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The role of familial confounding in the associations of physical activity, smoking and alcohol consumption with early exit from the labour market

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ABSTRACT

We investigated the associations between health behaviors and sustainable working life outcomes including all-cause disability pension, disability pensions due to musculoskeletal and mental diagnoses and unemployment. The role of familial factors behind these associations was studied by analysing discordant twin pairs. Our data included Swedish twins born in 1925–1986 (51891 twin individuals). Baseline data based on two independent surveys in 1998–2003 and 2005–2006 for health behaviors were linked to national registers on disability pension and unemployment until 2016. Cox proportional hazards models for hazard ratios (HR) with 95% confidence intervals (CI) were estimated for the whole sample adjusting for covariates. Analyses of health behavior discordant twin pairs ($n = 5903$ pairs) were conducted using conditional Cox models. In the whole cohort, the combination of healthy behaviors was associated with lower risk for all-cause disability pension, disability pension due to musculoskeletal diagnoses or mental diagnoses, and for unemployment (HRs 0.56–0.86, 95% CIs 0.51–0.92) as did being physically active (HRs 0.69–0.87, 95% CI 0.65–0.92). The discordant pair analyses confirmed the lower risk among those having healthy behaviors (HR 0.70–0.86) or being physically active (HR 0.86–0.87) for all-cause disability pension, disability pension due to musculoskeletal diagnoses, and for unemployment. To conclude, controlling the effects of covariates or familial confounding (i.e. discordant twin pair analyses) shows that being physically active or having several healthy behaviors predict better working life outcomes. This points towards independent association between healthy behavior and longer working life.

1. Introduction

Increasing labour market participation at both ends and in the middle of the working careers are important for longer working lives (Eurofound, 2015). Mental health and musculoskeletal disorders are especially important since they are known being important for the years lost due to disability (Dalys et al., 2015). Consequently, an important knowledge gap is to identify those who are not vulnerable for future work incapacity or other interruptions in labour market participation. Furthermore, research is warranted to unravel promoting factors (i.e. positive factors such as healthy behaviors) of sustainable working life.

For work incapacity, a life course perspective investigating the role of life events and health determinants across the individual's life course has become popular in recent years (Amick et al., 2016). For example, previous studies have shown that age and work incapacity are associated (Försäkringskassan, 2016) and health behaviors have both single and joint associations with future work incapacity (Ropponen et al., 2011a; Ropponen et al., 2016; Ropponen and Svedberg, 2014) and other poor employment outcomes (Danaei et al., 2017; Heikkala et al., 2020). Promotion of healthy lifestyle, i.e. being physically active, using alcohol moderately or less and not smoking, has been expected to increase work capacity and to promote sustainable working life (Airaksinen et al., 2019; Ervasti et al., 2019; Ervasti et al., 2018). Apparently, unhealthy behaviors including suboptimal diet, physical inactivity, smoking and excessive alcohol consumption, i.e. poor health behaviors or lack of healthy choices are known to have negative effects on health (Kramer, 2020; Mozaffarian et al., 2012; Zhang et al., 2021). Therefore, a lot of efforts have been targeted to promote healthy lifestyle since even modest improvements in health behaviors could substantially decrease the risk of several diseases and subsequently also the risk for early exit

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from the labour market (Chudasama et al., 2020; Flower et al., 2019; Heir et al., 2013).

Genetics play an influential role in health behaviors and the genetic contributions to physical activity, smoking and alcohol consumption have been estimated to vary from moderate to strong (de Vilhena e Santos et al., 2012; Rose et al., 2009; Young-Wolff et al., 2011). Furthermore, earlier studies based on twin cohorts have indicated that genetics may also influence the associations of health behaviors with labour market exit (Bockerman et al., 2015; Bockerman et al., 2018; Bockerman et al., 2016, 2017; Helgadottir et al., 2019; Ropponen et al., 2011a; Ropponen et al., 2016; Ropponen and Svedberg, 2014). However, these earlier studies utilizing twin data for the knowledge of genetics in these associations have been hampered by small sample sizes (Bockerman et al., 2018; Helgadottir et al., 2019; Ropponen and Svedberg, 2014), long time (decades) between health behavior assessment and labour market outcome (Bockerman et al., 2015; Bockerman et al., 2018; Bockerman et al., 2016; Ropponen et al., 2011b) and studies with rigor control on genetics are lacking. Therefore, studying health behaviors discordant twins, i.e. a twin in a twin pair with exposures/outcomes and the other twin without, offers a unique natural experiment to control for both genetic and childhood social factors and thus get more information on causality behind the association between healthy behaviors and sustainable working life. The interpretation of such study is that a lack of association within discordant twin pairs compared with individual level associations indicates confounding by familial factors (i.e. genetics and shared, mainly early; environment). If the associations would remain while adjusting for familial factors this would point towards direct link from health behaviors to sustainable working life (Kujala et al., 2002; McGue et al., 2010).

