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Intrapair Comparison of Life-Course Appetite and Physical Activity in Elderly Danish Twins: Reliability and Association With Subsequent Survival

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Avoiding overeating and being physically active is associated with healthy aging, but methodological issues challenge the quantification of the association. Intrapair comparison of twins is a study design that attempts to minimize social norm-driven biased self-reporting of lifestyle factors. We aimed to investigate the association between self-reported lifestyle factors and subsequent survival in 347 Danish twin pairs aged 70 years and older and, additionally, to investigate the reliability of these self-reports. The twins were interviewed in 2003 and followed for mortality until 2015. They were asked to compare their appetite and physical activity to that of their co-twins in different stages of life. On an individual level, we found a positive association between current self-reported physical activity and late-life survival for elderly twins. This was supported by the intrapair analyses, which revealed a positive association between midlife and current physical activity and late-life survival. A positive association between lower appetite and late-life survival was found generally over the life course in the individual level analyses but not in the intrapair analyses. Kappa values for the inter-twin agreement on who ate the most were 0.16 to 0.34 in different life stages, and for physical activity 0.19 to 0.26, corresponding to a slight-to-fair agreement. Approximately, 50% of the twin pairs were not in agreement regarding physical activity, and of these twins 75% (95% CI: 67–82%) considered themselves the most active twin. These findings indicate a still-existing tendency of answering according to social norms, even in a twin study designed to minimize this.

Keywords: physical activity, appetite, self-report, elderly, twins, reliability, survival

Avoiding overeating and being physically active have in numerous studies been documented as two lifestyle factors that improve multiple parameters of healthy aging (Beydoun et al., 2014; Kujala, 2011; Loef & Walach, 2012; Warburton et al., 2006). Conversely, a high-calorie diet without exercise increases the risk of cardiovascular disease and diabetes (Chen et al., 2015; Orozco et al., 2008), and furthermore, supresses specific longevity genes that are active in the cellular defense against aging and age-related diseases (North & Sinclair, 2012). Reviews of the association between physical activity and overall mortality of elderly persons typically report on studies showing a decrease in mortality of up to 40% when comparing physically active elderly persons to elderly persons with a more sedentary lifestyle (Rizutto & Fratiglioni, 2014; Taylor, 2014; Vogel et al., 2009). The J- or U-shaped association between Body Mass Index (BMI) and mortality is similarly well established for middle-aged and younger elderly persons (Bray, 1987; Gonzalez et al., 2010), although decreasingly U-shaped with advancing age for the age range 70–95 years (Thinggaard et al., 2010). The association between overeating and mortality is far less studied. This may be due to the complexity of such a study, as it is difficult to measure.
overeating. Moreover, the association may be influenced by numerous variables; for example, physical activity and stress (Torres & Nowson, 2007; Westerterp, 2010). Furthermore, methodological issues have challenged the quantification of the degree to which avoiding overeating and being physically active increases the chances of a long and healthy life. Traditionally, the quantification of the exposure has been based on self-reported food intake and physical activity. More recently, several direct measurements of food intake and physical activity have provided more accurate measures, such as urinary nitrogen, doubly labeled water, accelerometers, pedometers, and multisensor armbands (Kowalski et al., 2012; Park et al., 2014). However, most of these studies were smaller and with shorter follow-up compared to studies with self-reported measurements of food intake and/or physical activity. Studies based on self-reports are likely to be biased toward a healthier lifestyle, and the associations may be underestimated if those with the unhealthiest lifestyle have the most biased reporting (Pietiläinen et al., 2010).

Here, we report on a 12-year follow-up study of mortality among middle-aged and elderly twins who answered questions on intrapair differences in appetite and physical activity in childhood, adolescence, midlife, and at intake of the study. The aim was to test whether there was an association between intrapair differences regarding appetite and/or physical activity and subsequent survival.

This intrapair comparison design provides an opportunity to account for unobserved familial confounding, exploiting the fact that twins share their childhood environment and are matched partly (same-sex dizygotic [ssDZ] twins) or fully (monozygotic [MZ] twins) on genetic makeup. Hence, intrapair comparisons of exposure-discordant twin pairs will per design be controlling for these familial factors (McGue et al., 2010). When reporting on eating behavior and physical activity, twin studies are considered more accurate, since the tendency to answer according to social norms is diminished when the twins compare themselves to one another (Bogl et al., 2009). By comparing the co-twins’ responses, we assessed the degree of misreporting in self-reported current and previous lifestyle habits.

