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How you live is how you feel? Positive associations between different lifestyle factors, cognitive functioning, and health-related quality of life across adulthood

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Abstract

Purpose Self-reported health-related quality of life (HRQoL) represents one central indicator for the need of prevention or intervention with gaining importance for public health monitoring. As part of this framework, the present study aims to identify potentially supportive factors of HRQoL and to determine age-related differences.

Methods In a sample of young to older adults (18–79 years; $M = 52.71$, $SD = 16.06$) from the German Health Interview and Examination Survey for Adults (DEGS1 subsample, $n = 3667$, 52% female), we investigated interrelations between individual (e.g., chronic condition), social (e.g., social support), and lifestyle factors (e.g., healthy eating) and executive functioning with the physical composite scale (PCS) and the mental composite scale (MCS) of HRQoL with the help of path analyses. Secondly, we performed multiple regression analyses to determine age interactions.

Results Results suggest direct and indirect paths on PCS, respectively, MCS from various lifestyle factors and executive functioning in addition to individual and social factors with a good model fit (PCS: CD = .63, SRMR = .001; MCS: CD = .64, SRMR = .003). Furthermore, results suggest physical activity and healthy eating to become particularly relevant with advancing age (age group × physical activity on PCS, $\beta = .09$, $p < .05$; age group × healthy eating on MCS, $\beta > .50$, $p < .01$).

Conclusions Several lifestyle factors and executive functioning offer the potential to promote HRQoL in the everyday life of individuals at various ages, independent of individual or social determinants. Public health action might want to foster behavioral multicomponent approaches supporting healthy aging.

Keywords Health-related quality of life · Physical activity · Healthy eating · Sleep duration · Executive functioning · Age differences

Across the lifespan, at some points individuals have to face losses in their physical or mental health, such as when experiencing adverse life events, or acute or chronic diseases. As a consequence, individuals frequently show short- and long-term decreases in their health-related quality of live (HRQoL). More precisely, mobility and productivity constraints [1], frailty [2], feelings of loneliness or isolation, and the rise of mental disorders [3] were identified as negative consequences related to a reduced HRQoL. Hence, the question arises on how to meet this kind of life challenges in order to avoid the reduction or consolidation of constraints of HRQoL as well as everyday consequences in the long run. One central aim of current public health research is to identify risk and supportive factors for the prevention or intervention of health problems [4]. In this context, subjective reports on the current physical and mental health status play a key role for indicating disease severity and the need, or success of interventions [4]. Beyond somatic indication, the concept of HRQoL comprises how individuals physically and mentally feel, how they manage with others and cope with their everyday lives [5]. Thus, investigations on how HRQoL is related to the way individuals shape their everyday lives represent one crucial element for the derivation of public health recommendations. In line with these

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assumptions and with recent research perspectives, emphasizing the meaning of an early awareness and pursuit of a healthy lifestyle throughout adulthood, the present study aims to identify lifestyle factors promoting HRQoL from young to older adulthood rather than just focusing on the extension of the life span [6, 7].

HRQoL associations with individual and social factors

Previous research indicates that HRQoL is determined by certain individual and social characteristics. For example, low HRQoL was associated with chronic conditions such as arthrosis or Parkinson's diseases [8]. Older age was also associated with lower physical HRQoL (as often caused by chronic conditions) [9, 10], while the majority of research points toward an age-related increase in mental HRQoL [11–13]. Furthermore, findings suggest that being female is associated with lower physical and mental HRQoL possibly due to a higher educational level as well as a lower prevalence of living alone among men as compared to women [13, 14]. This assumption stems from indications of individuals with low socio-economic status (SES) having lower levels of both physical and mental health, in general [15, 16]. In addition, living alone and the absence of a solid partnership was associated with lower HRQoL levels substantiating the meaning of social resources [17, 18]. Particularly, the perceived level of security and availability of help from persons of trust, neighbors, or society were associated with HRQoL [19, 20] which moreover showed systematic variation in the population such as with differing age, sex, and SES [21].

HRQoL associations with lifestyle factors and executive functioning

Beyond individual and social factors, previous research identified several lifestyle factors as possible resources for maintaining a healthy and satisfied life. To date, evidence on positive effects from physical activity and healthy eating on diverse physical and mental health-related outcomes is accumulating [22–27]. Taken together, physical activity is supposed to affect both physical and mental HRQoL by stimulating weight loss, the cardiovascular system, mobility, self-esteem and improving cognitive functioning and positive affect [28, 29]. Again, physical activity and healthy eating scores varied by age and SES, demonstrating how the utilization of sports as well as the quality of diet is largely determined by social and environmental variables [30]. Negative consequences of an insufficient level of physical activity as well as obesity are a loss of mobility, an increased dependency in daily life, and lower social activity, which in turn constitutes the risk of lower HRQoL [18, 20]. In conclusion, the ability to maintain an active and independent lifestyle characterizes one central goal for HRQoL interventions, gaining relevance particularly with advancing age [31, 32].