The Nordic countries, such as Sweden, with comprehensive register data on labour market exit including, e.g., disability pension (DP) and unemployment linked with a twin cohort with survey data of health behaviors would provide relevant investigations on these associations. Hence, this study was designed to investigate the associations between health behaviors and sustainable working life outcomes including all-cause DP, DP due to musculoskeletal diagnoses (MSD), DP due to mental diagnoses and unemployment.

2. Methods

2.1. Study population

This is a prospective cohort study using the Swedish Twin project Of Disability pension and Sickness absence (STODS), which includes national register data on sick leave and disability pension as well as survey data from the Screening Across the Lifespan Twin Study (SALT) and the Study of Twin Adults - Genes and Environment (STAGE) (Zagai et al., 2019). The baseline surveys conducted by the Swedish Twin Registry (STR) targeted to all Swedish twins born in 1925–1986 were collected in 1998–2003 and 2005–2006 (64,680 twins together; the response rates 74% and 60%, respectively). We included those twins who were < 65 years old and not on old-age or DP at or before the time they participated in the survey. The final sample consisted of 51,891 twins (aged between 19 and 64 years, 53% women) including 18,273 complete twin pairs (6042 monozygotic (MZ) twin pairs, 5893 dizygotic (DZ) same-sex twin pairs, 5972 DZ opposite-sex twin pairs and 366 twin pairs with unknown zygosity) and 15,345 twins without information on co-twin.

2.2. Discordant twin pairs

Our twin sample enabled us to utilize the natural experiment based on two types of twins with different genetic similarity (MZ twins being virtually genetically identical at DNA sequence level and DZ twins sharing, on average, 50% of their segregating genes) but the equal share of childhood environment. Study design with a matched analysis of the discordant twin pairs, i.e. one twin has healthy behaviors and the other does not, adjusts for genetics and shared environment (familial factors). Stratification on zygosity provides knowledge on the effects of genetics with interpretation that if the association exists within DZ but not MZ twins, genetics affects the association due to fact that MZ twins are more closely matched on genetics (Kujala et al., 2002). Therefore, we can investigate if the same factors that predispose to health behaviors also predispose to DP and unemployment and explain the associations. In the sample, 6759 pairs were discordant for physical activity, 2469 for smoking, 1869 for alcohol consumption, and 5903 for overall health behaviors (Fig. 1).

2.3. Exposures

Leisure-time physical activity was measured with the question "If you consider the physical activity you take during your leisure time, which of these seven options fit you the best if you look at the year as a whole?" on a scale from 1 to 10. The responses were grouped into five categories: none (1 to 2), low (3 to 4), moderate (5 to 6), high (7 to 8), and vigorous (9 to 10) (Carlsson et al., 2006; Trolle-Lagerros et al., 2005). Physical activity question has been validated before (Bonn et al., 2015). Then, the categories "none", "low" and "moderate" were collapsed into one category "non-active at leisure-time" while the categories "high" and "vigorous" were collapsed into one category representing "physically active" for basis of identification of discordance within a twin pair (Ropponen and Svedberg, 2014).

A dichotomous variable smoking was created: current smokers and non-smokers based on the question: "Have you ever smoked or used snuff" with the response alternatives –1 = never even tried, 2 = yes, tried smoking, 3 = yes, tried snuff, 4 = smoking/smoked occasionally, 5 = smoking/smoked regularly, 6 = used/using snuff occasionally, and 7 = using/used snuff regularly. Those who answered 1 or 2 were identified never smokers (answering 1 or 2) and those answered 4 or 5 were classified as ever smokers. The individuals answering yes to one of the follow-up questions "Do you currently smoke cigarettes?" or "Do you currently smoke cigarettes occasionally or at parties?" were classified as current smokers (Ropponen et al., 2011a). The ever smokers answering no to these questions were classified as non-smokers, together with the never smokers. Altogether, we had two groups as defined above: non-smokers vs. current smokers.

