AN ABSTRACT OF THE DISSERTATION OF

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Title: Life Course Perspective: A Journey of Participation in Physical Activity

Abstract approved:

Bradley J. Cardinal

A life course perspective provide a meta-theoretical framework to understand human development. This perspective is characterized by studying the changing lives within the changing environment (George, 2004). Building upon the literature in the psychosocial paradigm and ecological models, Manuscript 1 discusses the uniqueness and the practical importance of a life course perspective for research in physical activity (PA) promotion. The organizing structure of time, together with the paradigmatic principles of a life course perspective, was described within the context of PA. Finally, the implications, methodological issues, and the possibilities of research within the aging population were discussed.

Two empirical studies that applied the principles of a life course perspective were used to illustrate its potential use, as well as the substantive implications of the studies. Manuscript 2 presents the first empirical study titled “Life-Threatening Diseases and Physical Activity Trajectories Along the Marriage Life Course: Opportunity or Obstacle?” This study explored the concordance of PA trajectories between husbands and wives and the relationships between life-threatening diseases (LTDs) and PA trajectories using the Panel Study of Income Dynamics. Stable active (SA), activity adopters (AA), activity relapsers (AR), and stable sedentary (SS) were four of the five theoretical PA trajectories developed from the transitional shift patterns in previous research (Levy & Cardinal, 2006), and that were included in the current study. Three relationships were hypothesized including 1) the relationship between wives’ PA trajectories and husbands’

PA trajectories, 2) the curvilinear relationships between husbands' and wives' LTD-related limitations and husbands' PA trajectories, and 3) the interaction effect between age and husbands' LTD-related limitations on husbands' PA trajectories. A latent class growth analysis (LCGA) was used to extract the four PA trajectories for husbands and for wives. Results from the LCGA model showed that wives' PA trajectories were related to husbands' PA trajectories. Wives' LTD-related limitations were not associated with husbands' PA trajectories, while a curvilinear relationship was found for husbands' LTD-related limitations on being in SA rather than AR. People diagnosed with LTDs with no resulting limitation showed an increased likelihood to be in SA rather than AR for vigorous PA. However, this protective effect declined and became negative with increased LTD-related limitations. The curvilinear relationship was moderated by age. Specifically, younger individuals were more strongly associated with both positive and negative effects of LTD-related limitations compared with older adults. Findings suggested couples and families can be viable intervening units for PA promotion, and that strategies should be tailored to meet the needs of people at different ages during the experience of LTDs.

Manuscript 3 presents the second empirical study titled "Change and Continuity of Physical Activity Trajectory at the Transition of Spousal Loss: The Australian Longitudinal Study of Aging." This study examined 1) whether pre-spousal loss PA trajectories including SA, AA, AR, and SS explained the post-spousal loss PA trajectories, and 2) whether advanced age predicted less favorable post-spousal loss PA trajectories. In addition, the multiple influences of contact with children, spousal care, and depression on the post-spousal loss PA trajectories were also explored. The sample included 930 widowed participants selected from the Australian Longitudinal Study of Aging (ALSA). The pre-spousal loss PA trajectories, age, contact with children, depression, spousal loss, and other covariates were used to predict the membership of the post-spousal loss PA trajectories using sequential LCGA. The pre-spousal loss PA trajectories (ORs=7.90-16.59, ps<.01) and spousal loss (ORs=4.10-4.63, ps<.05) were shown to predict the post-spousal loss PA trajectories. Early intervention aimed at developing habitual PA may prevent the less favorable PA trajectories after spousal loss. For future interventions, the social and environmental factors that may contribute to the changes in the PA trajectories in the transition of spousal loss should continue to be explored. Other life course events and transitions should also receive more attention for PA promotion.

Life Course Perspective: A Journey of Participation in Physical Activity

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

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Kin-Kit Li, Author

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CONTRIBUTION OF AUTHORS

Kin-Kit Li, M.Phil. conceptualized, drafted, and conducted all data analyses presented.

Dr. Bradley J. Cardinal provided editorial comments and suggestions on the interpretation of the findings.

Dr. Richard Settersten provided editorial comments and suggestions.

Dr. Alan Acock assisted with statistical analysis and the interpretation of the findings.

TABLE OF CONTENTS

LIST OF FIGURES

<u>Figure</u> <u>Page</u>

LIST OF TABLES

This dissertation is dedicated to

My parents,
Hong-Yu Cheng and Tat-Shing Li,
for their love and support in all the stages of my life.

Chapter 1. General Introduction

General Introduction

The life course perspective for physical activity (PA) is introduced in this dissertation. One theoretical article and two empirical studies are included. The first article titled, "Life Course Perspective and Physical Activity Promotion," discusses the relationships among the psychosocial paradigm, ecological models, and the life course perspective and how the field of study of PA promotion can benefit from taking the life course approach. The organizing framework of time and the paradigmatic principles of the life course perspective were then described within the context of PA. The implications for interventions, methodological issues, and the possibilities of research within the aging population were discussed.

Two empirical studies that applied principles of the life course perspective were used to illustrate its potential use, as well as substantive implications for the foci of interest. The first empirical study titled, "Life-Threatening Diseases and Physical Activity Trajectories along the Marriage Life Course: Opportunity or Obstacle?" investigated the effects of life-threatening diseases (LTDs) on PA trajectories including stable active (SA), activity adopters (AA), activity relapsers (AR), and stable sedentary (SS) among married couples. The second empirical study titled, "Change and Continuity of Physical Activity Trajectory at the Transition of Spousal Loss: The Australian Longitudinal Study of Aging", focused on the transition to widowhood among older adults in the Australian Longitudinal Study of Aging (ALSA). The pre-spousal loss PA trajectories, timing of the transition, and other possible factors were used to predict the post-spousal loss PA trajectories.

Chapter 2. Manuscript 1

Life Course Perspective and Physical Activity Promotion

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Abstract

Psychosocial theories and social ecological models have dominated the literature in physical activity promotion for the past few decades. This article introduces the life course perspective in the area of study of physical activity promotion to connect and supplement the current paradigmatic knowledge and potentially stimulate future research effort in this area. The first section provides a brief review of the psychosocial paradigm and ecological models, and discusses the significance of incorporating knowledge from the life course perspective and its organizing framework in physical activity promotion. The organizing structure of time in the life course perspective in the context of physical activity is described in section two. Section three presents the five paradigmatic principles of the life course perspective (G. H. Elder, Jr., Johnson, & Crosnoe, 2004), and the discussion section includes the implications for interventions, methodological issues, and the future research possibilities within an aging population.

Life Course Perspective and Physical Activity Promotion

Despite the recognized physical and psychological benefits of regular physical activity (U. S. Department of Health and Human Services, 1996), more than half of American adults are not physically active at levels that promote and maintain health (Centers for Disease Control and Prevention [CDC], 2005a). Some progress has been made in the past two decades (CDC, 2005b; Steffen et al., 2006). However, considering the current obesity epidemic and the prevalence of inactivity related diseases in our society, the results are still far from satisfactory. Hence, continued research effort on theory and intervention development is needed.

The purpose of this article is to discuss the potential use of the life course perspective to extend our current understanding of physical activity behaviors and inform future intervention efforts. The first section of this article describes the traditional paradigms for studying physical activity, including the psychosocial and ecological approaches. It further discusses the potential benefits of incorporating a life course perspective into the study of physical activity. The second and the third sections present the organizing structure of time, and the concepts and principles of the life course perspective, along with its applications within the domain of physical activity promotion. The final section discusses the implications of applying a life course perspective to the study of physical activity promotion from the perspective of interventions, methodological issues, and their implications among the older adult population.

Theoretical Approaches in Physical Activity Promotion

Physical activity interventions should rely on theory-based approaches, in which the theories are developed and refined through cumulative evidence and careful reasoning (Brug, Oenema, & Ferreira, 2005). Many theories applied in the context of physical activity behaviors are social cognitive in nature, with their origins being from the field of psychology (Jeffery, 2004). The emphasis on social and environmental influences on physical activity and other health behaviors has also been a dominant research paradigm since the introduction of the socio-ecological model in the 1980s (e.g., J. P. Elder et al., 2007; McLeroy, Bibeau, Steckler, & Glanz, 1988) and it has been widely applied in the public health arena (e.g., CDC, 2007). The life course perspective, which serves as a meta-theoretical framework aimed at facilitating communication among researchers and the accumulation of knowledge (Settersten, 2003), can potentially merge the strengths of these traditional research paradigms and, additionally, provide a unique temporal and developmental approach to the study of physical activity.

Psychosocial Paradigm

Many psychosocial theories have been applied to the study of physical activity and these theories vary to the extent of their specificity to physical activity behaviors. Generic theories are often developed in and imported from the field of psychology and the main goal of these theories is to understand a broad range of human behaviors. Some widely applied generic theories include the social cognitive theory (Bandura, 1986), theory of reasoned action (Ajzen & Fishbein, 1980), theory of planned behavior (Ajzen, 1991), self-determination theory (Deci & Ryan, 1985) and achievement goal theory (Nicholls, 1984). A few theories are specifically designed for explaining health behaviors including physical activity, such as the health belief model (Becker, 1974) and protection motivation theory (Maddux & Rogers, 1983). More specific theories originate from sport and exercise psychology like the movement confidence model (Griffin & Keogh, 1982), which highlights the importance of movement sensations in developing confidence in physical activity settings.

The basic tenet of these psychological theories is that individuals are the active agents of their behavioral choices and that their cognitions such as beliefs, values, attitudes, expectations, motivation, and goals are the determinants of their behaviors. Some theories, such as the social cognitive theory, have also addressed social and environmental influences, but the main interest remains on the relationships among the psychological variables (Jeffery, 2004) and also individuals' perceptions or interpretations of their social environments. For example, the perceived social support and perceived barriers to physical activity, rather than the actual available resources for social support and environmental barriers such as the accessibility to fitness facilities, are frequently used in the psychosocial approach. A recent position paper from the CDC Healthy Aging Research Network also stated that much less is known about the social and environmental correlates of physical activity compared with personal correlates, and hence future research should focus on assessment, intervention, and evaluation of physical activity from a social ecological framework, which places a stronger emphasis on social and environmental influences (Prohaska et al., 2006).

Ecological Paradigm

The ecological perspective in health behavior research emerged in the late 1980s and the fundamental focus of this perspective is that behaviors are affected by multiple levels of influence including the individual and the social environment (McLeroy et al., 1988; Sallis & Owen, 1999). From a public health perspective, neglecting the social and environmental influences may promote a victim-blaming ideology (McLeroy et al., 1988). An upstream approach (Orleans, 2000), which suggests interventions at the public policy or community levels, can potentially induce population-level changes in behavior (Spence & Lee, 2003), while a downstream approach may provide tailor-made strategies that are more sensitive to individual behavior change. Taking a multilevel approach to behavior change can possibly provide a comprehensive framework for understanding behavior changes without losing the specificity at each level. Ecological models also assume the inter-level relationships as being affected by and affecting each other in a reciprocal manner (McLeroy et al., 1988; Spence & Lee, 2003).

J. P. Elder et al. (2007) has contrasted the ecological models with psychosocial models in three distinct ways. First, ecological models offer domain- or level-specific recommendations to understand behaviors, but they do not provide guidance on which domain-specific variables are useful for a particular topic or area. Thus, psychosocial theories can be integrated in the ecological models at the intrapersonal and/or interpersonal level of influence to provide insights about the actual relevant determinants. Second, some behavioral influences such as self-efficacy, decisional balance and the processes of change are more generalizable to a wide range of behaviors. However, the environmental and policy influences are usually very behavior-specific. For instance, the policy changes such as increasing taxes on cigarettes and related products to reduce tobacco consumption may not be applicable to reducing sedentary behaviors. Hence, ecological models are suggested to be tailored to each population and behavior of interest. Third, studies of environmental and policy correlates of most health behaviors are relatively rare compared to correlates derived from psychosocial theories. Therefore, the consensus between practitioners and participants rather than empirical findings may play an important role in suggesting the key variables in behavior-specific ecological models beyond the intra-individual level.

With these features, ecological models provide a flexible and comprehensive theoretical framework that is readily applicable to health promotion at the population level as well as the individual level. For instance, the theory of triadic influence (Flay & Petraitis, 1994) provides such a meta-theoretical framework that shows how multiple factors at different levels of influence (including individuals, social contexts, and cultural environments) are streamlined to change individuals' decisions, intentions, and actual health behaviors. The theory of triadic influence also emphasizes the importance of the interactive nature of the influences and the feedback (e.g., thoughts and feelings) of the resulting behaviors on future behaviors.

In the area of physical activity promotion, more research effort in recent years has been placed on how the environment is engineered and how individuals interact with the environment. For instance, studies on multiple levels of contextual characteristics, including the neighborhoods that influence physical activity, have become a major line of research inquiry (e.g., Duncan, Duncan, Okut, Strycker, & Hix-Small, 2003; Dzator et al., 2004). Similarly, the influence of the built environment, including land use and transportation characteristics and policies on physical activity, has also called for serious urban planning and retrofitting efforts to encourage physical activity participation (e.g., Committee on Physical Activity, Health, Transportation, and Land Use, Transportation Research Board, Institute of Medicine of the National Academies, 2005). Furthermore, funding agencies have invested in programs that employ the social ecological model for physical activity promotion, such as the state-based programs funded by the Nutrition and Physical Activity Program to Prevent Obesity and Other Chronic Diseases (CDC, 2007) and research programs funded by the Robert Wood Johnson Foundation (e.g., Day & Cardinal, 2007).

Life Course Perspective

“Ecological models have been described as typologies of individual, social, and environmental features (Sallis & Owen, 1999), reflecting and building upon the work of Bronfenbrenner (1977)” (Spence & Lee, 2003, p. 9). Bronfenbrenner used a set of Russian dolls to symbolize the nested relationships of the ecological system including the microsystem, mesosystem, exosystem, and macrosystem in his model (refer to Bronfrenbrenner, 1979, for detail). Rather than solely focusing on the building blocks in the environment, such as dyad, role, social network, and culture, his model describes “the way in which these entities are related to each other and to the course of development” (p. 8). However, the developmental emphasis in Bronfenbrenner’s model is missing from most of the ecological models used in health promotion and physical activity promotion in particular. A temporal perspective could inform the timing of interventions regarding the needs, risks, and opportunities to change at a particular time in the life course, and the development of strategies at the individual, social, and environmental levels that match the timing of interventions.

Life course, by itself, refers to the multiple and interrelated trajectories, or social pathways, including education, work, family, leisure, and other domains within the lifespan (Settersten, 2003), while the *life course perspective* extends beyond the organization or structure of the lifespan and identifies the specific concepts and principles as to how an individual’s life course unfolds within the social environment. The life course perspective provides a meta-theoretical framework that can facilitate the formulation of research hypotheses and communication among researchers (G. H. Elder, Jr., 1998; G. H. Elder, Jr. et al., 2004; Giele & Elder, 1998). Common to the ecological paradigm, the life course perspective does not explicitly state and combine the specific psychological, behavioral, social, and environmental factors of interest as an integrated theory. Instead, the life course perspective is characterized by a unique organization of time-line and several basic principles that provide a flexible, comprehensive, and socially relevant guiding framework for understanding changing lives in changing environments (George, 2004). Extended from the ecological models that link an individual’s life to the physical and social context, the life course perspective connects the past to the present and examines the social pathways in their historical context.

Although life-span and life-course are sometimes used interchangeably, the two approaches are fundamentally different, but potentially supplementary in understanding human development (see Settersten, 2005, for discussion). Life-span psychology focuses more on the genetic, cognitive, volitional, and emotional factors, while life-course sociology focuses more on the "social facts" such as social constraints, opportunities, and incentives. While the primary emphasis of this paper is to introduce the life-course perspective, it does not disregard the importance of psychological processes. Conversely, the two approaches have been suggested to build stronger partnership to understand human development (Settersten, 2005). Hence, rather than taking an entirely sociological perspective, the life-course perspective suggested here aims to provide a guiding framework for comprehensive understanding and potential integration. Furthermore, the organization of time characterized in the life-course perspective also makes this approach appealing for future intervention development, which will be further elaborated on in the following section.

