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Perception of aging in the relation between sport activity and self-rated health in middle and older age - A longitudinal analysis

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ABSTRACT

Background: This study aims to generate more comprehensive knowledge regarding underlying mechanisms of health production in middle and older age by focusing on perception of aging in the relation between sport activity and self-rated health. More differentiated information can be generated by using more age-specific data and applying advanced empirical methods.

Methods: Panel data from the German Ageing Survey (DEAS) (n = 1027) is used, whereby individuals are included, that participated at least in two waves. First, a blockwise fixed effects logistic regression model is carried out, which allows to investigate mediation as well as moderation effects and controls for time invariant unobserved heterogeneity. Additionally, two recursive bivariate probit models are conducted to identify further indirect pathways.

Findings: A mediating and moderating effect of perception of aging regarding self-rated health is found in the fixed effects model. Indirect pathways of perception of aging and retirement over sport activity (mediator) are confirmed in the recursive bivariate probit models.

Conclusion: The results highlight the complexity of the underlying mechanisms as well as the importance of individual and needs-based designed health promotion. Here, public health policy should not solely focus on sport activity, rather it should include target group specific strategies to shape individual perceptions of aging towards a more positive view on aging, while considering the heterogeneity of middle and older age groups.

Introduction

Due to demographic aging in most Western countries (Eurostat, 2019) and age-specific health and physical changes, such as the increase in chronic diseases (multimorbidity) or decline in physical and cognitive functioning (Himes, 2015; Nowossadeck, 2012; Robert Koch-Institut, 2009), maintaining health, well-being and autonomy into middle and older age has become more important for health policy and society in several European countries, including Germany.

Even though an age-related decline in health capital is found, at the same time, health also gains in individual importance in older age (Böhm, Tesch-Römer, & Ziese, 2009; Robert Koch-Institut, 2015). For middle- and older-aged adults, self-rated health has been shown as a valuable measurement[1] for predicting mortality or morbidity (Idler & Benyamini, 1997; Mavaddat, Valderas, van der Linde, Khaw, & Kinmonth, 2014; Mossey & Shapiro, 1982; Szybalska et al., 2018; Vuorisalmi, Lintonen, & Jylhä, 2005). To achieve healthy aging, a deeper understanding of the mechanisms that explain the relationship between self-rated health and healthy behavior is crucial to make effective health-related policy for people in middle and older age. Particularly in Germany, a more comprehensive understanding regarding mechanisms of inequalities in health is needed, since socio-economic differences regarding health and health behavior in middle and older age are found (Böhm, 2009).

To promote healthy aging, physical activity is one of the crucial factors, since it is associated with a decreased risk of mortality and cardiovascular diseases, prolonged maintenance of cognitive functioning, mental health as well as an increased overall well-being as shown in previous studies and meta-analysis (see Daskalopoulou et al., 2017; Gayman, Fraser-Thomas, Dionigi, Horton, & Baker, 2017; Bragina & Voelcker-Rehage, 2018). Here, sport activity, which is the focus of this study, can be seen as a specific dimension of physical activity, and

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[1] See also Golini and Egidi (2016) for an overview of the dimensions of self-rated health.

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therefore, as one possible aspect of health-promoting behavior.[2] Despite the beneficial health effects of physical activity, the majority of middle- and older-aged adults in Germany do not meet the recommended activity levels (Robert Koch-Institut, 2015). Socio-economic variables such as income, education or employment have been shown to be factors influencing participation in sport activities (Downward, Lera-Lopez, & Rasciute, 2011; Jenkin, Eime, Westerbeek, O'Sullivan, & van Uffelen, 2017). Furthermore, subjective measurements such as health-specific attitudes or individual perception of aging have been shown to be relevant. This means that individuals with a positive perception of aging (e.g. negating conventional stereotypes about aging) are more likely to participate in health-beneficial behavior (Andrews et al., 2017; Beyer, Wolff, Warner, Schüz, & Wurm, 2015; Huy, Schneider, & Thiel, 2010; Massie & Meisner, 2019; Wurm, Tomasik, & Tesch-Römer, 2010).

Even though the effect of general physical activity on health is already confirmed in the literature, especially for sport activity, due to its specific health outcomes in middle and older age (Gayman et al., 2017), more comprehensive insights are needed and should be investigated. In the previous literature often only one dimension of physical activity is considered, which makes it difficult to determine public health implications since the specific contribution of sport activity remains unclear (Daskalopoulou et al., 2017; Gayman et al., 2017). Thus far, objective (e.g. individual resources) as well as subjective (e.g. perception of aging) influencing factors have often been considered separately. Hence, the complexity of underlying mechanisms as well as the heterogeneity of middle and older adults may not have been fully addressed in previous studies. Furthermore, the problem of endogeneity, which is mostly associated with unobserved heterogeneity, has not often been considered yet. This could generate biased estimators of interests and misleading conclusions that hinder us from deriving appropriate and concrete implications for effective health policy. The use of cross-sectional data, which is often found, also leads to problems in this context, as the temporal sequence of the effects cannot be addressed.