Another important factor for maintaining an independent and active lifestyle is represented by cognitive abilities. Although evidence is relatively rare, few studies show that physical activity can buffer age-related cognitive decline and that especially a combined training of executive functioning and physical activity can compensate functional losses and HRQoL perceptions [33, 34]. Moreover, insufficient sleep is associated with a variety of adverse health behaviors and a reduced HRQoL and thus represents one central public health concern [35, 36]. In sum, results point toward the interrelation of several lifestyle factors and executive functioning such as short sleep duration and lower cognitive functioning [37] or long sleep duration and inadequate food intake [38].

Rationale and hypotheses

To date, results on effects of lifestyle factors on HRQoL in a representative population sample covering a broad age-range are fragmentary and await further evidence. Thus, the present study aimed to (1) examine interrelations between lifestyle factors and executive functioning with HRQoL in a representative sample from young to old adulthood and while controlling for relevant individual and social factors and (2) determine age-related differences. The overarching aim was to identify factors positively related to HRQoL to derive recommendations for public health actions and the promotion of HRQoL in the everyday life of individuals from varying ages.

Based on the findings reviewed above, it can be assumed that lifestyle factors and executive functioning are supportive for maintaining independence in, and a better quality of, daily life. More precisely, we hypothesized in *Hypothesis 1* (H1) that a high level of healthy eating, physical activity, executive functioning, and moderate sleep duration show positive associations with HRQoL across the adult life span, while controlling for relevant individual and social factors. In *Hypothesis 2* (H2), we expected certain lifestyle factors and executive functioning becoming particularly important with advancing age for maintaining a healthy and satisfied life, as indicated by enhanced HRQoL levels.

Methods

Sample and procedure

The underlying sample is a subsample from the German Health Interview and Examination Survey for Adults

(DEGS1; performed from 2008 to 2011) which participated in the additional Mental Health Module (DEGS1-MH; performed with an average time lag of 6 weeks) containing $n = 3667$ individuals (52% female) ranging in age from young to old adulthood (18–79 years; $M = 52.71$, $SD = 16.06$). The original DEGS1 sample contained a nationally representative sample of $n = 8152$ randomly chosen individuals from local population registries covering 180 study sample points across Germany (see details in [39, 40]). Participants of this subsample completed both assessment parts (DEGS1 and DEGS1-MH) containing a face-to-face medical as well as a clinical interview, physical and laboratory examinations, and standardized self-report scales of approximately 3 h (DEGS1) plus 1 h (DEGS1-MH) in total at home or in community-owned facilities that were rented for the purpose of the survey. Present analyses include information from the standardized socio-demographic questionnaire (DEGS1), the food frequency questionnaire, the computer-assisted clinical interview (DEGS1), and the neuropsychological test battery (DEGS1-MH), only. Sample statistics for individual, social, and lifestyle factors and executive functioning are displayed in Tables 1 and 2. Informed consent was obtained from all participants. The research was approved by the Medical Ethics Review Committee of the Charité Berlin, Germany and by the Ethics Board of the Technische Universität Dresden, Germany.

Table 1 Averaged physical (PCS) and mental (MCS) composite scale scores grouped by sex, partnership status, social support, and SES, correlations with the age of participants

	N	PCS *M* [95% CI]	MCS *M* [95% CI]
Age group			
18–39 years		55.6 [55.1; 56.2]	48.1 [47.1; 49.0]
40–59 years		51.6 [51.0; 52.1]	49.2 [48.5; 49.9]
60–79 years		45.5 [44.7; 46.2]	51.6 [50.9; 52.4]
Sex			
Male	1707	51.6 [50.6; 51.5]	51.6 [51.2; 52.0]
Female	1840	50.1 [49.7; 50.5]	49.0 [48.6; 49.5]
Chronic diseases			
Yes	1280	45.2 [44.4; 46.0]	48.4 [47.5; 49.3]
No	2222	54.2 [53.8; 54,8]	50.2 [49.6; 50.8]
Partnership			
Yes	2854	50.9 [50.5; 51.2]	50.7 [50.4; 51.0]
No	655	47.8 [46.9; 48.6]	50.0 [49.2; 50.8]
Social support			
Low	362	46.3 [44.5; 48.0]	44.2 [42.4; 46.1]
Medium	1733	51.5 [50.9; 52.1]	49.2 [48.6; 49.8]
High	1440	52.2 [51.6; 52.8]	51.3 [50.7; 52.0]
SES			
Low	447	46.9 [45.8; 47.9]	48.6 [47.5; 49.6]
Medium	2142	50.3 [49.9; 50.6]	50.2 [49.8; 50.6]
High	953	52.9 [52.4; 53.7]	51.2 [50.7; 51.8]
Total	3547	49.5 [49.0; 50.0]	51.2 [50.8; 51.6]

PCS physical composite scale, *MCS* mental composite scale

Measures

Health-related quality of life

Health-related quality of life was assessed with the German version of the short form health survey SF-36.2 [41]. Psychometric validation of the German version of the SF-36 questionnaire yields comparable results for data reliability and construct validity with several non-German translations and samples [42–44]. The questionnaire consists of 36 items from eight multi-item scales subsuming general health concepts which can be summarized to one PCS including physical functioning, role limitations due to physical health problems, bodily pain, general health, and one MCS including vitality, social functioning, role limitations due to emotional problems, mental health (see Table S1, Supplementary material). Raw scores are summarized and transformed into *z*-standardized values ranging from 0 (min) to 100 (max) for each of the eight subscales as well as for the physical (PCS) and mental (MCS) composite scores, respectively.

