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SOCIAL ECOLOGICAL PREDICTORS OF LEISURE TIME PHYSICAL ACTIVITY

by

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A Dissertation

Submitted in Partial Fulfillment of the

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Major: Counseling Psychology

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Preface

This manuscript has been submitted to the *Journal of Physical Activity and Health*, and is currently under review. There was only one article submitted for publication, and the Table of Contents includes an introduction to the dissertation and a conclusion following the submitted manuscript.

Acknowledgements

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Abstract

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Background: Physical inactivity is a leading cause of death in the United States and smokers are more at risk to be physically inactive. Physical activity interventions can be one-dimensional and not attend to co-occurring variables that may impact health behaviors. This study examined interrelationships among social ecological variables and identified subgroups of individuals based on their engagement in leisure time physical activity (LTPA) six months after randomization into the comparison arm of a clinical trial for persons trying to quit smoking and not gain weight. **Methods:** Classification and regression trees (CART) analyses were conducted to form subgroups of individuals based on their level of LTPA within a social ecological framework. **Results:** Important variables identified by CART included neighborhood accessibility, occupational physical activity, sleep, age, and neighborhood safety. **Conclusions:** Findings from this study indicate that addressing the interactive nature of important, co-occurring variables on a person's LTPA may aid in the development of empirically-driven interventions.

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Dissertation Introduction

Physical inactivity and tobacco use are two of the leading causes of death in the United States, and modifying these behaviors is crucial to lowering healthcare costs, decreasing mortality rates, and increasing quality of life for persons in the United States.^{2,3} Most Americans do not meet the recommended levels of leisure-time physical activity (LTPA), 150 minutes per week of moderate to vigorous activity, yet a clear, positive association exists between LTPA and reduced mortality and morbidity of chronic disease.¹⁻³ In addition, smokers are at risk to gain weight when they quit smoking.³⁸ Individualized physical activity prescriptions are costly, and not everyone benefits from similar prescriptions because of sociocultural or other lifestyle factors.

There has been little investigation into the subgrouping of individuals across multilevel factors and its influence on LTPA that incorporates a social ecological approach. Social ecological theories posit that individual demographic characteristics and behaviors; interpersonal relationships; physical environment factors; and broad social, economic, cultural, health, and environmental conditions and policies interrelate on multiple levels in an attempt to explain health behavior.^{6,7} Since many interventions have not accounted for co-occurring behaviors or factors, identifying subgroups of individuals who share similar, important characteristics and addressing those characteristics when developing interventions, may assist in the development of more effective interventions, as they will be tailored for a subgroups' specific needs.

The purpose of this dissertation was to identify social ecological factors that combine to form subgroups of smokers who vary on their engagement in (LTPA) to assist in the development of physical activity interventions in smoking populations via a novel statistical analysis. Classification and regression trees (CART), a non-parametrical recursive partitioning

statistical procedure, was used to form subgroups of individuals based on shared characteristics and classifying individuals as physically active or inactive by examining interrelationships among variables. The primary research question was: “What combination of social ecological variables measured at baseline identifies subgroups of smokers who vary in their engagement in LTPA at a time point six months later?”

Manuscript Introduction

It is estimated that fewer than half of Americans meet the recommended level of leisure time physical activity (LTPA)¹; further physical inactivity has been causally linked to a shorter lifespan and is a risk factor for chronic disease (e.g., hypertension and diabetes).^{2,3} While considerable funding has been spent for the development of evidence-based behavioral interventions,⁴ many LTPA interventions have demonstrated only small to moderate effects.⁵

A potential explanation for the limited effectiveness of these interventions is that they address LTPA independent of other factors, yet no single causal determinant of physical activity can be isolated.⁵ In contrast, social ecological models postulate dynamic relationships that occur among individual, relational, and environmental variables, which in combination impact health behaviors.^{6,7} Failure to understand the role of these social ecological factors may perpetuate the limited effectiveness of LTPA interventions.⁸