Thus, the aim of this study was to investigate whether life-course appetite and physical activity were associated with late-life survival when familial factors were controlled for; and, additionally, to investigate the reliability of self-reports regarding appetite and physical activity in an intrapair twin comparison study.

Materials and Methods

Study Population

The population under study consisted of 1,826 same-sex twins of more than 70 years of age participating in the 2003 wave of the Longitudinal Study of Aging Danish Twins (LSADT), a subsample from the Danish Twin Registry (Skytthe et al., 2002; 2006). Figure 1 illustrates the selection process of the study population.

The LSADT began in 1995 with an assessment of same-sex twin pairs born in Denmark prior to 1920. The initial cohort was followed up every second year until 2005, including sequential assessments of participants who had aged into the catchment age range, and additional cohorts were added in 1997, 1999, and 2001. This study used the LSADT wave from 2003, since this was the only year the twins were asked to compare their appetite and physical activity to that of their co-twin. The survey also included twins whose co-twin had died or declined to participate,
and the survey had a participation rate of 82% (McGue & Christensen, 2007). Participants were interviewed face to face in their home by trained interviewers. If both twins participated, the co-twins were interviewed by different interviewers to minimize interviewer bias.

Measures

Co-twin comparison of lifestyle factors. In the face-to-face interview, the twins were asked individually to relate themselves to their co-twin when comparing their appetite and physical activity at four different stages of life: childhood, adolescence, middle age, and at intake of the study. They did so by answering the questions: ‘Who ate the most?’ and ‘Who was most physically active?’ Their response alternatives were ‘Me’, ‘My twin’, ‘Equally’, and ‘Don’t know’ (and missing if the co-twin was dead at that life stage).

Survival. Survival time was gathered from interview date and until follow-up was terminated by either death, emigration, or end of follow-up in March 2015, whichever came first. No subjects were lost to follow-up and no emigration occurred in the study period. Information on survival status was acquired through the Central Person Registry by the use of a unique personal identification number available to all persons with permanent residence in Denmark (Thygesen & Erbsøll, 2011).

Cognition. Cognitive functioning was based on five brief cognitive tests, which were sensitive to age-related changes in cognition: (1) a category fluency task in which the participant was asked to name as many animals as possible in 1 minute, (2) forward and (3) backward digit span, and (4) immediate and (5) delayed recall of a 12-item list. The overall composite measure of cognitive functioning was computed by adding the sum of the five standardized measures using means and standard derivations from the initial LSADT assessment in 1995 (McGue & Christensen 2001; 2002).

Smoking status. The twins were asked about their smoking behavior. They were categorized as a non-smoker, former smoker, or current smoker.

Body Mass Index (BMI). Height in meters and weight in kilograms were self-reported and were used to calculate BMI (weight/height²).

Data Analysis

Individual Level Survival Analysis

On an individual level, the association between appetite and physical activity and subsequent survival was analyzed using Cox regression models. The estimates for risk of death was given by comparing twins who answered ‘My co-twin ate most’ or ‘My co-twin was most physically active’ to their respective reference groups ‘I ate most’ and ‘I was most physically active’. Twins who answered ‘Equally’ or ‘Don’t know’ were not included in these analyses as the purpose was to compare the mortality risk when answering ‘Me’ versus answering ‘My twin’ when asked about appetite and physical activity. As the data partly pertained to twin pairs, and because observation within twin pairs might be correlated, the analyses were performed using the robust estimator of variance, assuming independence between pairs. The proportional-hazards assumption was tested using Schoenfeld residuals.

Four different Cox regression models were used to calculate the hazard ratio (HR) and 95% confidence interval (CI) for mortality risk. In models 1 and 2, appetite and physical activity were analyzed separately, and in models 3 and 4, both lifestyle factors were included in the same regression. Furthermore, models 1 and 3 were adjusted for age and sex, and models 2 and 4 were additionally adjusted for known risk factors for mortality in late life: cognition, smoking status, and BMI. Cognition was a continuous variable; smoking status was categorized into non-smoker, former smoker, and current smoker; and BMI was categorized into the following groups: < 18.5, 18.5–24.9, 25.0–29.9, 30.0–34.9, ≥ 35.0.

Intrapair Survival Analysis

In complete twin pairs, the twins served as each other’s control person regarding answers on the lifestyle factors appetite and physical activity. Intrapair analyses were performed on pairs discordant for these lifestyle factors, which enabled us to examine their association with late-life survival. Only pairs in which one or both twins had died were used in the intrapair analysis.