Alcohol consumption was measured by self-reported quantities of beer, wine and spirits consumed with frequency. Grams of alcohol per week were calculated from questions inquiring about type, amount, and frequency of alcohol consumption using the formula Grams ALC = (Frequency Week) (Centiliters) × (10) (%alcohol) (Gravity ALC). The daily consumption of alcohol was then grouped into two categories, i.e. abstainers, light and moderate users represented "moderate alcohol use" and those heavy users were assumed as "alcohol users", according to the sex-specific criteria of the National Institute on Alcohol Abuse and Alcoholism (Jarvenpaa et al., 2005). However, since being abstainer represented some earlier health aspect or being related with earlier alcohol overuse, we ran sensitivity tests with a grouping in which abstainers were excluded from the moderate alcohol use.

Health behaviors were defined as a sum score by using the amount of healthy behaviors (Ropponen and Svedberg, 2014). The median of physical activity was used as the cut-off score with the median value counted into the healthy group (i.e., active physical activity was considered healthy behavior). Drinking a moderate amount alcohol and being a non-smoker were considered being healthy behaviors. Groups were created as follows: unhealthy (one or none of the healthy behaviors), moderately healthy (two healthy behaviors), and healthy (three healthy behaviors). Unhealthy and moderately healthy were collapsed and we had one group of unhealthy behavior and one group of healthy behavior.

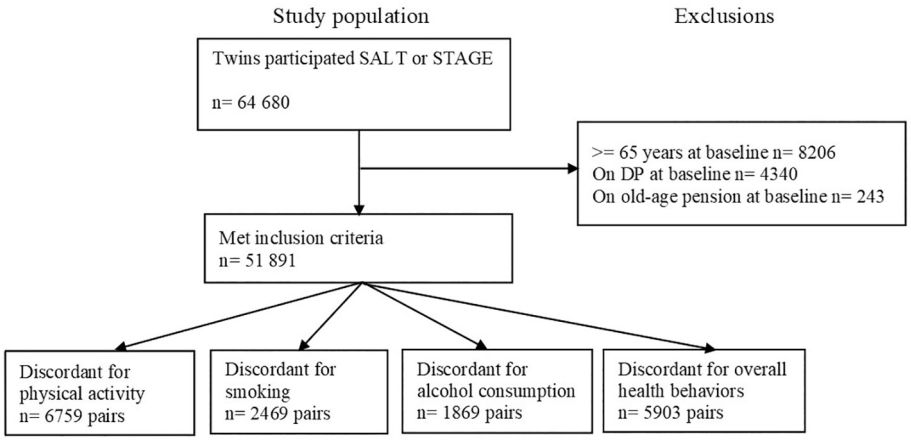

Fig. 1. Flow chart for the study population.

2.4. Outcomes

Outcomes included all-cause DP, DP due to musculoskeletal diagnoses (MSD) and mental diagnoses as well as unemployment. Follow-up started at the baseline until the outcomes, death, emigration or the end of follow-up 31st of December 2016, whichever came first. Utilization of national register data for the outcomes and censoring was without loss to follow-up, i.e. without attrition bias. Information on death was obtained from Cause of Death Register from National Board of Health and Welfare while emigration data were collected from the Longitudinal Integration Database for Health Insurance and Labour Market Studies Register (LISA) data from Statistics Sweden. Information on DP spells and diagnosis and unemployment days were obtained from MicroData for Analyses of Social insurance (MiDAS) register data and the LISA data from Social Insurance Agency and Statistics Sweden, respectively. Mental and musculoskeletal diagnoses were encoded using the 10th revisions of the International Classification of Diseases (ICD), F00-F99 and M00-M99.

2.5. Covariates

Data on marital status (unmarried/married) were obtained from LISA, Statistics Sweden, the same time point of conducting SALT and STAGE surveys. Information on age (continuous variable), sex (women/men), and zygosity was available in the STR as well as survey data on pain (pain in neck, shoulder or low back dichotomized "yes" in at least one of the locations vs. no) and common mental disorders (CMDs, yes vs. no). CMDs were measured by the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) major depression and anxiety.