Social Ecological Model Variables Related to LTPA

In examining demographic determinants of LTPA, numerous individual characteristics have been found to have relationships with LTPA. For instance, men, Caucasians, and persons with higher SES are more likely to be physically active.⁹⁻¹² Rates of LTPA decline through young adulthood and stabilize in later adulthood,¹³ and recent adult development theory suggests

‘emerging adulthood’ (ages 18-25) may serve as a critical time for establishing or adopting long-term health behaviors such as LTPA.¹⁴

In addition to demographic factors, behavioral and psychological characteristics of persons less likely to engage in LTPA include increased body mass index (BMI kg/m²) or weight;¹⁵ high frequency of fast food consumption¹⁶; manually intensive or highly active occupations^{17,18}; heavy alcohol use^{19,20}; and depressive symptomatology, such as diminished interest in activities, depressed mood, and fatigue.^{21,22} Healthy sleep behavior may increase the likelihood of being physically active; however, it is also possible that LTPA improves sleep.^{23,24}

The environmental level of the social ecological model, represented by aspects of the neighborhood in which an individual lives, includes built physical characteristics such as living within walking distance to shops, services, and recreation, or the presence of sidewalks, bike lanes, or parks.^{7,25} Built neighborhood characteristics have been positively associated with LTPA.^{26,27} Equally important in the physical environment are perceptions of safety that include seeing neighbors walking, neighborhoods free from crime, amount of motorized traffic, increased law enforcement, and social connectedness, or walking conditions safe from loose dogs.^{28,29} Perceptions of being unsafe in one’s neighborhood have been associated with lower levels of LTPA.^{29,30}

Numerous studies have reported on the separate relationships between these demographic, behavioral, psychological, and community factors with LTPA, while not considering the multidimensional and dynamic relationships proposed by the social ecological model. Utilizing a social ecological model perspective may help identify combinations of factors that, when appropriately addressed, lead to planning more effective physical activity interventions. The first step in developing such interventions begins by identifying subgroups of

individuals who are physically active or inactive based on their shared characteristics on variables across the model domains, while the second step addresses those characteristics when developing tailored interventions for specific subgroup needs.³¹⁻³³ This study accomplishes that first step by identifying subgroups of participants using Classification and Regression Trees (CART). CART is a non-parametric, non-linear statistical procedure able to identify or explore interrelationships among variables by recursively partitioning persons into groups, discriminating and developing exclusive groups based on shared characteristics for a particular outcome variable.^{8,32,33}

Smokers are at risk for being physically inactive^{34,35}; and in the United States it is estimated that 16.8% of the population smokes, with a higher number being male, multiracial, and having attained a GED.³⁶ Further, persons attempting to quit, or who successfully quit smoking are at risk to gain weight compared to when they smoked or persons who smoke, as smokers tend to have lower body weights^{35,37} and gain on average eight to ten pounds when they quit.³⁸ Although there is limited research understanding physical activity's role as a standalone aid to smoking cessation,³⁹ identifying persons at risk for not engaging in LTPA when trying to quit smoking may serve as a point for intervention when individuals choose to quit smoking.

Research Question

1. What combination of social ecological variables measured at baseline identifies subgroups of smokers who vary in their engagement in LTPA at a time point six months later?

Method

Study Design and Population

Participants were in the comparison arm of the TARGIT study, a 24-month longitudinal randomized clinical trial of young adults who are trying to quit smoking and not gain weight

conducted at The University of Tennessee Health Science Center (UTHSC). TARGIT had institutional approval of protocol and appropriately obtained participants' informed consent. TARGIT tested a behavioral intervention assessing the efficacy of interactive technology (iPod Touch) on weight management during smoking cessation in normal, overweight, and obese young adult smokers.