The hypothesis regarding the association between appetite and survival was that the twin who ate more lived a shorter life. Regarding physical activity, the hypothesis was that the twin who was more physically active lived longer. The association between appetite and physical activity and subsequent survival was examined, using the binomial distribution, by investigating the proportion of complete twin pairs that fulfilled the aforementioned hypotheses.

Reliability Analysis

The reliability of the twins’ answers regarding appetite and physical activity was analyzed by creating a three-by-three intratwin agreement matrix of the categorical variables, as depicted in Figure 2. There were three levels of agreement: ‘Agreement’, ‘Partly agreement’, and ‘Disagreement’. ‘Agreement’ included twins who were of the same opinion regarding who ate the most or who was most physically active at a given life stage. If one twin answered ‘Equally’ and the other answered ‘Me’ or ‘My twin’, the twins were categorized as being in ‘Partly agreement’. ‘Disagreement’ included twins who had completely opposite views on who ate the most or who was most physically active.
Cohen’s kappa value ($\kappa$) was used as a measurement of intertwin agreement. A $\kappa$ value of less than 0.0 was interpreted as poor agreement, 0.00–0.20 indicated slight agreement, 0.21–0.40 fair agreement, 0.41–0.60 moderate agreement, 0.61–0.80 substantial agreement, and more than 0.81 interpreted as almost perfect agreement (Landis & Koch, 1977).

A subanalysis was performed by calculating a weighted kappa, where a weight of 0.5 was given to answers categorized as partly agreement in order to mathematically distinguish those pairs from pairs in disagreement, as it could be argued that twins in partly agreement were closer to an agreement.

Of the twins in the categories partly agreement and disagreement, we also investigated whether there was a tendency for the twins to modify their answers toward a healthier lifestyle; for example, considering themselves to be eating less and/or being more physically active compared to their co-twin.

All statistical analyses were performed using Stata 13.1 (Stata Corporation, College Station, TX).

**Results**

Of the 1,826 twins in the study, 347 were complete pairs who were included in the intrapair analyses. The rest of the study population were single twins ($N = 1,132$) who, together with the individuals from the complete pairs, were included in the individual-level analyses.

The study population consisted of 809 (44%) males and 1,017 (56%) females, whereas the zygosity distribution was 651 (36%) MZ twins and 1,175 (64%) ssDZ twins. When we examined only complete pairs, the distributions were 147 (42%) male pairs and 200 (58%) female pairs, and when we divided the pairs into zygosity, the numbers were: 156 (45%) MZ pairs and 191 (55%) ssDZ pairs (Figure 1 and Table 1). Complete twin pairs were younger than the total study population, which explains the higher cognitive score (McGue & Christensen, 2001).

Of the 1,132 single twins, 849 (75%) twins had died after the 12-year follow-up. A similar percentage was found in the 347 complete twin pairs with 261 (75%) pairs where one or both twins had died after the follow-up.

**Individual-Level Survival Analysis**

We found an association between appetite and late-life survival in adolescence (HR: 0.81, 95% CI: 0.67–0.99) in model 1, where we adjusted for age and sex (Table 2). If further adjusted for known risk factors (cognition, smoking status, and BMI), an association was found in childhood (HR: 0.79, 95% CI: 0.65–0.97) and adolescence (HR: 0.79, 95% CI: 0.63–0.98) as seen in model 2, which showed a statistically significantly lower mortality risk for the twin who ate less.

In both model 3 (HR: 0.77, 95% CI: 0.60–0.99) and model 4 (HR: 0.73, 95% CI: 0.56–0.96), an association between middle-age appetite and late-life survival was found. All HRs in childhood, adolescence, and middle-age were less than 1, indicating that eating less might be a protective factor on the mortality risk, although not statistically significant.

We did find a statistically significant association between physical activity at intake of the study and late-life survival for elderly twins, indicating an increase in mortality risk for the less active twin (HR: 2.12, 95% CI: 1.52–2.95) when adjusting for age, sex, cognition, smoking status, and BMI. The association was statistically significant for all four Cox regression models. As an example, Table 3 shows the fully adjusted model 4 with physical activity and appetite at intake of the study, including all risk factors. These adjustments showed the expected pattern of low physical activity, older age, lower cognitive status, and both high and low BMI being associated with poorer survival in late life. If BMI was excluded from the analyses, the proportional hazards assumption was fulfilled, and it did not alter the estimates (results not shown).