2.6. Statistical analyses

Cox proportional hazards regression was performed to estimate the associations between health behaviors and DP and unemployment. Individuals with missing information on health behaviors were excluded from the analyses. Therefore, our final sample ($N = 51,891$) was reduced to 47,329 individuals included in the analysis for physical activity as the exposure, 42,887 for smoking, 37,551 for alcohol use and 51,278 for the overall health behaviors. In the analysis of unemployment as outcome, DP and old-age pension were censored while in the analysis of DP, old-age pension was censored as well. Besides the crude model, the multivariate model was adjusted for sex, age, marital status, pain and CMDs. The proportional hazards assumption was tested by examining the log-log curves and found to be accurate. To test the effect of categorization of alcohol consumption, we performed also sensitivity analyses (Supplemental material, Tables S1–2) in which we categorized alcohol without abstainers in the moderate alcohol use, and in the overall health behavior. The results were as in the main analysis; hence no interpretations were made.

Co-twin analyses were performed separately for each outcome on four groups of exposure discordant twin pairs (i.e. one twin in a pair were physically active and the other twin were non-active (reference group) at leisure-time; one twin in a pair were non-smoker and the other twin were current smoker (reference group); one twin in a pair were moderate alcohol user and the other twin were alcohol user (reference group); one twin in a pair were in the healthy group and the other twin were in the unhealthy group (reference group)) using conditional Cox proportional hazards models for hazard ratios (HR) with 95% confidence intervals (CI). Conditional Cox proportional hazards models were performed both for all discordant twin pairs and stratified on sex and zygosity. All the analyses were performed with SAS Statistical Software version 9.4.

2.7. Ethics approval and consent to participate

The study protocol was designed and performed according to the principles of the Helsinki Declaration. The ethical vetting was performed and approved by the Regional Ethical Review Board of Stockholm, Sweden (Dnr: 2007/524–31, 2010/1346–32/5, 2014/311–32, 2017/128–32).

3. Results

During the mean follow-up 10.5 years (3.4 SD, range 0–16.8 years), 4095 participants had all-cause DP events including 1528 MSD and 1031 mental diagnoses. Unemployment was met by 5452 individuals during the mean follow-up of 9.9 years (SD 3.9) (Table 1). Disability pension was more frequent among women, whereas unemployment was equally distributed among sexes. The mean ages were slightly higher among all-cause DP and DP due to MSD (51.3 years and 52.9 years, respectively) compared to DP due to mental (47.6 years) or unemployment (44.7 years).

The analyses based on the whole cohort, i.e. twins treated as singletons, indicated that being physically active (HR 0.69–0.87) or having healthy behaviors predicted lower risk (HR 0.56–0.86) of both all-cause DP, and DP due to MSD or mental diagnoses as well as unemployment (Table 2). This association retained in the models accounting for covariates. Instead, moderate alcohol use (HR 1.24–1.30) or being non-smoker (HR 1.30–1.36) indicated higher risk for all-cause DP or DP due to MSD in the crude models, but while controlling for covariates, this association turned into positive for being non-smoker (i.e. predicting lower risk, HR 0.70–0.78), whereas moderate alcohol consumption diluted to statistical non-significance (HR 0.97–1.00).

Table 1
Frequencies of socio-demographic factors, pain, CMDs, health behaviors, DP and unemployment.

