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1 Trajectories of terminal decline in the wellbeing of older women: The DYNOPTA project

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17 RUNNING HEAD: Physical health and terminal decline in wellbeing

Terminal decline in wellbeing is well established. However, the examination of co-varying physical health and functioning on mortality-related wellbeing decline is limited. This study tested the effect of physical health changes on mortality-related wellbeing decline and examined the extent to which mortality-related trajectories of different wellbeing dimensions are similar. Participants comprised 1,862 decedent Australian females (aged $M = 69.59$ years; $SD = 8.08$ years at baseline) from the Dynamic Analyses to Optimize Ageing (DYNOPTA) Study who were observed on up to 4 occasions for up to 16 years ($M = 6.04$ years; $SD = 2.14$ years) prior to death, and who provided data on two wellbeing indices, vitality and mental health. While, between and within-person change in physical health fully accounted for mortality-related wellbeing decline, further analysis indicated that prior level of physical health reported only small effects on subsequent level of wellbeing and was wholly unrelated to wellbeing change. Conversely, prior vitality only reported significant effects on the level of, and change in, physical health. In conclusion, terminal decline in vitality and mental health appears to be an artifact of within-person physical health change and not prior level of physical health. Future areas of research should focus on identifying other significant predictors of physical health change which subsequently impact on wellbeing decline. There is also a need to discriminate between different indices of wellbeing as mortality-related changes and associations with physical function are not consistent.

Keywords: terminal decline, wellbeing, mental health, physical health

There is increasing evidence that in late-life, wellbeing declines in the years preceding death. The presence of a general pattern of terminal decline and a more precipitous terminal drop in wellbeing has been well documented (Gerstorf, Ram, Estabrook, et al., 2008; Gerstorf, Ram, Rocke, Lindenberger, & Smith, 2008; Mroczek & Spiro, 2005; Vogel, Schilling, Wahl, Beekman, & Penninx, 2013). While terminal decline can best be described as a pattern of change that reflects a decline in mental health and wellbeing in the years approaching mortality, terminal drop reflects at least two phases of mortality-related change; a pre-terminal phase of stability or age-associated decline that is subsequently followed by a phase of accelerated decline as an individual approaches death (Bäckman & MacDonald, 2006). Mortality-related decline has been used to describe the accelerated rate of change in a number of human conditions. Most notable is its application to describe the late-life decline of cognitive function (Bäckman & MacDonald, 2006; Bosworth & Siegler, 2002; Sliwinski, Hofer, Hall, Buschke, & Lipton, 2003) and wellbeing (Gerstorf, Ram, Estabrook, et al., 2008; Gerstorf et al., 2010; Gerstorf, Ram, Rocke, et al., 2008; Vogel et al., 2013).

The examination of the association between physical health and terminal wellbeing decline has been little explored. Gerstorf et al. (2008) explored the effects of physical comorbidity and cognitive function on terminal wellbeing decline. However, all but one of the comorbidities measured were treated as time-invariant (p.158) and subsequently were measured several years from death; no effect for these physical health covariates on wellbeing decline was subsequently identified. As physical health factors, which may themselves decline with increasing proximity to mortality, are known to increase mortality risks in old age (Guralnik, 1991), failure to adjust for co-varying physical function and health covariates would appear to be a limitation of existing terminal wellbeing decline research. A highly plausible hypothesis that we evaluate in the present study is whether the decline in wellbeing can be accounted for by declining physical health in the years approaching death.

Nevertheless, there is a degree of consistency in the findings relating to wellbeing terminal decline across different national populations and wellbeing measures (Gerstorf et al., 2010). For instance, using data from large population surveys, including the German Socio-Economic Panel Study (SEOP), the British Household Panel Study (BHPS), and the U.S. Health and Retirement Study (HRS), Gerstorf and colleagues (2010) found evidence for terminal decline across three nationally representative samples. Furthermore, these population-based studies utilized three different measures of wellbeing, namely Life Satisfaction (Fujita & Diener, 2005) in the SOEP, the General Health Questionnaire (GHQ; (Goldberg, 1978); in the BHPS, and the Centre of Epidemiological Studies Depression Scale (CESD; (Radloff, 1977)) in the HRS. That terminal decline was so consistently reported between different national populations and different wellbeing components, suggests there is also utility in re-examining mortality-related changes in different dimensions of psychological wellbeing but within the same population.

Within the wellbeing literature, there is increasing recognition for the need to discriminate between distinct, yet related, components of mental health and wellbeing (Huppert et al., 2009). Indeed, there is substantial support for distinguishing between correlated dimensions of wellbeing (Burns & Machin, 2009; Gallagher, Lopez, & Preacher, 2009; Waterman, 1993). Discriminating between indices of mental health and wellbeing reflects increasingly normative practice as the antecedents of different wellbeing components also appear to be distinct (Burns & Machin, 2010; Huppert, 2009; Kahneman, Diener, & Schwarz, 1999). Consequently, there remains a need to complement prior research in wellbeing terminal decline (Gerstorf et al., 2010), with a comparison of the trajectories of different wellbeing components within the same population. It may be that different wellbeing components function differently when approaching mortality, a question which can only be fully explored by examining the trajectories of different wellbeing components within

the same population which has been little examined in prior studies. For instance, one recent study examined mortality-related change in affective wellbeing and concluded that mortality-related trajectories of positive and negative affect are not consistent (Vogel et al., 2013). We therefore focus here on comparing a measure of mental health or psychological distress, with a measure of vitality, a construct that reflects psychological energy and engagement (Ryan & Frederick, 1997). Vitality is positively related to a range of indicators of positive psychological functioning including self-esteem, intrinsic motivation and mindfulness (Kasser & Ryan, 1996; Ryan & Frederick, 1997), and is negatively related to mental health (e.g. depression and anxiety) and a range of physical health conditions including cardiovascular disorders, diabetes, hypertension, prostate disease and falls risk (Bjorner et al., 2007; Burns, Byles, Mitchell, & Anstey, 2012; Croog et al., 1986; Fowler et al., 1988; Nix, Ryan, Manly, & Deci, 1999). Of particular relevance for a late-life and mortality-related study, vitality has also previously been indicated as a significant predictor of both short and long-term mortality risk (Bjorner et al., 2007).

Using 16 years of mortality data from deceased female participants obtained from the Dynamic Analyses to Optimize Ageing Project (DYNOPTA; (Anstey et al., 2010), we seek to compare individual differences in mortality-related trajectories in two components of wellbeing, namely vitality and mental health, and to establish the effect of physical health and functioning on these trajectories. Three specific aims guide our study. First, we seek to confirm prior investigation of wellbeing changes in the years preceding death (Gerstorf et al., 2010) by concurrently comparing trajectories of two indices of wellbeing and mental health within the same population. Second, we then test the terminal drop hypothesis in wellbeing by utilizing a change-point analysis on both wellbeing dimensions. Finally, this study evaluates the extent to which mortality-related trajectories in these wellbeing dimensions are related to co-varying physical health and functioning. Since no effect for initial health,

113 cognitive function, socio-economic status, or sex on wellbeing trajectories in late-life has
114 been established (Gerstorf, Ram, Rocke, et al., 2008), we will extend current knowledge by
115 specifically examining the effect of intra-individual physical health change on wellbeing in
116 the years preceding death in order to determine the extent to which physical health impacts
117 on mortality-related wellbeing decline. Furthermore, as prior findings (Gerstorf et al., 2010)
118 utilized three population samples with three different wellbeing measures, the extent to which
119 different wellbeing dimensions change in similar ways in the years approaching death within
120 the same individuals will be explored.