Furthermore, we compared the group of twins who answered ‘I ate the most’ to the group who answered ‘My twin
TABLE 1

Descriptive Characteristics for All Twins in the Study Population (N = 1,826) and for Complete Twin Pairs (N = 694) Listed by Sex

<table>
<thead>
<tr>
<th>Study population N individuals (%)</th>
<th>Male 809 (44)</th>
<th>Female 1,017 (56)</th>
<th>N</th>
<th>Mean [95% CI]</th>
<th>N</th>
<th>Mean [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>809</td>
<td>78.6 [78.2–78.9]</td>
<td>1,017</td>
<td>80.1 [79.8–80.5]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at death</td>
<td>586</td>
<td>85.1 [84.6–85.5]</td>
<td>676</td>
<td>87.9 [87.4–88.3]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>806</td>
<td>172.3 [171.9–172.8]</td>
<td>1,013</td>
<td>161.5 [161.1–161.9]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>806</td>
<td>74.9 [74.2–75.7]</td>
<td>1,004</td>
<td>62.7 [61.9–63.4]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>806</td>
<td>25.2 [24.9–25.4]</td>
<td>999</td>
<td>23.9 [23.7–24.2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognition</td>
<td>749</td>
<td>1.8 [1.5–2.0]</td>
<td>928</td>
<td>1.7 [1.5–2.0]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Complete pairs N individuals (%)</th>
<th>Male 294 (42)</th>
<th>Female 400 (58)</th>
<th>N</th>
<th>Mean [95% CI]</th>
<th>N</th>
<th>Mean [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>294</td>
<td>76.9 [76.4–77.4]</td>
<td>400</td>
<td>77.9 [77.5–78.3]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at death</td>
<td>188</td>
<td>84.5 [83.8–85.2]</td>
<td>225</td>
<td>86.0 [85.3–86.7]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>293</td>
<td>172.8 [172.1–173.5]</td>
<td>399</td>
<td>161.9 [161.3–162.5]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>293</td>
<td>74.8 [73.6–76.0]</td>
<td>396</td>
<td>63.2 [62.1–64.4]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>293</td>
<td>24.0 [23.7–25.3]</td>
<td>396</td>
<td>24.0 [23.6–24.4]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognition</td>
<td>281</td>
<td>2.5 [2.0–2.9]</td>
<td>376</td>
<td>2.6 [2.2–2.9]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Population sizes differ due to missing data.

TABLE 2

Hazard Ratios (HR) for Mortality Risk Associated With Appetite and Physical Activity for Different Stages of Life

<table>
<thead>
<tr>
<th>Childhood</th>
<th>N</th>
<th>Model 1 HR [95% CI]</th>
<th>N</th>
<th>Model 2 HR [95% CI]</th>
<th>N</th>
<th>Model 3 HR [95% CI]</th>
<th>N</th>
<th>Model 4 HR [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appetite</td>
<td>674</td>
<td>0.85 [0.70–1.02]</td>
<td>628</td>
<td>0.79 [0.65–0.97]</td>
<td>425</td>
<td>0.88 [0.69–1.10]</td>
<td>396</td>
<td>0.85 [0.67–1.09]</td>
</tr>
<tr>
<td>Adolescence</td>
<td>830</td>
<td>0.94 [0.79–1.12]</td>
<td>764</td>
<td>0.90 [0.75–1.08]</td>
<td>595</td>
<td>0.95 [0.73–1.23]</td>
<td>562</td>
<td>0.82 [0.62–1.08]</td>
</tr>
<tr>
<td>Appetite</td>
<td>596</td>
<td>0.81 [0.67–0.99]</td>
<td>551</td>
<td>0.79 [0.63–0.98]</td>
<td>365</td>
<td>0.80 [0.62–1.03]</td>
<td>338</td>
<td>0.81 [0.61–1.06]</td>
</tr>
<tr>
<td>Middle-age</td>
<td>816</td>
<td>1.03 [0.87–1.23]</td>
<td>745</td>
<td>1.01 [0.83–1.22]</td>
<td>1.24 [0.95–1.61]</td>
<td>1.11 [0.83–1.51]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appetite</td>
<td>605</td>
<td>0.88 [0.72–1.07]</td>
<td>554</td>
<td>0.81 [0.66–1.01]</td>
<td>401</td>
<td>0.77 [0.60–0.99]</td>
<td>367</td>
<td>0.73 [0.56–0.95]</td>
</tr>
<tr>
<td>Intake</td>
<td>842</td>
<td>1.13 [0.94–1.36]</td>
<td>770</td>
<td>1.09 [0.88–1.35]</td>
<td>1.25 [0.93–1.68]</td>
<td>1.11 [0.79–1.56]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Appetite and activity estimates are risk of death if twin answered ‘My co-twin ate most/my co-twin was most physically active’ compared to the reference group ‘I ate most/I was most active’. All analyses are on an individual level. In model 1 and 2, appetite and physical activity were analyzed separately, and in model 3 and 4, both lifestyle factors were included in the same regression. Population sizes differ due to missing data and exclusion of the answers ‘Equally’ and ‘Don’t know’.