Chronic diseases

Participants answered the Mini European Health Module [45] and we used the item "Do you suffer from any long-standing illness or condition?" (no = 0, yes = 1) as an indication of chronic diseases.

Partnership status

Participants were asked to indicate whether they were currently married or in a solid partnership (no = 0, yes = 1). Both answers were combined to one indicator for the current partnership status.

Social support

Perceived social support was assessed via the three-item Oslo social support scale [46, 47] regarding the number of close persons (from 1 = none to 4 = six or more persons), the sense of concern or interest from others (from 1 = none to 5 = a lot concern/interest), and the easiness to get help from neighbors (1 = very difficult to 5 = very easy). Answers were summarized to a total score and thereafter

Table 2 Descriptive statistics for lifestyle factors (healthy eating, physical activity, sleep duration) and executive functioning grouped by sex, and age group

	N	Sex		Age group		
		Male	Female	18–39 Years	40–59 Years	60–79 Years
		M [95% CI]	*M* [95% CI]	*M* [95% CI]	*M* [95% CI]	*M* [95% CI]
Healthy eating	3605	52.4 [51.8; 53.0]	55.9 [55.4; 56.5]	50.5 [49.8; 51.2]	54.5 [53.9; 55.1]	58.1 [57.5; 58.6]
Physical activity	3618					
Never	1091	32.5 [29.5; 35.6]	29.0 [26.4; 31.7]	21.8 [18.3; 25.7]	33.0 [29.9; 26.3]	37.6 [34.4; 40.9]
< 2 h a week	1581	37.8 [34.7; 41.1]	47.5 [44.6; 50.4]	45.5 [41.6; 49.5]	42.3 [39.3; 45.5]	40.1 [36.7; 43.5]
> 2 h a week	946	29.7 [26.7; 32.7]	23.5 [21.0; 26.3]	32.7 [28.7; 37.0]	24.6 [22.0; 27.4]	22.2 [18.9; 25.9]
Sleep duration	3667					
< 7 h	419	42.6 [39.5; 45.8]	37.6 [34.6; 40.8]	32.7 [28.6; 37.1]	47.0 [43.5; 50.5]	38.7 [35.2; 42.3]
7–8 h	2982	50.7 [47.5; 53.9]	54.0 [50.8; 57.2]	59.2 [54.5; 63.7]	47.6 [44.1; 51.2]	51.5 [48.1; 54.9]
> 8 h	266	6.6 [5.2; 8.3]	8.3 [6.6; 10.4]	8.1 [6.0; 10.9]	5.4 [4.0; 7.2]	9.8 [7.9; 12.1]
Executive functioning	3643	− 0.02 [− 0.08; 0.05]	0.19 [0.14; 0.25]	0.70 [0.64; 0.76]	0.22 [0.18; 0.27]	− 0.78 [− 0.85; − 0.71]

categorized into three categories from low (< 9) to moderate (9–11) and high (> 11) perceived social support.

Socio-economic status

The socio-economic status (SES) is represented by an index score on the basis of the individual dimensions of education, occupation, and income [48]. The SES Index is used as a categorical variable, allowing a categorization of three groups (low, medium, high) to enable comparisons between the bottom and top 20% of the population and a broadly defined middle group which comprises 60% of the population [48].

Healthy eating

Participants completed a self-administered food frequency questionnaire containing consumption frequencies and portion sizes of a total of 53 food groups (e.g., vegetables, cereals, juices) consumed during the last 4 weeks [49]. A healthy eating index was constructed by comparing calculated daily amounts of particular food intakes against age-specific recommendations of the German Nutrition Society [50]. For several food groups, consumption scores in relation to meeting the recommendations were assigned and summarized, resulting in an overall healthy eating index ranging from 0 (min) to 100 (max) [50].

Physical activity

Participants' regular physical activity during the last 3 months was assessed via the item "How often do you do sports?". Answers were categorized as never (0), up to 2 h a week (1) and more than 2 h a week (2).

Sleep duration

The self-reported average number of hours slept during the last 4 weeks was used as an indicator for sleep duration. In line with recent sleep literature, we used the sleep duration as a categorical variable indicating rather short (< 7 h), moderate (7–8 h), and long (> 8 h) sleep [51, 52].

Executive functioning

As part of a larger neuropsychological testing battery (mean duration of 21 min), participants' executive functioning was assessed via four standardized tests including verbal fluency, trail making, digit span backwards, and letter digit substitution as described in Wagner et al. [53]. For the analyses, a composite measure of global executive functioning was created by converting and averaging each of the three test performances into a *z*-standardized score (adjusted by age and SES), as suggested by the results from a factorial analyses of all cognitive performance data [53].

Statistical analyses

The analyses were carried out in Stata 14 [54] and with a weighting factor which adjusts deviations of the present sample from the German population structure (as at 2010) in terms of age, sex, region, and nationality as well as municipality type and education [40, 55].