Method

Participants

Data were drawn from the DYNOPTA project (Anstey et al., 2010). DYNOPTA involves harmonizing data from nine Australian longitudinal studies of ageing. The harmonization of existing studies, by pooling data or parallel analysis, is increasingly recognized as an important method that contributes to and addresses the limitations of investment in individual longitudinal studies (Noale et al., 2005). Overall, there were 50,652 respondents in the pooled DYNOPTA dataset at baseline, which was conducted between 1990 and 2001. Of the five contributing studies to DYNOPTA providing the necessary vitality and mental health variables, only four provided data on mortality, two of which were the female-cohort studies, the Australian Longitudinal Study of Ageing (ALSWH) mid and old cohorts. Consequently, a significant proportion of participants were female (93%), therefore we restrict our analyses to females only. For this study, female participants ($N = 1,862$) were aged 45-86 ($M = 69.59$ years; $SD = 8.08$ years) at baseline and were observed on at least two occasions up to a maximum of 4 occasions over a 13 year ($M = 3.09$; $SD = 1.02$) period from baseline. The timing of measurement occasions occurred on average 3.11 years ($SD = 1.5$), 5.78 years ($SD = .43$) and 8.73 years ($SD = .46$) from baseline. All participants were eventual decedents who were observed from up to 16 years ($M = 6.04$; $SD = 2.14$) from death. Of the 1,862 decedents who completed a minimum of two observations, 1,754 (94 % of sample) completed three observations, and 1,084 (58 % of sample) four observations. The contribution of observations within the study, categorized by the number of years before death is shown in Table 1.

Measures

Wellbeing & Mental Health: Vitality and Mental Health. We derived wellbeing variables from the Short-Form Health Survey-36 (SF-36) (Ware et al., 1998). The vitality and mental

health indexes partly contribute to the SF-36 Mental Health Component Score. The vitality subscale comprises four items including, ‘Feel full of life’, ‘Have a lot of energy’, ‘Felt worn out’, ‘Felt tired’. The mental health subscale has been validated against clinical measures of depression (Rumpf, Meyer, Hapke, & John, 2001) and has been used in epidemiological studies worldwide as an indicator psychological distress (Gill et al., 2006; Skapinakis, Lewis, Araya, Jones, & Williams, 2005). The mental health subscale comprises five items including, ‘Been a nervous person’, ‘Felt so down in the dumps nothing could cheer you up’, ‘Felt calm and peaceful’, ‘Felt down’, ‘Been a happy person’. For both the vitality and mental health subscales, participants indicated the extent to which they experienced each statement on a 6-point Likert-type scale, ranging from ‘0’ (*None of the Time*) to ‘6’ (*All of the Time*) over the preceding four weeks. Despite moderate cross-sectional correlations between vitality and mental health in the DYNOPTA study over time with reported magnitudes of between $r = 0.46$ and $r = 0.58$, a significant amount of variance remains unexplained in either construct such as to warrant treating these variables as independent indicators of different wellbeing dimensions. Discriminating between related but distinct vitality and mental health constructs has been previously established in the DYNOPTA sample (Bartsch et al., 2011; Burns et al., 2012).

Time Dimension. In our analyses, we utilized a distance-to-death time metric that reflects the difference in time of each observation from the time of death for each participant; we annualized this metric so that each time measurement pre-mortality reflected an annual change. Participants were assessed at intervals of at least 1-year, over a 16 year period.

Covariates: Socio-demographic and health variables.

Time invariant covariates included baseline age, which was centered by subtracting baseline mean age in years ($M = 69.59$ years) from participants’ baseline chronological age (range: 45 - 88 years), and education status which were defined as No Post-School Education (the

reference category; coded as 0); Post-School Education: Non-Tertiary (coded as 1); Post-School Education: Tertiary (coded as 2). Time-varying covariates included Partner Status, which was simply defined as Partnered (the reference category; coded as 0) and Not Partnered (coded as 1). Physical health was assessed with the physical health subscales from the SF-36 Physical Component Score (Ware et al., 1998), which include measures of physical functioning, general health, role-physical and bodily pain. Physical functioning rates the extent to which participants' health limits their performance in a range of physical activities (e.g. to carry groceries, walk several blocks, bathe oneself). General health reflects how well participants rate their current health status, their susceptibility to disease, and their expectations for their future health. Role-physical reflects the extent to which participants' health impacts on their capacity to perform physical activities. Bodily pain rates the extent to which participants' health interferes with their day-to-day activities. These scales have been validated against objective health indicators (Kravitz et al., 1992), including cardiac disease (Zhang, Pozuelo, Brennan, Hoar, & Hoogwerf, 2010), diabetes mellitus (Davidson, 2005), stroke (Kappelle et al., 1994), low back pain (Garratt, Ruta, Abdalla, Buckingham, & Russell, 1993), lung disease (Viramontes & O'Brien, 1994), and renal disease (Osthus et al., 2012). Within-construct correlations over the course of the study indicated correlations of between $r = .53$ and $.75$ for physical functioning, $r = .36$ and $.53$ for role-physical, $r = .53$ and $.66$, and $r = .43$ and $.63$ for general health. Clearly, a significant amount of change is indicated such as to warrant including co-varying indicators of these health indices in our analyses.

Consequently, all physical health variables were decomposed into between and within-person effects following Singer and Willett (2003). Between-person effects reflected inter-individual differences in physical health baseline scores and which are retained as fixed variables in the dataset. Within-person effects reflected the level of intra-individual change in physical health

which was computed by subtracting time-varying scores for physical health from each individual's corresponding baseline physical health score.

Inspection of cross-sectional bivariate correlations across all waves of observations between wellbeing and the physical health covariates evaluated the extent to which wellbeing and physical health were associated with each other. Correlations of between .48 (for bodily pain) to .69 (general health) were reported with vitality indicating that between 53 and 77% of the variance was unshared. Partial correlations that adjusted for the other physical health variables, reported correlations of between .11 (for physical function) and .42 (for general health), indicating that between 83 and 99% of the variance is unshared with vitality. For mental health, bivariate correlations ranged from .29 (for physical functioning) to .46 (general health) indicating between 82 and 92% of the variance unshared. Partial correlations revealed correlations of between .00 (for physical function) and .30 (for general health), reflecting that between 91 and 100% of the variance is unshared for individual physical health covariates. Consequently, we concluded that there was substantive unshared variance between wellbeing and physical health, enough to warrant the current investigations.

