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The influence of learning style on the effectiveness of a worksite physical activity intervention in a university setting

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ABSTRACT

The influence of learning style on the effectiveness of a worksite physical activity intervention in a university setting

By Farrah Keong

Purpose: To evaluate the influence of learning styles on the impact of physical activity interventions at the workplace.

Design: The Physical Activity and Lifestyle study was a randomized control trial. Employees from 60 university departments were assigned to five treatment groups.

Subjects: University employees who were physically inactive were followed over 9 months. Only those who completed learning style questions (n=337) were included in these analyses

Main Exposure: Learning style (Assimilating, Accommodating, Converging, and Diverging) type based on the Kolb Learning Style Inventory

Intervention: Intervention components included gym membership, educational materials, or time during work hours to exercise. Participants were randomized to one of five treatment groups: 1) Control, 2) Gym Alone, 3) Gym+ Education, 4) Gym+ Time, 5) Gym+ Education +Time

Outcomes: The primary objective was to examine the effect of learning style on the interventions, measured by change in physical activity (number of days meeting CDC recommendations for physical activity). This hypothesis was tested by examining 1) whether Accommodators and Assimilators would respond more to educational interventions than Divergers, and 2) whether Accommodators would respond more to an intervention than Divergers and Assimilators. A secondary objective was to explore differences in the use of educational materials among Gym+ Education and Gym+ Time+ Education groups by learning style.

Analysis: Longitudinal generalized linear mixed models were used to model the interaction of learning style and treatment group on the outcome physical activity.

Results: The effect of the educational materials was not significantly different from the other interventions for Divergers compared to other learning styles (RR 1.12 (95%CI: 0.96-1.31)). Furthermore, the relationship between Accommodators and other learning styles did not differ for the Gym Alone and Gym+ Time interventions compared to the control (RR 1.10 (95%CI: 0.75-1.60)). There was no difference in the use of the educational materials by learning style. .

Conclusion: No significant effect of learning style on different intervention groups was found, even when learning style characteristics were considered to be aligned with treatment group. In this study, learning style seemed to have limited impact on physical activity. However, interventions which are specifically designed to target learning styles may see different results.

Key Words: Worksite wellness, physical activity, learning styles

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BACKGROUND / LITERATURE REVIEW

Introduction

Physical activity has long been cited as an essential component for overall health and wellness. As defined by the Physical Activity Guidelines Advisory Committee Report, physical activity is "any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level"(1). "Activity" includes both movement to accomplish everyday tasks, from house work to different forms of active transportation (e.g. walking, biking, etc.), and exercise, which is planned, routine activity for the purpose of improving of maintaining physical fitness. Historically there has been a distinction between the types of activity, and earlier studies focused on the health benefits of exercise for physical fitness. However, now emphasis is given to increasing physical activity of any kind because activity in general is associated with positive health outcomes, including increased life-span, improved bone health, and decreased risk for certain cancers, cardiovascular outcomes, and diabetes(2-4).

In a 2012 study, Hallal et al. found the current prevalence of physical inactivity among adults is 31.1% worldwide, with higher inactivity, up to 43%, in developed regions such as North America and South America and parts of Europe(5). They defined inactivity as "not meeting any of three criteria: 30 min of moderate-intensity physical activity on at least 5 days every week, 20 min of vigorous-intensity physical activity on at least 3 days every week, or an equivalent combination achieving 600 metabolic equivalent (MET)-min per week." Examining trends in physical activity from the past 50 years in the United States, Brownson et al. observed an overall trend of decrease in physical activity rates for adults across many categories, most notably regarding work-related and transportation-

related activity(6). A shift to increasingly sedentary jobs and increased reliance on cars for transportation are thought to be a few of the many factors contributing the decrease in physical activity among Americans. While this study examined only data from the United States, these data seem to correspond with trends in other developed and developing nations(5, 6).

Due to increasing concern for the potential health consequences of high rates of obesity, researchers have sought to better understand the mechanistic relationship between sedentary lifestyles and mortality and morbidity as well as factors or correlates that might influence physical activity levels(7, 8). Many public health interventions aimed at obesity and chronic disease prevention include provisions for increasing physical activity. Knowing the mechanisms of action and factors that influence effectiveness is integral to designing and implementing best practice strategies to increase physical activity.

Exploring physical activity itself, researchers have examined the intensity, frequency, duration, and mode of activity to determine whether there is a dose response in disease prevention(1). These factors have influenced the National Guidelines for Physical Activity, which specify the amount and type of activity people should attain for maintenance of health and disease prevention by life stage. For adults, the recommendation is 150 minutes of moderate to vigorous exercise each week, and for children the recommendation is at least one hour of moderate physical activity daily (1).

Additionally researchers have begun to explore how intrinsic and extrinsic features might also influence whether an individual partakes in physical activity. Intrinsic features might include such things as age or gender, while extrinsic features might include the

built environment (i.e. the features of a place such proximity to a park or presence of sidewalks that facilitate or impede activity) or cultural norms (i.e. whether people in one's peer group participate in activity or common types of activity among a group)(9). To better understand the correlates of physical activity, many researchers have looked at interventions in different target populations to determine what features might influence activity levels. Interventions often include an educational component to instruct people about physical activity and wellness. Delivery of the educational materials varies by intervention and can include: one-on-one counseling, group or classroom instruction with a trainer, computer-based learning modules, or written materials (in print or accessible online or through email), or a combination of approaches) (10-12). Using cognitive-based theories to evaluate the effectiveness of such materials has revealed that individual level factors may influence the success of a given physical activity intervention (13). These factors may include stage of change (one's level of readiness to make a change), self-efficacy (confidence in one's ability to make a change), and social support (whether one will receive encouragement from peers to maintain a change) (13, 14).

A further extension of these cognitive theories includes an examination of how people learn, or experiential learning theory, and how learning styles may also influence the effectiveness of educational materials (15-18). The influence of learning style on the effectiveness of educational materials has been applied in other health-related contexts (e.g. health professional school curricula, delivery of health education materials in clinical settings), but little research has focused on how individual characteristics such as learning style might impact the effectiveness of educational materials in physical activity interventions (15-21).

Measurement of Physical Activity

Accurate measurement of physical activity is one of the more challenging aspects of physical activity surveillance and studies, and techniques for measurement can vary greatly by study(5). Surveillance systems, both nationally and internationally, such as the National Health and Nutrition Examination Survey (NHANES) or Behavioral Risk Factor Surveillance System (BRFSS) in the United States, use self-reported levels of physical activity acquired from physical activity questionnaires (22, 23). For global surveillance, the World Health Organization has developed the global physical activity questionnaire (GPAQ), which allows for standardized collection of physical activity data from different countries, thus permitting easy comparisons of physical activity levels between countries (5, 24). Self-reported physical activity behavior, while perhaps not the most robust method of data collection, due to issues with bias and under-reporting of inactivity, is a cost-effective method that easily allows for collection of data especially across a large target population (25).

Use of other measures of physical activity depends on the research goals, and the desired focus -- whether on the individual or population level, or relating to environmental or policy factors. Common measures include pedometers, accelerometers, heart rate monitors, and direct observation, which may provide more objective data. Pedometers are small electronic devices which record the number of steps taken, distance covered, and duration of an activity, but can be limited into the types of activity they can measure. As self-monitoring tools, pedometers have been shown to increase overall physical activity (26, 27). Bravata et al. performed a systematic review of 8 randomized clinical trials 18 observational studies which examined the use of pedometers among adults to increase

physical activity, measured by number of steps per day (27). Among both types of studies, pedometers significantly increased participants' activity by 2491 (95%CI: 1098-3885steps) and 2183(95%CI: 1571-2796 steps) steps per day respectively.

De Cocker et. al. examined the effect of a multi-strategy intervention over 1 year, utilizing pedometers in conjunction with media campaigns and built environment changes, to encourage walking in Ghent, Belgium (28). They randomly selected participants (adults 25-75 years) from population registers in two communities, Ghent and Aalst, recruiting by phone and mail. The Ghent community (n=872) received the intervention, which included media initiatives, online education, sale and loan of pedometers, and marketing walking paths in the community. The community of Aalst (n=810) served as the control. Comparing physical activity at baseline to one year post intervention, De Cocker et al. found that this community intervention increased the mean number of steps per day by 896 steps, and that an additional 8% of people met the recommended 10,000 steps count (28). Since pedometers tend to be less expensive than accelerometers, they remain a popular tool for measuring physical activity with larger population groups. However, due to their limited ability to measure certain types of physical activity, such as circular motion (e.g. cycling) or activities such as swimming, they still may not be able to provide a complete picture of a person's physical activity.

Another objective measurement tool for physical activity is an accelerometer. These devices are more accurate than pedometers because they are better able to measure intensity (by measuring velocity over time) instead of merely frequency and duration of activity; however, they tend to be more expensive (25, 29). Troiano et al. examined physical activity data (by gender and age) from NHANES 2003-2004 from

approximately 7000 people aged 6 and older who wore accelerometers on the hip for seven days and provided a seven-day physical activity recall (25). They utilized accelerometry and recall data to determine the number of people meeting the physical activity recommendations and compared the data types to see whether participant recalls accurately reflected activity measured by the accelerometers. Generally, the number of minutes of activity reported and measured matched; however, the overall intensity of activity measured (vigorous vs. moderate vs. light) was lower than the level reported. Thus, while self-reports indicated that 22-35% of the population were meeting the activity recommendation of 30 min of moderate activity on five or more days per week, this dropped to 3-12% when using accelerometry data (25). These findings suggest that there may be discrepancies between a person's reported level of activity and actual level of activity (25, 30, 31). Since accelerometers are limited in the types of activity they can measure, they may underestimate overall physical activity in some cases (31). When examining activity data using accelerometers, it is important to pay attention to where accelerometers were worn (hip vs. wrist) as measurements can differ based on location of the device (30). Other types of physical activity measurement exist; however, these methods are the most commonly used.