	All-cause DP (n = 4095)	DP due to MSD (n = 1528)	DP due to mental diagnoses (n = 1031)	Unemployment (n = 5452)
	n (%)	n (%)	n (%)	n (%)
Sex				
Men	1508 (36.8%)	507 (33.2%)	307 (29.8%)	2700 (49.5%)
Women	2587 (63.2%)	1021 (66.8%)	724 (70.2%)	2752 (50.5%)
Age (mean, SD)	51.3 (8.1)	52.9 (6.5)	47.6 (10.2)	44.7 (11.1)
Zygosity				
Monozygotic	1064 (26.0%)	375 (24.5%)	297 (28.8%)	1559 (28.6%)
Dizygotic same sex	1397 (34.1%)	531 (34.8%)	327 (31.7%)	1906 (35.0%)
Dizygotic opposite sex	1540 (37.6%)	591 (38.7%)	387 (37.5%)	1856 (34.0%)
Unknown zygosity	94 (2.3%)	31 (2.0%)	20 (1.9%)	131 (2.4%)
Marital status				
Unmarried	1767 (43.2%)	576 (37.7%)	571 (55.4%)	2809 (51.5%)
Married	2326 (56.8%)	952 (62.3%)	460 (44.6%)	2623 (48.1%)
Missing	2 (0.0%)	0 (0.0%)	0 (0.0%)	20 (0.4%)
Pain	2815 (68.7%)	1246 (81.5%)	643 (62.4%)	2728 (50.0%)
CMDs	751 (18.3%)	198 (13.0%)	353 (34.2%)	793 (14.5%)
Physical activity				
Active	1657 (40.5%)	651 (42.6%)	406 (39.4%)	2418 (44.4%)
Non-active	2259 (55.2%)	829 (54.3%)	554 (53.7%)	2616 (48.0%)
Missing	179 (4.4%)	48 (3.1%)	71 (6.9%)	418 (7.7%)
Smoking				
Non-smoker	2536 (61.9%)	958 (62.7%)	623 (60.4%)	3704 (67.9%)
Current smoker	403 (9.8%)	143 (9.4%)	132 (12.8%)	698 (12.8%)
Missing	1156 (28.2%)	427 (27.9%)	276 (26.8%)	1050 (19.3%)
Alcohol use				
Moderate alcohol user	2253 (55.0%)	808 (52.9%)	560 (54.3%)	3520 (64.6%)
Alcohol user	218 (5.3%)	75 (4.9%)	65 (6.3%)	453 (8.3%)
Missing	1624 (39.7%)	645 (42.2%)	406 (39.4%)	1479 (27.1%)
Health behaviors[a]				
Healthy	610 (14.9%)	239 (15.6%)	156 (15.1%)	1166 (21.4%)
Unhealthy	3444 (84.1%)	1280 (83.8%)	866 (84.0%)	4224 (77.5%)
Missing	41 (1.0%)	9 (0.6%)	9 (0.9%)	62 (1.1%)

CMDs = common mental disorders; DP=disability pension; MSD = musculoskeletal diagnoses; SD=standard deviation.

[a] Health behaviors included active physical activity, drinking a moderate amount alcohol and being a non-smoker as healthy behaviors. The groups were created for unhealthy (0–2 healthy behaviors) vs. healthy (3 healthy behaviors).

The discordant pair analyses (i.e. conditional HRs) were significant for lower risk among those being physically active (HR 0.86–0.87) or having healthy behaviors (HR 0.70–0.86) for all-cause DP, DP due to MSD and for unemployment among all pairs only. The associations became statistically non-significant in analyses on same-sexed, opposite sexed or zygosity stratified twins although not losing the direction and magnitude (Table 2). Still we detected a statistically significant association between healthy behaviors and all-cause DP both among same-sexed and opposite-sexed twins suggesting the positive effect of healthy behaviors both among men and women. We had relatively few pairs for some of the analyses hence hampering the statistical power, but the results point towards that familial factors may play a minor or non-existing role in these associations.

4. Discussion

This large, prospective cohort study of 51,891 twins followed over 10.5 years for DP and unemployment provided knowledge on various health behaviors (being physically active, moderate or less alcohol consumption, non-smoker and for combinations of these into healthy behaviors) regarding sustainable working life. These results strengthen the assumption that familial confounding (i.e., genetics and early, mainly childhood, environment) affects little or not at all the associations between health behaviors and DP or unemployment. Instead, the found preventive role of being physically active or having healthy behaviors on risk of all-cause DP, DP due to MSD and unemployment suggests that emphasizing exercise or behaving healthy, i.e. being physically active, moderate alcohol consumption, and non-smoking, is important for sustainable working life. These results add to the earlier knowledge based on slightly smaller samples although not evaluating unemployment (Helgadottir et al., 2019; Ropponen et al., 2011a; Ropponen et al., 2020; Ropponen and Svedberg, 2014).

Our results support expectations that the promotion of healthy lifestyle, i.e. being physically active, moderate in alcohol consumption and non-smoker can improve work capacity and to promote sustainable working life (Airaksinen et al., 2019; Ervasti et al., 2019; Ervasti et al., 2018) as we detected them to lower the risk of DP and unemployment. These results are also in line with findings that health behaviors have single and joint associations with future work incapacity (Ropponen et al., 2011a; Ropponen et al., 2016; Ropponen and Svedberg, 2014) but also with other poor employment outcomes (Bockerman et al., 2018; Danaei et al., 2017; Heikkala et al., 2020). However, our results showed that a lower risk for all-cause DP, DP due to MSD and unemployment was found in the whole population and among the discordant twin pairs suggesting that the earlier results based on individual level data are not likely to be strongly affected by familial factors. This indicates that the familial predisposition to healthy behaviors (which are shared with the twin) is not a major factor behind the lower risk of DP or unemployment in those with healthy behaviors. This suggests a direct effect of health behaviors to sustainable working life thus emphasizing the importance of public health policy for improving healthy lifestyle.