Statistical Analysis

Vitality and mental health were *T*-scored ($M = 50$; $SD = 10$) and were standardized to baseline observation. Vitality, mental health, and physical health indices are coded so that high scores reflected positive health status. The intercepts for both vitality and mental health were centered at the last year before death. Statistical analyses were undertaken in STATA v.10 unless otherwise stated. Following the previously published findings of mortality-related population studies into mortality related decline (Gerstorf, Ram, Rocke, et al., 2008), incomplete data are treated as missing at random (Little & Rubin, 1987). As attrition-informative variables, correlates included in our analyses helped address longitudinal selectivity. Our multivariate multi-level models utilized Maximum Likelihood Estimation

(MLE) to determine changes in vitality and mental health and were specified with a Gaussian link. To compare within-person differences in mortality-related change on different wellbeing dimensions, we estimated multi-level models for vitality and mental health over a distance-to-death metric to determine wellbeing trajectories in the years preceding death by testing first linear and then quadratic growth functions in models unadjusted and then adjusted for physical health. We then examined single versus multiple phases of change to establish whether change in vitality and mental health were best described by a single slope parameter or by the estimation of two slope parameters that would describe a mortality-related shift in the slope of both wellbeing variables. Following procedures described in studies of cognitive terminal change (Sliwinski et al., 2003; Wilson, Beckett, Bienias, Evans, & Bennett, 2003), we compared the relative fit of standard growth models with a linear and quadratic slope parameters to a change-point model with two linear slope parameters.

The linear time model was parameterized as:

$$WB_{it} = \beta 0_i + \beta 1_i (\text{distance to death}_{it}) + e_{it} \quad (1)$$

where the wellbeing score, WB_{it} is independently estimated for vitality or mental health, for person i at time t , and is a function of $\beta 0_i$, an individual-specific intercept parameter, $\beta 1_i$, an individual-specific slope parameter that captures change over time and e_{it} , the residual error.

To test for more rapid decline in the years closer to death, a second model was parameterized as:

$$WB_{it} = \beta 0_i + \beta 1_i (\text{distance to death}_{it}) + \beta 2_i (\text{distance to death}_{it}^2) + e_{it} \quad (2)$$

where the wellbeing score, is now also a function of $\beta 2_i$, an individual-specific slope parameter that captures quadratic change over time. Finally a third model to capture terminal decline was parameterized as:

$$WB_{it} = \beta 0_i + \beta 1_i (\text{distance to death}_{it}) + \beta 2_i (\text{distance to death}_{it}) + e_{it}$$

if $\text{time}_{it} \leq k$ then $\beta 2_i = 0$, and

$$\text{if } \text{time}_{it} \geq k \text{ then } \beta_{1i} = 0 \quad (3)$$

where Equation 3 builds on Equation 1 by estimating a change point which incorporates a second slope parameter, β_{2i} , and a change point, k , reflecting when in time individuals move from one phase of change to another (e.g., the point in time when the terminal drop phase begins). To identify where k occurs, the model was repeatedly evaluated using values for the change point, k , incremented from 12 to 192 months before death in steps of one month and was assumed to be a fixed parameter across all individuals. The model with the largest log-likelihood value was then selected, with k reflecting the change point at which the terminal decline begins. At this value of k , the estimates β_1 and β_2 represent the rates of pre-terminal and terminal decline respectively. In all models, the slope parameters β_{1i} and β_{2i} are assumed to be normally distributed around a group mean, correlated with the β_{0i} and uncorrelated with the residual errors, e_{it} .

Post-Hoc Analyses

A number of follow-up analyses were undertaken within our existing multi-level framework to examine the associations between physical health and wellbeing, over a distance-to-death metric, in more detail. We compared lagged regression models whereby 1) current wellbeing was regressed onto prior physical health score and 2) current physical health was regressed onto prior wellbeing to compare the strength of lead-lag associations. We also explored associations of prior physical health and wellbeing with change in wellbeing and physical health by utilizing a residualized change score model whereby the change score reflected the residual in the dependent variable at a current observation after adjusting for the dependent variable at the prior wave. Finally, we also implemented a multiple growth processes model in Mplus v.7 to explore correlated growth in physical health and wellbeing. This allowed us to estimate multiple latent growth models for vitality, mental health and physical health in the

same model. These parallel growth models were specified with linear and quadratic slope factors and implemented over a distance-to-death metric.

Results

Before examining mortality-related changes in vitality and mental health, we first estimated the relative amount of between- and within-person variance in both wellbeing indices. The intraclass correlation coefficients (ICC) for vitality ($ICC = .53$) and mental health ($ICC = .58$) were estimated from random intercept-only models and indicated that 53% and 58% of the variance in vitality and mental health respectively was between-persons variance. Thus there was a substantial amount of within-person variation to model for both wellbeing constructs. The utility of including between and within-person measures of physical health was also assessed. ICC values indicated between 42% and 64% of variance reflected between-persons variance for all physical health variables: physical function ($ICC = .64$); role physical ($ICC = .42$), bodily pain ($.54$) and general health ($ICC = .58$). Again, there was a substantive amount of within-person variance remaining in the physical health covariates to warrant estimating the effects of time-varying physical health on terminal wellbeing decline. We then proceeded to estimate the amount of mortality-related decline in wellbeing and physical health without adjusting for any covariates. Significant decline in vitality (.68 T-score units per year) and mental health (.20 T-score units per year) were observed. Similarly, there was significant decline in physical health in the years preceding death: physical function indicated a .76 *T-score* ($SE = .04$) decline, general health a .62 *T-score* ($SE = .04$) decline, bodily pain a .38 *T-score* ($SE = .04$) decline, and role physical a .56 *T-score* ($SE = .04$) decline per year, warranting the inclusion of physical health change effects in estimating terminal wellbeing decline.

Table 2 summarizes the mean and variance estimates as well as model fit indices of adjusted linear and quadratic growth models over a distance-to-death time metric. As mental health and vitality were T-scored, rates of wellbeing decline can be directly compared. For those analyses unadjusted for physical health, significant linear changes in vitality (Models 1 & 2) and mental health (Models 5 & 6) were observed. That is, as the intercept was centered at death, higher wellbeing scores were associated with greater distance from death. Comparatively, stronger changes were observed for vitality. The inclusion of a quadratic effect for time identified substantive changes in vitality (Model 2) in the years preceding death, but these findings were not observed for mental health (Model 6). In those models that adjusted for physical health, neither linear nor quadratic time effects were now observed for mental health (Models 7 & 8). For vitality, a small linear time effect was still observed when adjusting for physical health (Model 3), although this effect was accounted for when testing for a quadratic time effect (Model 4). Comparison of Goodness of Fit Indices indicated that those models that adjusted for both between and within-person physical health reported better fit to the data. Comparison of those models for both vitality and mental health, that included linear (Models 3 and 7) and both linear and quadratic effects (Models 4 and 8) indicated comparable fit, though with larger Pseudo R^2 values for those models that included both time effects. Overall, there appears to be some support for the hypothesis that there are subtle differences in the way different wellbeing constructs change within individuals in the years preceding death; for instance, models unadjusted for physical health indicated more substantive linear and quadratic effects for vitality. However, it is clear that the concurrent examination of within-person change in physical functioning, bodily pain, role physical, and general health accounts for the rate of change in wellbeing, and most of the change in vitality.

We supplemented these analyses to investigate whether the effects of physical health were magnified as individuals approached death. None of the interactions between the inter-

and intra-person physical health variables with the linear or quadratic slopes were significant, indicating that the effects for between and within-person change in physical health on wellbeing were consistent over time.