TARGIT enrolled 330 participants, aged 18-35, who smoked at least 10 cigarettes per day, lived in the Memphis-Midsouth area, met study criteria, and were interested in quitting smoking and not gaining weight.⁴⁰ Further details of participant recruitment, eligibility criteria, and study procedures are described elsewhere.⁴⁰ To prevent interference from the effect of the weight management intervention, the 156 participants randomized into the comparison arm were selected as the study population for the current study, with additional inclusion criteria that individuals self-identified as African American or Caucasian and had outcome variable information (LTPA at six-months), which resulted in a sample size of 134 participants. The Comparison group received a smoking cessation program consisting of behavioral counseling delivered via a pro-active quit line plus nicotine patch dosed according to baseline smoking level. They also received the TARGIT smoking cessation App with seven podcasts on the iPod Touch to assist with their quit efforts. Comparison group participants were not provided behavioral counseling or interactive technology on weight management or increasing physical activity.

Data were used from two different time points, baseline and six-months following initial randomization. Trained study staff administered participant surveys and measured height and weight using a standardized protocol on a calibrated scale. All predictor variables were measured at baseline and selected based on empirical evidence of their relationship to LTPA and their fit

within the social ecological model. LTPA was measured at six months. After reviewing all variables, they were recoded into binary categories, which are described below.

Measures

Outcome variable. LTPA at six-months was measured by the Global Physical Activity Questionnaire (GPAQ),⁴¹ a 16-item self-report measuring physical activity at moderate and vigorous levels in the domains of activity at work, travel to and from places, and recreational activities.⁴² Six questions were used to calculate an LTPA summary score of minutes per week of moderate and/or vigorous intensity activity in recreational activity. Participants whose total minutes per week of LTPA met or exceeded the recommended 150 minutes per week of moderate to vigorous physical activity were categorized as “physically active (engaged in LTPA),” with all other participants categorized as “physically inactive (not engaged in LTPA).”⁴³

Predictor variables.

Demographic variables. Demographic predictor variables were self-reported and included age, race, sex, and education. Age was dichotomized into persons “30 years old or younger” and “31 years old or older.” Race was split into “African American” and “Caucasian.” Sex was categorized as “male” and “female.” Education was divided into two groups, “high school diploma or below” and “vocational training or some college or higher.”

BMI (kg/m²). BMI was dichotomized as: “normal or healthy weight,” BMI 18.5-24.9, and “obese or overweight,” BMI 25.0 and above.

Smoking status. Smoking status was assessed via self-reported number of cigarettes per day, and categorized as “10 to 20 cigarettes per day” and “more than 20 cigarettes per day.”

Occupational physical activity. Occupational physical activity was measured as a summative score of minutes per week of moderate- and vigorous-intensity activity at school/work compiled from summary scores on the GPAQ in these areas. Responses were categorized into “some reported occupational activity” or “no occupational activity.”

Alcohol use. Alcohol use was measured by number of drinks per day, with reclassification into “healthy alcohol use” and “unhealthy alcohol use” using sex-specific cut points of no more than one drink per day for women and two drinks per day for men.⁴⁴

Sleep. Sleep was measured via an average of self-reported hours of sleep per night, and classified as “healthy sleep” (seven to nine hours) and “unhealthy sleep” (less than seven hours or more than nine hours).⁴⁵

Fast food consumption. Fast food consumption was measured via a single-item assessing frequency of fast food intake per week on the Diet History Questionnaire Version 2.0⁴⁶ and categorized as “less than twice per week” and “more than three times per week.”

Depressive symptomatology. The 10-item version of the Center for Epidemiologic Studies Depression Scale (CES-D) assessed depressive symptomatology by asking frequency of depressive symptoms over the past week.⁴⁷ Scores range from 0 to 30, a cut-off score of 10 can indicate endorsement of depressive symptomatology;⁴⁸ thus scores 10 or higher were classified as “endorsement of significant depressive symptomatology,” whereas responses of nine or below were classified as “no endorsement of significant depressive symptomatology.”

Neighborhood accessibility. Five questions measuring perceived access to recreation facilities (i.e., sidewalks, bike lanes) and proximity to shops or markets were entered into a preliminary exploratory factor analysis to assess if these five items naturally clustered together

onto one underlying dimension to create a scale of perceived neighborhood accessibility, and indicated as such. Scale scores were averaged with higher scores indicating greater perceived neighborhood accessibility and showed adequate reliability with a Cronbach's alpha of .74. Responses were categorized as "perceived limited neighborhood accessibility" and "perceived neighborhood accessibility."