Targeted Interventions

Physical activity interventions have become a popular means of implementing lifestyle changes to improve chronic disease outcomes. Interventions can vary widely depending on a number of considerations including: target audience, life stage, setting for the intervention, measurement of activity, disease conditions, educational components, and use of technology (6-8, 32). Targeting an intervention toward a particular life stage may

be useful because physical activity guidelines are prescribed differently for different groups, for example school age children vs. adults, and it may be easier to find a site which is specific to the target population in which to implement the interventions (schools for children, worksites for adults). The scale of interventions can vary greatly too, with some programs implemented at the community level and others focusing on the individual.

Workplace Interventions

Workplace interventions are a common choice for interventions targeting adults because of the amount of time most adults spend at their worksites. According the U.S. Bureau of Labor Statistics, in 2011 employed U.S. adults spent 8.8 hours per day, five days per week on average performing work-related activities; 91% of these hours are spend at a workplace. In the United States, employer-based health insurance is common. Employers often have a vested interest in the health and well-being of their employees. Meta-analyses examining the effectiveness of workplace interventions have found they can induce small improvements in physical activity levels, depending on the type of intervention used and underlying theory of change employed (11, 33, 34).

A meta-analysis conducted by Conn et al. in 2009, explored the effect of workplace physical activity interventions on physical activity behavior, specific health outcomes (anthropometric measures, lipid levels, diabetes risk), well-being, and work-related outcomes (absenteeism, job stress, job satisfaction), and also assessed whether workplace specific characteristics influenced the effectiveness of the interventions overall (33). The authors examined 137 studies, reported in English between 1969 and late 2007. Although there were overall improvements in health outcomes when comparing the

treatment groups to the control groups (diabetes, anthropometric measures, lipid levels, etc.) the results were largely variable, and the effect size clinically insignificant in some cases. The effect size of improved fitness was equivalent to a 3.5 mL/kg/min difference in VO_{2max} between treatment subjects versus control subjects (Common Language Effect Size (CLES) = 0.66). Similar results were found for work-related outcomes, with the treatment group experiencing lower absenteeism, lower job stress, and higher utilization of health care services. Interventions conducted onsite and during work hours were shown to be more effective that those which encouraged activity after hours or at home. These results suggest that workplace interventions can be successful in improving physical activity, health, and work-related outcomes, but success may depend on the type of intervention and worksite characteristics.

In 2012, Hutchinson and Wilson conducted a meta-analysis of 31 studies of workplace interventions to promote physical activity or dietary changes, examining the theoretical frameworks associated with improvement, and characteristics of studies that encouraged maintenance of changes over time (11). The authors found that interventions which promoted maintenance of changes either in dietary or physical activity behavior at six months included those which focused on cognitive-behavioral or motivational approaches, over social influence. Cognitive-behavioral approaches to physical activity usually consist of methods to increase self-efficacy and to encourage and promote maintenance of activity (e.g. goal setting, skill reinforcement, etc.) (35). An intervention using a cognitive behavioral approach resulted in the largest effect (d=0.90) for a fitness measure. Interventions using motivational enhancement which might consist of

motivational interviewing[1], or providing incentives for behavior changes approaches were also seen to achieve large effects for physical activity (d=2.00 for 2 studies, n=622 total) (11).

Many workplace interventions incorporate both physical activity components and education or behavior counseling (36-38). The International University Walking Project assessed the impact of an automated (delivered by email and website) walking intervention program to increase step counts in five university settings: Baylor University (USA), Queensland University of Technology (Australia), The University of Queensland (Australia), The University of Toronto (Canada) , and the University of Ulster (United Kingdom and Northern Ireland) (39). The project recruited a total of 330 participants from all university sites to participate (n= 53, 47, 112, 43, 75 at each site respectively). At baseline, each participant received a pedometer to monitor step counts throughout the course of the ten weeks, three phase intervention. Each phase was delivered weekly via e-materials (emailed and online) alone and targeted increasing activity by 1000 steps/day, the first phase through movement during every day activity (incidental movement), the second phase through short walks throughout the day, and the third phase through one longer walk a day. Participants overall increased activity by 1477 daily steps (Largest increase at University of Ulster (1992 steps), and smallest at the University of Toronto (1122 steps))(39).

In a similar study, Aittasalo et al. used a randomized clinical design to explore whether a walking program combined workers with monthly email messages would improve

[1] Motivational Interviewing is a process whereby a trained facilitator uses tools such as open-ended questioning and reflective listening to counsel participants and elicit behavior change, through activities such as goal setting.

physical activity outcomes among office at 20 worksites with an occupational health care program in Finland (n=241) (26). Respondents who volunteered for the study and did not already meet the recommendations for physical activity for cardiovascular health (150 minutes of moderate intensity or 75 minutes of vigorous intensity physical activity per week, over at least 3 days) were eligible to participate and randomized to the intervention (n=123) or control arm (n=118). Those in the intervention arm participated in one group meeting, received a pedometer to monitor progress, and monthly email messages promoting increasing physical activity. At 2, 6 or 12 months, the intervention participants did not have higher walking levels compared to the control group whose activity alone was monitored (OR 1.25, 95%CI 0.98 to 1.59 at 12 months) (26). Workplace factors (e.g. environment for physical activity, break policies, etc.) and individual factors (e.g. stage of change, social support, etc.) may have played a role in moderating the effect of the intervention. Furthermore, the distribution of education materials at monthly intervals instead of more frequently may also have influenced the intervention.

These studies suggest that while workplace interventions are generally successful in inducing changes to physical activity, there are many factors, some inherent to the type of intervention, some inherent to workplace characteristics, and some individual level characteristics that might influence the success of a program.

Correlates and Mediators of Physical Activity

Researchers have sought to better understand why some people participate in physical activity more than others. Factors associated with physical activity behavior patterns are varied, ranging from demographic characteristics such as age and gender, to personal characteristics such as health status and self-efficacy, to external factors such as the built

environment(8). Baumann et al. conducted a systematic review of the correlates and determinants of physical activity that have been examined in research published after January 1, 1999 in children (aged 5-13), adolescents (12-18), and adults (18+) (40). They utilized a social ecological model to group and explain the various levels of influence these correlates might have on an individual's physical activity behavior. Studies have examined a wide variety of physical activity correlates and determinants including individual factors such as genetics, psychosocial factors such as self-efficacy, and external factors operating at the regional/national or even global scale such as transportation or health systems (40). The authors found that only a limited number of personal and environmental factors have been shown to be consistently correlated to physical activity in different age groups. They suggest that future research should focus efforts on verifying causal correlates, exploring multi-level influences on physical activity over time, and developing evidence-based interventions based on these findings (40).

Examining evidence-based physical activity interventions from around the world, Heath et al. report different factors influencing the success of physical activity interventions(41). They identified studies from 2000-2011 which showed promising results or practices in encouraging physical activity. Heath et al. categorized studies by approach, and included best practices for each approach. These approach types include: campaign and informational, behavioral and social, and policy and environmental. Focusing on the behavioral and social approach recommendations, successful programs might incorporate goal setting, social support, reinforcement through incentives, structured problem solving in order to get people to have physical activity as part of their

daily routine(41). Methods of delivery for these programs might be in person in a group setting, email, internet, phone, or mail, and can also be delivered and tailored to the individual.

This research to describe evidence-based practices in physical activity interventions is useful; however, it does not describe what theories to consider in designing an effective educational program. Little research has been done to see what factors, such as the underlying instructional foundation[2], might affect the successful delivery of these materials, and how these factors might affect the overall effectiveness of a given social or behavioral intervention (42). One such factor may be how adults learn and process information, and whether educational materials might cater to their learning style preference. Freedman et al. describe a model of instruction, the Better Education and iNnovation (BEAN) model, which posits that more effective learning might come about from incorporation of cognitive psychology, health literacy, and adult learning theory into the design of educational programs (42). In consideration of this model, and concepts of adult learning theory, this paper aims to explore how one's learning style might influence the effectiveness of a physical activity intervention.

Learning Style and Health Education

Grounded in experiential learning theory[3] (ELT), the Kolb Learning Styles Inventory (KLSI) is used to characterize adults based on how they process information and events to build knowledge (43). ELT posits that people learn by grasping experiences (acquiring and absorbing information) and transforming them (processing and reflecting) into

[2] Instructional Foundation refers to the underlying educational theory that may be applied to a program's design (e.g. Adult Learning Theory)
[3] Experiential Learning Theory explains the process by which people may acquire knowledge or learn from their experiences

knowledge in a four-stage cycle (18). Each of these processes, grasping and transforming, occur in two different modes. Grasping occurs through Concrete Experience (CE), where one relies on the senses and experiencing the tangible to acquire and absorb information, and Abstract Conceptualization (AC) where one thinks about and analyzes information in the abstract. Transforming occurs through Reflective Observation (RO), where one observes and reflects on the experience, and Active Experimentation (AE) where one chooses to actively participate in what is happening (18). Although people are thought to utilize all four learning modes when processing information, they tend to prefer certain modes over others.

Learning style refers to the mode of learning which optimally supports knowledge acquisition for a given person, and can be measured in a number of ways, including the KLSI. The KLSI assesses which of the grasping and which of the transforming modes people prefer and characterizes people into one of four learning style types: Converging, Diverging, Accommodating, and Assimilating. Converging refers to a person who likes to receive information by thinking/doing (AC/AE), Diverging by feeling/watching (CE/RO), Accommodating by feeling/doing (CE/AE), and Assimilating by thinking/watching (AC/RO) (18, 43). Factors that might influence an individual's learning style preference include personality, education, career/ job position, and demographic characteristics such as age, race, and gender (18).

The use of this inventory has been used to explore whether tailored educational materials and instruction for graduate students, medical students, nursing students and other could result in enhanced learning (15, 19-21, 44). Murray used the Kolb learning style inventory to tailor learning plans for eight first-year master of occupational therapy

students who had performed poorly in basic science courses in their first semester classes and were enrolled in a neuroanatomy course in their second semester (44). At the start of the course, students completed the KLSI and were provided information about what learning strategies might enhance knowledge acquisition based on the inventory results. They were also encouraged to create weekly study plan checklists based on the recommendations, and checked in with a program developer weekly over the course of the semester for feedback and support. Student's overall performance in the class was compared to their performance on the first test, and they provided qualitative feedback about whether the strategies were helpful. All students felt they had benefited from becoming aware of their learning style and applying the individualized learning strategies to studying and test preparation (44). While the findings of this descriptive study are promising, further examination of these strategies in a controlled experiment setting is needed.