Structure of Time and its Implications for Physical Activity Promotion

To further elaborate the potential utility of the temporal aspects reflected in the life course principles (which are described below), the structures and the defining properties of time in the life course perspective are presented. In the life course perspective, multiple and interdependent trajectories are punctuated by events, transitions, and turning points, and the defining features of these trajectories include timing, sequencing, spacing, density, and duration (for more detailed descriptions, see Settersten, 2003). Some of the key parameters of time and how they relate to physical activity promotion are elaborated on below.

Trajectories

"Trajectories are [simply] long-term patterns of change and stability" (George, 2004, p. 675). Life trajectories describe the sequence of states over time in biological, behavioral, psychological, and social terms. The pattern of physical activity that a person participates in over time can be summarized as a behavioral trajectory. Common behavioral patterns may show periods of being physically active or inactive, or increasing or decreasing activity levels over time. These states of physical activity patterns converge with the transitional shift pattern of physical activity idea, which suggests five common patterns of physical activity behaviors including stable active, stable sedentary, activity adopter, activity relapser, and perpetual preparer (Levy & Cardinal, 2006).

Within the segments of trajectories, the behavioral patterns are suggested to have inertia (Wethington, 2005), that is, the behavioral trend is rather resistant to disruption. Particularly, long *durations* (i.e., the length of time spent in a state) are suggested to increase the behavioral continuity over the life course (G. H. Elder, Jr. & Johnson, 2003). For instance, Lees and colleagues (2005) conducted a focus-group study among older adults and found that inertia was one of the most frequently mentioned barriers to exercise. In a sample of women with a history of breast cancer, lack of time and inertia were also found to be the most important barriers to exercise (Leddy, 1997). Similarly, studies with a social-cognitive perspective have shown that past physical activity behavior predicts future participation directly and indirectly through psychosocial constructs (Hagger, Chatzisarantis, & Biddle, 2001; Jackson, Smith, & Conner, 2003), which suggest that a habituation effect may take place. Hence, physical activity promotion may require more than an initiation of activity, but also the interference or disruption of the habitual behavioral pattern.

Transitions

In contrast to the consistency within the segments of trajectories, transitions characterize changes and variability on the trajectories. Transitions refer to changes from one state (or role) to another, which compose the inflection points on the trajectories together with events and turning points. Bronfenbrenner (1979) used the term *ecological transitions* to describe the shifts in role and/or setting. In contrast to transitions, events in the life course perspective that induce relatively abrupt changes are defined as turning points, while changes associated with transitions are usually more gradual (Settersten, 2003). Turning points are discussed in more detail below.

The meanings associated with life transitions are socially constructed. Furthermore, life transitions typically encompass changes in social roles and responsibilities, which may have transformational experiences that lead to major changes in an individual's life (Resnicow & Vaughan, 2006). States and roles are typically qualitative rather than quantitative in nature, such as transition from schooling to employment and transition from single to married. Some life transitions have been shown to influence physical activity. For instance, the “freshman 15” (i.e., a weight gain of 15 pounds during the first year of college) and “post-wedding weight gain” are considered the result of a deterioration in diet and eating habits coupled with physical inactivity during the transitions from high school to college and from single to married, respectively (Burke, Giangiulio, Gillam, Beilin, & Houghton, 2003; Lowe et al., 2006; Racette, Deusinger, Strube, Highstein, & Deusinger, 2005). Decreases in physical activity during the age range of 15-29 may also be at least partially attributed to the decrease in the availability of team sport activities (Zick, Smith, Brown, Fan, & Kowaleski-Jones, 2007). Transitions may not necessarily impose a negative influence on physical activity behaviors. For instance, a cancer diagnosis has been found to enhance the participation in physical activity for some individuals (e.g., cancer survivors in a fund-raising event; (Humpel, Magee, & Jones, 2007) and could be considered as a teachable moment or changeable moment in terms of intervention.

Turning Points

Wheaton and Gotlib (1997) define turning points as “a change in direction in the life course, with respect to a previously established trajectory, that has the long-term impact of altering the probability of life destinations” (p.5). Turning points are similar to transitions, and are sometimes used interchangeably. Turning points can be subjectively defined by individuals or objectively defined by researchers who have observed and examined changes in trajectories (Settersten, 2003). Turning points can be distinguished from transitions in certain aspects. First, turning points imply significant changes (typically to a different direction), while people may not respond drastically to life transitions. Second, turning points have a future time orientation, which defines the rest of life after that moment.

Kearney and O’Sullivan (2003) suggested that identity shift could be a turning point in health behavior change. Identity shift is initiated by the successful experience of a small behavior change and small behavior changes are triggered by a value conflict in response to accumulating distressing evidence about one’s health. Likewise, the health belief model (Becker, 1974) and protection motivation theory (Rogers, 1983) also suggest that the perceived threat or the threat appraisal may induce a motivation to take action in health behaviors. Although turning points seem to have important implications to behavior change, research on turning points in the physical activity promotion literature are rare. The challenges of defining and studying turning points may inhibit growth in this area of study.

Timing in Lives

Along with trajectories, transitions, and turning points, different timings of an event or a transition in life may have differential effects on the individual. G. H. Elder, Jr. (1999) found that the Great Depression had different impacts on the life trajectories of people entering this period at different ages. Similar concepts can also be applied to physical activity participation. For example, the blossoming of the video game industry, the increasing popularity and necessity of using the internet in everyday life, and the increased availability of private cars may have different ramifications on people of different age cohorts in terms of the patterns of their physical activity behavior. Additionally, a diagnosis of a life-threatening disease may mean different things to a child, a middle-aged person, or an older adult and, hence, it may lead to different patterns of physical activity. Events can be defined as normative versus non-normative within the life course perspective. Non-normative events are believed to have a stronger impact on behaviors (Neugarten, 1977, 1979); hence, the diagnosis of diabetes may be more likely to change the physical activity behaviors of a younger adult rather than a middle-aged adult or vice versa. These are interesting research questions, which need further investigation.

Paradigmatic Principles of the Life Course Perspective

There are five paradigmatic principles of the life course perspective: agency, linked lives, time and place, life-span development, and timing (G. H. Elder, Jr. et al., 2004). The principle of agency may, to some extent, reflect various psychosocial theories, which presume that individuals are the active agents of their behaviors and decisions are made within the opportunities and constraints of history and social environment. It is assumed that individuals’ choices or the adaptive strategies used can have important implications to their physical activity participation. The principle of linked lives refers to the interdependency of lives and how the social and historical context influences the network of these shared relationships. Linked lives resembles the interpersonal level of influence in the ecological models, for which both of them point to the possibility of using different possible intervening units, for example, couples, family, and networks of friends. The principle of time and place explains how the life course is shaped by the experience of historical events and geographical locations. One example in the domain of physical activity is the well-known impact of Title IX, which has provided increasing opportunities for women in the United States to participate in physical activity. Combining these three life course principles outlines the multiple levels of influence, which are the landmark of the ecological models.

The novel contributions of the life course perspective in physical activity promotion are the tenets that human development and aging are lifelong processes (i.e., the principle of life-span development), which start from birth and continue throughout the whole life, and that the determinants and impacts of events and transitions vary as a function of their timing in life (i.e., the principle of timing). The principle of life-span development connects the past to the present, and emphasizes that development is a lifelong process, which does not stop after adulthood. Some research has examined the effects of earlier physical activity experience on later participation, and how predictive earlier participation is of future participation (Telama, Yang, Laakso, & Viikari, 1997). Consistent with the ideology of preventive medicine, some evidence seems to suggest that early intervention is crucial to the prevention of physical inactivity (Pate, Heath, Dowda, & Trost, 1996). Conflict theory (Resnicow & Vaughan, 2006) and the idea of cumulative advantage or disadvantage (Crystal & Shea, 1990; Ross & Wu, 1996) also suggests the sensitivity and importance of an initial condition (or early experience), as it sets the stage for the cumulative experiences that reinforce the physical activity trajectory. Therefore, early life experiences may have enduring or even magnifying impacts on later development (Dotson, 1988). However, this proposition does not imply changes in later life are difficult or impossible. Intervention strategies should be designed to promote and maintain physical activity throughout the life course. Additionally, timing of the event in life, as described in the organizing structure of time, is also an important principle in the life course perspective that may afford differential effects with the same event or transition.

Discussion

Implications for Interventions

George (2004) suggested that there are two main approaches for using the life course perspective. First, the life course perspective can be used to examine how the life course is constructed. For example, studies using this approach would examine how social changes and historical events influence the social pathways insofar as the timing and sequencing of the transitions. Early works of G. H. Elder, Jr. (1999) that looked at the influence of the Great Depression and wars on individuals' life course fall into this category. The recent debates on the de-chronologization, de-institutionalization, and de-standardization of lives, which suggest that life course becomes more flexible (Settersten, 2003), are some other example of this type. Second, increasingly studies have used life course concepts and principles to study the outcomes of interest of researchers. For example, an increasing number of epidemiological studies have used the life course perspective to understand the development of diseases (Lynch & Smith, 2005). A special issue of the *Journal of Nutrition Education and Behavior* in 2005, which was devoted to the potential use of the life course perspective in the study of nutrition behaviors, is another example. Likewise, physical activity promotion can also benefit from the explicit use of life course principles to inform research and practice.

Behaviors at the time of transitional experiences seem to inherit a considerable malleability, which may result from the disruption of behavioral routines (Wilcox et al., 2003), the associated stress provided by these events or transition experiences (Wilcox et al., 2003), as well as insights and cues (Humpel et al., 2007). From this perspective, events or life transitions may open up some opportunities for behavior change. It is also speculated that cognitive-based changes (e.g., weighing of pros and cons) may be less enduring than changes arising from transformational experiences (e.g., traumatic events) (Resnicow & Vaughan, 2006). Hence, focusing attention on transition experiences can be a viable supplement to the psychosocial and ecological approaches used in physical activity intervention development.

Methodological Issues

As G. H. Elder, Jr. et al. (2004) described, the emergence of life course perspective was grounded in early longitudinal studies. The advancement in statistical techniques, especially with longitudinal analyses, has guided the development of the life course perspective. Specifically, two analytical models, linking outcomes to events (i.e., outcome-oriented model) and linking events to outcome (i.e., event-oriented model), are suggested approaches for answering the questions in life course research (G. H. Elder, Jr. & Pellerin, 1998; Settersten, 2003). The outcome-oriented model links multiple events, from proximal to distal, to the outcome of interest. Conversely, the event-oriented model links the events of interest to multiple proximal and distal outcomes. Both the outcome-oriented approach and the event-oriented approach can be applied to studies of physical activity promotion. Multilevel analyses are also suggested for examining the effects from multiple levels of influence.

With advances in statistical techniques and tools, multilevel analyses and latent growth models become increasingly common in the area of human development, as well as the physical activity behavior literature (S. C. Duncan, Duncan, Strycker, & Chaumeton, 2002; S. C. Duncan, Duncan, Strycker, & Chaumeton, 2007). Longitudinal studies of individual change reflect one type of two-level model, in which multiple time points are nested within a person. A model with three levels or more can estimate an individual's growth within the larger social context. For example, physical activity trajectories of groups of students can be modeled within different classrooms. Most statistical software, such as Hierarchical Linear and Non-Linear Modeling (HLM), Mplus, Statistical Analysis System (SAS) and Stata**,** can now support analyses of two or more levels.

Although not commonly seen in the literature, piecewise growth curve analyses (Chou, Yang, Pentz, & Hser, 2004; Heping, 2004; Li, Duncan, Duncan, & Hops, 2001) may match very well with how life course is conceptualized. The family of growth curve analyses includes various different forms/functions of the curves such as linear, quadratic, cubic, and piecewise. A piecewise growth analysis consists of at least two pieces of growth curves with the same or different functions. Individuals' life course trajectories and transitions can be better understood using this specific technique. This technique is suggested to suit the examination of changes in human development that are associated with some event or critical period (Naumova, Must, & Maird, 2001). For instance, how the trajectories of participation in physical activity changes before and after the spousal loss can be examined by this particular technique.

Future Research Possibilities in the Aging Population

The life course perspective has received increasing research attention in the area of aging (Settersten, 2003). Relative to physical activity promotion among older adults, some highly prevalent life events and transitions, such as retirement, diagnosis of life-threatening disease, acquiring a disability, and spousal loss, can become the foci of studies. These events or transitions can potentially change the behaviors of the individuals or provide opportunities for behavior change, and also the surrounding social context, such as the people in one's immediate social circle.

As discussed above, social events and transitions may provide the needs, risks, and opportunities to change. Older adults who have lived a longer time are more likely to experience more events and transitions than their younger counterparts. Hence, it is consistent with the notion that older adults are a heterogeneous age group. The principle of life-span development points to the importance and influence of early development. The cumulative effects of the personal history of older adults can have substantial impacts on behaviors. Thus, the studies of physical activity among older adults have afforded many challenges as well as opportunities.

Conclusion

Compared to the psychosocial paradigm and the ecological models of physical activity promotion, the life course perspective introduces a unique temporal perspective that can potentially inform future research in understanding physical activity behaviors across the life course, particularly the timing of interventions. Advances in statistical techniques, together with the accessibility of more longitudinal data bases with physical activity measures, have built up the platform for further investigation of the patterns of physical activity over time and across various life events and transitions. However, studies using principles of the life course perspective are not limited to quantitative methods. Qualitative studies that involve life reviews and life stories (Clausen, 1998) are able to answer different research questions as well as verifying, triangulating, or integrating with the quantitative results (Laub & Sampson, 1998).

Relative to physical activity promotion, the life course perspective has received considerably more attention in epidemiology and nutrition science. More explicit use of the life course principles within the physical activity domain can be particularly insightful and promising for future research and practice.

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Chapter 3. Manuscript 2

Life-Threatening Diseases and Physical Activity Trajectories Along the Marriage Life Course: Opportunity or Obstacle?

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Abstract

Applying the life course principles, this study explored physical activity (PA) trajectories among married couples and their relationships with physical limitations resulting from life-threatening diseases (LTDs) using the Panel Study of Income Dynamics. PA trajectories included stable active (SA), activity adopters (AA), activity relapsers (AR), and stable sedentary (SS), developed from the transitional shift patterns (Levy & Cardinal, 2006). 1) Wives' PA trajectories, 2) curvilinear relationships of disease limitations for husbands and for wives, and 3) the interaction between age and disease limitations for husbands, were hypothesized to predict husbands' PA trajectories. A Latent Class Growth Analysis (LCGA) was used to extract the trajectories and to examine the hypotheses. Results supported that wives' PA trajectories were related to husbands' PA trajectories. Wives' disease limitations were not associated with husbands' PA trajectories, while a curvilinear relationship was found for husbands' disease limitations on being in SA rather than AR. People diagnosed with LTDs with no resulting limitation showed an increased likelihood to be in SA rather than AR for vigorous PA. However, the protective effect declined and became negative with increased disease limitations. The curvilinear relationship was moderated by age. Specifically, younger individuals were more strongly associated with both positive and negative effects of disease limitations compared with older adults. Findings suggested couples and families can be viable intervening units for PA promotion, and that strategies should be tailored to meet the needs of people at different ages during the experience of LTDs.

Life-Threatening Diseases and Physical Activity Trajectories Along the Marriage Life Course: Opportunity or Obstacle?

Extended beyond social ecological models, which take into consideration multiple level of influences (e.g., individual, interpersonal, community, and policy) for the study of physical activity (PA), life course perspectives, which further infuse a unique temporal perspective (characterized by social trajectories and transitions) into social and physical contexts, provide a meta-theoretical framework for communication among researchers and integration of various theoretical perspectives (Li, Cardinal, & Settersten, 2008). Five paradigmatic principles, including agency, linked lives, time and place, life-span development, and timing of events (for detail, see Elder, Johnson, & Crosnoe, 2004) can be readily applied to extend the current knowledge of PA participation. In this study, the principles of linked lives and timing of events/transitions were used to better understand PA trajectories among married couples and the relationships between life-threatening diseases (LTDs) and PA trajectories.

