Establishing a Hierarchy for the Two Components of Restricted Activity

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Abstract

Background: Increasing evidence suggests that illnesses and injuries leading to restricted activity have adverse functional consequences, but whether the two components of restricted activity have comparable effects is unknown. We evaluated whether an illness/injury leading to bed rest represents a more potent exposure than one leading to cutting down on one's usual activities without bed rest.

Methods: We prospectively evaluated 754 community-living persons, 70+ years. Telephone interviews were completed monthly for >15 years to assess disability in four basic, five instrumental, and four mobility activities and to ascertain exposure to illnesses/injuries leading to cut down activities and bed rest, respectively. For each of the three functional domains, transitions between no disability, mild disability, and severe disability were evaluated each month.

Results: For each domain, cut down activities and bed rest were significantly associated with at least one transition. The associations were consistently stronger, however, for bed rest than for cut down activities. Bed rest was a particularly potent exposure for transitions from no disability to severe disability, with hazard ratios as high as 8.94 (95% CI, 5.69–14.1) for the mobility activities, and for all transitions from severe disability (representing recovery), with hazard ratios as low as 0.25 (0.12–0.54) for the transition to no disability for the basic activities.

Conclusions: In the setting of an illness/injury, bed rest was more strongly associated with a set of clinically meaningful transitions in functional status than cut down activities. Prompt medical attention may be warranted when an older person takes to bed because of an illness/injury.

Key Words: Disablement process—Epidemiology—Physical function.

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In the setting of an illness or injury, older persons often restrict their activities (1). Increasing evidence suggests that these episodes of restricted activity have adverse functional consequences (2–4). The deleterious effects of restricted activity, however, are dwarfed by those of illnesses and injuries leading to hospitalization (3,4), suggesting a hierarchy in the severity or magnitude of these intervening events. Whether a similar hierarchy exists for restricted activity is uncertain, but it is conceivable that an illness or injury that leads to bed rest represents a more potent event (or exposure) than an illness or injury that leads to cutting down on one's usual activities. Highlighting the importance of this question, an earlier editorial recommended that further data on the outcomes related to these two types of intervening events are needed (5).

The objective of this study was to evaluate the associations between the two components of restricted activity (cut down activities and bed rest) and transitions between states of no disability, mild disability, severe disability and death for basic, instrumental, and mobility activities of daily living, respectively. The completion of activities in these three functional domains permits independent living in the community. To...
accomplish our objective, we used data from a unique longitudinal study that includes monthly assessments of restricted activity and functional status for more than 15 years in a cohort of community-living older persons. Establishing a hierarchy for the two components of restricted activity would help clinicians to better understand the potential impact of intervening illnesses and injuries on their older patients and, in turn, would enhance patient management and decision-making in an attempt to minimize the adverse functional consequences of these events.

Methods

Study Population

Participants were members of the Precipitating Events Project, a longitudinal study of community-living persons, 70+ years, who were nondisabled in four basic activities of daily living—bathing, dressing, walking, and transferring (1). Exclusion criteria included significant cognitive impairment with no available proxy (6), inability to speak English, and diagnosis of a terminal illness.

The assembly of the cohort, which took place between March 1998 and October 1999, has been described in detail elsewhere (1,7). In brief, potential participants were identified from a computerized list of 3,157 age-eligible members of a large health plan in greater New Haven, Connecticut. Based on our initial sample size calculations, persons were oversampled if they had slow gait speed (8). Only 4.6% of persons contacted refused screening, and 754 (75.2%) of the 1,002 eligible members agreed to participate in the project. Persons who refused to participate did not differ significantly from those who were enrolled in terms of age or gender (1). The study protocol was approved by the Yale Human Investigation Committee, and all participants provided informed consent.

Data Collection

Comprehensive home-based assessments were completed at baseline and subsequently at 18-month intervals for 162 months (except at 126 months), while telephone interviews were completed monthly through June 2013. For participants who had significant cognitive impairment or were otherwise unavailable, a proxy was interviewed using a rigorous protocol, with demonstrated reliability and validity (6). Five-hundred eighty (77%) participants died after a median of 93 months, while 42 (5.6%) dropped out of the study after a median of 27 months. Data were otherwise available for 99.2% of the 79,446 monthly interviews.