Mammen et al. examine trends in learning style among general surgery residents over 12 years using the Kolb Learning Style Inventory (45). The inventory was administered yearly to general surgery residents (n=91) from 1994 -2006 and used to assess the prevalence of and changes in learning style over the course of residency training. The most common learning style among participants was Converging (57%), followed by Assimilating (18%), Accommodating (14%) and Diverging (12%). Over the course of the study, year in residency program did not predict prevalence of learning styles among residents. Furthermore, learning style was not associated with residents' performance on standardized tests (American Board of Surgery In-Training Examination (ABSIT/SBE)). The researchers found differences by gender, and more female residents were

accommodating learning style, whereas more males were assimilating. In this study, learning style was not utilized in the development of curricula or tailoring of educational materials; however, the authors suggest that these results could be applied to teaching methodology in the future (45). These studies show that learning style might be associated with one's choice of medical specialty (20), and that tailored instruction based on learning style preference might enhance knowledge acquisition and performance (19, 21). More in depth examination of learning style principles applied to controlled interventions and tailored educational materials is needed to strengthen these results.

Researchers have also examined learning style preference in the delivery of health information to patients in a clinical setting (16, 17). In a sequential randomized trial, Giuse et al. provided patient education information on hypertension, first tailored to health literacy alone, then to healthy literacy and learning style preference (using VARK-Visual, Aural, Read/Write or Kinesthetic Inventory). In the first experiment, the hypertension knowledge of 85 patients (English and Spanish speakers, recruited from Vanderbilt University Medical Center Emergency Department) was measured at baseline and at 2 weeks after receiving no education materials or education materials tailored to health literacy level alone. Similarly, in the second experiment, hypertension knowledge of 103 patients was assessed before and after receiving no education or education matched to both health literacy level and learning style (16). Giuse et al. found that those who received the information tailored to both health literacy and learning style preference showed greater improvement in high blood pressure knowledge ($\Delta \sim 6.3$ questions, $p<0.01$) during the posttest compared to the pretest than those who received information tailored to health literacy alone ($\Delta \sim 4.0$ questions, $p<0.01$). Both intervention groups

improved more than the control group, which did not receive tailored information (no significant difference in scores) (16). Although Guise et al. used the VARK inventory to assess learning style, these results might be extended to tailoring interventions based on other learning style inventories, such as the KLSI.

Learning Style and Physical Activity

Learning style preference has not been considered in the development and implementation of physical activity interventions. Attention to an individual's learning style preference may enhance the effectiveness of a given intervention, especially when educational materials are included as part of the program. As physical activity interventions continue to evolve to better influence change in activity level, greater considerations should be given to the factors which might affect intervention effectiveness. Electronic delivery of educational materials on the internet, email, or through phones is becoming more popular, and these forms of delivery lend themselves to provide easily customizable information (46). Therefore, determining whether underlying factors, such as how individuals learn, influences the effectiveness of a given intervention may provide important information for the design of future physical activity interventions and programs.

Objectives

The primary objective of this paper is to explore the potential relationship between learning style and the effectiveness of the PALS intervention (See Methods section for description of the interventions). We specifically were interested to see 1) whether Divergers (who prefer concrete experience) responded less to the educational interventions (Gym+ Education, Gym+ Time+ Education) compared to Accommodators

and Assimilators (abstract conceptualizers); 2) whether Accommodators (active experimenters)responded more positively to the Gym Alone and Gym+ Time intervention[4] compared to Assimilators and Divergers (reflective observers). These hypotheses are based on the theory that abstract conceptualizing learning styles would respond more to educational interventions than concrete experience learning styles, and that active experimenters would respond more to any intervention compared to reflective observers.

Rationale

Generally, it was thought that different intervention components might appeal to different aspects of a person's learning style and perhaps encourage more activity in some learning style types than others. Table 1 outlines how each learning style group may benefit from treatment group components. For example, educational materials provided in the Gym + Education and Gym+ Education+ Time interventions might appeal to those who prefer abstract conceptualization (Convergers and Assimilators) over concrete experience (Divergers and Accommodators). The written materials would allow the Convergers and Assimilators to analyze and process the information and perhaps translate the information into action. Preferring concrete experience/ reflective observation, Divergers might be both less likely to respond to "gym" or "time" aspect of the intervention than an active experimenter and less to the educational materials, preferring concrete experience type lessons.

[4] The relationship between Accommodators vs. Assimilators or Divergers in the Gym Alone and Gym+ Time groups was thought to be similar (i.e. the addition of "Time" would not change how the learning styles were related to one another between the intervention groups). The educational components of the Gym+ Education and Gym+ Time+ Education intervention might differentially appeal to different learning styles

Similarly, the interventions Gym Alone and Gym+ Time might favor active experimenters (Accommodators and Convergers), who prefer to learn by trying new experiences over reflective observation types (Assimilators and Divergers), who instead prefer to think and reflect about experiences before participating. Active experimenters might be more likely to take advantage of the gym membership or gym membership and time policy and improve overall physical activity compared to reflective observers. The effect of time should not confer favor to any learning style independently of the effect of gym.

METHODS

Data Source

Data for this study were collected from the Physical Activity and Life Styles (PALS) Study (47). The PALS study was a cluster randomized control trial designed to examine the effect of a physical activity intervention which addressed multiple barriers to physical activity in the workplace: policy, physical barriers to exercise, and education. The intervention was conducted between 2004 and 2007 with employees at Emory University, in Atlanta, Georgia. Emory University is a private university employing 12,000 faculty and staff.

Intervention

The study consisted of four intervention groups and one control group. The interventions included combinations of three components: time during the workday, gym membership, and education. Participants by department were randomly assigned to the groups "Gym membership only," "Gym membership +Time," "Gym membership+ Education," "Gym membership+ Education+ Time," or "Control." Time refers to 30 minutes of time on the clock given to participants for exercise during the work-day to be counted as regular work hours. This policy was approved by the department heads and employees' direct supervisors. PALS participants each received a gym membership certificate for one year of free access to Emory's main recreation center. Participants in the intervention groups received the certificate at the start of the intervention and those in the control group received certificates upon completion of the 9 month follow-up visit. Gym membership was provided to ensure that all participants had access to a facility on campus to exercise

during the work day, even in inclement weather. Physical activity education materials were distributed in print, through emails, and on a website. The materials included recommended amounts of physical activity, including definitions of moderate and vigorous activity, tips for becoming more physically active, maps of walking trails on campus, a log book for goals and tracking activity, and information about peer walking groups on campus.

Study Design

Eligibility

The sample was recruited based on eligibility requirements at both the department level (cluster) and individual level. Departments were invited to participate in the study by a letter sent to department heads (initially by email, followed up with phone call, and in-person meeting). Departments with fewer than six non-exempt employees (i.e. clocking in and out) were not eligible for the study. Once departmental approval had been received, individuals were recruited via campus mail (postcard), email, and phone call. A short survey was used to screen individuals for eligibility to participate. Employees were excluded from the study if they were already meeting the Centers for Disease Control (CDC) 2006 guidelines for physical activity (30 minutes of moderate activity on five days each week, or a minimum of 20 minutes of vigorous activity on three days each week)(48); worked nights; worked off campus; planned to be absent from work for more than a month in the next year (e.g. maternity leave); worked fewer than 20 hours per week; or had a flexible work schedule.

Randomization

Sixty departments were eligible and willing to participate. Only two departments that were initially randomly approached to participate declined; and two other departments were selected in their place. Each was randomized to one of two seasonal blocks (warm season = April-September or cold season= October-March) and to one of the five study groups. Facilities Management (FM) and non-FM departments were randomized separately so that there would be an even distribution of both in the two blocks. The nature of the study prevented blinding of intervention type to study administrators and participants.

Study Population

Invitations were sent to 1,107 employees in the 60 departments to participate and 497 people were initially determined to be ineligible (two thirds due adherence to CDC recommendations for physical activity), 173 declined to participate, and 27 could not be contacted. The PALS study enrolled 410 Emory University, on-campus, non-exempt employees working at least 20 hours per week. Initially, all participants who completed the questions pertaining to learning style were to be included in this analysis (n=337, 82.2%); however, the sample was reduced to only include participants with Assimilating, Accommodating, or Diverging learning styles (n=332) and excluding Converging learning style (n=5) to account for issues related to sparse data from the small Converging group size.

Data Collection

Data were collected at five points over a nine month period: at baseline, six weeks, three months, six months, and nine months (final), through a combination of in-person interviews, and paper, online, and phone surveys, and included basic demographics,

information about physical activity, participation in the interventions, learning styles, healthy literacy, attitudes toward exercise, health status and health behaviors.

Data Measures

Outcome

Effectiveness of the intervention was primarily determined by participation in physical activity, measured as days/week meeting CDC guidelines of 30 minutes or more of moderate/vigorous activity in ten minute increments or 20 minutes or more of sustained vigorous activity (48). Physical activity was measured at baseline, six weeks, six months, and nine months, using a seven day self-reported physical activity record (PAR)(49). The PAR asks participants to recall the day, time of day (morning, afternoon, evening), amount, and intensity (moderate, hard, and very hard) of physical activity performed in the previous seven days. Completion rate for physical activity recalls was relatively high throughout the study, with 100% of participants completing the recall at baseline, 94.7% at six weeks, 97.3% at six months, and 99% at nine months.

Receipt and use of the educational materials was explored as a secondary outcome among the Gym + Education group and Gym+ Time+ Education group). Self-reported utilization of the educational materials was measured at three months and nine months using a survey which asked about each of the educational materials: educational booklet, walking maps, activity log, website, and email and postcard tips and reminders. The survey asked whether participants had received the educational component (yes/no), how thoroughly they had explored or used the item, and whether the item prompted changes in behavior or physical activity. For example, for the campus map, the survey asked whether

the participant had “Read thoroughly,” “Glanced at,” or “Did not look at” the map. Then participants were asked whether they “Strongly agreed,” “Agreed somewhat, “Neither agreed or disagreed” or “Disagreed” that they had “taken a walk on campus” as a result of the map. For these analyses, responses to these questions were dichotomized into whether the item was used “Yes” or “No” and “Agree” or “Disagree” to simplify the number of comparisons learning style comparisons considered.