Neighborhood safety. Participants responded to a single statement assessing neighborhood safety, which was measured on a 4-point Likert scale ranging from 'Strongly Disagree' to 'Strongly Agree.' Based on responses, they were reclassified as "perceived neighborhood as safe" and "perceived neighborhood as unsafe."

Description of Statistical Analysis—Classification and Regression Trees (CART)

CART was conducted to identify subgroups of individuals based on their engagement in LTPA at six-months. As an exploratory analysis CART classifies observations with similar responses into easy to read small groups resembling a treelike structure.³² CART does not assume a particular relationship between predictor and outcome variables, has no statistical assumptions of normality or distribution, and includes missing data.^{49,50} CART accounts for partial interactive effects in a way not as easily possible in logistic regression model, which allows flexibility to examine undetermined *a priori* relationships among variables as well as higher-order interactions.⁴⁹ The analysis identifies the variable that best partitions subgroups at each "split" via measurement of the difference, also known as impurity, within a distribution (the Gini Index), and theoretically could reiterate until each subgroup is representative of one person, when there is no variability within the node.^{49,50} However, parameters identified *a priori* end the classification process when splitting no longer adds to the prediction of the outcome variable.

Within this study, analysis were conducted using IBM SPSS Decision Trees 22⁵¹ and the *a priori* parameters included a minimum sample size of 10 in each parent node, trees depth no larger than five levels (a parameter established within SPSS), and a minimum difference between the nodes, Gini index, of .001.^{32,52} A 10-fold cross-validation was used to prevent overfitting of the tree, which randomly split the sample into 10 subsets and ran 10 iterations, leaving one subset out each time (10-1).^{52,53} CART provided a classification percentage accuracy indicating the percentage of cases classified correctly for each category of the outcome variable.⁵¹ Additionally, measures of sensitivity, the probability of cases being correctly classified and specificity, the proportion of cases being accurately classified as a true negatives, are presented to assess the performance of the CART model.⁵⁴

Results

Thirteen variables (race, sex, age, education, BMI, smoking status, occupational physical activity, alcohol use, sleep, fast food consumption, depressive symptomology, neighborhood accessibility, and neighborhood safety) were included as possible predictors in the CART analysis. Descriptive statistics are reported in Table 1 and shown below, with the majority of the sample not engaging in LTPA at 6-months. Additionally, more persons in the sample were Caucasian, smoked 10-20 cigarettes per day, did not report significant depressive symptomology, and were categorized as overweight or obese, healthy drinkers, having healthy sleep behaviors, and perceiving their neighborhood as safe.

Table 1

Baseline Characteristics of Categorized Predictor Variables

LTPA at 6-Months (n, %)	
Physically active	55 (41.0%)
Non-physically active	79 (59.0%)
Race (n, %)	
African American	54 (40.3%)
White	80 (59.7%)
Sex (n, %)	
Male	68 (50.7%)
Female	66 (49.3%)
Age (n, %)	
30 Years or younger	61 (45.5%)
31 Years or older	73 (54.5%)
Education (n, %)	
High school diploma or less	45 (33.6%)
Vocational training or some college or higher	89 (66.4%)
BMI kg/m ² (n, %)	
Normal or healthy weight	35 (26.1%)
Overweight or obese	99 (73.9%)
Smoking status (n, %)	
10-20 cigarettes per day	114 (85.1%)
20 or more cigarettes per day	20 (14.9%)
Occupational physical activity (n, %)	
Engages in some occupational physical activity	66 (49.3%)
No occupational physical activity	68 (50.7%)
Alcohol use (n, %)	
Healthy alcohol use	77 (57.5%)
Unhealthy alcohol use	57 (42.5%)
Sleep (n, %)	
Unhealthy sleep behavior (<7 or >9 hours)	49 (36.6%)
Healthy sleep behavior (7-9 hours)	85 (63.4%)
Fast food consumption (n, %)	
Less than twice a week	55 (41.0%)
Greater than three times a week	79 (59.0%)
Depressive symptomology (n, %)	
No significant depressive symptomology	119 (88.8%)
Endorsement of depressive symptomology	15 (11.2%)
Neighborhood Accessibility (n, %)*	
Perceived neighborhood access	63 (47.0%)
Perceived limited neighborhood access	71 (53.0%)
Neighborhood Safety (n, %)*	
Neighborhood perceived as safe	77 (57.5%)
Neighborhood perceived as unsafe	52 (38.8%)