First, we performed two sets of path analyses to quantify multiple significant interrelations as well as direct and indirect paths from individual (age group, sex, chronic diseases), social (partnership, social support, SES), and lifestyle

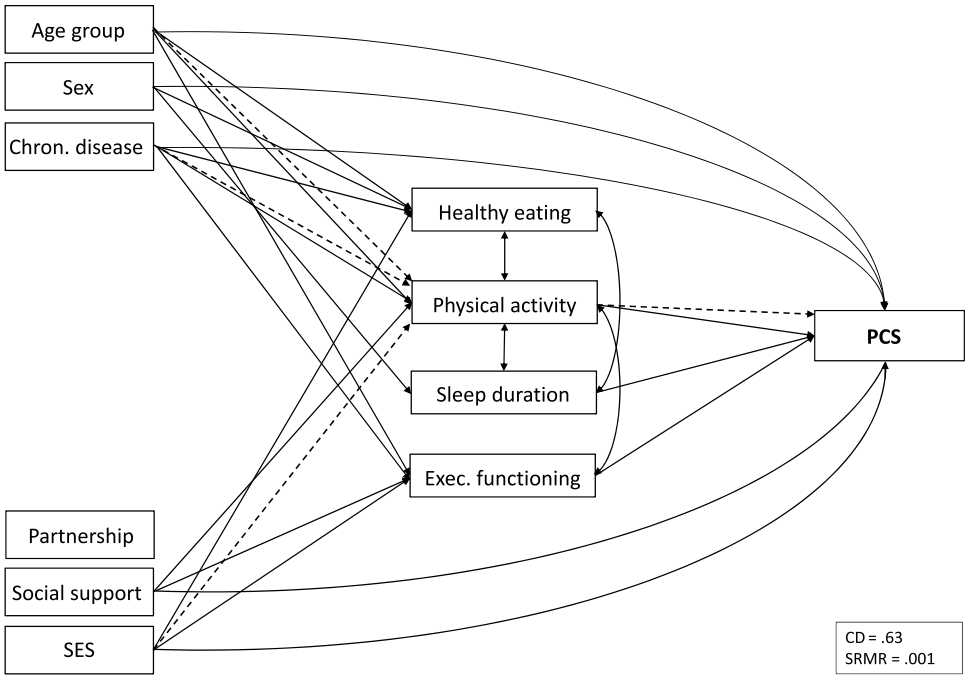

Fig. 1 Significant direct paths from individual (age group, sex, chronic diseases), social (partnership status, social support, SES), and lifestyle factors (healthy eating, physical activity, sleep duration) and executive functioning on the PCS of HRQoL are marked with solid lines. Indirect effects on PCS are marked with dashed lines. Model fit statistics for survey data: coefficient of determination (CD) = .63, standardized root mean-squared residual (SRMR) = .001

factors (healthy eating, physical activity, sleep duration) and executive functioning on MCS and PCS, respectively, with the help of structural equation modeling (SEM) based on maximum-likelihood (ML) estimation and with the weighted survey data estimation function (linearized SE).

Next, we conducted two multiple linear regression analyses for survey data on PCS and MCS, respectively, in order to investigate potential age-related differences in the significance of the lifestyle factors included in path analyses. Besides the individual, social, and lifestyle factors, and executive functioning, we therefore included age group × lifestyle factors and age group × executive functioning interactions as predictors in the same models.[1]

Results

Interrelations: results from path analyses

Results from path analyses showed several significant direct paths between individual, social, and lifestyle factors and executive functioning. Individuals with chronic diseases and at older age showed higher healthy eating scores (chronic disease: $\beta = .06$, $p < .05$; age group: $\beta = .31$, $p < .01$), lower physical activity (chronic disease: $\beta = -.08$, $p < .01$; age group: $\beta = -.14$, $p < .01$), and lower executive functioning (chronic disease: $\beta = -.10$, $p < .05$; age group: $\beta = .53$, $p < .01$), while women showed higher healthy eating scores ($\beta = .21$, $p < .01$) and sleep duration than men ($\beta = .07$, $p < .05$; see Figs. 1, 2 and Table S2 from the Supplementary material for more detailed information). Higher social support was related to higher physical activity ($\beta = .09$, $p < .01$) and executive functioning ($\beta = .06$, $p < .01$) and a higher SES was related to higher healthy eating scores ($\beta = 11$, $p < .01$), physical activity ($\beta = .18$, $p < .01$) , and executive functioning ($\beta = .26$, $p < .01$). Being in a solid partnership was neither related to lifestyle factors nor to executive functioning. Results also revealed various significant direct paths between lifestyle factors and executive functioning: Higher healthy eating scores were associated with higher physical activity ($\beta = .14$, $p < .01$), sleep duration ($\beta = .06$, $p < .01$); higher physical activity was associated with higher healthy eating scores ($\beta = .11$, $p < .01$) and executive functioning ($\beta = .09$, $p < .01$); higher sleep duration was related to higher healthy eating scores ($\beta = .05$, $p < .05$) ; and higher executive functioning was related to higher healthy eating scores ($\beta = .05$, $p < .01$) and physical activity ($\beta = .06$, $p < .01$) (see Figs. 1, 2, Table S2 in Supplementary information).