Exposure

Learning style was measured at nine months using the Kolb Learning Style Inventory (43). The Kolb Learning Style Inventory consists of twelve questions determine which learning modes (Concrete Experience or Abstract Conceptualization and Active Experimentation or Reflective Observation) a person prefers. Each question asked the participant to rank four options from “1= Most like you” to “4=Least like you” based on prompts such as “When I learn _____” or “I learn best when_____.” Accommodating, Assimilating, Converging or Diverging learning style was assigned based on scores in each of these areas.

Covariates

Other variables included in the analyses include age, sex, race/ethnicity, education, annual income, marital status, health literacy, and body mass index (BMI) (kg/m^2). Demographic data for the study were collected from Emory University Human Resources Department data (age and sex) and self-reported in baseline surveys (race, education, income, marital status, and BMI). Race/ethnicity was categorized into three groups: black, white, or other. Education was evaluated at four levels: high school graduate or less, some college (technical degree or less than a 4 year university degree), college

graduate (4 year university degree), and post-graduate (Master's, PhD, etc.). Annual income was dichotomized into earnings greater than $50,000 or earnings less than $50,000. Marital Status was groups into 2 categories: whether one was married or in a serious relationship, or whether one was single, or single, previously married (i.e. divorced, single). Health Literacy, "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" was also considered as a potential confounder(50). It was measured at baseline and answering at least four out of six questions correctly on the Newest Vital Sign Instrument, was considered adequate literacy(51).

Data Analysis

Descriptive Statistics

All statistical analyses were performed using SAS version 9.3 (Cary, NC) (52). Convergers were not included in these analyses. Descriptive measures of the population were evaluated at baseline by learning style type and adjusted for clustering by department (using proportion estimates for design correction with SAS Proc Surveyfreq and SAS Proc Suveyreg). All variables (age, race, sex, BMI, health literacy, marital status, education level, income, and treatment group) were assessed for adherence to normality assumptions. Health literacy was evaluated as a dichotomous variable (adequate or inadequate) because health literacy score did not satisfy normality assumptions. Bivariate analyses by learning style group were conducted, using t-tests to compare continuous variables and Rao-Scott χ^2 test for categorical variables. Significance was set at $\alpha = 0.05$.

Among the groups receiving "education" as part of their intervention, the receipt and use of educational materials by learning style group was explored using Rao-Scott $\chi 2$ test for categorical variables (Table 5). Additionally, those excluded from the study (missing learning style) were compared to the main study population to see whether the groups differed from each other (Appendix Table A-2). To visualize the outcome physical activity (days meeting the CDC requirements) over time, empirical growth plots at both the individual and group level were constructed. The plots were examined by the study group overall, learning style group, and learning style and treatment group combinations.

Covariate-Adjusted Methods

Intention to treat principle was used for all analyses involving treatment effects. Differences between learning style and intervention groups combinations were examined by comparing overall change in physical activity (number of days/week meeting the CDC guidelines for physical activity) for specific learning style and treatment group combinations. The outcome physical activity was modeled using Poisson regression (generalized linear mixed models using SAS Proc Glimmix) with random intercepts for the individual and for the department. A simple R-side residual effect was specified to adjust for potential overdispersion.

In the full models the main effect of learning style, treatment group, and the interaction of the two, were considered with the covariates gender, age, race, health literacy, education, income, marital status, baseline BMI, and baseline physical activity level. Collinearity for this model was evaluated by assessing whether condition indices (CI) were high (greater than 30) with Variance Decomposition Proportions (VDP) for variables excluding the intercept greater than 0.50. Covariates or interaction terms would be

removed from the model if these guidelines were violated. No variables in the full model violated these assumptions; thus, the gold standard model for these analyses was an interaction model with all stated covariates. After completing collinearity diagnostics, variables were removed from the models using stepwise backwards elimination. Covariates not found to be confounders (i.e. they did not change the main effect estimate by more than 10% from the gold standard when removed) or significant at $p<0.05$ were removed from the model one at a time. Estimated risk ratios are reported with 95% confidence intervals.

The primary objective was evaluated by exploring specific contrasts between learning style and intervention group combinations using the final model. To test the first hypothesis, Divergers were first compared to other learning styles within interventions receiving educational components (Gym+ Education and Gym+ Time+ Education). Then Divergers were compared to other learning styles in treatment groups without educational components (Control, Gym Only, and Gym+ Time). Finally, the first contrast (Divergers vs. other learning styles within education groups) was compared to the second contrast (Divergers vs. other learning styles within non-education groups) to see whether the overall effect of the educational component was different among Divergers compared to others.

To test the second hypothesis, Accommodators were compared to other learning styles within the Gym Alone and Gym+ Time intervention groups. Then, Accommodators were compared to other learning styles in the Control group. Finally the first contrast (Accommodators vs. other learning styles within Gym Alone and Gym+ Time groups) were compared with the second (Accommodators vs. other learning style within the Control group), to see whether the effect of the "Gym" component, independent of the educational components, was most beneficial to Accommodators.

RESULTS

Baseline Characteristics

Table 2 provides baseline demographic data for the study population (n=332), including Assimilating (n=30), Accommodating (n=60), and Diverging (n=242), which was used for all analysis. Baseline characteristics for all learning style types (including Converging, n=5) (n=337) is available in the appendix (Appendix Table A-1). Learning style type was not evenly distributed among the participants, and the majority were in the Diverging learning style categorization (72.9%), followed by Accommodating (18.1%), Assimilating (9.0%). The mean age of participants was 41.4 years (range 21-71 years) old, 64.2% were female, and 53.0% were black (Table 2). Controlling for the clustering by department, there were no significant differences between learning style groups for almost all covariates except sex (p=0.01). Participants who were in the Assimilating learning style group were more likely to be female (83.3% vs. 63.5%).

The overall study population was compared to those missing learning style information (n=72) (Appendix Table A-2). Participants who did not complete the learning style questions compared to those who completed these questions were significantly more likely to be black (78% vs. 53%), less likely to have adequate health literacy (40% vs. 70 %), and fewer were college or higher graduates; however, the groups did not differ in the outcome physical activity at baseline or nine months, assignment to treatment groups, BMI, age, or annual income.

The Effect of Learning Style on the Intervention

The mean number of days meeting the CDC recommendations for physical activity for each learning style group increased on average over the course of the study (Figure 1) from approximately 2 days per week at baseline to 3.3 days per week overall at nine months. Figures 2-6 show physical activity by learning style for each of the treatment groups. Overall the patterns for activity seem similar between and within treatment groups by learning style. Activity levels differed by learning style group at baseline, but the general trend of change over time was similar for all learning style groups, and seemed to increase linearly over time . There was more variability in physical activity over time by learning style and treatment group combinations. Assimilators in the Gym Only group seemed to have higher rates of physical activity compared to others within that group (Figure 3).

To examine the effect of learning style on the effectiveness of the interventions for the main outcome days per week meeting CDC physical activity recommendations, a covariate-adjusted longitudinal mixed model was constructed. The final model included the main effects for learning style, treatment group, and the interaction terms for the main effects and controlled for baseline physical activity, sex, and age (Table 3, Modeling Strategy can be found in Appendix Table A-3). This model was used to test the main hypothesis that components of the interventions would favor certain learning styles more than others.

Table 4 presents the results of the specific contrast analyses. Within the education groups, Divergers met the CDC recommendations for physical activity slightly more than others, but this difference was not statistically significant ($RR_{\text{Diverger v other in ED}}$ 1.07 (95%CI: 0.88-1.30)). Similarly, there was no significant difference between Divergers and other

learning style in non-education groups ($RR_{\text{Diverger v other in non-ED}}$ 0.79 (95%CI: 0.56-1.11)). Furthermore, the effect of the educational materials compared to other intervention components was not significantly different from the other intervention components for Divergers compared to other learning styles (RR 1.12 (95%CI: 0.96-1.31)).

There was also no statistically significant difference between Accommodators and other learning styles in the Gym Alone and Gym +Time treatment groups ($RR_{\text{Accom. v. other in Gym Alone/Gym +Time}}$ 0.99 (95%CI: 0.69-1.42)) or in the Control Group ($RR_{\text{Accom. v. other in Control}}$ 0.91 (95%CI: 0.65-1.27)). Finally, there was no difference in effect of the Gym Alone or Gym+ Time interventions between Accommodators and other learning styles (RR 1.10 (95%CI: 0.75-1.60)).

Examining educational tool usage in the Gym+ Education and Gym+ Education+ Time groups, no significant differences by learning style were found for any of the tools (Table 5). Table 5 shows the total participants randomized to either Gym+ Education or Gym+ Time+ Education groups, because stratification by learning group produced similar results, but included many more sparse data cells. Assimilators were the least likely to take a walk on campus as a result of reading the campus map (6.3% compared to 27.6% of Accommodators and 33.6% of Divergers), but this difference was non-significant overall (p=0.06).

DISCUSSION

Conclusion

The results of the study suggest that learning style was not associated with the effectiveness of the PALS intervention. No association was found between learning style and number of days meeting the CDC recommendations for physical activity, or for the use of the educational materials in the Gym+ Education, and Gym+ Time+ Education groups.

The PALS interventions were designed to target three barriers of activity in a worksite setting: policy regarding time, physical environment for activity, and education. It was hypothesized that an individual's learning style might interact with certain components of a given intervention favoring certain learning styles over others; however, the data presented here do not support this hypothesis. Learning style did not appear to impact the effectiveness of any of the interventions, as measured by change in physical activity over time, or by educational material use.

Looking specifically at treatment groups and learning styles that were in most concordance or least concordance, no relationship between learning style and treatment groups was found. In fact, some of the contrasts produced results which were opposite to what was expected. Although, Divergers were hypothesized to be least likely to respond to the educational interventions, Divergers seemed to respond equally or slightly better to the educational interventions compared to other learning styles. Furthermore, Accommodators were expected to respond more to the interventions of Gym Alone and Gym+ Time compared to other learning styles, but there was almost no difference

between the responses of Accommodators compared to other learning styles. These results suggest that learning style did not influence the PALS interventions in expected ways, if at all.