In most modern societies, marriage represents the consensual and contractual agreement recognized by law to connect two people together as husband and wife (Merriam-Webster Incorporated, 2007). These linked lives share a significant amount of time together in the marital environment, and hence their lifestyles are also likely to influence one another (Jeffery & Rick, 2002; Jurj et al., 2006; Wilson, 2002). Thus, research on couple's health behaviors such as smoking cessation and PA is not uncommon in the health behavior literature (Burke, Giangiulio, Gillam, Beilin, & Houghton, 2003; Goldsmith, Lindholm, & Bute, 2006; Jurj et al., 2006; Monden, 2007).

The diagnosis of a LTD can be considered as a significant event/transition in an individual's PA trajectory, be it as a motivator (Humpel, Magee, & Jones, 2007; Mullens, McCaul, Erickson, & Sandgren, 2004) or an inhibitor (Fredman, Bertrand, Martire, Hochberg, & Harris, 2006; Irwin et al., 2003) to future PA participation. Based on the principle of timing of events in life course perspectives, LTDs that happen at different ages may create different meanings and reactions depending on whether LTDs are more or less expected at certain ages (Neugarten, 1977). Hence, by applying the life course principles of linked lives and timing of events (Elder et al., 2004), this study aimed to 1) examine the relationship of PA trajectories between husbands and wives, and 2) the relationships between LTDs and PA trajectories. Cancer, heart attack, heart disease, and stroke were included in the current definition of LTDs with their strong links to mortality (Albano et al., 2007; Dankner, Goldbourt, Boyko, & Reicher-Reiss, 2003). These conditions accounted for more than a half of the causes of death in the United States in 2004 (Heron, 2007). Results of the current study can inform the development of future PA interventions that can be applied to this defined social unit (i.e., marriage) and timing (i.e., experience of a LTD).

Needs and Opportunities Between Linked Lives within Marriage

A moderate resemblance between husbands and wives in terms of health and lifestyle has been observed (e.g., Jurj et al., 2006; Wilson, 2002). For instance, the percentage of agreement was 66.4 (κ=.22) between husbands[1] and wives on whether they participated in exercise regularly in an epidemiological study with 66,130 participants conducted in Shanghai, China (Jurj et al., 2006). Wilson (2002) showed that the percentage of agreement between husbands and wives on the levels of exercise was 49.1% (κ=.13)[2] in the Health and Retirement Study in the United States among 4,746 married couples. One challenge in examining the spousal influence on PA is that the concordance between the couples may be due to both the selection process (i.e., marital selection model) and the shared environment (i.e., marital causation model) (Jeffery & Rick, 2002). These effects are difficult to tease out, as the selection process in a way may influence the type of shared marital environment among couples. Marital selection involves individual's decisions and choices and, hence, intervening on the selection process for the purpose of health promotion may not be appropriate. Hence, for PA promotion, more research attention should be given to how the shared marital environment and the mutual influence between couples can foster PA.

Instead of studying the cross-sectional spousal correlations on health and lifestyle, a longitudinal study that examines how a change in one spouse corresponds to changes in the other spouse may provide more evidence that supports the hypothesis of the shared environment (i.e., marital causation model). For example, Franks, Pienta, and Wray

(2002) showed that husbands aged 51 to 61 who quit smoking in the past two years were more likely to have wives that quit during the same time period. The selection model may better explain the resemblance between couples at the beginning of their marriage and the causation model (by shared marital environment) may be more likely to explain the similarity on change/trajectory thereafter. However, research on the resemblance of PA change/trajectory among married couples is not available in the extant literature. A strong resemblance would suggest that it takes both husbands and wives to create a shared marital environment that enhances PA participation and, hence, married couples can be a potential intervening unit. Thus, coinciding with the effects of the shared marital environment, the change in PA over time for husbands was hypothesized to correspond with the change in PA for wives.

Physical Activity Trajectories and Latent Class Growth Analysis

Latent growth modeling (LGM) is the conventional way to examine change over time (Duncan, Duncan, & Stoolmiller, 1994). LGM is best designed to examine the typical growth pattern, and the factors that associate with deviations of the pattern. A (single-class) LGM assumes the growth processes are monotonic, and trajectories vary regularly within the population (Nagin, 1999), such as the growth of heights and weights in early childhood. However, PA does not change monotonically, and individuals' trajectories do not vary regularly, which leads to a relatively low correlation between adjacent measurement occasions. Unless the measure at one occasion is perfectly correlated with the same measure at a subsequent occasion, the issue of regression toward the mean may exist and complicate the interpretation of the findings (Cohen, Cohen, West, & Aiken, 2003). For instance, a negative relationship may be found between the intercepts and the slopes of the growth model. Hence, covariates that can predict the intercepts can also predict the slopes, but in the opposite direction. In addition, the spousal concordance of the slope of PA is not readily interpretable in this case. Specifically, an upward bias may exist, as both people who remain active and people who remain sedentary over time have the value of zero for their slopes.

For non-monotonically changed outcomes with irregular variations of change within the population such as PA, a semiparametric, group-based approach for studying developmental trajectories, also known as latent class growth analysis (LCGA), can be a viable option (Nagin, 1999). This modeling technique relaxes the assumption that all the individuals' trajectories belong to one single population of growth. It can examine the propensity of the existence of multiple subpopulations of growth patterns, and it allows the growth factors (e.g., intercepts, slopes, and their variances) to vary across different trajectory latent classes (i.e., the subpopulations). LCGA also has the advantage of taking into account the uncertainty (i.e., measurement error) in assigning group membership and testing for group differences in the estimation (Roeder, Lynch, & Nagin, 1999).

In this study, four PA trajectories were extracted using the LCGA technique based upon the proposed trajectories in the transitional shift patterns (Levy & Cardinal, 2006). The transitional shift patterns, which capture the longitudinal change in the stages of change in PA, originally were conceived as stable active (SA), activity adopters (AA), activity relapsers (AR), stable sedentary (SS), and perpetual preparers (PP). SA, AA, AR, and SS represent four linear trajectories, which show the patterns of high, up, down, and low, respectively. The trajectory of PP can come with various different forms and cannot be adequately represent by a linear trajectory, so it was not included in the present study. SA was deemed the most favorable, while SS was considered the least favorable PA trajectory throughout the article. The longitudinal spousal concordance of this study was hence expressed in the matches of these four PA trajectories between husbands and wives.

Impacts of a Life-Threatening Disease

Among the shared experiences of married couples, a significant health crisis may have the most impact on an individual's health and PA participation. For instance, health behavior theories such as the protection motivation theory (Rogers, 1983) and the health belief model (Becker, 1974) suggest that the threat to individuals' health may trigger the motivation to engage in positive health behaviors (e.g., PA). For example, Mullens, McCaul, Erickson, and Sandgren (2004) observed that about half of the colorectal cancer survivors reported some positive post-treatment health behavior change. Family and friends of cancer survivors have also been shown to have an increased PA level (Humpel et al., 2007).

Conversely, the physical strains (e.g., disability) of a disease may, to some extent, inhibit an individual's ability to participate in PA. For example, a lower prevalence rate of PA participation among people with disabilities has been reported (Rimmer, Wolf, Armour, & Sinclair, 2007). Additionally, the physical strains from some cancer treatments have been found to be related to a decrease in PA participation (Demark-Wahnefried et al., 1997; Irwin et al., 2003) and, furthermore, the PA level did not fully recover within one to four years post-treatment (Courneya & Friedenreich, 1997).

These seemingly contradictory findings seem to suggest that LTDs may have a motivational effect on PA participation, but this motivational effect may deteriorate with the severity of the physical limitations resulting from the diseases. Hence, people with no or minimal physical limitations resulting from LTDs may be more likely to participate in PA, while people with moderate to severe physical limitations resulting from LTDs may not be as likely to be physically active. Partners of spouses with moderate to severe physical limitations resulting from LTDs may need to take up more family responsibilities and provide the primary care to their spouse, which would decrease the time available for PA (Nomaguchi & Bianchi, 2004). For example, studies of PA levels of caregivers have shown that a lower level of participation was found among spousal caregivers (Fredman et al., 2006; Lim & Taylor, 2005). Hence, for both the people with LTDs and their non-diseased partners, the effects of physical limitations resulting from LTDs were expected to correlate with more favorable PA trajectories. This protective effect may level off and gradually be outweighed by a deterring effect, as the diseases-associated physical limitations increase, which is indicative of a curvilinear relationship (i.e., an inverted-U relationship).

Timing of the Disease

The timing of the disease over the life course may also create different meanings and afford different social environments for individuals. Since the prevalence rates for stroke, heart attack, and cancer are lower in the younger population (Heron, 2007), these health conditions may be more stressful for younger adults. These non-normative events in the life course deviate from the expectations of younger individuals (Neugarten, Moore, & Lowe, 1965), which may create a health threat for individuals to take action (Rogers, 1983). On the other hand, accommodative strategies (e.g., downgrading the importance of a domain and lowering personal goals and standards) rather than active compensatory strategies (e.g., actively changing the situations and enacting self-regulatory interventions) become the primary coping strategies for adults in advanced ages (Rothermund & Brandtstädter, 2003), which suggests that some older adults may not engage in more positive health behaviors, but rather use emotion-focused strategies to deal with the medical conditions (Johnson & Barer, 1993). As such, all things being equal, a LTD in a younger age was hypothesized to foster more favorable PA trajectories.

Data Source: The Panel Study of Income Dynamics (PSID)

The PSID was used to examine the proposed relationship in this study. The PSID is a longitudinal study of a representative sample of individuals in the United States including men, women, and children residing in the family unit. The study was initiated in 1968 with funding provided by a variety of sources over the years, with current oversight by the National Science Foundation. The PSID was designed to study the dynamic aspects of economic and demographic behaviors, and it also contains sociological and psychological measures. With a broad spectrum of individuals at different ages, the PSID affords the potential to examine the timing of events and their relationship with other social pathways or trajectories. PA measures were included in 1986, 1999, 2001, 2003, and 2005. Consistent measures of PA were only available between 1999 and 2003. Hence, a longitudinal data base that comprised this particular time period was used for the current analysis.

Between 1999 and 2003, most of the interviews were conducted over the phone using computer-based instruments. In the PSID, the heads of the sampled households (mostly husbands for families where married couples resided) were interviewed to collect information including medical conditions and PA levels about the head, wife, and the household. Women were more likely to be interviewed if they were not married. Hence, only the reports from husbands were used in this study for consistency and a cleaner interpretation of the findings. Since the wives' PA behaviors were reported by husbands, the measures might not accurately reflect their actual PA levels, but rather the perceived/reported activity levels from the husbands' perspective. Although a past study did show that such proxy style reporting yielded moderately high correspondence on measures of PA with actual measures of self-report (Sacco et al., 1998), only the husbands' PA levels were used as the outcomes of this study because of their overall better validity, and the (perceived/reported) wives' activity levels were used as predictors.

Taking a life-course perspective in studying PA in marriages, and with the methodological concerns and limitations of the data source clearly acknowledged, this study aimed to examine: 1) the influences of wives' PA trajectories on husbands' PA trajectories, 2) the curvilinear effects of husband's and wives' physical limitations resulting from LTDs on husbands' PA trajectories, and 3) the interaction between age and the physical limitations resulting from LTDs on husbands' PA trajectories.

Method

Participants and the Treatment of Missing Values

As the purpose of the study was to explore the impacts of LTDs on married couples, only individuals who remained married within the defined time period (i.e., 1999-2003) were included. With this inclusion criterion, the sample size was reduced to 3,010 husbands' reports of their households' characteristics (including husbands' and wives' physical activity) from a total sample of more than 7,000 families. The amount of missing data on the covariates was minimal in this study, with the highest rate of 4.78% for husbands' education level. The highest rate of missing data for the outcome variable of PA was 9.21%. Cases with missing data on the covariates were listwise deleted, and missing values on the outcome were handled using full information maximum likelihood (Acock, 2005; Graham, Olchowski, & Gilreath, 2007). Although listwise deletion might induce possible biases, the effects should be rather minimal with this large of a sample size and the small percentage of missing values[3]. After the treatment of missing values, the sample size of the current analysis was 2,842 (i.e., 94.42% of the possible cases). Participants (i.e., husbands) ranged in age from 18 to 90 (*M*=45.26, *SD*=13.20), and the reported age range of their wives was 17 to 86 (*M*=42.97, *SD*=12.68) in 1999. Most of the participants were white (73.65%), and had an average taxable household income of US$ 66,741 with high variability (*SD*=US$ 75,325) in 1999.

Measures

Physical activity. Husbands' levels of PA and the reported levels of their wives were measured using two items: 1) "How often do you (does she) participate in vigorous physical activity or sports, such as heavy housework, aerobics, running, swimming, or bicycling?" and, 2) "How often do you (does she) participate in light physical activity, such as walking, dancing, gardening, golfing, bowling, etc.?" These items were worded exactly the same as the items used in the Health and Retirement Study, in which a composite of the frequency of PA items was found to reduce health decline and the development of new physical difficulties (He & Baker, 2004). Various single-item or single-response items (i.e., select one response from a few items options) have been found to be useful in assessing PA in large sample studies (Jackson, Morrow, Bowles, FitzGerald, & Blair, 2007; Sternfeld, Cauley, Harlow, Liu, & Lee, 2000).

Frequency was reported within the time units of day, week, month, and year for both items. Since the number of times with different time units was used, the resulting responses were very sparse for certain patterns of responses (e.g., 31 different responses on the frequencies were reported for husbands' light PA in 1999, and about 42% of them reported once a day or seven days a week; 36 different responses were reported for vigorous PA for the same group in the same year, and 39% of them answered zero). Therefore, the measures of PA were re-coded in a way that made subsequent analyses possible. The re-coding included creating five categories for both vigorous (0=*No activity*; 1=*Any activity to once a week*; 2=*Twice a week*; 3=*3-5 times a week*; 4=*More than 5 times a week*) and light PA (0=*No activity*; 1=*Any activity to twice a week*; 2=*3-4 times a week*; 3=*5-7 times a week*; 4=*More than 7 times a week*). These categories were developed so that a score of zero represented no activity and a score of three approximately represented that the participant met the PA recommendation of the American College of Sports Medicine and the American Heart Association (Haskell et al., 2007). The question of light PA in the study was treated as moderate PA listed in the recommendation, since the examples given in the light-intensity PA question in this study were comparable to the description of moderate-intensity PA in the recommendation. Since most of the public health recommendations in PA emphasize the importance of moderate-intensity PA (Haskell et al., 2007), different effects might be found for vigorous PA and light PA, and hence these outcome measures were analyzed separately to explore the potential differential patterns of effects.

Physical limitations resulting from life-threatening diseases. Study participants responded to a list of medical conditions with the question stem being, "Has a doctor ever told you (her) that you have (she has) or had any of the following – [conditions]?" As discussed above, cancer, heart attack, heart disease, and stroke were used for indicators of LTDs in this study. The questions were then followed by asking the degree of physical limitations resulting from the diseases. A participant with no reported LTD was coded as 0 for this composite item and the physical limitation for those who reported any of the conditions was coded in terms of their severity from 1 (*Not at all*) to 4 (*A lot*). Since the number of people with multiple LTDs was not large, and there might have been double reporting for heart attack and heart disease, the maximum score among the four conditions was used. Only new conditions that occurred between 1999 and 2003 were included. The measures of health and health behaviors in the PSID have been found to be comparable to other national studies such as the National Health Interview Survey (Andreski, Gouskova, McGonagle, & Schoeni, 2005). With some slight differences in the demographic characteristics between the two samples, the prevalence of the specific conditions such as stroke (2.8% [PSID] versus 2.1% [NHIS] in 1999), cancer (4.6% versus 6.5%), and myocardial infarction (3.7% versus 2.9%) aligned fairly closely across the two surveys.

Timing of disease. If the participant reported any LTDs, the timing of the disease was represented by its occurrence in terms of chronological age. In other words, the interaction between age and physical limitations resulting from LTDs would be an indicator of the effects of the timing of the diseases.