We reran our models to examine the individual effects of the separate physical health covariates that were included in our final multivariate model in order to identify any differences in the individual effects of the separate physical health indices. All the physical health covariates were strongly associated with vitality and reported comparable between-person and within-person effects: Physical Health (Between-Person: $\beta = .22$, $SE = .01$; $p < .001$; Within-Person: $\beta = -.18$, $SE = .01$; $p < .001$); Role Physical (Between-Person: $\beta = .15$, $SE = .00$; $p < .001$; Within-Person: $\beta = -.09$, $SE = .00$; $p < .001$); Bodily Pain (Between-Person: $\beta = .21$, $SE = .01$; $p < .001$; Within-Person: $\beta = -.14$, $SE = .01$; $p < .001$); General Health (Between-Person: $\beta = .29$, $SE = .01$; $p < .001$; Within-Person: $\beta = -.24$, $SE = .01$; $p < .001$). Similarly, all physical health covariates were strongly associated with mental health and reported comparative between-person and within-person effects: Physical function (Between-Person: $\beta = .12$, $SE = .01$; $p < .001$; Within-Person $\beta = -.08$, $SE = .01$; $p < .001$); Role Physical (Between-Person: $\beta = .09$, $SE = .00$; $p < .001$; Within-Person $\beta = -.05$, $SE = .00$; $p < .001$); Bodily Pain (Between-Person: $\beta = .13$, $SE = .01$; $p < .001$; Within-Person $\beta = -.08$, $SE = .01$; $p < .001$); General Health (Between-Person: $\beta = .19$, $SE = .01$; $p < .001$; Within-Person $\beta = -.14$, $SE = .01$; $p < .001$). It appears that although the general health factor reported the strongest effects in the multivariate model, results from those models that tested the physical health variables individual observed comparable effects by all physical health covariates.

Change Point Analysis and Terminal Decline

Despite non-significant linear or quadratic time effects in fully adjusted models for both vitality and mental health, we continued to explore the question about whether terminal drop was evident in these two indicators of wellbeing, and to identify the extent to which any terminal drop would be similarly accounted for by the inclusion of between and within-person physical health covariates. To identify the optimal change-points for both vitality and mental health, -2 log likelihood values from a series of change-point models were compared. Following Hall (2000), we calculated “profile likelihood values”, that range between 0 and 1, by subtracting the -2LL value at each time point from the lowest - 2LL value reported overall (the model with the best fitting change-point), dividing by 2 and then computing the exponent for this integer. Consequently a 95% confidence interval for change point estimate is estimated with a value of approximately 0.15 for the transformed profile likelihood values. For the unadjusted models, the optimal change point for vitality was 26 months (95% CI: 21 months to 33 months) and for mental health was also 26 months (95% CI: 19 months to 36 months). For those change-point models that adjusted for within and between-person physical functioning, bodily pain, role physical, and general health, the picture is less clear. The optimal change point for vitality was now 37 months and there was a substantial increase in the confidence intervals (95% CI: 13 months to 68 months). The adverse effect of physical health on inferring transition points for mental health decline was even more pronounced; the best fitting model indicated a change point in mental health of 28 months, but with an extremely large confidence interval (95% CI: 14 months to 101 months). That the 95% confidence intervals were so much larger in the adjusted models gives an indication that adjusting for physical health covariates prohibits us from accurately estimating k . However, to demonstrate the effect of adjusting for physical health on terminal drop, we report estimates from unadjusted and adjusted change-point analyses which reported the best fitting models of pre-terminal and terminal declines in vitality and mental health (Table 3). As k , the

transition point, was parameterized by a monthly increment in each model, the parameter estimates have been adjusted to reflect annual changes in wellbeing for ease of interpretation. Fixed and random effects as well as goodness of fit and likelihood ratio tests are also reported. In unadjusted models, a substantial terminal decline and a smaller pre-terminal decline in vitality were reported (effects reflect annualized T-score changes), while for mental health, only a significant terminal effect was observed. This gives support to the notion of terminal drop in both wellbeing dimensions. However, similar to the analyses from our linear and quadratic growth models, parameter estimates indicated that adjusting for physical health fully accounted for pre-terminal and terminal decline in mental health and terminal decline only in vitality (Table 3) and accounts for why determining k was so problematic in the adjusted models. Only a small overall decline in pre-terminal decline in vitality was reported. It is clear that the effect of controlling for physical health and functioning has significant implications for interpreting any pattern in terminal decline in our wellbeing indicators.

Overall, the change-point analyses confirmed the linear and quadratic models. Comparison of the GFI between these analyses indicated similar fitting models. For vitality, the LL indicated superior fit to the linear and quadratic models (Model 4), while the AIC and BIC indicated superior fit for the change-point models (Model 10). Comparison of Psuedo R^2 indicated comparable explained variance in both models. For mental health, the LL indicated superior fit to the linear and quadratic models (Model 8) and greater proportion of explained variance. The BIC indicated superior fit to the change-point model (Model 12) while comparison of the AIC were comparable. Regardless, it would appear that in adjusting for physical health, linear and quadratic growth models are comparable to the change-point analyses since they are both essentially indicating no change in wellbeing prior to death. For subsequent follow-up analyses, we focus on linear and quadratic models since the 95%

confidence intervals for k transition points for both vitality and mental health in adjusted change point analyses ranged from 12 months to 101 months in the adjusted models.

Follow-up Analyses – Exploring the impact of physical health

Results from both linear, quadratic and change-point analyses initially indicated mortality-related decline in both vitality and mental health, although these effects were fully accounted for when adjusting for between and within-person physical health. Further, the results of the change-point regression models indicated a lack of efficiency to adequately estimate a transition point for terminal decline when adjusting for physical health. Consequently, we supplemented our main analyses to explore the associations between physical health and wellbeing in more detail.

First, we utilized a multiple growth curve model to explore correlated decline in physical health and wellbeing in the years approaching death. Correlated multiple growth processors were modeled by estimating latent factors for the intercepts, and both linear and quadratic slopes for all physical health and wellbeing variables. We made no prior assumption about the lead-lag relationship between physical health and wellbeing slope factors. The multiple growth factors model was implemented in Mplus using a Bayesian estimator (Muthen & Asparouhov, 2012). We chose this approach because there were convergence issues when using MLE to estimate 6 correlated multiple growth processes with both linear and quadratic slope factors with sparse data (up to 4 observations over a period of up to 16 years), and with multiple random effects with little variance - all growth models indicated very small proportions of the variance (<1%) in the quadratic slope factors. Results indicated significant correlations ($p < .001$) between all intercept and growth factors, both within and between all constructs, supporting our earlier examination of the bivariate and partial correlations between the raw scores for both wellbeing and physical health. These

constructs are clearly highly inter-correlated. Substantial linear declines in most of the physical health variables (physical functioning, role physical, general health) were reported with comparatively smaller declines in vitality (though this was comparable to the unadjusted slopes reported in Model 2 - Table 2) and bodily pain (Table 4). No decline in mental health was reported. Importantly, significant quadratic slopes were reported only for physical function, role physical and general health, suggesting that significant terminal drop may only be observed in these physical health variables. As we had previously identified, most of the variance was accounted for at the intercept level with very little variance in the linear slope factors and virtually no variance in the quadratic slope factors.