Additionally, we found no patterns in educational material use by learning style. Educational materials seemed to be used consistently across learning styles, and there were no differences in educational material usage or influence on behavior by learning style. The broad array of educational materials available to participants might have appealed to a broader variety of learning styles than abstract conceptualizers alone.

Learning style may not have appeared to impact the PALS interventions for a variety of reasons. First, it is possible that learning style in the context of physical activity is different than other learning outcomes. Since physical activity, in its nature, demands active doing, traditional learning models may not directly translate to these interventions. The settings and types of learning a person prefers in an academic setting, for example, may not be relevant in other scenarios. Whereas traditional learning style preferences might hold for educational aspects of physical activity interventions (aimed at increasing exercise knowledge), adaptations for an activity setting should be further explored. For example, while a person may prefer to study alone in academic settings, for physical activity, he/she may prefer to participate in group activities. To this end, it may be useful to evaluate learning style preference specifically in relation to physical activity interventions, and approach learning style and physical activity in a more nuanced way.

Second, the learning style that one likes or prefers may not be the learning style which optimizes learning for the person. Therefore, while a person may report that they prefer

to read a technical manual to learn how to do something, they may actually learn best when they are actively performing the task. This discrepancy between what one reports or self-identifies with, and what actually improves learning outcomes for a person might explain the discrepancies in our data. One's learning style preference, as identified by the Kolb Learning Style Inventory may not be congruent with the technique or mode that optimizes learning.

Third, the effects of learning style may not have been detected because individual components of the different interventions may have worked to confound the effect of the other components, in unpredicted ways. "Gym" was the only intervention component which was administered alone, and thus the effect of learning style on "time" or "educational materials" alone could not be measured. There may have been different effects for abstract conceptualizers compared to concrete experience types for an intervention of educational materials alone (without "Gym"). However, this effect may have been attenuated or changed by the effect of "Gym" and therefore obscure the effect of the educational materials.

Strengths and Limitations

There are at least five strengths of this study. First, the design of the study as a longitudinal randomized control trial allowed for the examination learning style on the four interventions groups over time. Second, after removing participants who failed to answer the learning style questions from the study population, there were relatively few missing values (< 5%) for any variable. Since many of the covariates examined did not change over the course of the study (e.g. educational attainment, gender, etc.), they only had to be measured once at baseline. For these variables there was no risk of missingness

increasing over time (due to missed follow-up visits, or lack of response for survey questions) which helped ensure that the longitudinal mixed models would excluded fewer participants for missing values. Overall, this helped to ensure that the models ran on the largest sample possible and for the most reliable results. Third, we had a high rate of participation among participants for each follow-up visit, minimizing loss to follow-up. At nine months (study completion), only 2 people (<1%) were missing follow-up information, and no more than 6% of people at any other follow-up visit were missing outcome data. Fourth, the selection of people from different departments throughout the university ensured that a variety of jobs types were included. Other studies which have examined learning style have often limited their focus to a particular occupational or professional training group (e.g. nurses, surgical residents, etc.), which may select for particular learning style types (15, 19-21, 45). Finally, the analyses presented in this study are relatively innovative, as no other studies have examined learning style and physical activity outcomes.

Despite these strengths, there were some limitations. The skewed distribution of learning styles in this population created analytical challenges due to sparse data. Unexpectedly few people were classified as Convergers (n=5, 1.2%), and thus this group was excluded from all analyses. Only one person was a Converger in the Gym only, Gym+ Time, and Gym+ Time +Education treatment groups, and none was in the Control group. The exclusion of this group limited the number and types of comparisons that could be drawn between learning style and treatment group, and thus could introduce selection bias to the analyses. For example, some of the comparisons that could be considered only contrasted elements of one learning style domain (e.g. Active experimentation vs. reflective

observation), instead of both domains, because complete information for all four learning styles was not available. Other stratified comparisons (e.g. educational materials use by learning style) also suffered limitations due to the sparseness of the data. For the analysis of educational materials, both treatment groups had to be collapsed together to limit the number of sparse cells when respondents were stratified. As a result, we were unable to explore educational material use independently in each treatment group.

Another limitation of this study was the number of people who were missing learning style data. Only 82.2% of the original study population had learning style information. Furthermore, certain demographic characteristics of this group were significantly different from those included in the study, including race, income, health literacy and education. However, the group that did not answer the learning style questions did not differ significantly from the study group in treatment group assignment or the outcome days per week meeting physical activity recommendations. The absence of these people from the study might have introduced selection bias. If learning style influenced who answered the learning style questions (e.g. mostly Convergers failed to answer the questions), then the analyses could have missed an association between learning style and intervention.

Future Research

Despite the lack of association found between learning style and the PALS intervention, further investigation into the relationship between learning style and physical activity is warranted. The design of the PALS interventions did not target particular learning style preferences. Future research might examine the effects of a learning style tailored intervention on both exercise knowledge and activity levels as outcomes. Also, it is

unknown whether individual learning style preferences may differ based on the educational goals of the learning (i.e. learning preference for an academic purpose might differ from a physical activity purpose). Inquiry into a person's learning style and learning preferences should specify physical activity as the outcome, and perhaps even specify type of activity (i.e. aerobic vs. anaerobic or moderate vs. vigorous).

The workplace remains a popular setting for physical activity and other health interventions among adults. Increasing numbers of these interventions have also begun to incorporated electronic delivery of educational materials through websites, email, and text messaging (10, 26, 46). These platforms can be easily customized with messaging for the individual; however, few studies have examined how the delivery of physical activity educational materials could be enhanced through tailoring to participant characteristics, such as learning style. Tailored messages and materials could extend beyond scope of physical activity alone and also target individual health and nutrition concerns. More research into the potential benefits of such interventions is needed.

Public Health Implications

Physical inactivity is cited as one of the leading risk factors for all-cause mortality worldwide. Effective interventions to address physical activity are needed for a variety of age groups, and for implementation in a variety of settings. This research adds to the body of research on physical activity interventions for adults in workplace settings. In 2001, the Taskforce on Preventive Health Services recommended "individually adapted health behavior change" interventions for physical activity. Tailored learning style programs could be one method to individualize physical activity interventions. However,

these findings suggest that learning style may have limited application to physical activity. Interventions which are specifically designed to target learning styles may be needed to see any effect.

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TABLES

Table 1: Potential associations between learning style and PALS interventions

	Assimilating (AC/RO)	**Accommodating (CE/AE)**	**Diverging (CE/RO)**	**Converging (AC/AE)**
Gym Alone- Might appeal to the active experimenters (AE) more than the reflective observers (RO); There may be no difference between converging and accommodating groups with respect to who participates more.	The Reflective Observers (RO) might be less likely to "jump in" and try the gym membership. *Rank: 2 (tie)*	Active Experimenters (AE) might be more likely to try out the new gym membership. *Rank: 1 (tie)*	The Reflective Observers (RO) might be less likely to "jump in" and try the gym membership. *Rank: 2 (tie)*	Active Experimenters (AE) might be more likely to try out the new gym membership. *Rank: 1 (tie)*
Gym + Time- Might appeal to the AE more than the RO; "Time" component itself might not impact any one learning style; Learning style effect should follow the same pattern as the Gym Only group.	Reflective Observers (RO) might be less likely to "jump in" and try the gym membership and/ or time on clock. *Rank: 2 (tie)*	Active Experimenters (AE) might be more likely to try out the new gym membership and/or time on clock. *Rank: 1 (tie)*	Reflective Observers (RO) might be less likely to "jump in" and try the gym membership and/or time on clock. *Rank: 2 (tie)*	Active Experimenters (AE) might be more likely to try out the new gym membership and/or time on clock. *Rank: 1 (tie)*
Gym + Education- Educational materials might appeal to abstract conceptualizers (AC), but AE, might be more likely to participate more in new activity	Educational materials might appeal to the AC domain but RO domain may make Assimilators less likely to experiment with new activity cf. Convergers *Rank: 2 or 3(tie)*	Accommodators might be willing to experiment with new intervention (AE), but educational materials might not be best fit for CE *Rank: 2 or 3(tie)*	Divergers might be least likely to benefit from either gym or education. Appeals to neither CE or RO domains *Rank: 4*	The combination of the educational materials and gym membership might benefit Convergers most; Appealing to both AC and AE domains *Rank: 1*
Gym+ Ed +Time Educational materials might appeal to abstract conceptualizers (AC), but AE, might be more likely to participate more in new activity; addition of time might not make more of a difference compared to the Gym + Ed	Educational materials might appeal to the AC domain but RO domain may make Assimilators less likely to experiment with new activity cf. Convergers *Rank: 2 or 3(tie)*	Accommodators might be willing to experiment with new intervention (AE), but educational materials might not be best fit for CE *Rank: 2 or 3(tie)*	Divergers might be least likely to benefit from either gym or education. Appeals to neither CE or RO domains *Rank: 4*	The combination of the educational materials and gym membership might benefit Convergers most; Appealing to both AC and AE domains *Rank: 1*
Control	No LS favored	No LS favored	No LS favored	No LS favored

*Within each intervention group, each learning style is ranked based on which is thought would benefit the most (Rank=1) to the least (Rank= 4).

Table 2: Baseline demographic information for study population by learning style type, from PALS (Physical Activity and Lifestyles Study) (controlling for clustering by department).