In line with earlier studies (Bockerman et al., 2018; Ropponen et al., 2011a; Ropponen et al., 2020; Ropponen and Svedberg, 2014), our results indicate the need to promote not only separate health behaviors (i.e., encouragement for participation to physical activity or cessation of smoking) but also applying in general healthy behaviors in one's life course for decreasing the risk of exit from labour market. The public health campaigns should focus both on returning the work incapacity (i.e., loss due to DP) and on those unemployed or at risk of unemployment due to recession or other societal effects.

Our data had important strengths but also limitations. We had a large sample size with comprehensive and good quality register data. Furthermore, the relatively long follow-up (over 10 years on average) resulted a prospective design without response bias or loss in follow-up. Although we relied on the relatively high welfare in Sweden as context of this study, the results should be applicable to other countries with similar welfare system, at least in the Nordic countries. Despite the large sample size (nearly 52,000 individuals), we lacked statistical power in some of our analyses. Therefore, caution should be applied in interpretations of our results for the DP due to MSD and mental diagnoses and for conditional Cox models. This calls for further studies with even larger sample sizes available when pooling cohorts collected in different countries. Although, our results provide initial findings for similar associations between health behaviors across DP diagnosis groups and for

Table 2
Hazard ratios with 95% confidence intervals for the associations between health behaviors and all-cause disability pension, disability pension due to musculoskeletal diagnoses, disability pension due to mental diagnoses, and unemployment in the whole sample and of the co-twins discordant for exposure.

	All-cause disability pension										
	n	Unconditional analysis crude	Unconditional analysis multivariate[a]	n	Conditional cox all	n	DZ[b] opposite sex pairs	n	DZ same sex pairs	n	MZ[c] pairs
Physically active	1657	**0.69 (0.65–0.74)**	**0.77 (0.72–0.82)**	518	**0.87 (0.77–0.98)**	205	0.85 (0.71–1.03)	180	0.87 (0.71–1.06)	130	0.90 (0.71–1.13)
Non-smoker	2536	**1.17 (1.06–1.30)**	**0.78 (0.70–0.87)**	128	0.93 (0.73–1.18)	55	0.92 (0.64–1.33)	38	0.93 (0.60–1.44)	34	0.92 (0.58–1.47)
Moderate alcohol use	2253	**1.30 (1.13–1.50)**	1.00 (0.87–1.15)	92	0.89 (0.67–1.18)	32	0.77 (0.49–1.23)	36	1.35 (0.82–2.23)	23	0.67 (0.40–1.14)
Healthy behaviors	610	**0.56 (0.51–0.61)**	**0.61 (0.56–0.66)**	309	**0.70 (0.60–0.81)**	98	**0.55 (0.43–0.70)**	108	**0.74 (0.58–0.95)**	102	0.89 (0.68–1.16)
Disability pension due to musculoskeletal diagnoses											
Physically active	651	**0.75 (0.67–0.83)**	**0.85 (0.77–0.94)**	191	0.95 (0.78–1.16)	75	0.88 (0.64–1.20)	71	1.10 (0.78–1.53)	44	0.86 (0.58–1.29)
Non-smoker	958	**1.24 (1.04–1.48)**	**0.70 (0.58–0.84)**	44	0.77 (0.52–1.14)	24	1.09 (0.61–1.94)	13	0.77 (0.37–1.58)	<10	**0.33 (0.13–0.83)**
Moderate alcohol use	808	**1.36 (1.07–1.72)**	0.97 (0.77–1.23)	22	0.64 (0.38–1.10)	<10	0.53 (0.21–1.33)	<10	0.82 (0.34–1.99)	<10	0.59 (0.22–1.64)
Healthy behaviors	239	**0.60 (0.52–0.69)**	**0.66 (0.58–0.76)**	124	**0.77 (0.61–0.97)**	38	**0.60 (0.40–0.89)**	48	0.91 (0.61–1.34)	38	0.84 (0.55–1.30)
Disability pension due to mental diagnoses											
Physically active	406	**0.70 (0.62–0.80)**	**0.75 (0.66–0.85)**	138	0.96 (0.76–1.21)	56	1.07 (0.74–1.57)	46	0.90 (0.61–1.34)	36	0.95 (0.60–1.50)
Non-smoker	623	**0.88 (0.73–1.06)**	**0.78 (0.65–0.95)**	31	0.81 (0.51–1.31)	13	0.72 (0.35–1.47)	<10	0.58 (0.23–1.48)	11	1.38 (0.56–3.44)
Moderate alcohol use	560	1.08 (0.84–1.40)	1.04 (0.80–1.34)	27	0.96 (0.57–1.64)	<10	0.63 (0.25–1.63)	12	1.52 (0.62–3.71)	<10	0.89 (0.34–2.31)
Healthy behaviors	156	**0.58 (0.49–0.69)**	**0.64 (0.54–0.76)**	78	0.89 (0.66–1.21)	19	**0.54 (0.31–0.94)**	30	0.96 (0.58–1.59)	29	1.45 (0.82–2.57)
Unemployment											
Physically active	2418	**0.87 (0.82–0.92)**	**0.91 (0.86–0.96)**	696	**0.86 (0.78–0.96)**	264	0.91 (0.77–1.07)	244	**0.82 (0.69–0.97)**	176	0.85 (0.70–1.04)
Non-smoker	3704	0.99 (0.92–1.08)	0.94 (0.86–1.02)	244	0.94 (0.79–1.11)	87	0.79 (0.60–1.05)	89	1.21 (0.89–1.64)	62	0.87 (0.62–1.22)
Moderate alcohol use	3520	0.97 (0.88–1.07)	**0.89 (0.81–0.99)**	208	1.03 (0.85–1.25)	64	1.02 (0.72–1.44)	79	1.03 (0.76–1.41)	62	1.07 (0.75–1.53)
Healthy behaviors	1166	**0.86 (0.81–0.92)**	**0.88 (0.82–0.93)**	566	**0.86 (0.76–0.96)**	188	0.82 (0.68–1.00)	199	0.87 (0.71–1.05)	173	0.88 (0.72–1.08)