Covariates. To control for possible confounding effects, variables that might influence the PA trajectories but were not the direct interest of this study were served as covariates. Two groups of covariates including households' and husbands' characteristics were controlled for in the model. Household covariates included the household taxable income and the number of children less than 18 years of age living in the same household. The covariates for husbands' characteristics included their race (0=*non-white*; 1=*white*), education level (ranged from 0 to 17), perceived health status (0=*poor* to 4=*excellent*), body mass index (BMI), their total number of other medical conditions including arthritis, asthma, high blood pressure, diabetes, and lung diseases (ranged from 0 to 5), and the linear and quadratic effects of any past physical limitations resulting from LTDs (0=*no disease* to 4= *limited a lot by the disease*). All of these covariates were reported in 1999.

Statistical Analysis

The outcomes of vigorous and light PA were analyzed independently using two sets of LCGAs (Nagin & Tremblay, 2001). Although the approach of LCGA assumes that individuals within the same class do not vary in their growth parameters, it was preferred over the general GMM for the following reasons: 1) only limited variance might remain in the within-class growth factors as the variation was represented by the latent classes (B. Muthén, Khoo, Francis, & Boscardin, 2003), 2) the primary purpose of the study was to examine the correspondence in PA trajectories between husbands and wives, and factors that can differentiate the PA trajectories, rather than the within-class variations, and 3) estimating the within-class variances further complicated the model and led to computation difficulties. All the following analyses were conducted using Mplus 5 (L. Muthén & Muthén, 1998-2007).

Initial stage of the latent class growth analysis. Although theory validation was not the primary purpose of the study, an exploratory approach of LCGA was first taken to examine whether the transitional shift patterns provided a reasonable fit to the current data. Four latent class variables including husbands' and wives' trajectory classes on vigorous and light PA were initially examined independently without the inclusion of covariates (i.e., the unconditional models). A sequence of models with increasing numbers of extracted latent classes were compared to examine whether the four expected trajectory classes fit the data adequately for each of the latent factors. A few indices, including the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), the adjusted BIC, and the Lo-Mendell-Rubin (LMR) test (Nylund, Asparouhov, & Muthén, 2007), were used to compare the models. Smaller values on AIC, BIC, adjusted BIC, and a significant LMR test for the k-class model compared with the k-1 class model suggest that the model fit the data better with the additional latent class. Entropy was also reported to show the quality of classification (see B. Muthén et al., 2002, p.465). Entropy ranges from 0 to 1, with a larger value indicating clearer classification of the latent classes. For each of these models, a linear growth function was defined and the correlated residual variances between the adjacent measurement occasions for PA were freely estimated across classes.

Final stage of the latent class growth analysis. Two sets of final analyses were conducted for vigorous and light PA, respectively. In each set of analysis, the husbands' and the wives' PA trajectories were defined as two separate latent class variables as shown in Figure 1. The wives' PA trajectories, the husbands' and the wives' physical limitations resulting from LTDs, and other covariates were used to predict the husbands' PA trajectories. The correlated residual variances of the adjacent measurement occasions for PA, and the correlated residual variances between husbands' and wives' PA at the same measurement occasions were freely estimated. A confirmatory latent class approach (B. Muthén et al., 2003) was used to impose the latent trajectory classes that were consistent with the proposed trajectories. The growth parameters (i.e., intercepts and slopes) for the four PA trajectories across husbands and wives were constrained to be equal, so the definitions of the transitional shift patterns were comparable across husbands and wives. The percentage of agreement and kappa coefficient for the correspondence between husbands' and wives' PA trajectories were computed for a convenient comparison with the findings in the literature. Results of the multinomial regression analyses on the latent classes of the husbands' PA trajectories were used for the purpose of testing the class differences. To examine the effects of LTDs and timing, the comparisons between SA and AR, and between AA and SS, were the most meaningful due to the facts that these pairs possessed similar initial values (i.e., intercepts) and only varied by their rate of change (i.e., slopes).

--- Insert Figure 1 here ---

Results

Descriptive Statistics

The means/percentages and standard deviations of the studied variables are presented in Table 1. The mean scores of husbands' self reports of vigorous and light PA levels, and the reported values for their wives' PA both declined between 1999 and 2003. The numbers of individuals who experienced one or more LTDs between 1999 and 2003 were 173 and 179 for husbands and wives, respectively.

--- Insert Table 1 here ---

Validation of the Transitional Shift Patterns

The BICs, AICs, adjusted BICs, and the Lo-Mendell-Rubin tests revealed that the model fits improved subsequently from a one-class solution to a four-class solution for both latent class variables for husbands and wives across the two outcomes, vigorous and light PA, respectively (Table 2). However, the four class solution for husbands' light PA did not replicate the expected trajectories in the transitional shift patterns (Levy & Cardinal, 2006). Rather, the transitional shift patterns were shown as a stable solution at a local maximum log-likelihood value, which might suggest that it could be a possible solution, but that some better competing solutions may exist. A five-class solution showed better model fits for two of the four latent class variables, though one of them could not be replicated by random starting values. The other two estimated models did not terminate normally. The entropy measures of the models were all satisfactory, ranging from .88 to 1.00. Based upon the empirical evidence and the usefulness in classifying the trajectories based upon the theoretical proposition, the four PA trajectories including SA, AA, AR, and SS seemed to fit the current data relatively well.

--- Insert Table 2 here ---

Correspondence Between Husbands and Wives

The entropy measures for the final models were satisfactory, with .90 for the model on light PA, and .93 for the model on vigorous PA. The estimated intercepts and the slopes of the trajectory classes for husbands and wives across the two outcomes and the class counts estimated from the most likely latent trajectory classes are shown presented in Table 3. Four clear patterns of PA trajectories corresponding to SA, AA, AR, and SS were identified from the estimated intercepts and slopes. For vigorous PA, most of the people were classified as SS (48% for wives and 49% for husbands), while most of the people were classified as SA for light physical activity (50% for wives and 48% for husbands). The percentages of agreement between husbands and wives on the PA trajectories were 51.83% for vigorous PA and 53.20% for light PA. The kappa coefficients for both of these outcomes were .29, which indicated a fair agreement (Landis & Koch, 1977, p.165). The most inconsistent patterns between husbands and wives were for cases where one was classified as AA and the other as AR. The percentages of couples that fell into these categories were 2.78% for vigorous PA and 2.89% for light PA.

--- Insert Table 3 here ---

The results of the estimated multinomial regressions of the husband's PA trajectories predicted by the wives' PA trajectories and covariates are presented in Table 4. SS was the reference group for the final analyses. In addition, a comparison between SA and AR (reference group) was also added for both vigorous and light PA, shown in the fourth column of Table 4 for both outcomes. The comparisons between the classes shown in Table 4 were organized in a way that the reference class always showed a less favorable PA trajectory than the predicted class (i.e., SA>AA, AR>SS). For the results on both vigorous and light PA from the reference group of SS, all combinations of the wives' PA trajectories significantly predicted the husbands' PA trajectories, odds ratios (ORs) ranged from 2.68 (p<.001), to 17.50 (p<.001), except the contrasts for using AA of the wives to predict AR of the husbands and for using AR of the wives to predict AA of the husbands. These results collectively suggested considerable correspondence between husbands and wives, which supported the first hypothesis.

--- Insert Table 4 here ---

Effects of Household and Husbands' Characteristics

Consistently, age negatively predicted a more favorable PA trajectory across all the contrasts in vigorous PA with the reference group of SS, ORs ranged from .85 (p<.05) to .75 (p<.001), which suggested that older people were less likely to change or maintain their vigorous PA in a positive fashion. However, the opposite pattern was found for light PA, ORs ranged from 1.06 (n.s.) to 1.52 (p<.001), which suggested that more favorable PA trajectories were observed among older adults. Education level predicted SA positively against SS (OR=1.10, p<.001) and AR (OR=1.14, p<.001), respectively, for vigorous PA only, indicating people with higher education were more likely to be in the

SA class. Perceived health status predicted a more favorable PA trajectory across all the contrasts (ORs ranged from 1.18, n.s., to 1.87, p<.001). That said, people who perceived themselves to be more healthy were also more likely to be in a favorable PA trajectory. Finally, body mass index predicted SA negatively against SS for vigorous PA, which suggested that people with higher BMI were more likely to be classified as SS.

Curvilinear Relationship Between Physical Limitation and Trajectory Classes

The effects of new physical limitations resulting from LTDs were best considered in the contrasts between AA and SS, and SA and AR. No linear or quadratic predictors of husbands' or wives' physical limitations significantly predicted AA against SS, which meant new physical limitations resulting from LTDs for both husbands' and wives' did not differentiate people between AA and SS. No effect of the wives' new physical limitations was significant for the contrast between SA and AR either. Husbands' new limitations showed a positive linear effect (OR=4.03, p<.05) and a negative quadratic effect (OR=.49, p<.01) on the contrast between SA and AR, for vigorous PA, which partially supported the hypothesis that the effect of physical limitations resulting from LTDs on husbands' PA trajectories was curvilinear. However, this effect was conditional with a significantly higher interaction occurring with age. The interaction effect will be further elaborated upon in the following section. Although there were other significant effects on the contrasts of SA versus SS, and AR versus SS, the interpretation for effects of new limitations were not substantively interesting because of their different initial values (i.e., intercepts), which was a motivating factor for using the LCGA approach initially.

Effects of the Timing of Diseases

The effects of the timing of diseases were examined by the interaction between husbands' ages and their physical limitations resulting from LTDs, and the interaction between age and the quadratic term of limitations. For the comparison between SA and AR on vigorous PA, the age by limitations interaction was negative and non-significant (OR=.51, n.s.), while the age by the square of limitations was positive and significant (OR=1.41, p<.05). The relationships between physical limitations resulting from LTDs and PA trajectories, for people at the mean age, and at one standard deviation below and above the mean age, are plotted to show the interaction effect (Figure 2). As expected, there was a curvilinear relationship between physical limitations resulting from LTDs and the husbands' PA trajectories. Specially, this effect only occurred in the comparison between SA and AR for vigorous PA. For people who had LTDs with minimal physical limitations, they were more likely to maintain their vigorous PA level. However, as the degree of physical limitations increased, the protective effect on the maintenance of vigorous PA diminished, resulting in a higher likelihood of being associated with AR. The age by limitations interaction showed that younger people were more sensitive to the effect of physical limitations resulting from LTDs. The protective effect and the deterring effect were both more apparent compared to their older counterparts.

Discussion

Applying the life-course perspective (Elder et al., 2004), this study sought to examine two major life-course concepts including the linked lives and the timing of events in the context of PA behaviors among married couples. Although the sum of the mean scores for vigorous and light PA was higher than three, it was unlikely that the average PA participation level exceeded the recommended level with this population. The measure of light-intensity PA was used as a surrogate measure of moderate-intensity PA due to operational consistency; however, it might not adequately reflect moderate-intensity PA in a conceptual sense. Also, since the average duration of each activity was not available, the true rate of exceeding the recommended PA level could not be accurately estimated.

The LCGA approach was used to empirically extract the latent PA trajectories. Results of the LCGA have basically supported that four latent linear trajectories could explain the data reasonably well in comparison to models with fewer classes. The entropy measures for the quality of classification were also satisfactory, meaning the individuals could be accurately classified into the PA trajectories accurately by the estimated models. Although competing solutions for different patterns of trajectories might exist, the transitional shift patterns were still preferred for the reasons that: 1) it provided meaningful comparison groups, 2) it resolved the problematic interpretation of the effects on the slopes with the issue of regression toward the mean, and 3) the current empirical findings suggested that the transitional shift patterns fit reasonably well compared to models with fewer classes. Collectively, the evidence derived from the initial stage of LCGA has primarily supported the usefulness of classifying individuals into the transitional shift patterns for the longitudinal study of PA, and that LCGA can be used to empirically extract these PA trajectories with the consideration of the uncertainty in assigning group membership.

Influences from Household and Husbands' Characteristics

Although household and husbands' characteristics were not the primary focus of the study, some interesting patterns were observed, which might be worth further consideration. On average, older adults were more likely to be classified in less favorable PA trajectories according to their vigorous PA, while in more favorable PA trajectories for light PA. This may, in part, be due to a natural shift in activity preferences and the availability of opportunities for older people to engage in more vigorous PA. For instance, older adults may prefer to engage in PA on their own or in other group-based PA programs rather than in an instructor-led program (Wilcox, King, Brassington, & Ahn, 1999). However, other opportunities may not be made available for this population. Hence, possible social units or structures that can aid in the delivery of PA programs need to be further explored.

Perceived health status has shown a consistent effect over many comparison groups in this study. People who reported a better perceived health status were more likely to be classified in more favorable PA trajectories for both vigorous and light intensity PA. It might also mask some of the effects of other health related factors such as the LTDs.

Correspondence Between Husbands and Wives

The evidence from the percentage agreement and the kappa coefficient between husbands' and wives' PA trajectories, coupled with the subsequent multinomial regressions on the latent class of husbands' PA trajectories, have shown that husbands and wives were likely to have the same PA trajectories. However, the results should be interpreted with caution since the wives' PA trajectories were built upon their husbands' reports of their PA. Given that PA levels were reported by husbands only, the true correspondence was likely to be attenuated in reality. Nevertheless, compared with the cross-sectional correspondence between husbands and wives in past studies, such as kappa coefficients of .22 (Jurj et al., 2006) and .19 (Wilson, 2002), the magnitude of the longitudinal correspondence (κ=.29) shown here was consistent and substantively important.

The low concordance rates between husbands and wives on the PA trajectories of AA and AR were especially promising to the future development of PA interventions. Since a concurrent analysis on the correspondence between husbands' and wives' PA level may be subject to the influence of the marital selection process (Jeffery & Rick, 2002), in which physically active people may be more attractive to other active people and vice versa, the longitudinal correspondence expressed in the associated increases (i.e., AA) or the associated decreases (i.e., AR) may be more favorable to the marital causation model.

Life-Threatening Diseases in the Marriage Life-Course

Results showed that the effects of wives' physical limitations resulting from LTDs on husbands' PA trajectories were minimal and non-significant. The empirical evidence did not support either the protection motivation factor or the family responsibility factor, and these potential opposing effects could have been evened out or partly mediated by the wives' PA trajectories. Since the measure of the wives' PA was less than ideal, a mediation analysis was not applied in this study. Hence, the effects of wives' physical limitations resulting from LTDs on husbands' PA trajectories were inconclusive and further examination is needed. Apart from that, due to the differential roles of husbands and wives in the families, wives may be more influenced by husbands' LTDs, but not vice versa.

A significant effect was found for husbands' limitations resulting from LTDs between SA and AR. The effects were also conditioned by husbands' age. Specifically, with few resulting limitations, a small protective effect on maintaining vigorous PA was found. However, with moderate to severe limitations, an accelerating detrimental effect was observed. Older adults were less susceptible to both the positive and the negative effects associated with the physical limitations resulting from LTDs, whereas younger adults might be more reactive to these conditions. Consistent with the expectation, younger adults may perceive a heightened threat when rare incidents of LTDs happen early in life. This uncommon timing of events might have a strong protective effect for maintaining PA. The stronger negative effect of severe limitations resulting from LTDs on the maintenance of vigorous PA was not expected. However, the results coincided with the notion that older adults are more adaptive to the limited resources (it may also apply to the physical resources such as functional ability and health), in which selection, optimization, and compensation are some prominent tools in resources reallocation (Baltes & Baltes, 1990). Therefore, older adults might be less affected by physical limitations.

Limitations

The major limitation of the study was that wives' PA levels and their physical limitations resulting from LTDs were reported by their husbands. The information for wives might be less accurate and subject to potential bias. In addition, self-reports were used for husbands' PA levels. Although self-report is more cost-effective, convenient, and has been widely used in population-based surveys, more objective measures of PA such as records from pedometers or accelerometers would be desirable. Apart from that, a LCGA that was built from three measurement occasions that could only allow a linear model, and the linear growth function relied more on the reliability of the two end points. Lastly, even though secondary data analyses can afford the possibilities of studying a relatively long-term change in PA in a population-based sample with various covariates, results of these analyses are only observational. Possible relationships can be suggested, but no causality can be implied. The measurement properties can also limit the interpretation of some lines of research in secondary analyses.