	Total		**Accommodating**		**Assimilating**		**Diverging**		**p-value**
Total (N, %)	**332**		**60**	18.1	**30**	9.0	**242**	72.9	
Number of Departments	**60**		**33**		**21**		**57**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Age (years)	41.4	11.0	38.9	10.9	46.4	11.7	41.4	10.7	0.02*
Body Mass Index	30.0	7.1	29.8	7.0	31.5	7.4	29.9	7.2	0.43
Physical Activity	1.9	2.0	2.0	2.0	1.5	1.8	2.0	2.0	0.42
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Treatment Group									0.40
Control	61	18.4	7	11.7	9	30.0	45	18.6	
Gym Only	52	15.7	12	20.0	3	10.0	37	15.3	
Gym+ Education	84	25.3	17	28.3	8	26.7	59	24.4	
Gym +Time	61	18.4	12	20.0	2	6.7	47	19.4	
Gym+Ed+Time	74	22.3	12	20.0	8	26.7	54	22.3	
Sex									0.03*
Female	213	64.2	33	55.0	25	83.3	155	64.1	
Male	119	35.8	27	45.0	5	16.7	87	35.9	
Race									0.56
White	136	41.0	21	35.0	11	36.7	104	43.0	
Black	176	53.0	36	60.0	16	53.3	124	51.2	
Other	20	6.0	3	5.0	3	10.0	14	5.8	
Marital Status									0.02*
Married or Couple	160	50.3	21	35.0	13	43.3	126	52.1	
Other[2]	158	49.7	36	60.0	17	56.7	105	43.4	
Annual Income									0.48
Less than $50,000	214	68.4	42	75.0	20	66.7	152	62.8	
Greater than $50,000	118	31.6	18	25.0	10	33.3	90	37.2	
Body Mass Index									0.75
< 25	88	26.5	15	25.0	5	16.7	68	28.1	
≥25 and < 30	101	30.4	18	30.0	11	36.7	72	29.8	
≥ 30	143	43.1	27	45.0	14	46.7	102	42.2	
Health Literacy									0.52
Adequate	230	69.3	43	71.7	18	60.0	169	69.8	
Education									0.45
High School or Less	43	13.5	7	11.7	6	20.0	30	12.4	
Some College	149	46.7	22	36.7	13	43.3	114	47.1	
College Graduate	102	32.0	23	38.3	7	23.3	72	29.8	
Master's or Higher	25	7.8	5	8.3	4	13.3	16	6.6	

1 Physical Activity= number of days per week meeting CDC recommendations for physical activity
2 Other Marital Status= Single, or Single, previously wed

Continuous Variables: p-value for T-Test for regression (controlling for clustering by department)
Categorical Variables: p-value for Rao-Scott Chi-Square

Table 3: Rate ratios for final longitudinal mixed model learning style, PALS Study (N=332)

FINAL MODEL Removing Health Literacy, Initial BMI, Marital Status, Income, Race, Education				
		Rate Ratio	**Lower 95% CI**	**Upper 95% CI**
Days in Study		2.40	1.81	3.20
MAIN EFFECTS				
Learning Style (Ref=Diverging)		1.00	1.00	1.00
Accommodating		0.99	0.89	1.09
Assimilating		0.88	0.68	1.15
Intervention (Reference=Gym+ Ed + Time)				
Control		0.81	0.64	1.03
Gym Only		1.02	0.84	1.24
Gym+ Education		1.16	0.93	1.43
Gym+ Time		1.18	0.97	1.44
Interaction of Learning Style with Intervention				
Control by	Accommodating	1.02	0.77	1.34
	Assimilating	1.39	0.82	2.35
Gym Only by	Accommodating	1.16	0.97	1.39
	Assimilating	1.46	1.04	2.07
Gym+ Education by	Accommodating	0.95	0.72	1.26
	Assimilating	1.21	0.84	1.74
Gym+ Time by	Accommodating	0.97	0.71	1.32
	Assimilating	1.06	0.78	1.44
COVARIATES				
Baseline Physical Activity (Ref= 7 days meeting guidelines)				
0		0.36	0.28	0.45
1		0.50	0.41	0.61
2		0.61	0.50	0.74
3		0.76	0.63	0.93
4		0.91	0.75	1.12
5		1.01	0.85	1.19
6		1.20	0.97	1.49
Sex (Ref=Female)				
Male		1.23	1.13	1.33
Baseline Age		1.01	1.00	1.01

Table 4: Rate ratios for contrasts comparing specific learning style and treatment group combinations for the PALS Study.

CONTRASTS	Est.	SE	P-value	Rate Ratio	95 % CI Lower	95 % CI Upper
Diverging vs. other learning styles in education groups[1]	**0.07**	0.10	0.49	**1.07**	0.88	1.30
Diverging vs. other learning styles in non-education groups[2]	**-0.24**	0.18	0.17	**0.79**	0.56	1.11
Diverging vs. other in Ed groups VS. Diverging vs other in Non-Ed groups	**0.11**	0.08	0.14	**1.12**	0.96	1.31
Accommodating vs. other learning styles in Gym Alone and Gym + Time groups	**-0.01**	0.18	0.96	**0.99**	0.69	1.42
Accommodating vs. other learning styles in control group	**-0.10**	0.17	0.57	**0.91**	0.65	1.27
Accommodating vs. other in Gym Alone and Gym+ Time groups VS. Accommodating vs. other in control group	**0.09**	0.19	0.63	**1.10**	0.75	1.60

[1] Education Groups= Gym+ Education and Gym+ Time+ Education;
[2] Non-education groups= Control, Gym Alone, and Gym+ Time

Table 5: Use of educational materials by learning style among Gym+ Education and Gym + Time + Education treatment groups, PALS Study (N=158)

	Accommodating		Assimilating		Diverging		Total		p
EDUCATIONAL BOOKLET	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Received									0.38
Yes	28	96.6	14	87.5	108	95.6	150	94.9	
Read or flipped through									0.98
Yes	26	92.9	14	100.0	102	93.6	142	94.0	
Wrote in the booklet									0.22
Yes	2	7.7	4	28.6	24	23.3	30	21.0	
Learned something new									0.97
Strongly or somewhat agree	16	64.0	9	64.3	68	66.7	93	66.0	
More active as a result									0.62
Strongly or somewhat agree	8	32.0	5	35.7	42	40.8	55	38.7	
CAMPUS WALKING MAP									
Received									0.29
Yes	26	89.7	15	93.8	109	96.5	150	94.9	
Read/ looked at map									0.50
Yes	23	82.1	14	93.3	93	83.8	130	84.4	
Took walk on campus									0.06
Yes	8	27.6	1	6.3	38	33.6	47	29.7	
ACTIVITY LOG BOOK									
Received									0.37
Yes	29	100.0	14	87.5	107	94.7	150	94.9	
Book used to track PA									0.46
Yes	12	41.4	9	56.3	47	41.6	68	43.0	
Book used to track goals									0.92
Yes	8	27.6	4	25.0	27	23.9	39	24.7	
More active as a result									0.87
Strongly or somewhat agree	8	66.7	7	77.8	37	68.5	52	69.3	
WEBSITE									
Website used:									0.78
Less than once a month	24	82.8	12	80.0	97	85.8	133	84.7	
TIP OF THE WEEK:									
Learned something new									0.96
Strongly or somewhat agree	21	72.4	11	73.3	85	75.2	117	74.5	

More active as a result									0.60
Strongly or somewhat agree	14	48.3	7	46.7	63	55.8	84	53.5	
Read campus mail tips									0.77
All or some of the time	27	93.1	15	100.0	97	85.8	139	88.5	
Read email tips									0.79
All or some of the time	26	89.7	14	93.3	99	87.6	139	88.5	
Read website tips									0.60
All or some of the time	8	27.6	3	20.0	22	19.5	124	79.0	
Categorical Variables: p-value for Rao-Scott Chi-Square									

FIGURES

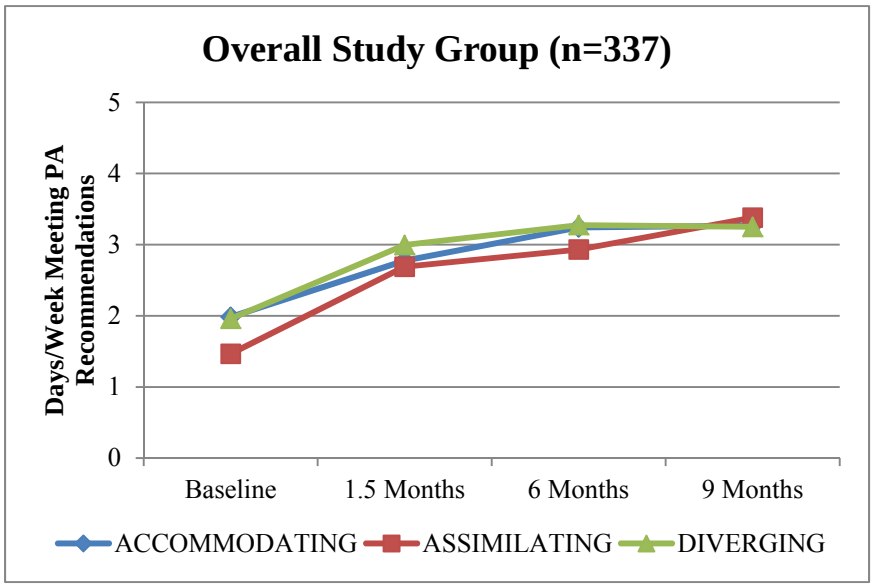

Figure 1: Physical Activity (mean number of days/week meeting CDC physical activity recommendations) over 9 month enrollment by learning style in PALS (Physical Activity and Lifestyles Study), 2004-2007.

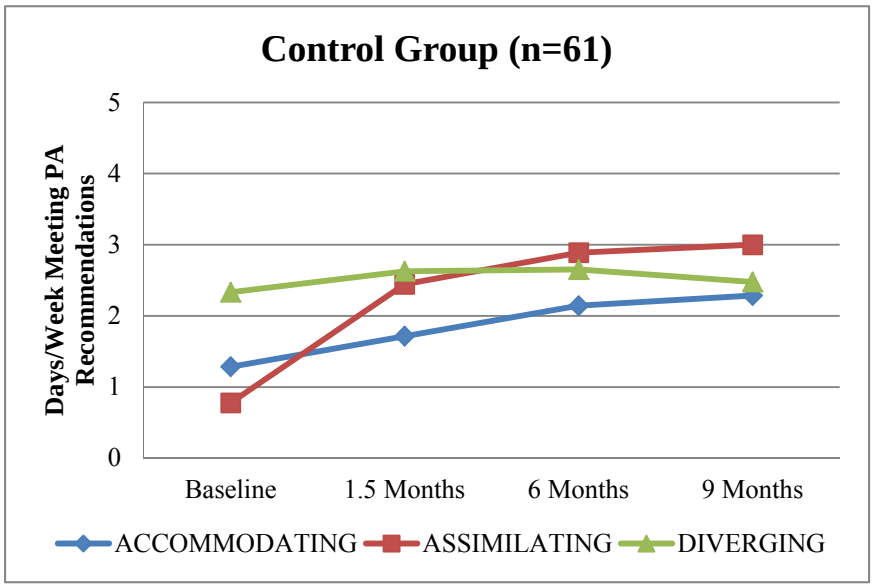

Figure 2: Physical Activity (mean number of days/week meeting CDC physical activity recommendations) over 9 month enrollment for Control treatment group in PALS (Physical Activity and Lifestyles Study), 2004-2007.