Moreover, a series of factors was related to HRQoL. PCS was lower in individuals with chronic diseases ($\beta = -.31$, $p < .01$), at older age ($\beta = -.21$, $p < .01$), female sex ($\beta = -.06$, $p < .01$) and higher in individuals with high social support ($\beta = .05$, $p < .05$), SES ($\beta = .11$, $p < .01$), physical activity ($\beta = .10$, $p < .01$), sleep duration ($\beta = .05$, $p < .05$), and executive functioning ($\beta = .11$, $p < .01$; Fig. 1). Besides, healthy eating showed an indirect path on PCS

[1] We tested multicollinearity by taking the correlation between indicators and the variance inflation factor (VIF) of all indicators of the regression model into account. All values were below the conventional limits of $r < .70$ and VIF < 10 (e.g., [56]).

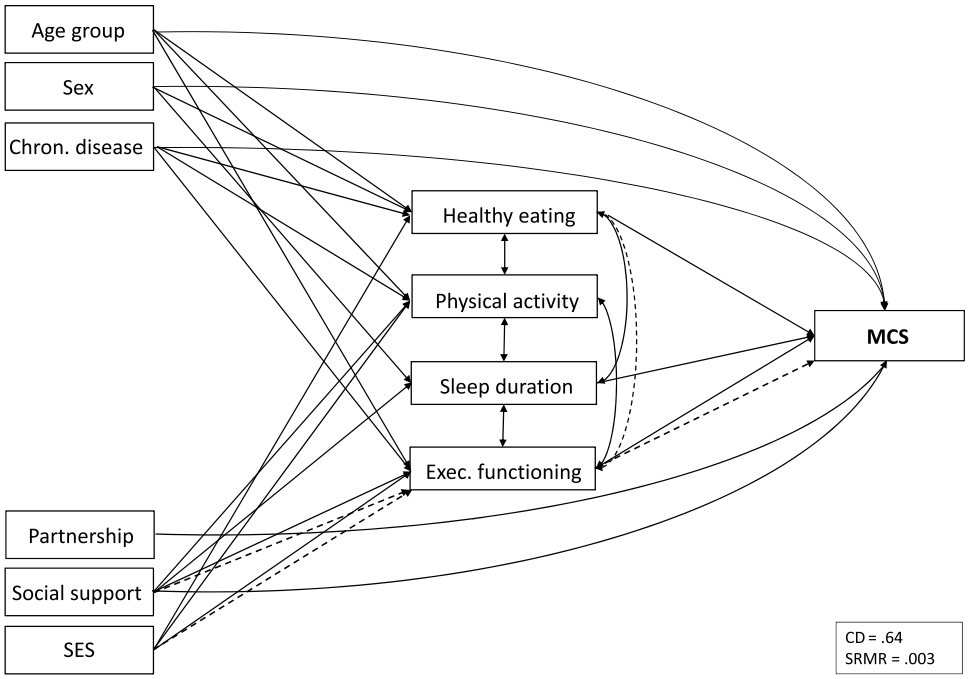

Fig. 2 Significant direct paths from individual (age group, sex, chronic diseases), social (partnership status, social support, SES), and lifestyle factors (healthy eating, physical activity, sleep duration) and executive functioning on the MCS of HRQoL are marked with solid lines. Indirect effects on PCS are marked with dashed lines. Model fit statistics for survey data: coefficient of determination (CD) = .64, standardized root mean-squared residual (SRMR) = .003

($\beta = .08$, $p < .01$) mediated by physical activity. Chronic diseases ($\beta = -.02$, $p < .01$), age ($\beta = -.03$, $p < .01$) , and SES ($\beta = .06$, $p < .01$) also showed indirect paths through physical activity on PCS. MCS was lower among individuals with chronic diseases ($\beta = -.11$, $p < .01$), female sex ($\beta = -.16$, $p < .01$) and higher among individuals at older age ($\beta = .21$, $p < .01$), with a solid partnership ($\beta = .10$, $p < .01$), high social support ($\beta = .17$, $p < .01$), high healthy eating scores ($\beta = .04$, $p < .05$), long sleep duration ($\beta = .08$, $p < .01$) , and high executive functioning ($\beta = .07$, $p < .05$; Fig. 2). Healthy eating also showed an indirect path on MCS ($\beta = .06$, $p < .01$), mediated by executive functioning. In addition, MCS was indirectly related to SES ($\beta = .09$, $p < .01$),, and social support ($\beta = .04$, $p < .01$), through executive functioning.