Conclusion

Three major contributions can be summarized from the current study. First, it demonstrated how a life-course perspective can benefit the investigation of PA behaviors and inform future PA promotion programs. Second, findings suggested that a moderate proportion of agreement on PA trajectories was found between husbands and wives in a natural setting. Third, the relationship between the physical limitations resulting from

LTDs and the membership of PA trajectories depends on both age and the severity of limitations.

For future PA promotion efforts, married couples can be considered as the intervening units, since the concordance of trajectories in PA seems to suggest husbands and wives may change similarly in a natural setting. Hence, encouraging the couple or the family, rather than solely individuals, to adopt healthy lifestyle may be more effective.

Unlike interventions among children in which schools can be the readily accessible social institutions for interventions, older adults may be less reachable due to no similar, far-reaching intervention channel. Interventions that target different social groups with different social timing or different common events may increase the coverage of a population in need. For example, the incidents of LTDs have long been considered as the moments for interventions to prevent secondary conditions or future reoccurrence of the diseases. Targeting couples in these rehabilitation settings has been one of the strategies (e.g., Pyke, Wood, Kinmonth, & Thompson, 1997). The current findings suggest that the timing of the diseases should also be considered. Couple or family interventions should be more sensitive the age groups as they may respond to LTDs differently. Specifically, although the findings showed that older adults were less affected by severe physical limitations resulting from LTDs, they may need more motivation, social and physical support to initial or maintain PA with less severe conditions. Future studies can also examine the possibility of transferring couple and family interventions to other life transitions and life events, such as child-raising and retirement, to better infuse a physically active lifestyle to all segments of the population.

Footnotes

[1]Husbands' regular participation of exercise was reported by the wives with the help of the husbands in Jurj et al.'s (2006) study.

[2]The percentage of agreement and the kappa coefficient were computed from the results reported in Table 2 of Wilson's (2002) article. In Wilson's study, three categories of exercise were used including none, moderate, and high. Both husbands' and wives' exercise were their self-responses.

[3]Using either multiple imputations or defining the distributional assumptions for the covariates in a structural equation model to retain the complete sample is computationally intensive with this large of a sample size, especially given the complexity of the model. Furthermore, the gain in prediction accuracy from such approaches is also likely small.

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Table 1
Means/percentages and standard deviations of the studied variables resulting from the first imputation (*N*=2,842).

	Husband		Wife	
	Mean/%	SD	Mean/%	SD
Vigorous Physical Activity				
Year 1999	1.44	1.48	1.39	1.42
Year 2001	1.39	1.48	1.39	1.42
Year 2003	1.33	1.44	1.30	1.38
Light Physical Activity				
Year 1999	2.11	1.11	2.15	1.08
Year 2001	2.09	1.11	2.12	1.09
Year 2003	2.06	1.09	2.07	1.07
Household Characteristics:				
Household taxable income	66741	75325	--	--
Number of children <18 years of age	1.11	1.20	--	--
Personal Characteristics:				
Age	45.26	13.20	--	--
White versus other races	73.65%	--	--	--
Education level	13.17	2.83	--	--
Health and Physical Conditions				
Self-rated health status	2.81	1.01	--	--
Body mass index	27.49	4.37	--	--
Number of other medical conditions in 1999	.46	.73	--	--
Limitations from LTDs in 1999	.22	.73	--	--
Limitations from LTDs between 1999 and 2003	.11	.52	.10	.47

Note. LTD = Life-threatening disease, which included cancers, heart diseases, heart attacks, and strokes. The wives' physical activity values and medical conditions were reported by their husbands. The number of observations for the physical activity measures ranged from 2,771 to 2,820.

Table 2
Model fit of 1-class model through 5-class model for husbands and wives

	AIC	BIC	Adj. BIC	LMR Test	Entropy
VPA – Husband's Models					
1-Class	29329.68	29371.35	29349.11	--	--
2-Class	27498.26	27569.68	27531.55	1796.25***	.93
3-Class	27185.38	27286.57	27232.55	314.95***	.91
4-Class	26167.17	26298.11	26228.21	1070.97***	.92
5-Class[a]	--	--	--	--	--
VPA – Wives' Models					
1-Class	28973.90	29015.57	28993.32	--	--
2-Class	27559.85	27631.27	27593.15	1389.12***	.92
3-Class	27279.06	27380.25	27326.23	283.65***	.89
4-Class	26460.94	26591.88	26521.99	807.80***	.90
5-Class	26245.06	26405.77	26319.99	220.33***	.89
LPA – Husband's Models					
1-Class	24942.42	24984.09	24961.85	--	--
2-Class	23850.95	23922.37	23884.24	1074.45***	.90
3-Class	23436.85	23538.03	23484.01	413.69***	.97
4-Class[b]	20663.18	20794.12	20724.22	2715.38*	1.00
5-Class[c]	20543.95	20704.65	20618.87	126.05	.99
LPA – Wives' Models					
1-Class	24596.23	24637.89	24615.65	--	--
2-Class	23635.89	23707.32	23669.19	946.53***	.88
3-Class	23397.42	23498.61	23444.60	242.37***	.89
4-Class	22814.69	22945.64	22875.74	335.35***	.89
5-Class[a]	--	--	--	--	--

Note. ***p*<.01, ****p*<.001. VPA=Vigorous Physical Activity; LPA=Light Physical Activity; AIC=Akaike Information Criterion; BIC=Bayesian Information Criterion; Adj. BIC=Adjusted BIC; LMR Test=Lo-Mendell-Rubin Test. The number of observations for all of the husbands' models was 2,841, with one person missing all the physical activity items. [a]The estimated model did not terminate normally. One of the latent classes had zero count. [b]The latent trajectory classes did not follow the theoretical proposition of the transitional shift patterns. The solution of the proposed trajectory patterns hit a local maximum with several replications of the likelihood values. [c]The best likelihood was not replicated with 3,000 random starts and 300 optimizations.

Table 3

Husbands' and wives' physical activity trajectories based on the most likely latent class patterns and the growth factors of each trajectory in the latent class growth analysis.

	Husbands' VPA Trajectory					Intercept[a]	Slope[a]
Wives' VPA Trajectory	SA	AA	AR	SS	Total		
Stable Active	269	74	66	124	533	3.13***	-.03
Activity Adopters	105	145	48	175	473	.59***	1.17***
Activity Relapsers	123	31	149	175	478	3.10***	-1.29***
Stable Sedentary	129	153	166	910	1,358	.42***	-.03**
Total	626	403	429	1,384	2,842		
	Husbands' LPA Trajectory					**Intercept[a]**	**Slope[a]**
Wives' LPA Trajectory	SA	AA	AR	SS	Total		
Stable Active	938	156	209	110	1,413	2.82***	-.01
Activity Adopters	132	200	38	99	469	.88***	.92***
Activity Relapsers	164	44	187	111	506	2.81***	-.97***
Stable Sedentary	117	74	76	187	454	.80***	-.00
Total	1,351	474	510	507	2,842		

Note. ***p*<.01, ****p*<.001. VPA=Vigorous Physical Activity; LPA=Light Physical Activity. SA=Stable Active; AA=Activity Adopters; AR=Activity Relapsers; SS=Stable Sendentary. [a]The intercepts and slopes were constrained to be equal between husbands' and wives trajectory classes.

Table 4

Multinomial regression coefficients in the latent class growth analysis (*N*=2,842).

	Vigorous Physical Activity				Light Physical Activity			
Pair of Contrasts	SA vs. SS	AA vs. SS	AR vs. SS	SA vs. AR[a]	SA vs. SS	AA vs. SS	AR vs. SS	SA vs. AR[a]
Wife's Physical Activity trajectory:								
SA vs SS	11.91***	3.10***	2.75***		17.50***	3.92***	5.35***	
AA vs SS	3.33***	4.28***	1.30		2.68***	5.57***	1.07	
AR vs SS	4.75***	1.05	4.54***		2.73***	1.00	4.66***	
SA vs AR				4.15***				5.58***
AA vs AR				2.45***				4.29***
SS vs AR				.96				1.71*
Household Characteristics:								
Income	1.18**	1.04	1.09	1.08	.99	1.08	.91	1.09
Number of Children < Age 18 yrs. in Household	.94	1.08	.93	1.01	.94	.99	.99	.96
Husband's Variables:								
Age	.75***	.83*	.85*	.88	1.52***	1.06	1.25**	1.21**
White vs. Non-white	1.34*	1.18	1.15	1.17	1.25	1.17	.88	1.42*
Education Level	1.10***	1.03	.97	1.14***	1.03	1.00	.99	1.03
Health Status	1.87***	1.18	1.43***	1.30**	1.73***	1.19*	1.31**	1.32***
BMI	.96**	.99	.98	.98	1.00	.99	1.02	.98
Other Medical Conditions	1.01	.81	1.01	.99	1.06	.99	.94	1.13
Husband's Limitations resulting from LTDs								
Past Limitations	1.65	.90	1.38	1.20	1.23	.83	.78	1.59
Square of Past Limitations	.86	1.01	.87	.99	.91	1.03	1.05	.86
New Limitations	2.68	2.10	.67	4.03*	.80	1.77	1.20	.66
Square of New Limitations	.57*	.45	1.16	.49**	1.06	.80	.90	1.18
Age by New Limitations	.76	1.20	1.49	.51	2.25	1.42	2.13	1.05
Age by Square of New Limitations	1.23	1.09	.87	1.41*	.80	.91	.84	.95
Wife's Limitations resulting from LTDs								
New Limitations	.84	1.29	.86	.98	.70	.68	.43*	1.62
Square of New Limitations	1.01	.95	.97	1.04	1.20	1.15	1.32*	.91

Note. **p*<.05, ***p*<.01, ****p*<.001. SA=Stable Active; AA=Activity Adopters; AR=Activity Relapsers; SS=Stable Sedentary; SA vs. SS = Stable Active is the predicted/target group, while Stable Sedentary is the reference group. [a]The reference group was changed from Stable Sedentary to Activity Relapsers for the comparison between Stable Active and Activity Relapsers. Past limitations referred to the physical limitations resulting from LTDs in the past, reported in 1999. New limitations referred to the physical limitations resulting from LTDs during the study period, reported in 2001 and 2003. Age and Income are expressed in the standardized unit. All the coefficients are expressed in odd ratios.

Figure Caption

Figure 1

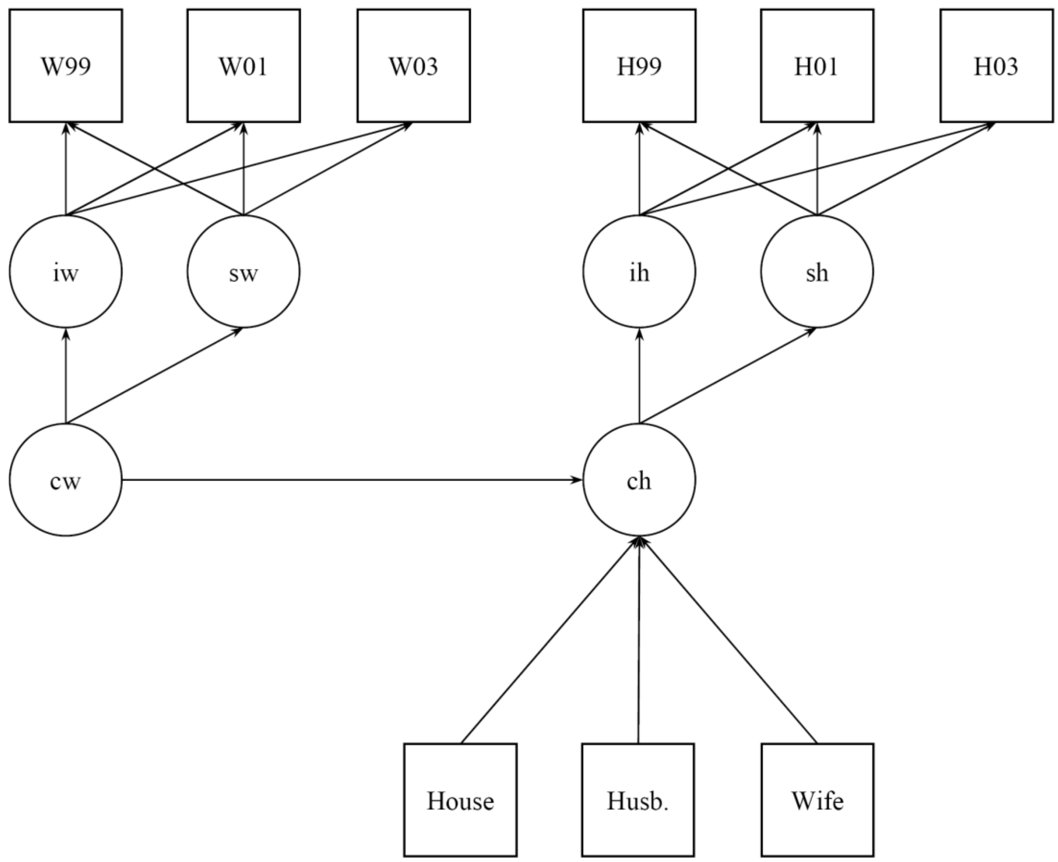
Latent class growth analysis on the correspondence between husbands' and wives' physical activity patterns with covariates.

Note. W99 = Wife's Physical Activity Level in the year 1999; H99 = Husband's Physical Activity Level in the year 1999; iw = Intercept of the growth trajectory for Wife's Physical Activity; sw = Slope of the growth curve for Wife's Physical Activity; cw = Latent Class for Wife's Physical Activity trajectory; House = Household Characteristics; Husb. = Husband's variables; Wife = Wife's variables.

Figure 2

Effects of husbands' physical limitations resulting from life-threatening diseases on the class membership of stable active versus activity relapsers moderated by age.

Note. LTDs=Life-threatening diseases; SA=Stable Active; AR=Activity Relapsers. The y-axis is expressed in logit unit. The figure shows the conditional relationship derived from the multinomial regressions in the final model controlling for other covariates.