Assessment of covariates

During each of the comprehensive assessments, data were collected on several covariates, including demographic characteristics, slow gait speed, cognitive status as assessed by the Mini-Mental State Examination (MMSE (9)), depressive symptoms as assessed by the Center for Epidemiologic Studies Depression (CES-D) Scale (10), and nine self-reported, physician-diagnosed chronic conditions: hypertension, myocardial infarction, congestive heart failure, stroke, diabetes mellitus, arthritis, hip fracture, chronic lung disease, and cancer. Data on these covariates were 100% complete at baseline and greater than 95% complete during the subsequent comprehensive assessments. Participants were considered to be cognitively impaired if they scored ≤24 on the MMSE (9), and to have high depressive symptoms if they scored ≥20 on the CES-D (10).

Assessment of disability

Our disability assessment was adapted from established instruments (11–14) and included a broad array of basic, instrumental and mobility activities (15). Complete details, including the use of proxy respondents and formal tests of reliability and accuracy, are provided elsewhere (6,16). During the monthly interviews, we asked participants, “At the present time, do you need help from another person to (complete the task)?” for each of the four basic, five instrumental (shopping, housework, meal preparation, taking medications, and managing finances), and three mobility (walk 1/4 mile, climb flight of stairs, and lift/carry 10 pounds) activities. For these 12 activities, disability was operationalized as the need for personal assistance. Participants were also asked about a fourth mobility activity, “Have you driven a car during the past month?” Participants who responded “No” were deemed to have stopped driving. To maintain consistency with the other activities, these participants were classified as being “disabled” in driving that month (16).

For the basic, instrumental and mobility activities, respectively, the severity of disability was denoted by the number of disabled tasks in a specific month. For each of these three functional domains, disability in 1–2 activities was considered as mild, while disability in ≥3 activities was considered as severe (7,17). To address the small amount of missing data on disability, multiple imputation was used with 100 random draws per missing observation (18).

Functional transitions

Based on prior research (4,19), four states were defined for each of the three functional domains: no disability, mild disability, severe disability, and death. Transitions were possible among all of the nondecedent states, and from each nondecedent state to death.

Assessment of hospitalization

During the monthly interviews, participants were asked whether they had stayed overnight in a hospital during the past month. The accuracy of these reports was high, with Kappa = 0.94 (20).

Assessment of restricted activity

During the monthly interviews, participants were also asked two questions related to restricted activity using a standardized protocol with high reliability, i.e. Kappa = .90:1) “Since (date of last interview), have you stayed in a hospital during the past month? (2) “Since (date of last interview), have you been admitted to a hospital during the past month?” These questions were derived from the 1984 National Health Interview Survey (21).

To accomplish our objective, we evaluated two distinct exposure definitions of restricted activity. In the first, referred to as cut down activity, participants were considered to have restricted activity during a specific month if they answered “yes” to cut down on usual activities, but “no” to bed rest. In the second, referred to as bed rest, participants were considered to have restricted activity if they answered “yes” to the bed rest question, regardless of their response to the cut down question. Based on prior research (1), relatively few episodes of best rest are not accompanied by cutting down on one’s usual activities.

Use of discontinuous risk intervals for assessing effects of restricted activity components

In the setting of a hospitalization, it is not possible to distinguish the effects of the two restricted activity components for the following reasons. First, most hospitalizations are accompanied by restricted activity (1). Second, the adverse functional consequences of hospitalization are much greater than those of restricted activity (3,4). Hence, in prior studies (3,4), exposure to these intervening events...
was categorized hierarchically as hospitalization, restricted activity without hospitalization, and neither hospitalization nor restricted activity. To evaluate exposure to each of the two restricted activity components (cut down activities and bed rest) without the confounding effects of hospitalization, it was necessary to omit months with hospitalization from the risk intervals (or exposure windows). The resulting exposure window for assessing the effects of cut down activities and bed rest on functional transitions included the person-months in a specific functional state until a participant died or was hospitalized. Nondecedents returned to the risk set the month following a hospitalization. To illustrate, if a participant was in the hospital in months 10, 50, and 92 and died in month 100, the exposure windows would be from month 1 to 9, 11 to 49, 51 to 91, and 93 to 100.