Age-related differences: results from regression analyses

In general, results from multiple regression analyses replicate findings from path analyses: PCS but not MCS is lower with older age; men as well as individuals without chronic conditions or with medium or high social support showed higher PCS and MCS, on average; being in a solid partnership was positively related to MCS, while low SES was negatively related to PCS, only (Table 3). Several lifestyle factors as well as executive functioning showed positive relations with both PCS and MCS: physical activity, medium sleep duration, and higher levels of executive functioning were related to higher PCS; healthy eating, medium sleep duration as well as higher executive functioning were related to higher MCS. The relation between healthy eating and PCS as well as between sleep duration and MCS was marginally significant, only (Table 3). Results revealed a significant interaction of age group × physical activity on PCS, indicating a higher increase in older as compared to younger adults with regular physical activity (Fig. 3a; Table 3). Moreover, age group × physical activity as well as age group × healthy eating interactions were significantly related to MCS. While MCS increased with more than 2 h physical activity per week in younger and middle-aged adults, it remained constantly high for older adults (Fig. 3b; Table 3). On the contrary, higher healthy eating scores were related to higher MCS in older adults, only (Fig. 3c).[2]

[2] We furthermore tested for HRQoL differences between the three physical activity (none, < 2 h, > 2 h) and healthy eating categories (low, medium, high) for each age group, separately. PCS scores differed significantly regarding physical activity for young (none vs. < 2 h $B = -0.14$, $SE = 0.75$, $p = .85$; none vs. > 2 h $B = 1.67$, $SE = 0.70$, $p = .02$), middle-aged (none vs. < 2 h $B = 0.41$, $SE = 0.73$, $p = .58$; none vs. > 2 h $B = 2.71$, $SE = 0.72$, $p < .01$) as well as older adults (none vs. < 2 h $B = 2.85$, $SE = 0.83$, $p < .01$; none vs. > 2 h $B = 5.21$, $SE = 0.94$, $p < .01$), while MCS scores did not differ significantly regarding physical activity for young (none vs. < 2 h $B = 1.47$, $SE = 1.24$, $p = .24$; none vs. > 2 h $B = 1.96$, $SE = 1.30$, $p = .14$), middle-aged (none vs. < 2 h $B = 0.31$, $SE = 0.82$, $p = .71$; none vs. > 2 h $B = 1.49$, $SE = 0.85$, $p = .08$) , and older adults (none vs. < 2 h $B = -0.36$, $SE = 0.85$, $p = .67$; none vs. > 2 h $B = -0.08$, $SE = 0.98$, $p = .94$). MCS scores differed significantly regarding healthy eating for older (low vs. medium $B = 4.04$, $SE = 1.86$, $p = .03$; low vs. high $B = 6.43$, $SE = 1.96$, $p < .01$) but not for young (low vs. medium

Discussion

The present study provides new insights into interrelations and the age relevance of several factors that have been identified as potentially supportive for HRQoL across adulthood. In addition to social and individual characteristics such as chronic conditions or age, we identified positive associations with lifestyle factors and executive functioning that can be addressed by public health measures. Taken together, results suggest that certain factors are essential for the promotion of both physical and mental HRQoL (e.g., moderate sleep duration, executive functioning) during adulthood in general, while others seem to be of particular relevance for physical or mental HRQoL and gain importance with advancing age (e.g., healthy eating, physical activity).

Results underline previous findings on varying HRQoL levels among individuals with differing individual and social factors such as age or SES [12, 16, 55]. For example, chronic diseases and high age was indicative of low physical activity and physical HRQoL. Possible explanations for an age-related decrease in physical HRQoL are a higher risk of chronic diseases and related consequences such as less physical ability. At the same time, older age was associated with high healthy eating scores and mental HRQoL. Thus, apart from the negative effects that older age and chronic conditions might have on physical HRQoL, mental HRQoL is not necessarily affected in the same way and the negative effects might even be initiative for promoting lifestyle factors that can be modified such as healthy eating. This interpretation corresponds with other findings on relatively high coping and emotion regulation abilities in older adults, allowing adjustments to changes of physical health or other adverse life events [11, 33, 57].

In the past, SES differences have been explained by a higher exposure to stress and anxiety, a lack of proper medical services, and also by certain unhealthy lifestyle behaviors such as the consumption of unhealthy food or less physical activity [17, 58]. In line with these explanations, the present results indicate besides lower healthy eating scores, physical activity, and executive functioning also lower physical HRQoL with lower SES. Noticeably, the strength of association between SES and mental HRQoL attenuated when entering lifestyle factors and executive functioning into the same model suggesting a potential to buffer negative effects from SES by, for example, promoting executive functioning (as suggested by the found indirect effects). Furthermore, the relatively low proportion of explained variance in mental HRQoL indicates how other so far unconsidered factors can additionally contribute to the enhancement of mental HRQoL and compensate certain individual and social risk factors. Additionally, present findings underpin previous assumptions on salutary effects from social support on well-being and health. One possible explanation is related to (interpersonal) coping abilities helping to buffer adverse life circumstances [21, 59]. A lack of perceived social support on the contrary seems to be related to lower mental HRQoL as well as lower cognitive functioning, as already discussed before [59, 60].

As expected in H1, lifestyle factors and executive functioning showed positive relations with HRQoL in addition to individual and social factors. Individuals with above-average executive functioning, healthy eating, regularly conducting sport more than 2 h per week, and average sleep duration of 7–8 h showed higher physical and mental HRQoL as compared to individuals not fulfilling the aforementioned criteria. Present findings also underpin the central role of physical activity, being related to almost all of the included factors as well as to mental and physical HRQoL. Thus, findings are in line with the success rates of physical activity interventions on different health-related outcomes [46] and with previous assumptions on the benefits of physical exercise mediating or even surpassing modifications in eating behavior [26]. Correspondingly, in the present study, the relation between healthy eating and physical HRQoL was only marginally significant but showed a significant indirect relation through physical activity. Hence, it is to be assumed that individuals who eat healthy also do regularly sports and thereby promote several healthy lifestyles at the same time.