W99
W01
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iw
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House
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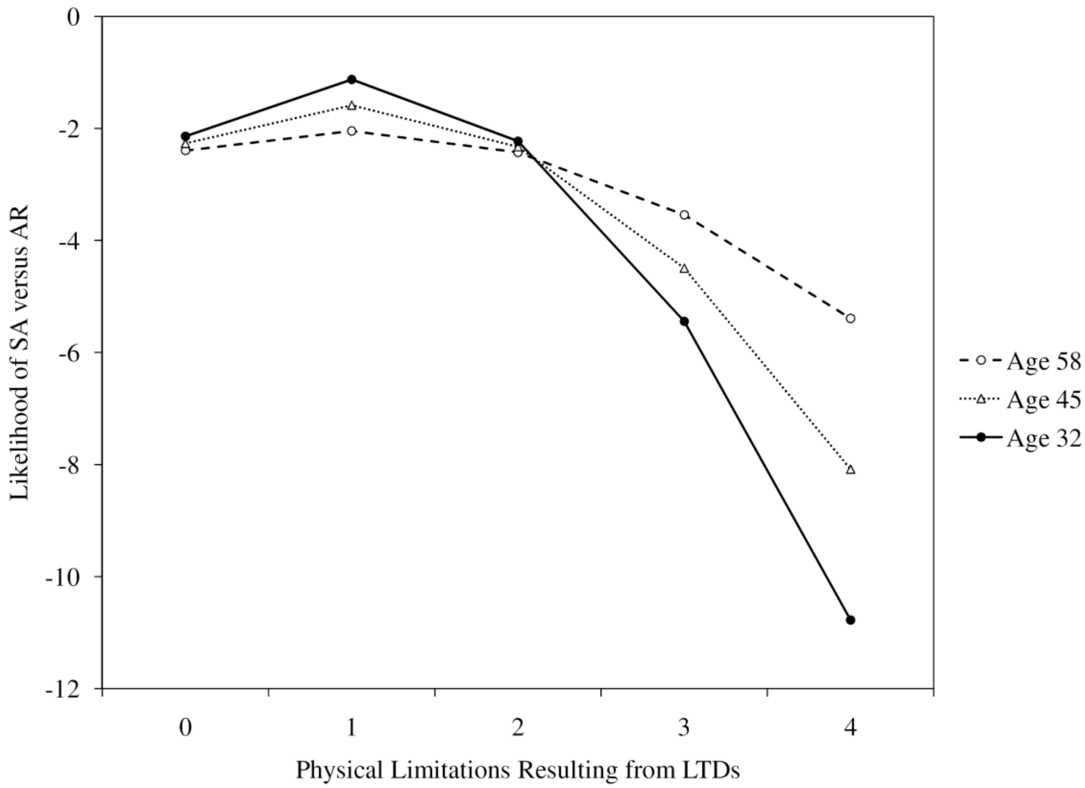
Wife


0
-2
-4
-6
-8
-10
-12
Likelihood of SA versus AR
0
1
2
3
4
Physical Limitations Resulting from LTDs
Age 58
Age 45
Age 32

Chapter 4. Manuscript 3

Change and Continuity of Physical Activity Trajectory at the Transition of Spousal Loss: The Australian Longitudinal Study of Aging

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Abstract

This study applied the principles of life-span development and the timing of event in the life course perspective to examine 1) whether pre-spousal loss physical activity (PA) trajectories including stable active (SA), activity adopters (AA), activity relapsers (AR), and stable sedentary (SA) (Levy & Cardinal, 2006) explained the post-spousal loss PA trajectories, and 2) whether advanced ages predicted less favorable post-spousal loss PA trajectories. In addition, the multiple influences of contact with children, spousal care, and depression on the post-spousal loss PA trajectories were also explored. The sample included 930 widowed participants selected from the Australian Longitudinal Study of Aging (ALSA). The pre-spousal loss PA trajectories, age, contact with children, depression, spousal loss, and other covariates were used to predict the membership of the post-spousal loss PA trajectories using sequential latent class growth analysis. The pre-spousal loss PA trajectories (ORs=7.90-16.59, *p*s<.01) and spousal loss (ORs=4.10-4.63, *p*s<.05) were shown to predict the post-spousal loss PA trajectories. Early intervention aimed at developing habitual PA may prevent the less favorable PA trajectories after spousal loss. For future interventions, the social and environmental factors that may contribute to the changes in the PA trajectories in the transition of spousal loss should continue to be explored. Other life-course events and transitions should also receive more attention for PA promotion.

Change and Continuity of Physical Activity Trajectory at the Transition of Spousal Loss: The Australian Longitudinal Study of Aging

Education, work, family, and leisure have been described as the major social trajectories or pathways in the life course perspective (Elder, Johnson, & Crosnoe, 2004; Settersten, 2006). Some social pathways may be less likely to change in late life. For example, education usually takes place early in life. Even though we sometimes see people obtain a college diploma at an advanced age, these events are relatively rare. As the social structure of society continues to change, it is expected that more older adults will extend their working years or switch the nature of their work (e.g., from full-time to part-time, or from paid job to volunteer work), but many will still decide to completely retire at a certain age (e.g., 62, 65, 67). Among various events and transitions that are common in later life, spousal loss seems to be one of the most stressful experiences (Holmes & Rahe, 1967), even within an ever-changing society. Since an individual’s life course is composed of multiple and interrelated trajectories (Settersten, 2003), the transition to spousal loss may also have important implications to other arenas of life such as engaging in physical activity (PA). Thus, a better understanding of the change and continuity of PA at this transition may provide important information to further develop programs and services aimed at promoting well-being through PA.

Widowhood, in general, seems to be associated with negative outcomes, although it can also provide an opportunity for personal growth (Taročková, 1996). Widows and widowers are found to be especially vulnerable to psychological distress and depression (Carr, 2003; Carr, House, Wortman, Nesse, & Kessler, 2001; G. Lee, DeMaris, Bavin, & Sullivan, 2001; Wilcox et al., 2003). Additionally, widowhood also relates to a higher risk of functional limitation, poor health, and mortality (Christakis & Iwashyna, 2003; M.-A. Lee & Carr, 2007; Manor & Eisenbach, 2003; Schulz et al., 2001; van den Brink et al., 2004; Wilcox et al., 2003). Being married has been shown to have some health benefits and participation in some health behaviors is suggested as one of the reasons for this observation (Umberson, 1987). Married couples may externally regulate their partners’ health behaviors or facilitate their self-regulation. For instance, results from the

Changing Lives of Older Couples Study showed the effect of widowhood on health risk behaviors (including physical inactivity, unhealthy body weight, smoking, and insufficient sleep) depended on the decline of the social regulation of health, in which widowed individuals were more likely to engage in health risk behaviors if they received less care and reminders about health (Williams, 2004). However, the relationship between widowhood and specific health risk behaviors such as physical inactivity, which may, in part, be attributed to the increased health risks, is small and inconsistent (Schulz et al., 2001; Wilcox et al., 2003). One specific challenge in unraveling the influence of spousal loss on PA is that the reactions to spousal loss can vary greatly depending on individuals' experience and other attributes such as marital satisfaction, prior health conditions of the deceased spouse, changes in the role of a caregiver, and socio-demographic differences (Balk, 2007; Carr, 2003; Carr et al., 2000; M.-A. Lee & Carr, 2007; Lefebvre & Levert, 2006; Manor & Eisenbach, 2003).

Life Course Perspectives

Life course perspectives, which encompass a temporal perspective in understanding the social trajectories of individuals within the social and physical environment, provide a meta-theoretical framework to integrate various theoretical perspectives and facilitate the communication among researchers (Elder et al., 2004). The five paradigmatic principles including agency, life-span development, time and place, linked lives, and timing of events can be applied to further our current knowledge in PA behaviors (K.-K. Li, Cardinal, & Settersten, 2008). Considering the multiple factors that contribute to the possible change in PA trajectories at the spousal loss transition, the overriding goal of the current study was to incorporate various factors that might explain the variability of the PA trajectories during the widowhood transition. The PA trajectories were anchored at the widowhood transition (i.e., centering the time metric at the widowhood transition; see detailed description in the method section) for an event-focused approach in the life course perspective (Elder & Pellerin, 1998). In addition, examining the connection between the outcome of interest (i.e., PA) before and after an important life event, which was coherent with the principle of life-span development, corresponded to a key premise of the life course perspective (Elder et al., 2004).

The PA trajectories before a stressful life event may have important implications for the post-event trajectories. The transitional shift pattern (Levy & Cardinal, 2006), as a longitudinal extension of the stages of change in the transtheoretical model (Prochaska & DiClemente, 1983), categorizes the patterns of change or continuity of PA over time. Five patterns including stable active (SA), activity adopters (AA), activity relapsers (AR), stable sedentary (SS), and perpetual preparers (PP) have been identified. People who have maintained their PA may have potentially created a physically active identity that is more resistance to change (Cardinal & Cardinal, 1997). However, people who have just adopted an active lifestyle may be more vulnerable to temptations and challenges, even though they have the same activity level as the stable active people. Similarly, SS people may be less likely to change compared to people who have relapsed from an active lifestyle, as the previous successful experience strengthens one’s perceived competence, which results in continued PA participation (Harter, 1981; Weiss, 1987). PP, who have thought about being active and who might have attempted to take action and yet remain oscillating between trying and stopping, are most variable and challenging in terms of predicting their behaviors.

For this study, SA individuals were hypothesized to be more resistant to the negative impacts of spousal loss compared to AA, while SS individuals were less likely to take the opportunity from spousal loss to be physically active compared to the AR. PP were not included in the study due to the difficulty in modeling the behaviors of PP in a linear function. SA is referred to as a more favorable PA trajectories than AA and AR, while SS presents the least favorable PA trajectories throughout this article.

Another life course principle, the timing of event (Elder et al., 2004), was also examined, as the experience of widowhood at different ages may lead to different future experiences and opportunities. Previous studies have shown that younger married couples participate in less PA than their single counterparts, while older adults are more likely to be physically active if they are married (Burke, Beilin, Dunbar, & Kevan, 2004; Jeffery & Rick, 2002; Pettee et al., 2006). In terms of physical health, then, these findings seem to suggest that younger adults are better off being single, while remaining married may benefit older adults. In accordance with the socio-emotional selectivity theory

(Carstensen, Isaacowitz, & Charles, 1999), social interaction with emotionally close individuals such as family members and close friends become increasingly important when the perceived future time is limited, which also supports the proposition that the benefits of marriage may become more salient, as people enter into advanced ages. Hence, spousal loss at an older age may have a more negative effect on PA participation.

Other Impacts of Widowhood on Physical Activity

In a large scale epidemiological study, the percent of agreement on whether or not couples participated in regular exercise was 66.4%, with a kappa coefficient of .22 among 66,130 married couples in Shanghai, China (Jurj et al., 2006). In their study, the shared marital environment was suggested to be responsible for the similarity of lifestyle patterns between married couples. Besides the shared environment, spousal support has also been found to be important for both individuals to be physically active (Hong et al., 2005). Hong and colleagues found that cardiac patients and their spouses who have a similar pattern of PA also report higher levels of support in PA. Stressful life events may erode older adults self-esteem, the feeling of personal control (Krause & Borawski-Clark, 1994), and the meaning of life (Krause, 2004). A strong social network and the availability of support from emotionally close individuals or significant others such as children, can potentially replenish these psychological resources by redefining the problem situation, and implementing a plan of action (Caplan, 1981; Carstensen et al., 1999; Krause, 2006). Spousal support is lost at widowhood. Similar-aged friends and relatives may disconnect from the social network, as they decease. The remaining stable social contact and support, with close relationships, is from children. Hence, in this study, more frequent contact with children[1], which can potentially mitigate the negative effects of widowhood, was hypothesized to be associated with a more favorable PA trajectory.

Apart from the above, research in the adjustment of caregivers to the death of a spouse has shown that strained caregivers of the deceased spouse had better improvement in their health risk behaviors before the death, while nonstrained caregivers and noncaregivers did not show changes during the transition (Schulz et al., 2001). Additionally, noncaregivers experienced weight loss, while strained and nonstrained caregivers maintained their weight. Given the stressful nature in some care-giving situations, a spousal loss can potentially decrease the mental, physical, and temporal strains of the caregivers. Time availability is also an important factor for engaging in PA, and studies have shown that family roles can potentially curtail the time available for physical activity, especially in intensive care-giving situations (Nomaguchi & Bianchi, 2004). For instance, compared to a group of women who remained married over a three-year period, women who were widows and remarried had a significant larger decrease in their level of physical activity (Wilcox et al., 2003). Similar to the experience of a life-threatening disease of a close family member, the death of a spouse can also be a cue to take positive actions with regard to one's own health behaviors (Humpel, Magee, & Jones, 2007). Finally, spousal loss can also offer an opportunity for personal growth (Taročková, 1996). Some people, for example, have transcended from such life events with a more positive outlook on life, including improvements in or maintenance of positive health behaviors. Hence, spousal caring before spousal loss was hypothesized to be associated with a more favorable PA trajectory.

Conversely, some negative influences have been observed. For instance, widows and widowers are thought to be less likely to participate in physical activity because of increased levels of stress and psychological distress (Wilcox et al., 2003). Thus, PA may show a decrease during the transition of widowhood, which may be attributed to the loss in spousal support or social/external control in the regulation of health behaviors, and a high level of stress and depression. In this study, the level of depression was hypothesized to contribute to a less favorable PA trajectory after spousal loss.

Methodological Issues

Between-group versus within-group approach. Many studies have used a group comparison approach such as cross-sectional comparison between married versus unmarried (Nomaguchi & Bianchi, 2004) or a longitudinal comparison between people who remained married to people who became widowed (van den Brink et al., 2004; Wilcox et al., 2003; Williams, 2004). However, the individual differences in the reactions to the same life experience in the context of health behaviors are given considerably less attention in the literature. Taking an event-oriented approach, this study examined the change and continuity of PA trajectories within the people who had experienced spousal loss to better understand this within-group heterogeneity.

A categorical approach to model physical activity over time. Latent growth modeling (LGM) has become the conventional approach for studying the change in outcomes over time in longitudinal studies (Duncan, Duncan, & Stoolmiller, 1994). A simple linear LGM is composed of a latent factor for the initial value (i.e., intercept) of the trajectory, a latent factor for the rate of change (i.e., slope), the variances and covariance between the intercept and the slope, and the structure of the residual variances of the outcomes. Of particular interest in modeling PA over time is how covariates (or predictors) can explain the intercept and the slope of the model. From a theoretical standpoint, SS and SA people would have different initial PA levels, but their slopes are the same, namely zero. Clearly, these zero values on the slope may have very different meanings, thus, combining these groups of people in one set of growth factors would impose some challenges in interpretation of the slope. Hence, a growth mixture modeling (GMM) approach (B. Muthén et al., 2002; B. Muthén & Shedden, 1999) with four latent growth trajectory classes including SA, AA, AR, and SS was used. In this study, two sequential growth trajectory classes (B. Muthén, Khoo, Francis, & Boscardin, 2003), referring to the pre-spousal loss PA trajectories and the post-spousal loss PA trajectories, were defined, which allowed the memberships of the pre-spousal loss PA trajectories to predict the memberships of the post-spousal loss PA trajectories.

Purpose of the Study

Taking a life course perspective, this study aimed to examine the multiple influences that may explain the change and continuity of PA trajectories during the widowhood transition. Derived from the life course principles, including the life-span development and the timing of events, the primary goals were to test 1) whether the pre-spousal loss PA trajectories explained the post-spousal loss PA trajectories, and 2) whether spousal loss that was experienced in later life had a more negative effect on post-spousal loss PA trajectories than the same experience that happened earlier in life. A secondary purpose of this study was to incorporate multiple factors including contact with children, spousal caring, and depression that have been suggested to influence post-spousal loss health behaviors or health into an integrated model to examine their interrelationships.

Data and Method

The Australian Longitudinal Study of Aging (ALSA)[2,3] was used for examining the proposed relationships. The general purpose of the ALSA was to understand the social, economic, biomedical, and environmental influences on the health and well-being of people 70 years or older. Spouses aged 65 or older of the selected persons were also invited to participate. The project began in 1992 and participants were interviewed annually for the first four waves of data collection, wave five was collected two years after wave four, and a three-year interval was used between wave five, six, and seven.

For the purpose of this study, only individuals who were known to be widowed, or were married in a previous wave and widowed in a subsequent wave were included in the current analyses. Hence, all participants were independent rather than related observations nested in a dyadic unit. This inclusion criterion yielded a sample size of 930 participants.

Analysis Strategies

Reorganizing time and missing values management. Since spousal loss happened at different time points throughout the study period, rather than using the conventional “time to study”) as the time metric (i.e., using the measurement occasions as the design of the longitudinal panel study, the data set was reorganized so that the pre-spousal loss PA trajectories were centered at the last measurement occasion before spousal loss, while the post-spousal loss PA trajectories were centered at the first measurement occasion after spousal loss. Table 1 shows the data availability for PA measures after this centering. Data points were organized in a one-year interval, so each piece of the trajectory represented a period of three years. Since the exact timing of spousal loss was unknown, this analysis aimed to examine the relatively long-term patterns, rather than acute reactions, to spousal loss. Measures of PA frequency were not included at wave 2 and wave 5 of the study. Another source of missingness included the varying intervals (longer than one year) among the interviews for waves 4, 5, 6, and 7. The sample sizes for each cohort of transition time are also presented in Table 1.