Statistical Analysis
Cumulative exposures rates were estimated for cut down activities and bed rest, respectively, using a generalized estimating equation (GEE) Poisson model. For each of the three functional domains, similar GEE Poisson models were used to estimate cumulative incidence rates for transitions from each of the three functional states to the two other nondecedent states and death. Rates were calculated per 1000 person-months over the entire follow-up period after omitting months with a hospitalization.

To evaluate the multivariable relationships between the two intervening events (cut down activities and bed rest) and nine transitions, we used a multistate Cox model for recurrent events (22). In this model, persons are simultaneously at risk for several “competing” outcomes. For example, participants with no disability could transition to mild disability, severe disability, or death. The model calculates the respective associations based on the amount of time participants spend in a specific state prior to transitioning to another state. The calculated hazard ratio refers to the risk of making a specific transition between month t and month t+1 based on exposure to cut down activities and bed rest, respectively, relative to participants who had no restricted activity (cut down activities or bed rest) during this 1-month interval. A separate model was run for each of the three functional domains.

The multivariable models included three fixed covariates—sex, race/ethnicity, and years of education—and six time-varying covariates—age 85+ years, living alone, number of chronic conditions, slow gait speed, cognitive impairment, and depressive symptoms. These covariates represent important sociodemographic factors and pertinent clinical factors that have been linked to disability in prior studies (3,4). The time-varying covariates were updated using data from the comprehensive assessment that immediately preceded entry into the state. The time-varying covariates were used for multiple comparisons assuming a false discovery rate of 5% (23). For the GEE and multistate Cox models, 95% confidence intervals (CIs) were derived using the robust standard error estimators. All analyses were performed using SAS V9.3 (SAS Institute), and p < .05 was used to denote statistical significance.

Results
The baseline characteristics of the study participants are shown in Table 1. The median age was 78 years; about two-thirds were female and 90% were non-Hispanic white. Slow gait speed was present in about two out of five participants, while cognitive impairment and depressive symptoms were each present in more than one out of 10 participants. The prevalence of disability was slightly higher in instrumental activities than mobility activities.

Table 1. Baseline Characteristics of Study Participants*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Overall (n = 754)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>78 (74–82)</td>
</tr>
<tr>
<td>85 or older</td>
<td>102 (13.5)</td>
</tr>
<tr>
<td>Female</td>
<td>487 (64.6)</td>
</tr>
<tr>
<td>Non-Hispanic white</td>
<td>682 (90.5)</td>
</tr>
<tr>
<td>Lives alone</td>
<td>298 (39.5)</td>
</tr>
<tr>
<td>Education, median (IQR), years</td>
<td>12 (10–14)</td>
</tr>
<tr>
<td>Chronic conditions, median (IQR)</td>
<td>2 (1–2)</td>
</tr>
<tr>
<td>Slow gait speed</td>
<td>322 (42.7)</td>
</tr>
<tr>
<td>Mental status</td>
<td></td>
</tr>
<tr>
<td>MMSE score, median (IQR)</td>
<td>27 (25–29)</td>
</tr>
<tr>
<td>Cognitive impairment†</td>
<td>86 (11.4)</td>
</tr>
<tr>
<td>Psychological status</td>
<td></td>
</tr>
<tr>
<td>CES-D score, median (IQR)</td>
<td>8 (3–14)</td>
</tr>
<tr>
<td>Depressive symptoms‡</td>
<td>100 (13.3)</td>
</tr>
<tr>
<td>Disability in instrumental activities</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>466 (61.8)</td>
</tr>
<tr>
<td>Mild</td>
<td>215 (28.5)</td>
</tr>
<tr>
<td>Severe</td>
<td>73 (9.7)</td>
</tr>
<tr>
<td>Disability in mobility activities</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>411 (54.5)</td>
</tr>
<tr>
<td>Mild</td>
<td>250 (33.2)</td>
</tr>
<tr>
<td>Severe</td>
<td>93 (12.3)</td>
</tr>
</tbody>
</table>

Notes: CES-D score, Center for Epidemiologic Studies Depression Scale; IQR, interquartile range; MMSE, Mini-Mental State Examination.
† Data are presented as no. (%) unless otherwise indicated. All participants were nondisabled in basic activities at baseline.
‡ Defined as an MMSE score less than 24.
§ Defined as a CES-D score of 20 or higher.

