory mechanism in some people [64]. There has been little corresponding interest in biological influences on physical activity. Adiposity offers promise as a limiting influence on physical activity [53]. Differences between people in the extent to which they feel energized or fatigued [65] by the same bout of activity which could be genetically determined [66] may offer other opportunities for advancing this line of inquiry.

Cross Disciplinary Similarities and Cross Fertilization in Intervention

Interventions to change diet and/or physical activity have been mounted in parallel sites: worksites [67,68], churches [69], clinical settings [70], and schools [71]. There has been about equal difficulty in demonstrating effectiveness from the diet [51] or physical activity [52] interventions. At this time there is no reason to believe that changing one of these behaviors is easier than changing the other, nor that any synergy can be attained by changing both together. However, in light of the likely enhanced joint benefits of changing both together, e.g. obesity [72], diabetes prevention [73], efforts to attain such synergy seem warranted.

At this time, the mediating variable model (Figure 1) appears to offer the most promise for promoting change in diet [51] and physical activity [52]. According to this model, interventions change mediating variables, and the change in the mediating variables results in change in the behavior. The mediating variables come from the correlates research and could include personal or psychosocial (e.g. preferences [74], self-efficacy [75,76]), physical environmental (e.g. availability [61]), social environmental [53,54,75], or related behavioral (e.g. skills) variables. Other variables have been demonstrated to moderate the effects of change programs, e.g. gender [77,78]. Of course, any variable found to be a mediator could also act as a moderator [79].

A number of mediating variable analyses have been conducted, demonstrating that the selected mediators accounted for generally small proportions of variability in change in the dependent variables [80]. These analyses are enormously important to elucidate the pathways of effect of the interventions which should be useful to strengthen ensuing interventions by enlarging the effects of the strong mediators, deleting efforts to change non mediators or attempting to enhance the effects of theoretically important variables not demonstrated to be empirically mediating. Both the diet and physical activity fields should learn from the other, once advances are obtained in establishing mediation.

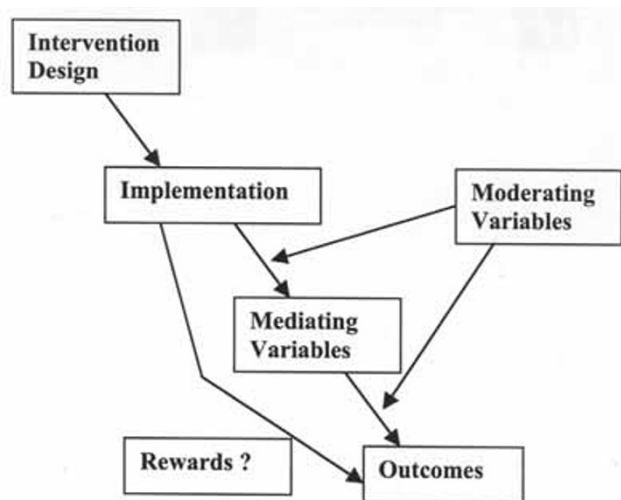


Figure 1
Mediating variable model

To advance or promote the success of mediated interventions, research is needed on the optimal (or any) methods for promoting change in mediating variables [51,52]. At the present time, interventions are most often designed based on intuition or hunch, rather than procedures documented to result in changes in mediators in particular populations in particular circumstances. Procedures to promote change in physical activity self-efficacy should lead to parallel procedures changing diet self-efficacy.

Collaborative Progress: What can the Fields do Together?

Research has revealed that diet and physical activity are interrelated [81]. For example, among 8 to 10 year old African-American girls, levels of moderate to vigorous physical activity were inversely related to percent of kcal of dietary fat ($r = -0.19$), and positively related to percent of kcal from carbohydrate ($r = 0.18$) [82]. Thus, people with healthier physical activity patterns ate healthier. This suggests that changes toward a healthier diet would more easily facilitate healthier changes in physical activity (or vice versa), but in one study there were no relationships between changes in physical activity and changes in diet [83]. However, higher levels of change in one behavior may have been needed to facilitate changes in the other [83].

There has been substantial interest in the tracking of diet and physical activity behaviors across ages, i.e. do children with higher levels of the behavior become adults with higher levels of the behavior. Tracking provides a major portion of the conceptual foundation for intervening with children to prevent adult onset chronic diseases [84]. No

one has analyzed covariability in tracking, e.g. do cases of greater tracking of diet co-occur with cases of greater tracking of physical activity? Do cases of covariability of change in diet and physical activity relate to adult chronic disease risks?

Current national guidelines for diet and physical activity [85-88] tend to address diet and physical activity, but deal with them separately. Perhaps dietary guidelines should be specific to certain levels of activity? From one perspective, it is possible that high nutrient density is most important at low levels of activity since caloric intake should be low and some minimal level of all nutrients are necessary to maintain healthy functioning. Alternatively, it is possible that people at higher levels of activity have higher turnover rates, and higher excretion rates [81], thereby requiring even higher levels of nutrient intake at higher levels of energy expenditure. Except for research among athletes who are interested in exceptionally high levels of physical athletic performance [89], there is little research relating diet and physical activity combined in regard to chronic disease or other health outcomes [83]. Similarly, there is little controlled research on the effects (or not) of following the dietary guidelines or physical activity guidelines, no less combined.