In waves 2, 3, and 5, short versions of interviews were used in the ALSA. Therefore, not all the items for the studied variables were available in each wave. With this type of missing data, the varying intervals among the data collections, and the missing values for PA all resulting from the study design, the assumption of missing completely at random (MCAR) hold, so applying multiple imputations was a viable option to handle the missing values (Acock, 2005; Rubin, 1987). Mortality and item non-response were other sources of missingness (i.e., missing at random can be assumed if covariates that can predict the missingness were included in the imputation model) and these types of missing values, together with the missing by design, were handled by a two-stage multiple imputation method designed for studies of aging (Harel, Hofer, Hoffman, Pedersen, & Johansson, 2007). Five sets of imputations were generated using the multiple imputation by chained regressions available in Stata 10 (StataCorp, 2007) with all the studied covariates, time-to-death, and the age by time-to-death interaction included in the imputation model. Only the values of time-to-death were retained and each set of time-to-death values were attached to the original dataset for the second stage of imputation. Another five imputations were generated for each set of the time-to-death values. A total of 25 imputations were used to incorporate missing-data uncertainty and ameliorate the potential power falloff from a few imputations with a considerable portion of missing values (Graham, Olchowski, & Gilreath, 2007). All the values of PA that temporally existed after the time-to-death were removed and this type of missingness was handled by full information maximum likelihood when fitting the final model (Acock, 2005). The pre- and post-spousal loss PA trajectories were each limited to four time points, as inclusion of all the available data yielded an even higher ratio of missing values to observed values, while four time points were deemed sufficient for modeling a linear trajectory.

Sequential latent class growth analysis. Considering the theoretical propositions that several PA trajectories may exist, a GMM approach was used in this study to empirically cluster observed data to the theoretical trajectory classes. Rather than a piecewise growth mixture model that is suggested for studying transitions or critical periods (F. Li, Duncan, Duncan, & Hops, 2001; Naumova, Must, & Maird, 2001), a sequential latent class growth analysis (LCGA) with two latent class variables categorizing the pre-spousal loss PA trajectories and post-spousal loss PA trajectories was used. LCGA is a special case of GMM, in which the variance and covariance of the intercept and the slope are fixed to zero. The simplicity of the technique over the general GMM was considered an advantage, and it fits the current research inquiry, as the between-class differences were the subject of interest. A sequential LCGA allowed the two pieces of trajectories to be separated rather than connected, which was conceptually and practically well-suited for the current study. First, spousal loss can be considered as a turning point, which is characterized by a significant change or change of direction in a very short time frame (Elder et al., 2004), connecting the pre- and post-spousal loss PA trajectories may not appropriately capture the sudden change with the current intervals of measurement occasions. Second, a sequential LCGA can determine how the pre-spousal loss PA trajectories explained the post-spousal loss PA trajectories. Figure 1 shows the sequential LCGA for the current study.

Initial stage latent class growth analysis. Although the number of classes was pre-determined by theory (four classes with SA, AA, AR, SA), the first effort of the analysis was to examine how well the theory fit the data. A stepwise model comparison approach, comparing the *k*-class to the *k-1*-class model, for the latent variables of pre- and post-spousal loss PA trajectories was conducted independently[4] using Mplus 5.0 (L. Muthén & Muthén, 1998-2007). The stepwise comparisons were assessed by Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), adjusted BIC, and the Lo-Mendell-Rubin (LMR) test (Nylund, Asparouhov, & Muthén, 2007). Smaller values for AIC, BIC, adjusted BIC, and a significant LMR test indicate the *k*-class-solution fits the data better than a solution with *k-1* classes.

Final stage latent class growth analysis. For better interpretability and theoretical consistency, the four classes that corresponded to the transitional shift patterns were extracted from both the pre- and post-spousal loss PA trajectories for the final model regardless of the model fit from the exploratory LCGA. The growth factors of the same trajectory class (i.e., SA, AA, AR, and SS) across the two latent class variables were constrained to be equal to ensure the same interpretation of the trajectory classes before and after spousal loss. The residual variances of PA were correlated between adjacent measurement occasions within each of the latent class variables and were held equal across trajectory classes. An initial run of the final model from the 25 imputations was used to compute the average values of the growth factors for the four trajectory classes. These values were then imposed on the model so that the values of the growth factors and, hence, the underlying definitions of the latent classes across the 25 imputations were the same. The memberships of pre-spousal loss PA trajectories, contact with children, spousal care, depression, and other covariates were used to predict the memberships of the post-spousal loss PA trajectories.

Measures

Physical activity. Two leisure-time PA items (i.e., vigorous exercise and walk for recreation or exercise) were used to form a composite score for PA. Participants were asked whether they engaged in these types of PA and the number of times they had participated in the past two weeks. All the values were re-coded so that a value of zero reflected no PA and a value of three represented approximately that a person met the PA recommendation from the American College of Sports Medicine and the American Heart Association (Haskell et al., 2007). All of the items ranged from zero to four (Vigorous exercise: 0=*No activity*, 1=*1-2 times*, 2=*3-5 times*; 3=*6-10 times*, 4=*11 times or more*; Less vigorous exercise, walk, and home-/work-tasks: 0=*No activity*, 1=*1-5 times*, 2=*6-9 times*, 3=*10-14 times*, 4=*15 times or more*) and the sum of the items represented their level of physical activity. Combinations of activities at different levels could also meet the PA recommendation. Since the numbers of individuals with scores of 5-8 were very small, which may bias the imputed values, the composite scores were capped at 4.

Adjusted age, contact with children, spousal caring, and depression. Age of the participants was adjusted to reflect their age at the first measurement occasion after spousal loss. Contact with children was measured by two items including the frequency of personal contact and the frequency of phone contact with children or children-in-law ranged from 0 (*never*) to 4 (*more than once per week*). These two items were a subset of items measuring social network, which were used in previous studies (Giles, Glonek, Luszcz, & Andrews, 2005; Giles, Metcalf, Anderson, & Andrews, 2002). Only these two items were used, as they were measured more frequently at the subsequent waves, which matched the best with the new time metric in this study. A composite score was computed by the arithmetic mean of the two items. Spousal caring was coded as *yes* or *no* and was assessed by an item, “Does he or she [spouse] depend on you for help with things like getting around the house or bathing?” The item has some variation across waves. Alternatively, two items, “Is there anyone who depends on you for help with things like getting around the house, or bathing?” and “Who is this person?” were asked in some waves of data collection. A response of *yes* and *spouse* on the two questions indicated whether the participants provided spousal care. Symptoms of depression were measured by the 20-item CES-D scale (0=*Rarely or none of the time*, 1=*Some of the time*, 2=*Quite a bit of the time*, 3=*Most of the time*) (Radloff & Teri, 1986). The internal consistency for the CESD score at wave 1 with this subsample was .85.

Covariates. To control for possible confounding, several covariates including sex, household income (1= *Less than AUD 5,000 per year* to 7= *More than AUD 50,000 per year*), education level (1=*Never went to school* to 7=*Eighteen or more years*), self-rated health (1=*Poor* to 5=*Excellent*), physical limitation, time-to-death, and the age by time-to-death interaction were entered into the model. Physical limitation was the sum of the difficulty scores of five conditions including 1) pulling or pushing large objects, 2) stooping, crouching, or kneeling, 3) lifting or carrying weights over 10 pounds, 4) reaching or extending your arms above shoulder level, and 5) writing or handling or fingering small objects (1= *No difficulty at all* to 5=*Just unable to do it*). The date of death was reported among 663 of the 930 participants in the original data. It was adjusted to reflect the time between the first measurement occasion after spousal loss and the time at death.

Results

Descriptive Statistics

Descriptive statistics for the first imputations are reported in Table 1. The average age adjusted at the first measurement occasion after spousal loss was 81.86 years (*SD*=6.35). The average time-to-death between the first measurement occasion and the time of death was 6.86 years (*SD*=3.91). The PA levels at various time points of the new time metric ranged between 1.24 and .94 (*SD*s ranged between 1.26 and 1.37). The percentages of older adults who participated in PA at or above the recommended level (i.e., a score of 3 or above) ranged from 20% to 30% at various time point, which showed that this sample of older adults was not sufficiently active at the recommended level during given time points using the current measures.

Initial Stage of Latent Class Growth Analysis

For both the latent class variables for the pre- and the post-spousal loss PA trajectories, the AIC, BIC, adjusted BIC, and the LMR test all suggested that the stepwise comparisons of the models favored the solutions with higher numbers of classes at least from 1-class to 4-class solutions (Table 3). The best solution of the 4-class models did not correspond well with the theoretical predictions of the four trajectories as SA, AA, AR, and SS (see Figures 2a and 2b). Hence, in addition, models that represented the theoretical predictions were fitted (Figures 2c and 2d) and compared to the 3-class solution. The theoretical 4-class models were generated by setting starting values for the intercepts and the slopes that closely followed the theoretical patterns. The theoretical 4-class models showed improved model fit compared to the 3-class model, but they were not as favorable as the best solution for the 4-class models. The 5-class solution for the pre-spousal loss latent class did not terminate normally, while the 5-class solution showed improvement in the model fit compared to the 4-class model (the best model) for the latent class of post-spousal loss PA trajectories.

Final Stage Latent Class Growth Analysis

The most likely class counts are shown in Table 4, with the estimated growth factors. The entropy for the final model was .93, which indicated the quality of classification of the final model was satisfactory. Most of the people were classified in the SS group, with 52% before spousal loss and about 58% after spousal loss. The fewest counts for the combinations of the pre- and post-spousal loss PA trajectories were 9 (less than 1%), from AA to AA (i.e., classified as AA at both time periods).

The results of the multinomial regressions of the post-spousal loss PA trajectories on the pre-spousal loss PA trajectories, adjusted age, contact with children, spousal care, depression, and other covariates are shown in Table 5. The comparison between SA and

AR was also presented for its meaningful contrasts (similar intercepts) and the testing of the hypothesis (see the last column of Table 5). Interpreting the contrast between AR and SS was challenging and might not be particularly meaningful as these two groups did not begin at similar values and their rates of change were also different.

For the first hypothesis, which examined the continuity between the pre- and post-spousal loss PA trajectories, being in AR rather than SS before spousal loss significantly predicted the membership of being in AA rather than SS (Odd Ratio[OR]=7.90, $p<.01$), which supported part of the first hypothesis. However, being in AA rather than SA did not significantly predict the memberships of being in AR rather than SA (OR=3.90, n.s.), although the direction of the effect was in the expected direction. Two other significant relationships between the pre- and post-spousal loss PA trajectories were that being either SA or AR, rather than in SS before spousal loss predicted the memberships of being in SA rather than SS, OR=16.59, $p<.01$ and OR=11.99, $p<.01$, respectively. These relationships also suggested the continuity of PA trajectories before and after spousal loss. Collectively, the hypothesis that pre-spousal loss PA trajectories were associated with the post-spousal loss PA trajectories was partially supported.

For the second hypothesis, the effect of age on the post-spousal loss PA trajectories was examined. No significant age effect was found in the final analysis. Time-to-death and the interaction between age and time-to-death were also non-significant.

The secondary purpose of the study was to investigate the interrelationships among the effects of contact with children, depression, and spousal loss. Significant effects were only found for spousal care on being in SA rather than SS (OR=4.10, $p<.05$), and AA rather than SS (OR=4.63, $p<.05$) for the post-spousal lost PA trajectories. That said, people who took care of their spouses before their spouses died were more likely to either maintain or increase their PA level after spousal loss, in which the results were consistent with expectation. However, no other effect was shown for contact with children and depression.

Discussion

This study applied the life course concepts of life-span development and timing of events to the study of PA trajectories at the transition of spousal loss. The continuity and change of the PA trajectories before and after spousal loss was examined, coupled with the effect of age on the post-spousal loss PA trajectories. Since the exact timing of spousal loss was unknown, long-term (i.e., a three-year period before and after spousal loss) rather than acute patterns of PA were examined.

Evidence for the Theoretical Propositions: Methodological and Substantive Concerns

Results of the initial stage LCGA showed that the four-class solutions were better than the other solutions with fewer classes and the results for five-class solutions were not consistent. However, the best four-class solutions did not follow the theoretical expectations of the four distinct classes of SA, AA, AR, and SS. In the best four-class-solutions, four slightly diverging lines (see Figures 2a and 2b) were observed. On one hand, the analysis seemed to disconfirm the theoretical trajectories from an empirical data-driven perspective. On the other hand, it could not reject the usefulness of applying these trajectories to understand the long-term PA patterns. From a substantive point of view, the patterns of diverging lines estimated by the best solutions did not adequately represent the differences at the initial time point, while the theoretical solutions provided more meaningful and interpretable categories capturing the differences at both the initial point and end point. In addition, findings also showed that the PA trajectories from the theoretical model also outperformed the three-class solution, which provided some empirical support for the transitional shift patterns. Given its better substantive interpretation and practical utilities, the theoretical model was still preferred.

Although the PA trajectories derived from the theoretical proposition could indicate whether individuals had changed, which adequately served the purpose of this study, they could not identify the timing of adapting PA and the rate of adapting in the current LCGA models. These additional research questions can be examined by relaxing the linear growth patterns and allowing the variances and covariance for the intercepts and the slopes be freely estimated (i.e., general GMM). These research questions are especially relevant for PA interventions, in which the baseline is clearly defined, and the rate of change and the timing of change are particularly interesting and important.

Life-Span Development and Timing of Events

Results of the final model showed that about 52% of the participants were classified as SS before the spousal loss and about 58% of them were in SS after spousal loss. Only about 6% of the people were SA before and after spousal loss consistently. The current findings suggested that people who increased their PA rather than SS before spousal loss were more likely to decrease rather than maintain their activity levels. People who were SA might have developed a physically active/exercise identity (Cardinal & Cardinal, 1997), which might be more resistant to external challenges, such as the loss of spousal support or emotional distress. It might also apply to the findings that SA and AR compared to SS were more likely to be SA compared to SS after spousal loss. These findings seemed to favor the proposition that past PA behavior is connected to future PA behavior during the transition of spousal loss.

Interestingly, however, compared to people who remained sedentary, people who decreased their PA before spousal loss were not significantly more likely to increase their PA levels after spousal loss compared to SS people, although it was in the predicted direction. This might suggest that the importance of PA participation history is less important for PA initiation, but more important for PA maintenance. Collectively, this partially supported the idea that pre-spousal loss PA patterns are connected to post-spousal loss PA patterns.

The benefit in health behaviors from marriages were hypothesized to be stronger in older adults compared to their younger counterparts. However, no age effect was found in the post-spousal loss PA trajectories. Since the average age at the time of the first measurement occasion after spousal loss was 81.86 years, the absence of an age effect may be because the age range was not sufficiently wide enough to detect any differences that might exist. Future researchers may consider investigating the effect of spousal loss on PA with samples of wider age ranges.

As a secondary purpose, the interrelationship among the effects of contact with children, spousal care, and depression on the post-spousal loss PA trajectories were examined. Only spousal loss was found to be significant for SA and AA compared to SS, while it was non-significant for SA compared to AR; but the effect was in the expected direction. These results suggest that older adults who took care of their spouses before spousal loss were, in general, more likely to have more favorable PA trajectories compared to spouses who did not, which was consistent with the results of past research (Schulz et al., 2001). It may also speak to the need of better care and support for the spousal care-givers before spousal loss.

Limitations

PA was measured using self-reported questions in this study, which might induce potential recall and response biases. Future studies may attempt to include objective measures of PA such as using pedometers and accelerometers. With the observational nature of this secondary data analysis, causal relationships cannot be assumed. Since post-spousal loss was preceded by pre-spousal loss in the physical time, it was naturally confounded with participants' age. However, this study did not intend to imply that the changes which occurred in PA trajectories were due to spousal loss only. The natural changes of PA trajectories before and after spousal loss were simply the main focus of this research.

Conclusion

With the use of an event-oriented approach in life course perspectives, this study examined the relationship between pre- and post-spousal loss PA trajectories. Examining the change and continuity of PA trajectories at particular transitions not only may show the importance of early intervention, but it may also allow for the identification of individuals who are more likely to develop less favorable PA trajectories after spousal loss. Social and environmental factors that contribute to the differences in PA can also be explored. These factors are particularly important for identifying the social settings and strategies for future PA interventions.

Methodologically, this study demonstrated how SA, AA, AR, and SS can be identified from repeated measures of PA using LCGA. Practically, this categorical approach of examining longitudinal changes provides a useful tool to understand how changes in PA may happen in transitional moments, especially with heterogeneous populations. Future studies can also transfer the current design to study other life transitions such as retirement, graduation, and marriage, to better understand the timing, social situations, and their associated opportunities and challenges for PA behavior change.