Similar to the high relevance of physical activity especially on physical HRQoL, executive functioning can be interpreted as a particularly relevant resource contributing to the enhancement of mental HRQoL. The present findings are in favor of interpretations of executive functioning as one central aspect for mental HRQoL and as a prerequisite for the ability to cope with everyday life demands [47, 61]. Social support as well as healthy eating showed indirect relations through executive functioning on mental HRQoL, underpinning previous results on interdependencies between executive functioning and relevant coping resources for mental health [62, 63]. In conclusion, results substantiate current suggestions of multimodal training approaches for the successful and comprehensive promotion of lifelong physical and mental health [47, 64].

In line with H2, present findings indicate that certain factors gain importance especially with advancing age. Physical HRQoL increased stronger with higher physical activity and mental HRQoL increased stronger with higher healthy eating scores among older individuals. These findings correspond with previous research suggesting a high risk of (a) insufficient physical activity for chronic conditions and (b) poor diet for reduced immunity, muscle strength,

Footnote 2 (continued)

$B = -0.49$, $SE = 1.14$, $p = .67$; low vs. high $B = -2.61$, $SE = 2.21$, $p = .24$) or middle-aged adults (low vs. medium $B = -0.46$, $SE = 1.34$, $p = .73$; low vs. high $B = -0.73$, $SE = 1.88$, $p = .64$)

Table 3 Results of two multiple linear regression analyses from individual (chronic diseases, age group, sex), social (partnership, social support, SES), and lifestyle factors (healthy eating, physical activity, sleep duration), and executive functioning as well as age group interactions on the physical (PCS) and mental (MCS) composite scales of HRQoL

	PCS		MCS	
	B (*SE*)	*β*	*B* (*SE*)	*β*
Intercept	39.09** (3.41)		37.41** (3.05)	
Individual factors				
Age group				
60–79 years versus 18–39 years	12.86 (4.08)	.65**	3.90 (4.43)	.19
60–79 years versus 40–59 years	12.45 (4.10)	.66**	−9.07 (4.26)	−.46*
Sex				
Male versus female	−1.47 (0.73)	−.08*	−2.86 (0.75)	−.15**
Chronic diseases				
No versus yes	−6.08 (0.47)	−.30**	−2.13 (0.50)	−.10**
Social factors				
Partnership status				
No versus yes	1.29 (0.99)	.06	3.60 (1.30)	.15**
Social support				
Low versus medium	3.47 (1.29)	.19**	3.19 (1.30)	.16*
Low versus high	2.98 (1.42)	.16*	5.19 (1.31)	.26**
SES				
Low versus medium	2.19 (1.04)	.12*	0.72 (1.10)	.04
Low versus high	4.22 (1.09)	.18**	0.37 (1.33)	.02
Lifestyle factors				
Healthy eating	0.09 (0.05)	.09°	0.23 (0.04)	.20**
Physical activity				
None versus < 2 h	1.97 (0.83)	.11*	−1.50 (0.82)	−.07
None versus > 2 h	3.67 (0.93)	.18**	−1.83 (0.92)	−.08*
Sleep duration				
7–8 versus < 7 h	−2.27 (0.77)	−.12**	−2.12 (0.75)	−.11**
7–8 versus > 8 h	−1.73 (1.38)	−.05	−2.52 (1.39)	−.06°
Executive functioning	1.40 (0.64)	.14*	1.35 (0.42)	.12**
Age group × lifestyle factors				
Age group × healthy eating				
60–79 years versus 18–39 years	−0.04 (0.06)	−.11	−0.23 (0.07)	−.57**
60–79 years versus 40–59 years	−0.11 (0.06)	−.32°	−0.26 (0.06)	−.72**
Age group × physical activity				
60–79 years versus 18–39 years, none versus < 2 h	−2.43 (1.09)	−.09*	2.72 (1.41)	.09°
60–79 years versus 18–39 years, none versus > 2 h	−2.84 (1.17)	−.09*	3.23 (1.49)	.10*
60–79 years versus 40–59 years, none versus < 2 h	−1.45 (1.09)	−.06	1.48 (1.17)	.06
60–79 years versus 40–59 years, none versus > 2 h	−0.76 (1.18)	−.03	2.62 (1.30)	.08*
Age × sleep duration				
60–79 years versus 18–39 years, 7–8 versus < 7 h	1.58 (0.96)	.05	−1.69 (1.19)	−.05
60–79 years versus 40–59 years, 7–8 versus < 7 h	1.66 (1.77)	.03	−2.75 (2.39)	−.04
60–79 years versus 18–39 years, 7–8 versus > 8 h	0.82 (0.95)	.03	−0.86 (1.00)	−.03
60–79 years versus 18–39 years, 7–8 versus > 8 h	−0.94 (2.15)	−.01	−0.65 (2.51)	−.01
Age × executive functioning				
60–79 years versus 18–39 years	−0.65 (0.83)	−.04	−1.20 (0.77)	−.06
60–79 years versus 18–39 years	−0.80 (0.80)	−.04	−0.56 (0.71)	−.03
R^2	.35		.17	