Intrapair Survival Analysis

We examined the intrapair association between appetite and physical activity and subsequent survival for twins who were in agreement, partly agreement, and both combined. The associations between appetite and late-life survival found in the individual-level survival analysis were not supported by the intrapair analyses.

There was an indication that eating more at intake of the study might be a protective factor on survival for elderly twins, although the observed tendency was not statistically significant. This can be seen in Table 4A which shows that twin pairs who confirmed the hypothesis, meaning where the twin who ate less lived longer, comprised a little more than 50% in childhood, adolescence, and middle age, and a little less than 50% at intake of the study.

A statistically significant association was found between midlife and physical activity at intake of the study and late-life survival with 61% (95% CI: 53–70%) and 74% (95% CI: 67–81%), respectively (Table 4B), as also suggested by the individual level analyses.

Reliability Analysis

The proportion of twin pairs in agreement about their appetite were between 52% and 62% (κ: 0.16 to 0.34) for different stages of life. For physical activity, the agreement was even higher, ranging from 52% to 63% (κ: 0.16 to 0.34) for different stages of life. Differences in the reliability estimates were found between the two groups who answered ‘I was most active’ and ‘My twin was most active’ (results not shown).
percentage of twin pairs in agreement, partly agreement, or complete disagreement was 98% (95% CI: 97–99), on average. With three out of four twins answering 'Myself' to the question 'Who was most active?' the tendency for the twins to consider themselves the most physically active was found to be significant. In twin pairs who did not agree on their answers, that is, in pairs discordant for physical activity, it did not alter the kappa values (results not shown).

As shown in Table 6, a clear tendency for the twins to regard themselves as the most physically active was found in twin pairs who did not agree on their answers, that is, in partly agreement, disagreement, or both combined. The percentages of twins considering themselves the most active were between 73% (95% CI: 64–80) and 90% (95% CI: 73–98) for different life stages. If the twins were in complete agreement, the twin who ate more lived shorter and vice versa, the twin who was more physically active lived longer. The hypothesis for physical activity is that the twin who ate more lived shorter and vice versa; the twin who ate less lived longer.

**The hypothesis for physical activity is that the twin who ate more lived shorter and vice versa; the twin who ate less lived longer.**

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of physical activity toward a healthier lifestyle was indicated (Adams et al., 2005). The twin study design was designed to minimize the tendency of answering according to social norms when participants were asked about lifestyle factors (Bogl et al., 2009), but as the present study showed, this tendency was not eliminated.

Previous studies strongly supported an inverse association between physical activity and all-cause mortality (Physical Activity Guidelines Advisory Committee, 2008). As expected, the present study found a positive association between physical activity at intake of the study and late-life survival in elderly Danish twins, when important covariates were controlled for. Previous reviews have shown a lower mortality risk for the most active elderly (Rizzuto & Fratiglioni, 2014; Taylor, 2014; Vogel et al., 2009). Our study hereby supports the existing studies suggesting that the most active tend to live longer, also when familial factors are controlled for.

In adolescence and middle age, physical activity seemed to be a protective factor for late-life survival for the most physically active twin with HRs greater than 1, although not statistically significant. A tendency for the mortality risk to increase throughout life was observed for the less active twin, which was supported by the intrapair analyses. This tendency was not found in intrapair comparisons in a previous study of twins in adulthood, which only found a statistically non-significant lower risk of death, although not statistically significant, for the twin engaged in persistent vigorous physical activity (HR 0.72, 95% CI: 0.48–1.07) compared to the non-persistent vigorously physically active twin, when controlling for covariates (Karvinen et al., 2015). Additionally, more misclassification in the reporting of lifestyle factors in early life could be the basis for the observed tendency toward increasing mortality risk through life for the less active twin. It is also likely that the association found was confounded by one twin having a known or unknown disease at intake of the study, which could influence both discordance of physical activity within the twin pair and late-life survival.