Second, reverting back to our multi-level analytical approach, we then compared regression models whereby we 1) lagged current wellbeing onto prior physical health score with 2) models where current physical health was lagged onto prior wellbeing (Table 5). Confirming our prior quadratic models, results indicated no change for mental health in the years leading to death; however, there was now a significant and substantive linear and quadratic change in vitality. Since all prior physical health variables indicated only small significant effects on subsequent vitality it would appear that prior physical health has less impact on current vitality than change in physical health. Only two of the physical health covariates, bodily pain and general health, reported small effects on subsequent mental health, but this was sufficient to account for the terminal decline in mental health. Overall, these findings are important and suggest that current wellbeing, in particular vitality, is not as strongly related to prior physical health status as is the change in physical health that was reflected earlier in our results of the within-person physical health effects (Tables 2). In contrast to wellbeing, analysis of physical health indicated significant decline in the years leading to death, while only physical functioning and general health reported significant quadratic changes that would support a terminal-drop hypothesis. Interestingly, results

indicated more substantive effects for prior vitality on physical functioning ($\beta = .18$, $SE = .01$; $p < .001$), role physical ($\beta = .15$, $SE = .01$; $p < .001$), bodily pains ($\beta = .16$, $SE = .01$; $p < .001$) and general health ($\beta = .19$; $SE = .01$; $p < .001$). Mental health was indicated as a significant predictor for general health only ($\beta = .04$, $SE = .01$; $p = .001$) and is reported here since the significance of the effect only just failed to reach our arbitrary cut-off point ($p < .001$); all other mental health effects were highly non-significant ($p > .05$). That vitality was overall such a stronger lead-lag indicator of physical health further supports the importance of examining multiple wellbeing dimensions.

Third, we explored associations of prior physical health and wellbeing with change in wellbeing and physical health. Table 6 reflects the estimates of adjusted regression models whereby residualized change in wellbeing and physical health were regressed on prior physical health and wellbeing respectively. The intercept now reflects the level of change in the last two observations prior to death. Clearly, both wellbeing variables indicate a substantial decline in the final observations before death, while for the physical health variables, only perceptions of general health reported a significant decline between these two observations. Effects for time (distance-to-death), parameterized here by linear and quadratic functions of distance-to-death, revealed the extent to which change has occurred prior to death. Only results for vitality, physical functioning and general health appear to support a mortality-related decline that is reflected by a precipitous decline in the years preceding death when adjusting prior physical health and wellbeing; evidenced by a significant negative linear effect for time (wellbeing/physical health increases further from death) and a significant positive quadratic effect for time (wellbeing/physical health increase slows further from death). For mental health, change was only reported at the intercept (the difference between the last two observations) while no change in role physical and bodily pain was indicated in these adjusted models. Surprisingly, and perhaps of most importance for the current paper,

prior physical health was wholly unrelated to change in either vitality or mental health. In contrast, vitality had small but significant effects on change in all physical health outcomes and appears to account for the unadjusted change in role physical and bodily pain.

Discussion

Co-varying Physical Health Accounts for Mortality-Related Wellbeing Decline

The primary purpose of this study was to evaluate the role of comorbid covarying physical health in accounting for the trajectories of mental health and wellbeing in late-life, specifically in the years preceding death. Despite identifying significant decline in both vitality and mental health in unadjusted growth and change-point models, this decline was fully accounted for when controlling for between and within-person physical health and functioning indices. This contrasts with other findings where terminal wellbeing decline was unaffected by baseline health comorbidities (Gerstorf, Ram, Estabrook, et al., 2008; Gerstorf et al., 2010; Gerstorf, Ram, Rocke, et al., 2008). We posit that this disparity can be attributed to our having adjusted for both inter and intra-individual physical health and functioning status. While physical health status, distal to mortality, appears to impact little on trajectories of wellbeing in the years preceding death (Gerstorf, Ram, Rocke, et al., 2008), we have demonstrated that within-person change in physical health accounts for much of this change in wellbeing.

Since change in physical health appeared to impact so strongly on mortality-related wellbeing decline, we subsequently extended our investigations to consider a number of possible relationships between physical health and wellbeing. Exploration of this relationship indicated a number of important findings. First, we modeled terminal decline in all wellbeing and physical health variables in a multiple parallel processes context. Correlated growth models indicated support for mortality-related decline in all variables except mental health,

although support for a terminal-drop in the years approach death was only reported for physical functioning, role physical and general health. This suggests that mortality-related decline is not common across all faculties, even within those individuals who may report terminal decline in other areas of functioning. In particular, it highlights the differences between different wellbeing dimensions within the same individuals since decline was reported in vitality and not mental health. Second, prior levels of physical health appear to have less impact on subsequent wellbeing than prior levels of wellbeing have on subsequent physical health. Finally, prior physical health was wholly unrelated to subsequent change in vitality or mental health. This would again appear to support the prior findings of Gerstorf, Ram, Rocke, et al. (2008). In contrast, prior levels of vitality, appears to be a small but significant driver in changes in physical health status, suggesting that there may be some reciprocal mechanisms underlying the associations between physical health and vitality. Overall, our initial findings indicated that change in physical health was strongly associated with wellbeing and accounted for terminal decline in both vitality and mental health. In contrast prior levels of physical health were only weakly associated with subsequent levels of wellbeing and only with change in vitality, while the terminal decline in vitality was still reported. This suggests that it is change in physical health that is accounting for terminal wellbeing decline.

Implications of the Study Findings

A number of implications can be drawn from our findings. Importantly, changes in different wellbeing components in the years preceding death are not consistent. Terminal decline was evident in both our wellbeing measures when unadjusted for health co-morbidities. However, since the substantive changes between our wellbeing indices were not comparable, our findings support the need to delineate between components of wellbeing and mental health, which although related, are indeed distinct, with differential antecedents and

consequents (Burns & Machin, 2010; Huppert, 2009; Huppert et al., 2009; Kahneman et al., 1999). However, that most of this change is accounted for by other health comorbidities raises questions about the independence of the wellbeing terminal decline phenomenon. Quite simply, we cannot discount the likelihood that wellbeing decline is a consequence of other underlying mortality-related dysfunctions, including decline in physical health corollaries. It is possible that there exists a cascade of decline in multiple domains of functioning that are strongly inter-correlated particularly in the years preceding death. This leads us to propose that subsequent investigation needs to explore the interrelated nature between physical health, wellbeing and mortality. Specifically, several important hypotheses need to be explored. For example, the utilization of a bivariate dual change score model would allow future researchers to estimate the lead-lag associations between wellbeing and physical health to determine whether: 1) wellbeing leads change in physical health; 2) physical health leads change in wellbeing; or 3) whether wellbeing and physical health exert equal effects on each other. Alternatively, questions relating to the extent to which a common-cause underlies change in both physical and mental health, remains unanswered. It may well be that changes attributable to normal biological ageing factors may be fundamental determinants of changes in both physical health and mental health in the years approaching death.

However, the results from our post-hoc analyses provide important information that begins to address these questions. For instance, using a lagged regression framework, we identified that prior physical health reported only small effects on subsequent vitality, and to a lesser extent mental health. In contrast, prior vitality, but not mental health reported substantial effects on subsequent physical health. Similarly, prior physical health was unrelated to change in either vitality or mental health, while prior vitality reported small but significant effects on change in physical health. Further analysis may be warranted to examine more specifically the changes in physical health and wellbeing from observation to

observation. Currently, our own multiple processes growth model incorporates growth factors that only capture ‘average’ change and may fail to assess particular moment-moment changes.