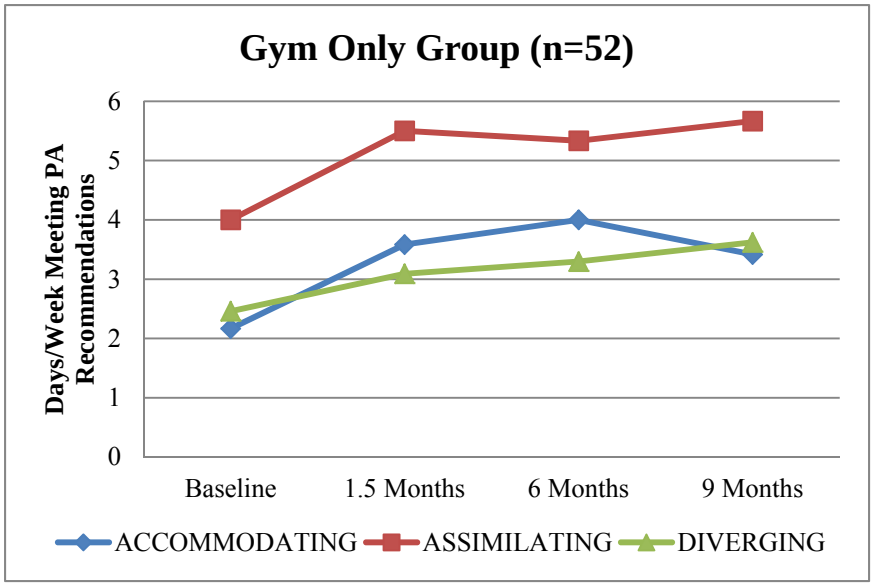

Figure 3: Physical Activity (mean number of days/week meeting CDC physical activity recommendations) over 9 month enrollment for Gym Only Group in PALS (Physical Activity and Lifestyles Study), 2004-2007.

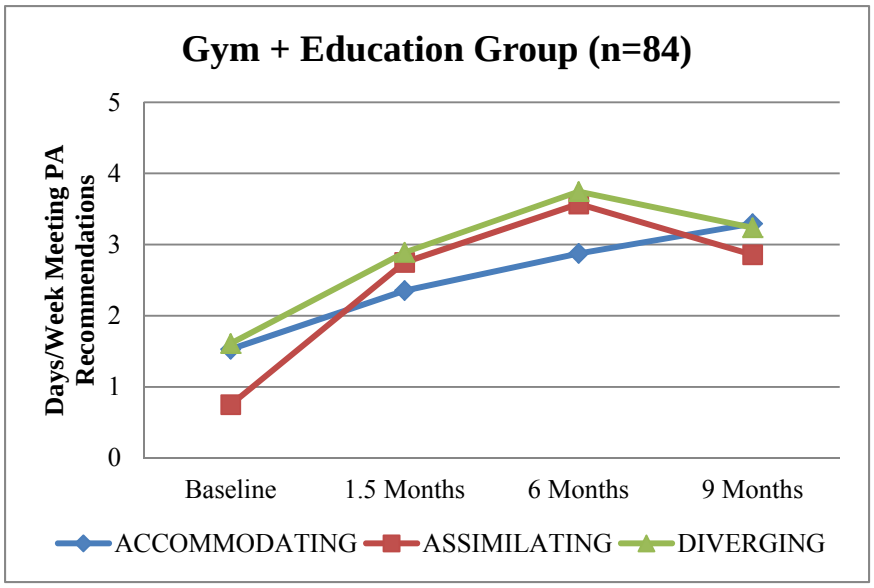

Figure 4: Physical Activity (mean number of days/week meeting CDC physical activity recommendations) over 9 month enrollment for Gym+ Education Group in PALS (Physical Activity and Lifestyles Study), 2004-2007.

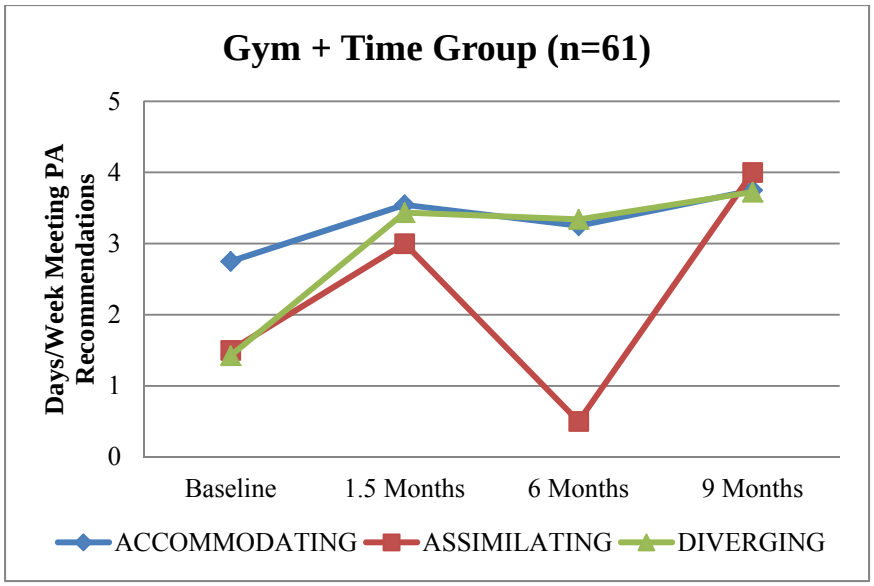

Figure 5: Physical Activity (mean number of days/week meeting CDC physical activity recommendations) over 9 month enrollment for Gym+ Education+ Time Group in PALS (Physical Activity and Lifestyles Study), 2004-2007.

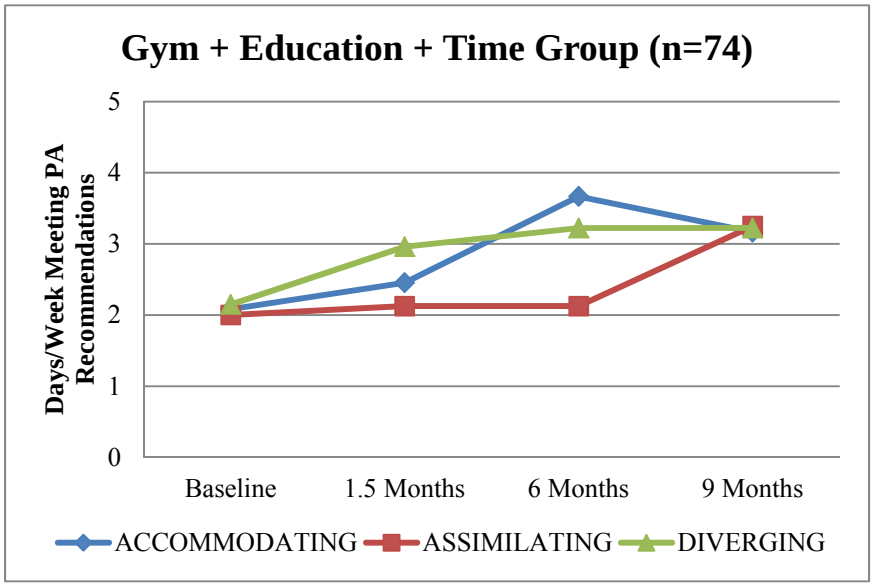

Figure 6: Physical Activity (mean number of days/week meeting CDC physical activity recommendations) over 9 month enrollment for Gym+ Education+ Time Group in PALS (Physical Activity and Lifestyles Study), 2004-2007.

APPENDIX

Table A-1: Baseline demographic information for all learning styles population from PALS (Physical Activity and Lifestyles Study) by learning style type, controlling for clustering by department, 2004-2007.

	Total		Accomm.		Assimil.		Converg.		Diverg.		p
Total (N, %)	**337**		**60**	**17.8**	**30**	**8.9**	**5**	**1.5**	**242**	**71.8**	
# of departments	**60**		**33**		**21**		**4**		**57**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Age (years)	41.4	10.96	38.9	10.9	46.4	11.58	39.0	10.39	41.3	10.7	0.04*
Physical activity [1]	2	2	2	2.03	1.5	1.76	4.2	2.95	2	1.98	0.25
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Treatment Group											0.40
Control	61	18.1	7	11.7	9	30.0	--	--	45	18.6	
Gym Only	53	15.7	12	20.0	3	10.0	1	20.0	37	15.3	
Gym+ Education	86	25.5	17	28.3	8	26.7	2	40.0	59	24.4	
Gym +Time	62	18.4	12	20.0	2	6.7	1	20.0	47	19.4	
Gym+ Ed +Time	75	22.3	12	20.0	8	26.7	1	20.0	54	22.3	
Sex											0.03*
Female	214	63.5	33	55.0	25	83.3	1	20.0	155	64.1	
Race											
White	137	40.7	21	35.0	11	36.7	1	20.0	104	43	0.56
Black	179	53.1	36	60.0	16	53.3	3	60.0	124	51.2	
Other	20	5.9	3	5.0	3	10.0			14	5.8	
Marital Status											0.02
Married or Couple	163	48.4	21	35.0	13	43.3	3	60.0	126	52.1	
Other	159	47.2	36	60.0	17	56.7	1	20.0	105	43.4	
Annual Income											0.48
Less than $50,000	218	68.8	42	75.0	20	66.7	4	80.0	152	62.8	
Body Mass Index											0.75
< 25	90	26.7	15	25.0	5	16.7	2	40.0	68	28.1	
≥25 and < 30	102	30.3	18	30.0	11	36.7	1	20.0	72	29.8	
≥ 30	145	43.0	27	45.0	14	46.7	2	40.0	102	42.2	
Health Literacy											0.52
Adequate	233	69.1	43	71.7	18	60	3	60.0	169	69.8	
Education											0.45
High School or Less	44	13.1	7	11.7	6	20.0	1	20.0	30	12.4	
Some College	151	44.8	22	36.7	13	43.3	2	40.0	114	47.1	
College Graduate	103	30.6	23	38.3	7	23.3	1	20.0	72	29.8	
Master's or Higher	25	7.4	5	8.3	4	13.3	--	--	16	6.6	

[1] Physical Activity= number of days per week meeting CDC recommendations for physical activity
Continuous Variables: p-value for T-Test for regression (controlling for clustering by department)
Categorical Variables: p-value for Rao-Scott Chi-Square

Table A-2: Comparison of those missing learning style (n=73) to study population (n=332) (controlling for clustering by department), PALS Study (2004-2007).