*item response of 'don't know' was removed, leaving less than 100%

CART developed a tree containing five nodes with sample sizes of approximately 10 or larger, which is represented on Figure 1 and seen on the following page. Predictor variables represented on the tree diagram included sleep, occupational physical activity, neighborhood accessibility, age, neighborhood safety, BMI, and education. Within the model, sensitivity was .64 and specificity was .75. As a whole, CART achieved a classification accuracy of 70.1%.

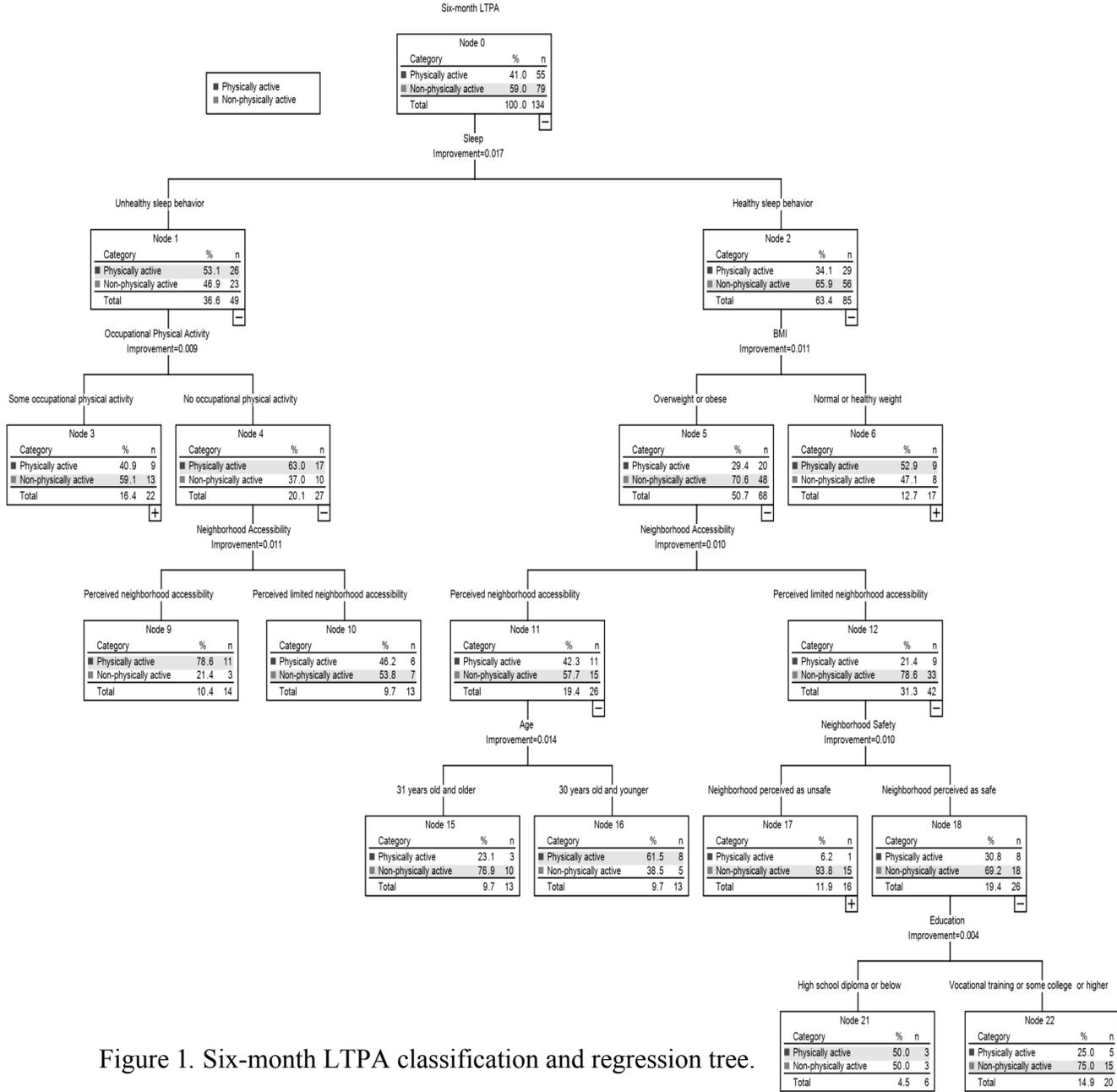


Figure 1. Six-month LTPA classification and regression tree.

The primary variable that separated the sample was sleep behavior, with a higher percentage of the sample being categorized as having healthy sleep behavior ($n = 85$, 63.4%). Among those with unhealthy sleep behavior ($n = 49$), occupational physical activity was the next splitting variable, with persons reporting some occupational physical activity ($n = 13$, 9.7%) being classified as inactive. Comparatively, a small subgroup identified as having unhealthy sleep, reporting no occupational physical activity, and perceiving access to neighborhood facilities were classified as active ($n = 11$, 8.2%).

For persons categorized as healthy sleepers, they were next separated by BMI, with a higher percentage of overweight or obese individuals being inactive. From this subgroup of obese or overweight individuals with healthy sleep, various inactive subgroups emerged that differed based on perceived neighborhood accessibility. Persons reporting perceived access to neighborhood facilities within this subset were then divided based on age of persons 31 or older and were unable to be further divided ($n = 10$, 7.5%). Individuals reporting limited access to neighborhood facilities were then split on neighborhood safety, which identified a subgroup of persons reporting their neighborhood to be unsafe (unsafe $n = 15$; 11.2%). Comparatively, individuals reporting a safe neighborhood were then separated as having vocational training or some college or higher ($n = 15$; 11.2%).

Discussion