The cumulative exposure rates (95% CI) for the two intervening events—cut down activities and bed rest—were 70.3 (65.8–75.3) and 66.2 (59.7–73.5), respectively, per 1,000 person-months. Figure 1 shows the rates of transitions between states of disability and death for the basic, instrumental and mobility activities, respectively. Overall, the rates were highest for transitions between adjacent states, such as no disability to/from mild disability and mild disability to/from severe disability. Differences in rates across the three functional domains were relatively modest, except for the transition from no disability to mild disability, which was considerably less common for basic activities than for instrumental and mobility activities. Transition rates to death were very low except from severe disability in basic activities.

The multivariable associations between the two intervening events and each of the functional transitions are shown in Table 2. For each of the three domains, cut down activities and bed rest were significantly associated with at least one functional transition. However, with only a few exceptions, the associations were consistently stronger for bed rest than for cut down activities. Bed rest was a particularly potent exposure for transitions from no disability to severe disability, with hazard ratios as high as 8.94 (95% CI, 5.69–14.1) for the mobility activities, and for all functional transitions from severe disability (representing recovery), with hazard ratios as low as 0.25 (95% CI, 0.12–0.54) for the transition to no disability for the basic activities. The associations between bed rest and transitions from no disability and severe disability, respectively, were generally consistent across the three functional domains. For the basic
activities, neither cut down activities nor bed rest was significantly associated with any of the transitions from mild disability. Of the 49 comparisons, only one anomalous result achieved statistical significance: for the instrumental activities, cut down activities reduced the likelihood of transitioning from no disability to mild disability, with an adjusted hazard ratio of 0.72 (95% CI, 0.59–0.88).

**Discussion**

This study provides strong evidence that staying in bed for at least 1/2 day because of an illness or injury represents a more potent exposure among older persons than cutting down on one’s usual activities for a series of clinically meaningful transitions in functional status, thereby supporting the postulated hierarchy of these two components of restricted activity. These results may help clinicians to better understand the functional consequences of illnesses and injuries leading to bed rest, prompting more timely medical attention and/or preventive efforts.

With relatively few exceptions, we found that episodes of bed rest were associated with both an increased likelihood of transitioning to states of more severe disability and a decreased likelihood of transitioning to states of less severe disability. These results were generally consistent across three distinct domains of function, although the effect of bed rest was attenuated for transitions from mild disability in basic activities. While the associations were less pronounced and consistent than those for bed rest, cutting down on one’s usual activities because of an illness or injury greatly increased the likelihood of transitioning from no disability to severe disability, especially for basic and mobility activities, and considerably reduced the likelihood of recovering from mild disability in instrumental and mobility activities.

The importance of restricted activity was recognized more than 30 years ago in a landmark report (24), which identified the reduction of restricted activity as one of two major goals for older persons. Subsequently, several clinical trials of preventive interventions included restricted activity as a key outcome measure (25–28). In response to suggestions that restricted activity might simply be a benign feature of old age (5), we have shown that restricted activity has adverse consequences on an array of functional outcomes (2–4,16,29,30). This study advances this earlier work by demonstrating that “taking to bed” in the setting of an illness or injury represents a more potent insult than simply cutting down on one’s usual activities.