Limitations of Mortality-Related Wellbeing Decline Studies

Limitations of both the study design and our assessment of mortality need to be considered. In particular, cause of death amongst DYNOPTA participants is unknown. It is likely that the extent to which mortality-related changes in wellbeing occur would be directly in proportion to the extent to which death was anticipated or unforeseen. For instance, it would be difficult to argue for declines in wellbeing in the instance of an unexpected or accidental death. However, this limitation may be most pertinent for unknown-cause mortality in younger adulthood and by restricting our analyses to adults from 45 to 88 years of age at baseline ($M = 69.5$ years) who were followed for 16 years, we can expect that most of the reported mortality could be attributed to expected or anticipated mortality as a consequence of increasing normative age-related disease. However, such a limitation is indeed a feature of most terminal decline studies and the current authors are unaware of any terminal decline studies that have explicitly excluded death that could be attributed to mechanisms that would be unrelated to the terminal decline hypothesis (e.g. accidental death in late life).

While the assessment of physical health and wellbeing were derived from validated measures of health, our assessments are dependent on self-report. Importantly, it is known that self-perceptions of health are confounded by personality characteristics whereby high neuroticism and low extraversion are associated with poor perceptions of health (Chapman, Duberstein, Sorensen, & Lyness, 2006). Examination of the influence of individual personality characteristics on wellbeing terminal decline was not possible with participants from the DYNOPTA study and is one area for subsequent study. Also, while the SF-scales

utilized are validated against objective measures of health (Davidson, 2005; Garratt et al., 1993; Kappelle et al., 1994; Kravitz et al., 1992; Osthus et al., 2012; Viramontes & O'Brien, 1994; Zhang et al., 2010), our findings need to be confirmed with data that incorporates objective measures of physical health and functioning including shortness of breath, tiredness, and appetite, which are related to increasing proximity to mortality (Chochinov, Tataryn, Clinch, & Dudgeon, 1999; Tataryn & Chochinov, 2002).

Finally, our change point analyses attempted to model transitions between pre-terminal and terminal drop whereby k , the transition point, was fixed and assumed to be invariant across participants. It is possible to relax this assumption and to allow k to vary between participants; however, relaxing this assumption would require a larger density of observations than is provided in the current sample where participants were observed 2-4 (Mode = 3) times over a 16-year ($M = 6.04$; $SD = 2.14$) period. Despite these limitations, we do believe that these findings add important information to our understanding the course of wellbeing in the years approaching mortality.

Conclusions and Future Directions

Overall, our results suggest that the association between wellbeing and mortality are moderated by physical health. Although Gerstorf et al. (2008) found little association between mortality-related changes in life satisfaction with dementia risk and intellectual functioning, following our results, there is a need to examine the impact of cognitive decline in explaining wellbeing decline, particularly with the substantive evidence for terminal cognitive decline (Bäckman & MacDonald, 2006; Ghisletta, McArdle, & Lindenberger, 2006). Since change in physical health and not level were most strongly related to wellbeing decline, it is possible that change in physical health, wellbeing and cognitive functioning in the years leading to death may reflect other underlying organic changes. It will be important to examine our findings in this context and with different populations. For instance, it is

unclear whether our effects may be replicated amongst males. Also, related to our earlier discussion about known versus all-cause mortality, we hypothesize that younger birth cohorts may experience different mortality-related wellbeing trajectories compared to older birth cohorts as their mortality may be driven by quite different factors.

To conclude, we have demonstrated that the extent to which any decrement in wellbeing is directly related to mortality is tenuous at best. While unadjusted trajectories appear to indicate a terminal decline in different dimensions of wellbeing and mental health, we identified that any mortality-related wellbeing decline was fully accounted for when adjusting for between and within-person physical health and functioning. Despite the substantive effect of within-person physical health change on wellbeing trajectories, prior levels physical health reported only small effects on subsequent wellbeing levels, and no effect on the changes in wellbeing from one observation to the next. Finally, we have identified that not all wellbeing indicators function in the same way. In comparison with mental health, vitality reported a substantially larger decline when unadjusted for physical health. Further, only vitality, and not mental health, was associated with subsequent physical health or change in physical health. There is clearly a complexity in the interplay of multiple facets of human functioning that need to be considered in examining mortality-related decline.

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784 Table 1. Contribution of observations to the analysis models as a function of distance-to-
785 death

Distance-to-death	Observations (Total # of observations = 4,560) N (%)	Vitality M (SD)	Mental Health M (SD)
0 to < 1 year	216 (4.7)	42.1 (10.4)	46.9 (11.3)
1 to < 2 year	496 (10.9)	45.9 (10.2)	48.7 (9.9)
2 to < 3 year	402 (8.8)	47.3 (10.8)	50.2 (10.5)
3 to < 4 year	463 (10.2)	48.0 (10.6)	49.9 (9.6)
4 to < 5 year	604 (13.3)	48.2 (10.3)	49.7 (10.1)
5 to < 6 year	465 (10.2)	48.9 (10.5)	49.8 (10.4)
6 to < 7 year	477 (10.5)	49.4 (10.3)	50.2 (9.9)
7 to < 8 year	530 (11.6)	49.7 (9.8)	50.5 (10.0)
8 to < 9 year	285 (6.3)	50.6 (10.0)	50.5 (9.9)
9 to < 10 year	283 (6.2)	51.1 (9.6)	50.6 (9.7)
10 to < 11 year	287 (6.3)	51.5 (9.4)	50.3 (9.8)
11 to < 12 year	9 (0.2)	49.6 (10.8)	48.9 (9.4)
12 to < 13 year	18 (0.4)	47.6 (9.6)	49.9 (12.3)
13 to < 14 year	14 (0.3)	51.9 (10.9)	52.5 (6.2)
14 to < 15 year	14 (0.3)	49.8 (9.4)	48.5 (10.3)

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Table 2 Results of terminal decline in vitality and mental health over a distance-to-death metric