Joint Policy Relevance & Survival

At a recent seminar an advocate of pharmacologic approaches to disease treatment and prevention correctly identified the causes of the recent epidemics of obesity and type 2 diabetes as social in nature, but went on to state that these would be the first social problems that would be solved by pharmacologic agents. This true anecdote highlights the fact that the behavioral and social sciences are engaged in a struggle with our biological/genetic/pharmacologic colleagues for capturing the imagination of the public in regard to what constitutes science, for research funding and ultimately how socially induced health related problems are solved in our society. For example, many physicians are reluctant to promote lifestyle change to treat a health problem because they do not believe people will change their behavior [90]. The first line of prevention of type 2 diabetes among children is metformin [91], despite the Diabetes Prevention Program (DPP) trial showing stronger effects from diet and physical activity in preventing diabetes [92].

The behavioral sciences are at a disadvantage. Pharmacologic agents are often perceived as silver bullets that are relatively low effort, low discomfort, but highly targeted solutions to health problems. On the downside, pharmacologic agents are mostly single mechanism agents, and since many diseases are multifactorial, multiple pharmacologic agents may be necessary to treat the disease,

leading to likely increased side effects, likely increased discomfort, regimen complexity and expense.

Diet and physical activity change, alternatively, involve substantial effort and discomfort (which many people wish not to do). On the upside, however, relatively small changes in a couple of behaviors can have pervasive effects preventing several chronic illnesses, with no aversive side effects. While the behavior changes themselves are relatively personally inexpensive (e.g. substituting water for carbonated beverage intake), the social costs of programs inducing such behavior changes have been expensive with little documented effect to date [51,52].

To my mind this argues that diet and physical activity researchers need to join hands and combine efforts in the areas of research, public advocacy and research funding policy advocacy. The exciting possibilities for collaboration in research were outlined above. In regard to public advocacy, the average consumer who might benefit from our research programs doesn't care what our parent discipline is. They want obesity prevented in the best way possible. Our pharmacology colleagues will be selling the idea that the easiest way to do that is through some new designer drug. Medicalizing what is basically a behavioral problem seems to have many longer-term aversive social consequences [93]. Although scientists often disdain attempts to portray their research in the popular media, more such efforts, and more attractive such efforts need to be pursued to capture the voting public's attention and confidence.

In regard to research funding, in the U.S. the National Institutes of Health have 40 years or so of major investment in biomedical research, thereby facilitating the enormous current breakthroughs in understanding the biology of disease processes and the highly targeted (e.g. at the level of cell receptors) effective treatments. The current NIH appropriation is approximately \$24 billion, with only a small percent going to behavioral research. Thus, there is about 40 years of catch up that needs to be done for behavioral science to have had the ample research resources necessary to make substantial contributions to the nation's health. There are groups of professionals already advocating for increased funding for behavioral research in diet, physical activity and health in general. We must join with them, enhance their effectiveness, and generate and protect increased funding for behavioral nutrition and physical activity in the U.S. and throughout the world.

Conclusions

Research in diet and physical activity started in very different traditions, with behavioral science input being uneven in their development. At the biological level, there is rea-

son to believe that diet and physical activity working in concert can remodel physiological structures and processes toward healthful ends. Investigators and policy makers in Europe have recognized this complementarity of diet and physical activity and incorporated them both under the label Public Health Nutrition.

The diet and physical activity behaviors themselves vary in characteristics and are similar in others. The behavioral science components of these two disciplines face similar problems, and can learn from the advances made by the other, in the areas of measurement, correlates and intervention. By working together, there is ample reason to believe that knowledge will be enhanced from uncovering complementary and interactive relationships between diet and physical activity, and in relation to disease risks, that may result in designing more effective and efficient interventions and policies.

Since the behavioral sciences are at a disadvantage in comparison to the biological sciences in terms of scientific advances, and thereby in capturing the popular imagination for solutions to health problems, we must redouble our efforts to enhance funding for behavioral research in regard to diet and physical activity, and to make the research advances necessary to prevent the medicalizing of essentially social and behavioral problems. Joining forces internationally offers the opportunity to benefit all since the problems addressed are human, not specific to any one country.

What an exciting future we face, together.

List of abbreviations

ISBNPA – International Society of Behavioral Nutrition and Physical Activity

PA Physical Activity

U.S. United States

AIDS Acquired Immunodeficiency Syndrome

WHO World Health Organization

PAHO Pan American Health Organization

NIH The United States' National Institutes of Health

METS Metabolic Equivalent Units

kcal Kilocalorie

POSP Point Of Service Purchase information

IRT Item Response Theory

DPP Diabetes Prevention Program

Competing Interests

None declared.

Author's Contributions

Only one author.

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