High and low BMI at intake of the study was associated with higher mortality. We found no alteration in the overall conclusion when including and excluding BMI as a covariate in the survival analyses. Furthermore, BMI was statistically significantly higher for twins who considered themselves as eating the most compared to the twins who considered their co-twin as eating the most on an individual level in all four

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**TABLE 5**

Intrapair Reliability of Answers Regarding Appetite and Physical Activity

<table>
<thead>
<tr>
<th></th>
<th>Pairs N</th>
<th>Agreement %</th>
<th>Partly agreement %</th>
<th>Disagreement %</th>
<th>Kappa</th>
<th>Agreement weight 0.5 %</th>
<th>Kappa weight 0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appetite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Childhood</td>
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<td>69</td>
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Note: *agreement + ½ * partly agreement. For description of agreement, partly agreement and disagreement see Figure 2. Agreement corresponds to quadrants A, E, and I, Partly agreement corresponds to quadrants B, D, F, and H, and Disagreement corresponds to quadrants C and G. N does not include pairs were one or both twins answered ‘Don’t know.’

**TABLE 6**

Description of Twins not in Agreement in Their Intrapair Comparison in Different Life Stages

<table>
<thead>
<tr>
<th></th>
<th>Pairs Answered ‘Myself’ N</th>
<th>% [95% CI]</th>
<th>Pairs Answered ‘Myself’ N</th>
<th>% [95% CI]</th>
<th>Total N</th>
<th>% [95% CI]</th>
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<td>74</td>
<td>[68–81]</td>
<td>30</td>
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<td>[73–98]</td>
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</table>

Note: For description of partly agreement and disagreement, see Figure 2. Partly agreement corresponds to quadrants B, D, F, and H and disagreement corresponds to quadrants C and G.
stages of life. This indicated that the answers regarding appetite were reliable. On the individual level, an association between appetite over the life course and late-life survival was found, but in the intrapair analyses, which controls for genetic factor (full or partly) and shared early life environment, no association was found. The lack of an association could be due to measurement error of appetite and/or lack of statistical power. However, the sample size was large enough to be able to demonstrate an association between midlife and physical activity and survival also in the intrapair analyses.

We found that 33% to 66% of the twins considered themselves to be eating most when examining whether a tendency of answering according to social norms existed for twins not in agreement. There was a slight tendency for twins who disagreed on their appetite in middle age and at intake of the study to consider their co-twin as eating more, but the population number in this group was too small for the result to be conclusive.

Information on appetite and physical activity is collected retrospectively (except at intake of the study), which makes recall bias a possibility. However, the study design seeks to minimize the influence of both social norm-driven bias as well as recall bias by comparing twins’ answers on an intrapair level and by getting the information from two individuals.

Some other limitations of this study must be noted. On an individual level, 806 of the 1,826 participants could not answer the questions of co-twin difference in appetite and physical activity at intake since their co-twin had died. Only complete pairs where one or both twins had died were useful in the intrapair analyses when investigating the influence of appetite and physical activity on late-life survival. This reduced the study population by approximately 25%. However, the results from our individual analyses, showing an increase in mortality throughout life for the less active twin, were supported by the results from the intrapair analyses.

Another concern could be that twins differ from the background population, but previous research has repeatedly shown that twins are similar to the background population regarding adult mortality and major causes of death, except suicide, for which twins have a lower risk (Öberg et al., 2012; Christensen & McGue, 2008; Christensen et al., 1995; Tomassini et al., 2003).

The strengths of this study include complete follow-up on mortality, as national population registers were used. Twin-pair comparisons provided a unique opportunity to examine the association between appetite and physical activity on late-life survival, allowing the twins to function as each other’s control persons. By comparing twin responses on lifestyle factors, we were not only able to examine late-life survival, but also to categorize the twins’ answers according to level of agreement and thereby investigating the reliability of their answers.

Our study indicates social norm-driven biased reporting of life style — even in a study designed to minimize this tendency. The bias can lead to an overestimation of the effect size of continuous exposures if the misreporting corresponds to those with the most extreme values misreporting the most. For binary exposures, social norm-driven biased reporting will tend to underestimate the effect as the unexposed group will be ‘diluted’ with individuals who are actually exposed to the harmful factor.

In conclusion, late-life physical activity is associated with better survival even when familial factors are controlled for. However, the reliability of self-reports on lifestyle factors, even in designs made to minimize social norm-driven reporting bias, is low and it seems that elderly Danish twins tend to romanticize their own performance when comparing themselves to each other.

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References