Distinguishing between these two components of restricted activity could help guide triage decisions for busy clinicians. For example, when a patient reports a new or worsening illness or injury, it might be advisable for the clinician to inquire whether this problem led the patient to stay in bed for at least 1/2 day. Prompt medical attention may be warranted for an illness or injury that leads to bed rest, while watchful waiting may be sufficient for an illness or injury in the absence of bed rest and other severity indicators or “red flags”, such as high fever and chest pain. When an illness or injury leads to bed rest, moreover, interventions to prevent functional decline may be indicated. Based on findings from recent mechanistic studies (31–34), preventive interventions might focus, at least in part, on protecting or maintaining muscle mass and strength during episodes of bed rest (35).

Our study is unique in that it included monthly assessments of restricted activity and functional status over an extended period of time. To our knowledge, comparable data are available in no other study. Although causality cannot be established by an observational study, the frequency of our assessments increases the likelihood that the two components of restricted activity at least preceded the functional transitions. The validity of our results is strengthened by the nearly complete ascertainment of restricted activity and functional status, by the high reliability and accuracy of these assessments, by the low rate of attrition, by adjustment for several relevant covariates at 18-month intervals with few missing data, and by adjustment of p values for multiple comparisons. Additional strengths of the study include the evaluation of three clinically distinct and important domains of function, a focus on meaningful transitions in functional status, and a novel analytic plan that allowed us to distinguish the effects of the two restricted activity components.

The use of discontinuous risk intervals could also be considered a limitation. Months with hospitalization, representing about 3.5% of the follow-up period, were omitted from the risk intervals. This was necessary because the adverse functional consequences of hospitalization are so pronounced (3,4), and because unbiased methods do not exist to disentangle these effects from those of the two restricted activity components. Since a disproportionate number of deaths occur during or shortly after hospitalization (4,36), the omission of
### Table 2. Multivariable Associations between Intervening Events and Functional Transitions for Basic, Instrumental and Mobility Activities*.

<table>
<thead>
<tr>
<th>Transition</th>
<th>Intervening Event</th>
<th>Basic Activities</th>
<th>Instrumental Activities†</th>
<th>Mobility Activities‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR (95% CI)</td>
<td>p Value</td>
<td>HR (95% CI)</td>
<td>p Value</td>
</tr>
<tr>
<td>No disability to Mild disability</td>
<td>Cut down activities</td>
<td>1.16 (0.93–1.45)</td>
<td>.40</td>
<td>0.72 (0.59–0.88)</td>
</tr>
<tr>
<td></td>
<td>Bed rest</td>
<td>1.42 (1.09–1.85)</td>
<td>.03</td>
<td>0.95 (0.76–1.20)</td>
</tr>
<tr>
<td>Severe disability</td>
<td>Cut down activities</td>
<td>2.77 (1.67–4.61)</td>
<td>&lt;.001</td>
<td>1.54 (1.17–2.03)</td>
</tr>
<tr>
<td></td>
<td>Bed rest</td>
<td>6.54 (4.33–9.87)</td>
<td>&lt;.001</td>
<td>1.90 (1.36–2.66)</td>
</tr>
<tr>
<td>Death</td>
<td>Cut down activities</td>
<td>0.67 (0.27–1.67)</td>
<td>.54</td>
<td>2.70 (0.85–8.54)</td>
</tr>
<tr>
<td></td>
<td>Bed rest</td>
<td>0.33 (0.09–1.41)</td>
<td>.32</td>
<td>—</td>
</tr>
<tr>
<td>Mild disability to No disability</td>
<td>Cut down activities</td>
<td>1.05 (0.79–1.39)</td>
<td>.78</td>
<td>0.57 (0.47–0.69)</td>
</tr>
<tr>
<td></td>
<td>Bed rest</td>
<td>0.81 (0.56–1.16)</td>
<td>.41</td>
<td>0.57 (0.45–0.72)</td>
</tr>
<tr>
<td>Severe disability</td>
<td>Cut down activities</td>
<td>1.02 (0.76–1.37)</td>
<td>.91</td>
<td>1.47 (1.23–1.75)</td>
</tr>
<tr>
<td></td>
<td>Bed rest</td>
<td>1.36 (0.94–1.96)</td>
<td>.26</td>
<td>1.81 (1.41–2.31)</td>
</tr>
<tr>
<td>Death</td>
<td>Cut down activities</td>
<td>0.30 (0.04–2.34)</td>
<td>.41</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Bed rest</td>
<td>0.62 (0.19–1.99)</td>
<td>.54</td>
<td>—</td>
</tr>
<tr>
<td>Severe disability to Death</td>
<td>Cut down activities</td>
<td>1.77 (0.62–5.07)</td>
<td>.43</td>
<td>0.77 (0.51–1.16)</td>
</tr>
<tr>
<td></td>
<td>Bed rest</td>
<td>0.25 (0.12–0.54)</td>
<td>.0.02</td>
<td>0.30 (0.19–0.47)</td>
</tr>
<tr>
<td>Mild disability</td>
<td>Cut down activities</td>
<td>1.16 (0.51–2.65)</td>
<td>.78</td>
<td>1.09 (0.82–1.45)</td>
</tr>
<tr>
<td></td>
<td>Bed rest</td>
<td>0.32 (0.20–0.52)</td>
<td>&lt;.001</td>
<td>0.44 (0.33–0.58)</td>
</tr>
<tr>
<td>Death</td>
<td>Cut down activities</td>
<td>1.43 (0.52–3.95)</td>
<td>.59</td>
<td>0.75 (0.36–1.57)</td>
</tr>
<tr>
<td></td>
<td>Bed rest</td>
<td>2.28 (1.56–3.34)</td>
<td>&lt;.001</td>
<td>2.65 (1.98–3.53)</td>
</tr>
</tbody>
</table>