Statistically significant HR (95% CI) in boldface.
[a] Adjusted for age, sex, marital status, pain and common mental disorders.
[b] DZ: Dizygotic twins.
[c] MZ: Monozygotic twins.

independency of familiar factors. Our survey data included missing information for health behaviors and in particularly for alcohol consumption as has been the case in many other studies (Grittner et al., 2011). Hence, this may have diluted our estimations since those with missing information were excluded from the analyses. Furthermore, survey data means self-reports for assessment on health behaviors which means potential memory bias or tendency for under (alcohol) or over (physical activity) reporting (Adams et al., 2005; Tucker et al., 2011). These might have affected our results although gathering data of several ten thousand twins would be impossible in other means than via survey. Another aspect related to healthy behaviors was the selection of reference group for discordant pair definition. We utilized those with score three for healthy behaviors (i.e. a twin within a twin pair should have all the three healthy behaviors – being physically active, moderate in alcohol consumption and non-smoker) compared to his/her co-twin who lacked the score. Although this might have influenced the power in our sample, this was a necessary decision in order to assure the discordance within a pair. However, this implies the importance of all the health behaviors in prevention of the risk of DP or unemployment and is in line with earlier studies showing mutual associations between health behaviors (Ropponen et al., 2020; Ropponen and Svedberg, 2014). Furthermore, if under- or over-reporting bias in health behaviors exist, our results still show the association which could be tested in further studies with objective measures or larger sample sizes (Ferrari et al., 2007; Ng et al., 2020). Yet another limitation should be kept in mind since we could not control all putative factors. It is possible that some work-related factors such as occupation or other factors, e.g. change in health behaviors over time, may have affected the observed associations in an unknown way.

5. Conclusions

Both the analyses of the whole cohort controlling for covariates and discordant twin pair analyses that controlled familial factors by matching showed being physically active or having healthy behaviors to predict lower risk for all-cause DP, DP due to MSD and unemployment. Therefore, public health policies to support physical activity, moderate to low alcohol consumption, and non-smoking would be important for sustainable working life.

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Data statement

The datasets generated and analysed during the current study are not publicly available. According to the General Data Protection Regulation, The Swedish law SFS 2018:218, The Swedish Data Protection Act, the Swedish Ethical Review Act, and the Public Access to Information and Secrecy Act, these type of sensitive data can only be made available after legal review, for researchers who meet the criteria for access to this type of sensitive and confidential data. Readers may contact the second author regarding these details.

Declaration of Competing Interest

The authors declare no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2021.106717.

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