PCS physical composite scale, *MCS* mental composite scale

R^2 for individual (chronic diseases, age group, sex) and social factors (partnership, social support, SES), only, was .33 for PCS and .12 for MCS

°$p < .10$, *$p < .05$, **$p < .01$

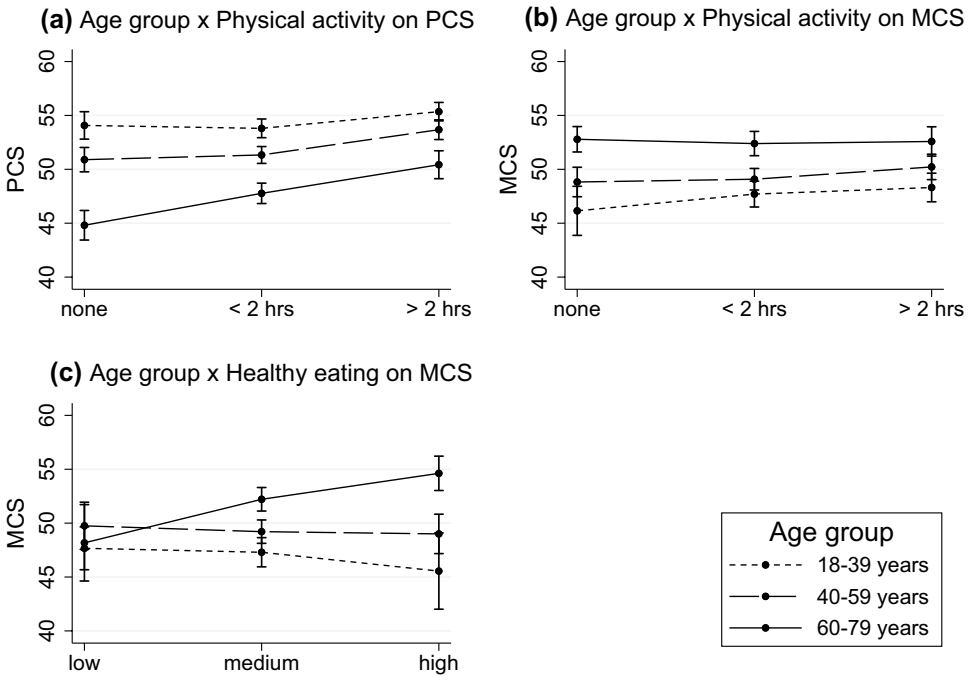

Fig. 3 Interaction effects between age group (18–39 years, 40–59 years, 60–79 years) and **a** physical activity (none, less than 2 h per week, more than 2 h per week) on the PCS of HRQoL, **b** physical activity on the MCS of HRQoL, **c** healthy eating (low = M − 1 SD, medium = M, high = M + 1 SD) on the MCS of HRQoL

or depression in turn also leading to frailty and functional limitations, especially in older ages [27, 63, 65]. Results also suggest that physical activity seems to be less important to mental HRQoL in older as compared to younger or middle-aged adults. It is to be assumed that older adults accept having less physical capacity and thus focus on other modifiable opportunities [57]. In conclusion, the active pursuit of a healthy lifestyle might become particularly apparent in eating behaviors among older adults, but awaits further investigations. This refers specifically to the healthy eating index as a general summary score of an individual's compliance with meeting several recommendations. Some of these recommendations may be more relevant than others in relation to HRQoL which does not become apparent in the present study. Further differentiations of healthy food recommendation specificity and quality with regard to age-related physiological fitness might add insights to the observed conflicting associations with mental and physical HRQoL in older age [46].

Limitations

The cross-sectional design of the present study represents a limitation as it does not allow drawing conclusions on causality or within-person change. Future research should investigate changes in HRQoL associated with lifestyle by following individuals over time as they age.

Conclusions

Present finding underpins the need to improve lifestyle conditions, behavior, and social supply offers and thereby reduce the risk of health problems for individuals with low social support and low SES, also because possibilities on how to reach such high-risk groups through lifestyle interventions are not fully explored, yet [15]. However, another central finding of the present research lies in the interrelation and potential of other factors to promote HRQoL beyond environment and disposition. As a consequence, health intervention might want to foster behavioral multicomponent approaches addressing simultaneously several potentially supportive factors for the promotion and maintenance of an independent and satisfied life, such as physical activity and cognitive functioning. Few preventive lifestyle recommendations have already been formulated for older individuals [22] but should be extended to younger ages for an early habitualization of salutary behavior and the consolidation of a healthy lifestyle. From a perspective of health education, an early awareness of potentially buffering effects might be beneficial to actively implement supportive factors in the daily lives of high-risk groups such as persons with chronic conditions.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The present research was approved by the Medical Ethics Review Committee of the Charité Berlin and by the Ethics Board of the Technische Universität Dresden, Germany. Informed consent was obtained from all individual participants included in this research. The present research (DEGS1) is primary funded by the German Ministry of Health (BMG) and additionally by the German Association of Psychotherapy and Psychiatry (DGPPN) for implementing the module on mental health (DEGS1-MH).

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