**Notes:** CI, confidence interval; HR, hazard ratio.

*As described in the Methods, a single multivariable model was run that included three fixed covariates—sex, race/ethnicity, and years of education, and six time-dependent covariates—age 85 years or older, living alone, number of chronic conditions, slow gait speed, cognitive impairment, and depressive symptoms. p values were adjusted for multiple comparisons assuming a false discovery rate of 5%.

†Hazard ratios refer to the risk of making the specific transitions between month t and month t + 1 based on exposure to the relevant intervening event during this 1-month interval. A hazard ratio less than 1.0 indicates that the transition of interest is less likely to occur in the presence of the specific exposure.

‡Values for some transitions to death could not be estimated because no participant died in these exposure groups.
months with hospitalization led to unstable (i.e. wide CIs) or no risk estimates for transitions to death from no disability and mild disabil
ity, respectively.

Our study has at least four additional limitations. First, information was not available on the duration of cut down activities and bed rest, respectively. The severity of these intervening events may be related to their duration, with longer episodes representing more potent events than shorter episodes. Second, the illnesses and injuries leading specifically to cut down activities and bed rest, respectively, were not ascertained, preventing us from evaluating the mechanisms underlying these two components of restricted activity. We have previ
ously found that older persons usually attribute their restricted activity (cut down activities and/or bed rest) to several concurrent health-related problems, including (most commonly) fatigue, pain/stiffness in the back or joints, dizziness or unsteadiness while stand
ing, and cold/flu symptoms (1). If bed rest serves as a severity indicator, distinguishing the specific reasons for restricted activity may not be necessary. Third, given the large number of functional transitions and extended follow-up period, it was not possible to summarize distinct patterns of disability in the basic, instrumental, and mobility activities, respectively. Fourth, because our study participants were members of a single health plan and were oversampled for slow gait speed, our results may not be generalizable to older persons in other settings. However, the demographic characteristics of our cohort reflect those of older persons in New Haven County, Connecticut, which are similar to the characteristics of the US population as a whole, with the exception of race/ethnic group (37). The generalizability of our results is enhanced by our high participation rate, which was greater than 75%.

Our results provide additional evidence that restricted activity plays an important role in precipitating and, subsequently, perpetuating the disabling process. In the setting of an illness or injury, bed rest is a more potent exposure than cut down activities, establishing a hierarchy for these two components of restricted activity. Prompt medical attention may be warranted when an older person takes to bed because of an illness or injury, both to address the underlying condition leading to bed rest and to prevent the adverse functional consequences of bed rest.

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References