Using a novel statistical approach (CART), this study examined the relationships among social ecological variables to LTPA and identified subgroups of individuals based on variables associated with their 6-month engagement in LTPA following randomization to a smoking cessation program. As an exploratory hypothesis-generating tool, CART appeared to adequately answer the initial research question of what social ecological variables group together to identify

subgroups that are associated with 6-month LTPA. This information may aid in the development of future evidence-based physical activity interventions.^{31,55,56}

CART identified sleep, occupational physical activity, neighborhood accessibility, BMI, neighborhood safety, age, and education as variables important in classifying young adults in the study as 1) engaged or 2) not engaged in LTPA six months after TARGIT study enrollment. The current exploratory study extends previous research by examining combinations of variables in domains specified in the social ecological model by recognizing how multiple determinants may work together to influence LTPA. Identifying barriers to regular physical activity is not only important in the larger population, but also among persons quitting smoking may aid in the cessation process and be a useful tool for preventing weight gain during a quit attempt. Further, identifying strategies to increase LTPA during smoking cessation may aid in prevention of relapse to smoking and be useful to researchers developing interventions for this population at risk for weight gain.

Via CART analysis, sleep was identified as the most important partitioning variable within this sample, but its relationship to LTPA remains unclear, as sleep behavior was important to persons both engaging and not engaging in LTPA. With regard to the 10% of persons not engaged in LTPA who reported unhealthy sleep and engagement in occupational physical activity, a possible underlying factor in this CART-derived subgroup may be nighttime employment (i.e., physically demanding shift work). Individuals working at night are less likely to be physically active and may have disrupted sleep²³; thus, understanding the role of occupational physical activity and its interaction with sleep behavior, smoking, and LTPA may serve as a point of intervention at workplaces.