	Total (excluding those missing LS)		Missing LS		p-value
Total	**332**		**73**		
# of Departments	**60**		**36**		
	Mean	**SE**	**Mean**	**SE**	
Age (years)	41.4	0.9	43.4	1.7	0.24
Physical activity[1]	1.9	0.2	2.1	0.3	0.71
	n	**%**	**n**	**%**	
Treatment Group					0.49
Control	61	18.4	9	12.3	
Gym Only	52	15.7	19	26.0	
Gym+ Education	84	25.3	20	27.4	
Gym +Time	61	18.4	11	15.1	
Gym+Ed+Time	74	22.3	14	19.2	
Sex					0.14
Female	213	64.2	40	54.8	
Race					<0.001
White	136	41.0	11	15.3	
Black	176	53.0	56	77.8	
Other	20	6.0	5	6.9	
Marital Status					0.96
Married or Couple	158	49.7	31	42.5	
Other	160	50.3	25	34.3	
Annual Income					0.08
Less than $50,000	214	68.4	54	74.0	
Body Mass Index					0.65
< 25	88	26.5	16	21.9	
≥25 and < 30	101	30.4	24	32.9	
≥ 30	143	43.1	33	45.2	
Health Literacy					<0.001
Adequate	230	69.3	29	39.7	
Education					<0.001
High School or less	43	13.5	28	40.0	
Some College	149	46.7	28	40.0	
College Graduate	102	32.0	11	15.7	
Master's or higher	25	7.8	3	4.3	

[1] Physical Activity= days/week meeting CDC recommendations for activity
Continuous Variables T-Test for regression (controlling for clustering by department)
Categorical Variables: Rao-Scott Chi-Square

Table A-3: Rate Ratios for mixed longitudinal models included in backwards elimination modeling strategy for study population (n=332) in PALS Study.

		Gold Standard			MODEL 1: Removing Education			MODEL 2: Removing Race, Education			MODEL 3: Removing Income, Race, Education			MODEL 4: Removing Marital Status, Income, Race, Education			MODEL 5: Removing Initial BMI, Marital Status, Income, Race, Education			MODEL 6: Removing Health Literacy, Initial BMI, Marital Status, Income, Race, Education		
		RR	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**	
Days in Study		2.18	1.45	3.29	2.17	1.51	3.11	2.26	1.65	3.11	2.34	1.68	3.26	2.39	1.70	3.37	2.68	1.90	3.78	2.40	1.81	3.20
MAIN EFFECTS																						
Learning Style (Ref=Diverging)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Accommodating		1.02	0.90	1.15	1.02	0.92	1.14	1.02	0.91	1.14	1.02	0.92	1.13	1.00	0.90	1.10	0.98	0.89	1.09	0.99	0.89	1.09
Assimilating		0.85	0.64	1.14	0.85	0.63	1.14	0.86	0.64	1.15	0.86	0.65	1.15	0.87	0.66	1.15	0.87	0.66	1.14	0.88	0.68	1.15
Intervention (Reference=Gym+ Ed + Time)																						
Control		0.78	0.61	1.01	0.78	0.60	1.00	0.78	0.61	1.01	0.80	0.62	1.02	0.80	0.63	1.02	0.81	0.63	1.03	0.81	0.64	1.03
Gym Only		0.98	0.80	1.19	0.97	0.80	1.18	0.98	0.81	1.19	0.99	0.82	1.20	0.99	0.82	1.20	1.00	0.82	1.22	1.02	0.84	1.24
Gym+ Education		1.10	0.88	1.38	1.10	0.88	1.38	1.10	0.88	1.38	1.14	0.92	1.41	1.14	0.92	1.41	1.14	0.92	1.41	1.16	0.93	1.43
Gym+ Time		1.18	0.97	1.43	1.18	0.98	1.43	1.18	0.97	1.43	1.19	0.98	1.43	1.19	0.99	1.44	1.18	0.97	1.44	1.18	0.97	1.44
Interaction of Learning Style with Intervention																						
Control by	Accommodating	0.97	0.75	1.26	0.98	0.76	1.27	0.98	0.76	1.27	0.98	0.76	1.27	1.01	0.78	1.32	1.03	0.79	1.33	1.02	0.77	1.34
	Assimilating	1.47	0.83	2.59	1.48	0.84	2.61	1.47	0.83	2.59	1.46	0.83	2.57	1.42	0.81	2.48	1.42	0.82	2.48	1.39	0.82	2.35
Gym Only by	Accommodating	1.17	0.94	1.47	1.15	0.95	1.40	1.17	0.97	1.40	1.15	0.97	1.38	1.17	0.97	1.40	1.18	0.97	1.42	1.16	0.97	1.39
	Assimilating	1.60	1.09	2.37	1.61	1.09	2.39	1.58	1.08	2.30	1.55	1.07	2.24	1.51	1.03	2.19	1.52	1.05	2.20	1.46	1.04	2.07
Gym+ Education by	Accommodating	0.87	0.63	1.18	0.86	0.64	1.16	0.88	0.66	1.17	0.94	0.71	1.24	0.94	0.71	1.24	0.96	0.73	1.26	0.95	0.72	1.26
	Assimilating	1.28	0.88	1.88	1.29	0.88	1.89	1.29	0.88	1.91	1.23	0.85	1.76	1.19	0.84	1.70	1.21	0.85	1.72	1.21	0.84	1.74
Gym+ Time by	Accommodating	0.91	0.67	1.24	0.90	0.67	1.23	0.92	0.68	1.24	0.93	0.69	1.26	0.95	0.71	1.29	0.96	0.70	1.31	0.97	0.71	1.32
	Assimilating	1.04	0.73	1.49	1.05	0.73	1.50	1.02	0.72	1.44	1.01	0.72	1.40	1.03	0.75	1.42	1.05	0.76	1.44	1.06	0.78	1.44
COVARIATES																						
Baseline Physical Activity (Ref= 7 days meeting guidelines)																						

	Gold Standard			MODEL 1: Removing Education			MODEL 2: Removing Race, Education			MODEL 3: Removing Income, Race, Education			MODEL 4: Removing Marital Status, Income, Race, Education			MODEL 5: Removing Initial BMI, Marital Status, Income, Race, Education			MODEL 6: Removing Health Literacy, Initial BMI, Marital Status, Income, Race, Education		
	RR	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**		**RR**	**95% CI**	
0	0.36	0.29	0.45	0.36	0.29	0.45	0.36	0.29	0.45	0.36	0.29	0.45	0.36	0.28	0.45	0.36	0.28	0.45	0.36	0.28	0.45
1	0.51	0.42	0.62	0.51	0.42	0.62	0.51	0.42	0.62	0.50	0.41	0.61	0.50	0.40	0.61	0.50	0.40	0.61	0.50	0.41	0.61
2	0.64	0.54	0.76	0.64	0.53	0.76	0.64	0.54	0.76	0.62	0.52	0.74	0.62	0.52	0.75	0.61	0.50	0.74	0.61	0.50	0.74
3	0.80	0.66	0.96	0.80	0.66	0.96	0.79	0.66	0.96	0.77	0.64	0.93	0.77	0.63	0.94	0.77	0.63	0.94	0.76	0.63	0.93
4	0.93	0.77	1.12	0.93	0.77	1.12	0.93	0.77	1.12	0.92	0.76	1.10	0.92	0.75	1.11	0.91	0.74	1.11	0.91	0.75	1.12
5	1.06	0.89	1.27	1.06	0.89	1.27	1.06	0.89	1.26	1.04	0.88	1.22	1.03	0.87	1.22	1.01	0.86	1.20	1.01	0.85	1.19
6	1.27	1.01	1.61	1.27	1.00	1.61	1.26	1.01	1.58	1.25	1.00	1.55	1.23	0.99	1.53	1.22	0.98	1.52	1.20	0.97	1.49
Sex (Ref=Female)																					
Male	1.25	1.15	1.36	1.25	1.15	1.36	1.24	1.14	1.34	1.22	1.13	1.33	1.23	1.14	1.34	1.23	1.14	1.33	1.23	1.13	1.33
Baseline Age	1.01	1.00	1.01	1.01	1.00	1.01	1.01	1.00	1.01	1.01	1.00	1.01	1.01	1.00	1.01	1.01	1.00	1.01	1.01	1.00	1.01
Health Literacy (Ref=Inadequate)																					
Adequate	0.91	0.79	1.05	0.92	0.80	1.04	0.90	0.80	1.01	0.90	0.80	1.01	0.90	0.80	1.01	0.91	0.81	1.02			
Baseline Body Mass Index	1.01	1.00	1.01	1.01	1.00	1.01	1.01	1.00	1.01	1.00	1.00	1.01	1.00	1.00	1.01						
Marital Status (Ref= Single)																					
Couple or Married	1.09	0.95	1.26	1.10	0.95	1.26	1.09	0.95	1.26	1.07	0.96	1.20									
Annual Income (Ref= < $50,000)																					
Greater than or equal to $50000	0.96	0.85	1.08	0.96	0.85	1.07	0.95	0.85	1.07												
Race (Ref=White)																					
Black	1.04	0.92	1.18	1.03	0.91	1.17															
Other	1.07	0.81	1.41	1.07	0.82	1.40															
Education (Ref=Master's Degree or Higher)																					
High School or Less	0.95	0.75	1.22																		
Some College	0.98	0.84	1.14																		
Bachelor's Degree	1.00	0.84	1.19																		