Footnotes

[1] The full components of social network were measured at wave 1 and wave 7 of the Australian Longitudinal Study of Aging. Shorter versions of the surveys were used at some other time points. Technically, the most frequently measured items of social network were personal contact and phone contact with children. That said, a consistent measure of social network was not available. Instead, contact with children, which is one important component of the social network, was included in the analysis.

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[4] The unconditional models rather than models with covariates predicting the latent class variable were used, as the sets of covariates for the pre-spousal loss and post-spousal loss latent class variables were different.

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Table 1
Data availability for measures of physical activity corresponding to the timing of transition

	Pre-Spousal Loss				Post-Spousal Loss				
	1[b]	2	3	4	5	6	7	8	*N*[c]
Wave 1[a]	--	--	--	--	w1	--	w3	w4	594
Wave 2	--	--	--	w1	--	w3	w4	--	78
Wave 3	--	--	w1	--	w3	w4	--	--	46
Wave 4	--	w1	--	w3	w4	--	--	--	43
Wave 5	w1	--	w3	w4	--	--	--	w6	59
Wave 6	w3	w4	--	--	w6	--	--	w7	67
Wave 7	--	--	--	w6	w7	--	--	--	43

Note. w1-w7=measures of physical activity were available at the specified data wave; The dash lines represent data unavailability by the design of the study. [a]The first column of the table specified the data wave, at where the change in marital status was observed. Participants were centered at 1) the last measurement occasion of being married, and 2) the first measurement occasion of being widowed, for pre-spousal loss and post-spousal loss trajectories, respectively. [b]The new time metric is represented at the second row ranged from 1 through 8. [c]The sample sizes of the cohorts of individuals who had reported spousal losses at different data waves are listed in the final column.

Table 2
Means/percentages and standard deviations of the studied variables from the first imputation (*N*=930).

	Mean/Percentage	Standard Deviation
Physical Activity Level		
Pre-Spousal Loss – Time 1	1.20	1.37
Pre-Spousal Loss – Time 2	1.05	1.34
Pre-Spousal Loss – Time 3	1.24	1.41
Pre-Spousal Loss – Time 4	1.10	1.29
Post-Spousal Loss – Time 5	1.11	1.34
Post-Spousal Loss – Time 6	1.02	1.29
Post-Spousal Loss – Time 7	1.07	1.33
Post-Spousal Loss – Time 8	.94	1.26
Personal Characteristics		
Age[a]	81.86	6.35
Time-to-Death[b]	6.86	3.91
Male	38%	
Education Level	3.64	1.38
Gross Household Income[c]	2.42	.89
Self-Rated Health[c]	3.10	1.09
Physical Limitations[c]	10.80	5.23
Contact with Children[c]	3.01	1.06
Depression – CESD[c]	.51	.40
Spousal Care[d]	31%	

Note. [a]Age was adjusted to reflect the participants' ages at the first measurement occasion after spousal loss. [b]Time-to-death was the duration between the first measurement occasion and the time of death. [c]Gross household income, self-rated health, physical limitations, contact with children, and CESD score were measured at the first measurement occasion after spousal loss. [d]Spousal care was measured at the last measurement occasion before spousal loss. The sample sizes for physical activity measured between the second and the final measurement occasions were 891, 813, and 736 for this imputation, as people who were known to have died were excluded from the final analysis.

Table 3
Model fit statistics for 1-class-solution through 5-class-solution for pre- and post-spousal loss physical activity trajectories

	AIC	BIC	Adj. BIC	LMR Test	Entropy
Pre-Spousal Loss Models					
1-Class	12.63.54	12409.06	12380.48	--	--
2-Class	11541.27	11541.27	11561.18	791.67***	.95
3-Class	11382.19	11454.72	11008.61	157.40***	.97
4-Class (Theoretical Model)[a]	11242.22	11329.25	11272.09	139.18***	.94
4-Class (Best Solution)	10921.58	11008.61	10951.44	444.92***	1.00
5-Class[c]	--	--	--	--	--
Post-Spousal Loss Models					
1-Class	11227.17	11270.69	11242.11	--	--
2-Class	10659.44	10717.46	10679.35	547.05***	.86
3-Class	10447.84	10520.37	10472.73	207.483**	.84
4-Class (Theoretical Model)[a]	10200.77	10287.80	10230.63	241.31***	.92
4-Class (Best Solution)[b]	9752.89	9839.92	9782.76	668.36	.86
5-Class	9719.23	9820.23	9754.07	37.82*	.80

Note. *p<.05, **p<.01, ***p<.001. AIC=Akaike Information Criterion; BIC=Bayesian Information Criterion; Adj. BIC=Adjusted BIC; LMR Test=Lo-Mendell-Rubin Test. [a]It was the four-class-solution that followed the theoretical expectations. The solution was stable with a few replications from sets of random starts, but a better solution, with a better log-likelihood, was found from 800 sets of random starts and 50 full optimizations. [b]The log-likelihood value of the best 4-class-solution could not be replicated with 500 sets of random starts and 50 full optimizations. [c]The estimated model did not terminate normally.

Table 4
Tabulation of the most likely classes between the pre-spousal loss and post-spousal loss physical activity trajectories from the latent class growth analysis combined across multiple imputations.

	Post-Spousal Loss					Intercept[a]	Slope[a]
Pre-Spousal Loss	SA	AA	AR	SS	Total		
Stable Active	54	18	36	50	158	2.94***	-.02
Activity Adopters	16	9	30	63	118	.59***	.70***
Activity Relapsers	36	35	27	71	169	2.65***	-.77***
Stable Sedentary	30	38	65	352	485	.35***	-.03
Total	136	100	158	536	930		

Note. ***p*<.01, ****p*<.001. SA=Stable Active; AA=Activity Adopters; AR=Activity Relapsers; SS=Stable Sedentary. [a]The intercepts and slopes were constrained to be equal between the post-spousal loss and pre-spousal loss trajectories. The *p*-values were recorded from the initial run of the final model without setting fixed values across the imputations.

Table 5
Multinomial regressions on post-spousal loss physical activity trajectories across the multiple imputations (*N*=930).

	SA vs SS	AA vs SS	AR vs. SS	SA vs. AR[a]
Pre-Spousal Loss Physical Activity trajectory:				
SA vs SS	16.59**	3.98	4.41	
AA vs SS	2.44	.39	2.53	
AR vs SS	11.99**	7.90**	2.63	
SA vs SS				3.76
SA vs AA				3.90
SA vs AR				.83
Personal Characteristics:				
Age	.98	.95	1.04	.94
Time-to-Death	1.02	.96	1.10*	.93
Age by Time-to-Death	1.21	1.30	1.00	1.21
Male	1.51	1.04	1.07	1.40
Education Level	1.03	1.15	.90	1.14
Gross Household Income	1.12	.85	1.07	1.05
Self-Rated Health	.97	.75	1.01	.97
Physical Limitations	.86***	.91	.88***	.97
Contact with Children	1.21	1.12	1.17	1.03
Depression – CESD	2.07	1.15	1.11	1.86
Spousal Care	4.10*	4.63*	1.19	3.45

Note. *p<.05, **p<.01, ***p<.001. SA=Stable Active, AA=Activity Adopters, AR=Activity Relapsers, SS=Stable Sedentary; SA vs. SS = Stable Active was the predicted/target group, while Stable Sedentary was the reference group. [a]The reference group was changed from Stable Sedentary to Activity Relapsers for the comparison between Stable Active and Activity Relapsers. Coefficients are presented in odds ratios in the above table.

Figure Captions

Figure 1

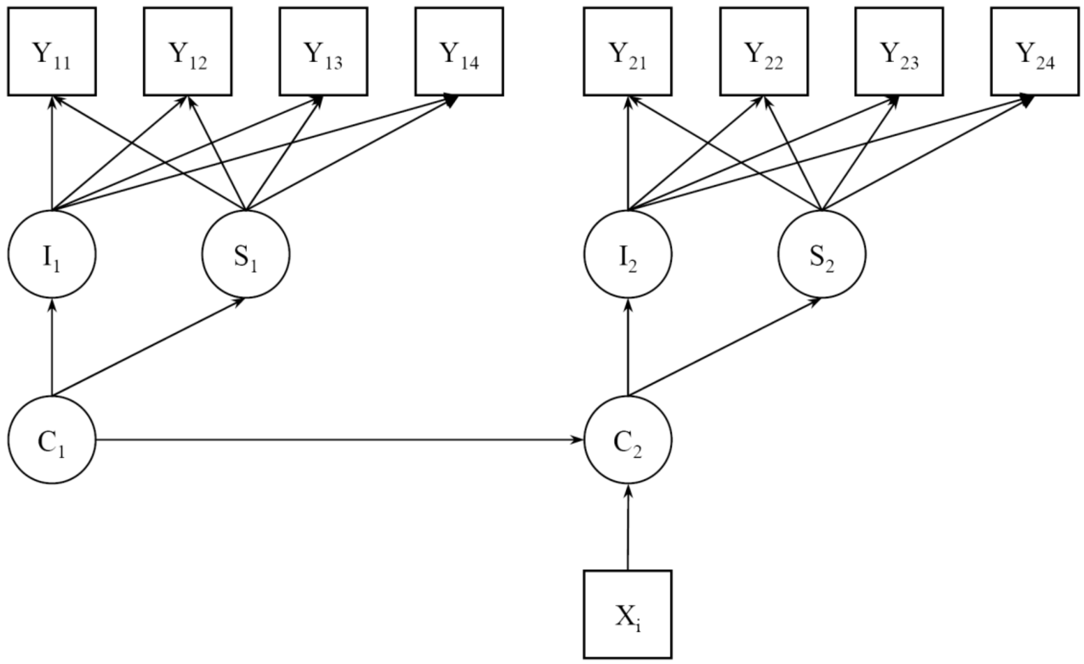
Latent class growth analysis using pre-spousal loss trajectories and covariates to predict post-spousal loss trajectories.

Note. X_i = covariates; C_1 = pre-spousal loss physical activity trajectory classes; C_2 = post spousal loss physical activity trajectory classes; I_1 & I_2 = intercepts of C_1 and C_2; S_1 & S_2 = slopes of C_1 and C_2; Y_{11}-Y_{14} = physical activity levels measured before spousal loss; Y_{21}-Y_{24} = physical activity levels measured after spousal loss.

Figures 2a-2d

Pre- and post-spousal loss physical activity trajectories for the best 4-class solutions and the theoretical 4-class solutions.

Note. Figure 2a shows the pre-spousal loss PA trajectories for the best 4-class solution; figure 2b shows the post-spousal loss PA trajectories for the best 4-class solution; figure 2c shows the pre-spousal loss PA trajectories for the theoretical 4-class solution; and figure 2d shows the post-spousal loss PA trajectories for the theoretical 4-class solution.



Y_{11}
Y_{12}
Y_{13}
Y_{14}
Y_{21}
Y_{22}
Y_{23}
Y_{24}
I_1
S_1
I_2
S_2
C_1
C_2
X_i

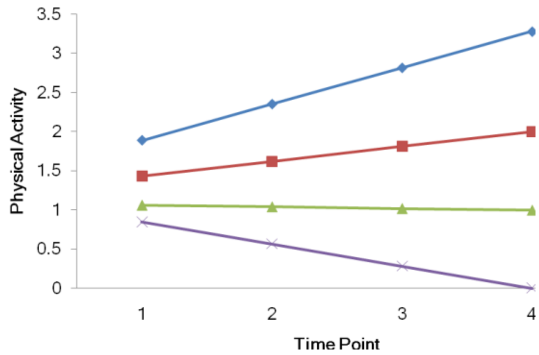


Figure 2a

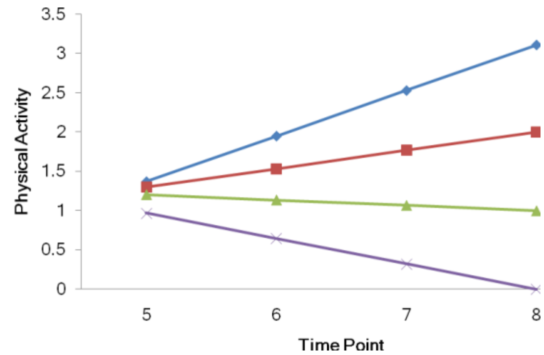


Figure 2b

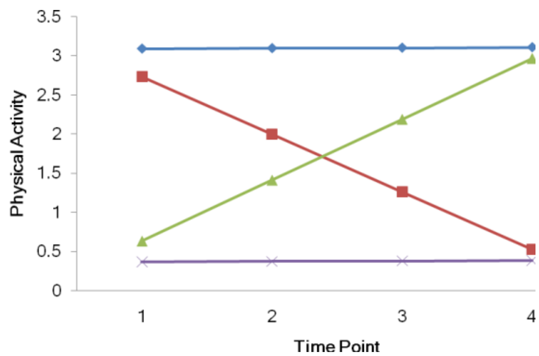


Figure 2c

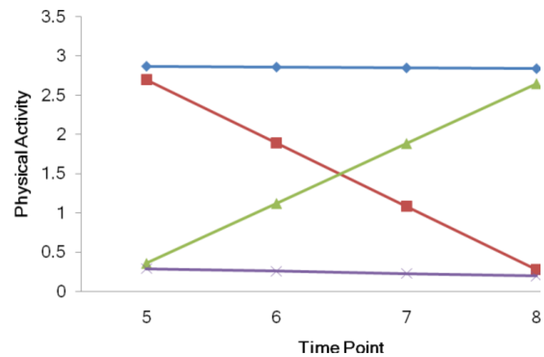


Figure 2d

Chapter 5. General Conclusion

General Conclusion

From a theoretical perspective, this series of studies demonstrated the importance and the practical utility of using the life course perspective for physical activity (PA) promotion. The life course perspective provides a comprehensive framework to incorporate different levels of influence, as ecological models do, while considering too temporal matters. By considering the transitional moments or life-changing moments, researchers and practitioners can capitalize on the possibility for change, either by reducing the risks for negative changes or by providing more opportunities for positive changes. In other words, these transitional moments or life-changing moments can possibly be transformed to turning points for positive health behaviors. The important questions for this approach simply include where, when, what, and how. These components refer to defining the social structures for change (e.g., school, family, worksite, and hospital), defining the timing of change (e.g., transition to college, transition to marriage, and transition to retirement), identifying the factors for change within the defined contexts, and developing strategies to change. The most unique contribution of this perspective lies within the timings for changes, for which individuals' trajectories and transitions are the primary foci.

Methodologically, the categorical approach of studying the longitudinal change of PA was further developed. The transitional shift patterns (Levy & Cardinal, 2006) was designed to capture the longitudinal change in the stages of change (Prochaska & DiClemente, 1983). The five stages of change include precontemplation, contemplation, preparation, action, and maintenance. Hence, the possible longitudinal changes and continuity for two measurement occasions comprise 25 possible combinations. A scheme was developed to categorize these combinations into the five proposed transitional shift patterns including SA, AA, AR, SS, and PP by their substantive meanings. The method used in the two empirical studies was different from this original approach in at least four major aspects. First, rather than the repeated measures of the stages of change, the repeated measures of the reported PA were used in these studies. Second, rather than two measurement occasions, three and four measurement occasions were used in the PSID and the ALSA studies, respectively. Third, only four transitional shift patterns were used in the two empirical studies. Finally, rather than using a theory-driven classification scheme, a LCGA, which considers the uncertainty of the classification, was used to empirically divide the individuals' trajectories into the theoretical categories. Using this method has extended the possibility of examining the longitudinal shift patterns in longitudinal panel studies with multiple measurement occasions using different types of PA measures.

In addition, the PSID study has demonstrated how the longitudinal correspondence can be empirically examined using the above method, which might provide better quality evidence for the marital causation model (Jeffery & Rick, 2002), though causation still cannot be assumed. Finally, the ALSA study has shown a possible way to connect two sequential processes or trajectories by using LCGA. This method is particularly useful for studying the continuity and discontinuity of behavioral trajectories.

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