The built environment and perceptions of safety were also important. In one subgroup, a larger portion of persons perceiving limited neighborhood accessibility were not engaging in LTPA, and neighborhood safety was secondary to accessibility. This is not surprising since characteristics such as having parks or shops within walking distance, adequate recreation facilities, and close physical proximity to biking or walking paths, along with safe footpaths in a neighborhood safe from crime, are positively associated with LTPA.⁵⁶

However, some persons in this sample with neighborhood accessibility or who perceived safety in their neighborhood despite perceived inaccessibility, did not engage in LTPA. Therefore, a person's primary modality for LTPA may not depend upon personal safety exclusively, but rather personal safety may be more relevant when local outside activities are used as a primary source of physical activity, but less relevant for those who go elsewhere (e.g., gyms, parks, trails, or other neighborhoods perceived as safe) for LTPA.^{27,57} Past research has found LTPA interventions may be ineffective if physical activity interventions fail to identify or provide safe or comfortable modalities for physical activity;⁵⁸ thus, inclusion of the community context (e.g., perceived neighborhood environment) is vital. Travel to exercise facilities or accessible areas perceived as safe may present a challenge to those desiring to engage in LTPA, so studies addressing potential community and environmental barriers when testing interventions to increase LTPA engagement may increase the efficacy and effectiveness of such interventions.

One strength to the study was its recruitment of a diverse sample; however, as with all studies, limitations exist. The use of secondary data, which inherently does not permit determination of exclusion or inclusion criteria, is one such limitation.⁵⁹ Some of the variables may have had a limited range of variance, and their relationships with LTPA may have been more evident, with a greater range of sample variance in the study population (e.g., majority of

sample reported smoking less than 20 cigarettes per day; nor were persons with major depressive disorder included in the larger TARGIT study).

Recommendations for Future Research

Future studies could examine the differences in hypothesis-developing statistical procedures. For example, utilizing approaches such as C5.0 or QUEST, which allows for multiple categorical or continuous node splits, may result in more refined categorizations to assist in identifying persons at risk or unlikely to adopt healthy behaviors.^{32,33} Also, assessing LTPA at various time points to address the importance of variables longitudinally may extend this line of research. And, although neither sex nor race served as a splitting variable, further analyses by sex or race may also highlight factors that may be important to consider in designing interventions for males or females, or African Americans or Whites.

Results of this study add to the body of literature for the social ecological model and further substantiate the need for interventions that address individual characteristics, modifiable behaviors, and community/perceived environment factors when attempting to increase LTPA.^{12,60} The use of CART assists researchers in identifying important co-factors influencing LTPA that might go undetected in other forms of statistical analysis.

Conclusion

This study, which was conducted with Comparison arm participants of a randomized clinical trial of young adults who are trying to quit smoking and not gain weight conducted at The University of Tennessee Health Science Center (UTHSC), found that various variables were important in developing subgroups of persons who vary on their level of LTPA. Variables identified as important in classifying persons as engaged or not engaged in LTPA included sleep, occupational physical activity, neighborhood accessibility, BMI, neighborhood safety, age, and education. This study identified possible factors to consider when developing LTPA

interventions and appeared to adequately serve as a hypothesis-generating tool. Via use of CART, researchers may be able to better identify barriers to regular LTPA among persons quitting smoking with aims to prevent weight gain, such as identifying safe modalities for LTPA or providing psychoeducation in the workplace on the importance of LTPA, while identifying persons most at risk to be physically inactive.

The findings from this study are important in the context of the recent increases in funding being allocated for patient-centered research. These findings can allow for tailored interventions for different identified subgroups. Further, this study lends to the support of community-based participatory research methods, and the necessity to better understand the barriers or challenges in the populations of persons targeted for LTPA interventions. In addition, results of this study add to the body of literature for the social ecological model and further substantiate the need for interventions that address individual characteristics, modifiable behaviors, and community factors.

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