	Vitality					Mental Health		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>
Fixed Effects Estimates								
β_0 (Intercept)	44.07 (.71)*	42.75 (.75)*	45.01 (.48)*	45.00 (.54)*	45.26 (.70)*	44.55 (.74)*	46.27 (.65*)	46.26 (.70)*
β_1 (Linear Slope)	-.68 (.04)*	-1.34 (.14)*	-.19 (.03)*	-.21 (.11)	-.20 (.04)*	-.57 (.13)*	-.06 (.04)	-.03 (.13)
β_2 (Quadratic Slope)		.06 (.01)*		.00 (.01)		.04 (.02)		.00 (.01)
Not Partnered	-.34 (.43)	-.22 (.43)	.34 (.27)	.37 (.27)	-.07 (.42)	-.02 (.01)	.40 (.37)	.40 (.37)
Non-Tertiary Education	1.88 (.61)	2.07 (.61)	.94 (.38)	.94 (.38)	1.99 (.60)	2.07 (.60)	1.45 (.52)	1.42 (.52)
Tertiary Education	.74 (1.09)	.84 (1.08)	.18 (.69)	-.18 (.69)	1.93 (1.07)	1.99 (1.07)	1.26 (.94)	1.27 (.94)
Age	.04 (.03)	.04 (.03)	.13 (.02)*	.13 (.02)*	.13 (.03)*	.13 (.03)*	.16 (.02)*	.16 (.02)*
Physical Function _{bp}			.06 (.01)*	.06 (.01)*			-.01 (.01)	-.01 (.01)
Physical Function _{wp}			-.06 (.01)*	-.06 (.01)*			-.01 (.01)	-.01 (.01)
Role Physical _{bp}			.05 (.00)*	.05 (.00)*			-.02 (.00)*	.03 (.01)*
Role Physical _{wp}			-.04 (.00)*	-.04 (.00)*			.06 (.01)*	-.02 (.01)*
Bodily Pain _{bp}			.06 (.01)*	.06 (.01)*			-.03 (.01)*	.05 (.01)*
Bodily Pain _{wp}			-.05 (.01)*	-.05 (.01)*			-.03 (.01)*	-.03 (.01)*
General Health _{bp}			.16 (.01)*	.16 (.01)*			.13 (.01)*	.13 (.01)*
General Health _{wp}			-.15 (.01)*	-.15 (.01)*			-.11 (.01)*	-.11 (.01)*
Random Effects Estimates								
β_0	76.65 (5.29)	81.28 (7.38)	21.12 (2.54)	27.34 (3.06)	73.77 (5.06)	81.46 (7.14)	51.90 (4.07)	56.13 (5.87)
β_1	.43 (.09)	5.53 (.99)	.11 (.06)	2.45 (.51)	.36 (.09)	3.53 (1.03)	.28 (.08)	2.36 (.93)
β_2		.03 (.01)		.01 (.00)		.02 (.01)		.01 (.01)
$\beta_0 \beta_{1cov}$	-2.70 (.60)	-8.25 (2.27)	-.60 (.34)	-4.29 (.74)	-2.43 (.58)	-7.51 (2.26)	-1.80 (.49)	-4.77 (1.96)
$\beta_0 \beta_{2cov}$		.40 (.19)		.27 (.00)		.43 (.20)		.24 (.17)
$\beta_1 \beta_{2cov}$		-.42 (.09)		-.18 (.05)		-.26 (.09)		-.18 (.08)
<i>e</i>	41.52 (1.37)	36.57 (1.41)	30.17 (0.98)	27.98 (1.05)	39.62 (1.30)	36.96 (1.45)	34.81 (1.17)	32.97 (1.34)
Goodness-of-fit indices								

LL	-16465	-16416	-14447	-14435	-16352	-16339	-15207	-15203
AIC	32950	32861	28930	28913	32724	32706	30450	30450
BIC	33014	32951	29045	29047	32788	32796	30565	30591
Pseudo R ²	.23	.39	.69	.79	.10	.18	.25	.32

Note. * $p < .001$. Age mean-centred at 70 years; Education reference category is 'No Post-School Education'; Partner Status reference category

is 'Partnered'. Pseudo R^2 computed following Snijders and Bosker (1999): $R^2 = 1 - \sigma_{e(u)}^2 / \sigma_{e(c)}^2$ where $\sigma_{e(u)}^2$ is the residual variance within-person variance obtained from an intercept-only models and where $\sigma_{e(c)}^2$ reflects the $\sigma_{e(u)}^2$ from the conditional model.

Table 3. Two-phase growth models for vitality and mental health over a distance-to-death metric

	Vitality		Mental Health	
	Model 9	Model 10	Model 11	Model 12
	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>
Fixed Effects Estimates				
β_0 (Intercept)	40.97 (.87)*	45.00 (.55)*	43.08 (.85)*	45.57 (.79)*
β_1 (Terminal Decline) ⁺	-2.50 (.03)*	-.18 (.11)	-1.50 (.30)*	-.34 (.26)
β_2 (Pre-Terminal Decline) ⁺	-.52 (.00)*	-.21 (.05)*	-.06 (.05)	.09 (.05)
Not Partnered	-.20 (.43)	.38 (.27)	.000 (.42)	.42 (.37)
Non-Tertiary Education	1.99 (.61)	.96 (.38)	2.04 (.60)	1.45 (.52)
Tertiary Education	.70 (1.09)	-.15 (.67)	1.94 (1.07)	1.25 (.94)
Age	.04 (.03)	.13 (.02)*	.14 (.03)	.16 (.02)*
Physical Function _{bp}		.06 (.01)*		-.01 (.01)
Physical Function _{wp}		-.06 (.01)*		.00 (.01)
Role Physical _{bp}		.05 (.00)*		.03 (.01)*
Role Physical _{wp}		-.04 (.00)*		-.02 (.00)*
Bodily Pain _{bp}		.06 (.01)*		.05 (.01)*
Bodily Pain _{wp}		-.05 (.01)*		-.03 (.01)*
General Health _{bp}		.16 (.01)*		.13 (.01)*
General Health _{wp}		-.15 (.01)*		-.10 (.01)*
<i>k</i>	25 months	47 months	25 months	28 months
Random Effects Estimates				
β_0	95.27 (11.81)	30.87 (4.51)	98.58 (11.73)	66.16 (9.14)
β_1	.14 (.02)	.01 (.00)	.08 (.02)	.05 (.01)
$\beta_0 \beta_{1cov}$	-2.30 (.46)	-.40 (.10)	-1.80 (.42)	-1.07 (.32)
<i>e</i>	39.53 (1.20)	28.41 (.94)	39.68 (1.20)	35.41 (1.10)
Goodness-of-fit indices				
LL	-16409	-14436	-16335	-15206
AIC	32841	28910	32692	30450
BIC	32911	29031	32763	30571
Pseudo R^2	.29	.79	.10	.23

Note. * $p < .001$. ⁺estimates reflect annual changes; Vitality estimated with a transition point 47 months from death; Mental Health estimated with a transition point 28 months from death;

Age mean-centred at 70 years; Education reference category is 'No Post-School Education';

Partner Status reference category is 'Partnered'. Pseudo R^2 computed following Snijders and

Bosker (1999): $R^2 = 1 - \sigma_{e(u)}^2 / \sigma_{e(c)}^2$ where $\sigma_{e(u)}^2$ is the residual variance within-person

variance obtained from an intercept-only models and where $\sigma_{e(c)}^2$ reflects the $\sigma_{e(u)}^2$ from the

conditional model.

Table 4. Correlated multiple growth model of physical health and wellbeing variables over a distance-to-death metric

	Vitality	Mental Health	Physical Functioning	Role Physical	Bodily Pain	General Health
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
<i>Fixed Effects</i>						
β_0 (intercept)	42.77 (40.21; 45.34)**	45.78 (43.31; 48.23)**	47.93 (45.52; 50.35)**	46.17 (43.80; 48.54)**	45.55 (43.03; 48.17)**	40.78 (38.26; 43.33)**
β_1 (linear slope)	-1.52 (-.40; -2.65)*	.15 (.12; -.96)	-2.64 (-1.61; -3.66)**	-2.42 (-1.27; -3.53)**	-1.58 (-.42; -2.71)*	-3.06 (-1.97; -4.14)**
β_2 (quadratic slope)	.10 (.22; -.02)	-.04 (.08; -.15)	.19 (.30; .08)**	.17 (.29; .04)*	.11 (.23; -.01)	.21 (.32; .10)**
<i>Random Effects</i>						
β_0	146.8 (127.1; 171.6)	132.9 (112.2; 154.9)	123.8 (102.7; 146.7)	109.6 (88.8; 130.2)	130.7 (108.1; 154.6)	155.3 (135.1; 178.2)
β_1	23.1 (19.6; 27.5)	16.0 (12.3; 19.5)	15.1 (11.9; 18.6)	19.7 (15.9; 24.1)	16.5 (13.0; 20.5)	19.6 (16.3; 23.0)
β_2	0.2 (0.2; 0.3)	0.2 (0.1; 0.2)	0.2 (0.1; 0.2)	0.2 (0.2; 0.3)	0.2 (0.1; 0.2)	0.2 (0.2; 0.2)

** $p < .001$ * $p < .01$; All analyses adjusted for age, education and partner status; β_0 – intercept; β_1 –linear slope; β_2 –quadratic slope. 95% CI - reflects 95% confidence interval of the standard deviation of the estimate.

Table 5 Lagged regression models for vitality and mental health over a distance-to-death metric

	Vitality	Mental Health	Physical Function	Role Physical	Bodily Pain	General Health
	Model	Model	Model	Model	Model	Model
	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>
Fixed Effects Estimates						
β_0 (Intercept)	41.31 (.72)*	43.78 (.79)*	50.02 (.74)*	49.36 (.70)*	47.80 (.78)*	45.19 (.73)*
β_1 (Linear Slope) ⁺	-1.58 (.26)*	-.72 (.23)	-1.93 (.24)*	-1.34 (.26)*	-1.16 (.26)*	-2.01 (.25)*
β_2 (Quadratic Slope) ⁺	.13 (.03)*	.06 (.03)	.16 (.03)*	.10 (.03)	.10 (.03)	.16 (.03)*
Not Partnered	.56 (.38)	.89 (.44)	-.77 (.41)	.21 (.38)	-.24 (.43)	.29 (.39)
Non-Tertiary Education	1.18 (.53)	1.83 (.61)	1.12 (.58)	-.31 (.53)	-.17 (.60)	.70 (.55)
Tertiary Education	-.95 (.95)	1.36 (1.10)	1.84 (1.03)	-.45 (.94)	1.20 (1.07)	-.38 (.97)
Age	.12 (.02)*	.16 (.03)*	-.26 (.02)*	-.17 (.02)*	-.04 (.03)	-.05 (.02)
Physical Function _{t-1}	.06 (.01)*	.02 (.01)				
Role Physical _{t-1}	.02 (.01)*	.01 (.01)				
Bodily Pain _{t-1}	.04 (.01)*	.04 (.01)*				
General Health _{t-1}	.11 (.01)*	.06 (.01)*				
Vitality _{t-1}			.18 (.01)*	.15 (.01)*	.16 (.01)*	.19 (.01)*
Mental Health _{t-1}			.00 (.01)	.01 (.01)	.01 (.01)	.04 (.01)**
Random Effects Estimates						
β_0	33.06 (6.53)	67.09 (6.18)	52.29 (6.15)	17.02 (6.59)	39.29 (7.21)	50.50 (6.64)
β_1	.84 (.34)	.72 (.28)	.28 (.28)	.08 (.35)	.09 (.35)	.48 (.31)
$\beta_0 \beta_{I_{cov}}$	-3.14 (1.31)	-3.50 (1.15)	-2.23 (1.13)	.19 (1.32)	-.54 (1.39)	-3.86 (1.26)
e	52.97 (3.22)	34.50 (2.28)	40.04 (2.60)	58.95 (3.57)	54.36 (3.44)	47.12 (2.97)
Goodness-of-fit indices						
LL	-9653	-9670	-9605	-9663	-9808	-9622
AIC	19337	19370	19236	19352	19642	19270
BIC	19425	19459	19313	19430	19718	19347
Pseudo R ²	.31	.15	.09	.50	.27	.44

Note. * $p < .001$. ** $p = .001$. Age mean-centred at 70 years; Education reference category is 'No Post-School Education'; Partner Status reference category is 'Partnered'. Pseudo R^2 computed following Snijders and Bosker (1999): $R^2 = 1 - \sigma_{e(u)}^2 / \sigma_{e(c)}^2$ where $\sigma_{e(u)}^2$ is the residual variance within-person variance obtained from an intercept-only models and where $\sigma_{e(c)}^2$ reflects the $\sigma_{e(u)}^2$ from the conditional model.

Table 6 Lagged regression models for residualized change scores in vitality and mental health over a distance-to-death metric

	Vitality	Mental Health	Physical Function	Role Physical	Bodily Pain	General Health
	Model	Model	Model	Model	Model	Model
	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>	<i>B(SE)</i>
Fixed Effects Estimates						
β_0 (Intercept)	-3.43 (.68)*	-3.45(.65)*	-1.80 (.62)	-.65 (.71)	-1.51 (.71)	-4.23 (.61)*
β_1 (Linear Slope) ⁺	-1.46 (.30)*	-.80 (.28)	-1.56 (.28)*	-1.17 (.27)	-.82 (.28)	-1.88 (.26)*
β_2 (Quadratic Slope) ⁺	.14 (.04)*	.07 (.04)	.14 (.03)*	.08 (.04)	.06 (.04)	.16 (.03)*
Not Partnered	.40 (.32)	1.06 (.31)	.18 (.29)	.85 (.36)	.08 (.36)	.81 (.31)
Non-Tertiary Education	.42 (.44)	.71 (.43)	.63 (.40)	-.12 (.50)	.22 (.50)	.38 (.43)
Tertiary Education	-.85 (.76)	.31 (.75)	.44 (.70)	-.64 (.89)	-.15 (.89)	-.69 (.75)
Age	.02 (.02)	.06 (.02)	-.06 (.02)	.09 (.02)	-.01 (.02)	.01 (.01)
Physical Function _{t-1}	.02 (.01)	.01 (.01)				
Role Physical _{t-1}	.00 (.01)	.00 (.01)				
Bodily Pain _{t-1}	.01 (.01)	.02 (.01)				
General Health _{t-1}	.03 (.01)	.02 (.01)				
Vitality _{t-1}			.05 (.01)*	.05 (.01)*	.04 (.01)*	.04 (.01)*
Mental Health _{t-1}			-.01 (.01)	.00 (.01)	-.01 (.01)	.00 (.01)
Random Effects Estimates						
β_0	70.72	44.17	55.32	49.09	86.10	95.83
β_1	24.71	13.66	18.16	20.86	18.52	33.10
β_2	.32	.18	.22	.32	.35	.44
$\beta_0 \beta_{1cov}$	-41.25	-24.31	-31.68	-30.11	-25.94	-54.93
$\beta_0 \beta_{2cov}$	4.54	2.70	3.49	3.33	1.10	6.04
$\beta_1 \beta_{2cov}$	-2.77	-1.54	-2.01	-2.53	-2.14	-3.76
<i>E</i>	58.34	57.96	50.30	89.99	52.09	58.96
Goodness-of-fit indices						
LL	-9505	-9421	-9271	-9682	-9690	-9396
AIC	19034	18864	18560	19383	19398	18811
BIC	19099	18929	18613	19436	19451	18864
Pseudo R ²	.05	.02	.04	.03	.02	.06

Note. $*p < .001$. Age mean-centred at 70 years; Education reference category is 'No Post-School Education'; Partner Status reference category is 'Partnered'. Pseudo R^2 computed following Snijders and Bosker (1999): $R^2 = 1 - \sigma_{e(u)}^2 / \sigma_{e(c)}^2$ where $\sigma_{e(u)}^2$ is the residual variance within-person variance obtained from an intercept-only models and where $\sigma_{e(c)}^2$ reflects the $\sigma_{e(u)}^2$ from the conditional model.