To bridge these conceptual and methodological gaps, German age-specific data will be used, which contains information for both sport activity as well as general physical activity. This panel dataset allows us to identify the effect of sport activity more clearly by controlling for general leisure-time physical activity measures. In the following, an integrative approach is used, which combines both objective as well as subjective influencing factors. Moreover, our analysis will consider more carefully mediating and moderating effects as well as further indirect pathways in a longitudinal perspective. Furthermore, advanced empirical methods will be used which allow us to partly address endogeneity and provide more robust information.

The purpose of this study is to provide deeper insights into the complex relation between health-specific perception of aging, sport activity and self-rated health in middle and older age. Here, the aim is to generate more robust and comprehensive information, which is needed for target-group-specific health policy.

Conceptual framework

The conceptual framework of this study is based on the health capital model by Grossman (1972) as a starting point. In the model, people are supposed to invest in their health capital to maximize their utility, subject to their individual resources and constraints (Grossman, 1972; Humphreys, McLeod, & Ruseski, 2014). Here, we focus on regularly sport activity as an investment decision in health capital, which is also associated with individual resources, such as human capital and socio-economic status, to compensate or delay the age-related decline in health capital (Grossman, 1972). Therefore, sport activity is included as main predictor of self-rated health and following Daskalopoulou et al. (2017), Gayman et al. (2017) and Warburton and Bredin (2017), a positive effect is expected.

It is assumed that not only individual resources are decisive in this respect. Rather, the transformation of individual resources in health-related behavior via mediating factors such as perception of aging is also crucial (Bourdieu, 1978, 1984; Cockerham, 2005). Perception of aging has shown to be relevant regarding various health-related lifestyle choices in middle and older age, such as physical activity (e.g. Andrews et al., 2017; Beyer et al., 2015; Massie & Meisner, 2019; Wurm et al., 2010) as well as health outcomes (e.g. Warmoth, Tarrant, Abraham, & Lang, 2016). This might be explained by changing age structures and age norms, whereby older age is understood as independent and active phase of life (Robert Koch-Institut, 2009). Especially sport activity is used as attractive medium to create this phase of life more active and healthier (Huy et al., 2010). Therefore, health is a crucial motive for sports activities in older age groups (e.g. Jenkin et al., 2017). Furthermore, it can be assumed, that people with a positive perception of aging may consider healthy or active aging as more desirable (e.g. Beyer et al., 2015). Moreover, perception of aging also has shown as partly modifiable via physical activity interventions in middle and older age, whereas a positive link is found (e.g. Beyer, Wolff, Freiberger, & Wurm, 2019; Klusmann, Evers, Schwarzer, & Heuser, 2012; Wolff, Warner, Ziegelmann, & Wurm, 2014). Therefore, an interrelation in the sense of mutual reinforcement between perception of aging and sport activity can be assumed.

Due to its positive link to sport activity and self-rated health on the one hand and the health promoting effect of sport activity on the other hand, perception of aging is considered as further main predictor of self-rated health in the conceptual model. Here, it is expected that a positive perception of aging is associated with more frequent sport activity and better self-rated health. Furthermore, it is expected that more frequent sport activity is associated with a more positive perception of aging.

Perception of aging has shown as relevant for health behavior as well as cognitive functioning and quality of life (e.g. Beyer et al., 2015; Warmoth et al., 2016). Here, a negative perception of aging is assumed as barrier for participation in health behavior (e.g. Huy et al., 2010). Thus, it can be assumed that individuals with more positive perception of aging value and invest more in health behavior (e.g. in sport activities), are aware of its health promoting effects and are more likely to avoid health-risking behavior (e.g. smoking, unhealthy nutrition). It can be expected, that these factors are able to prolong the effect of sport activity on self-rated health. Accordingly, an influencing role of perception of aging regarding the relation between sport activity and self-rated health in middle and older age is assumed.

Therefore, perception of aging is not only expected to be explanatory regarding sport activity and self-rated health (whereby indirect effects of perception of aging as well as sport activity are assumed), moreover, perception of aging may also constitute the prerequisite of the strength of the health promoting effect of sport activity (moderation effect).

The transition to retirement has shown as crucial factor regarding sport activity and self-rated health (e.g. Barnett, van Sluijs, & Ogilvie, 2012; Behncke, 2011; Stenholm et al., 2016), it is included as a predictor. Here, both negative as well as positive effects are found in the literature.

Based on previous research findings (e.g. Downward, Lera-Lopez, & Rasciute, 2014; Jenkin et al., 2017) on the relevance of sociodemographic factors, the variables gender, age and partner are considered as confounder. Socioeconomic characteristics (education, income) have shown to be decisive regarding sport activity and (self-rated) health (e.g. Downward et al., 2011; Jenkin et al., 2017; Kawachi, Adler, & Dow, 2010), and therefore, considered as predictors. Here, a social gradient is expected. Objective health (physical diseases) is included as confounder, since physical functioning is crucial for sport activity (e.g. Jenkin et al., 2017). Gardening and walking are domains of leisure-time physical

[2] Physical activity is often used as a general term for light and moderate physical as well as vigorous physical activity. Here, sport activity can also be seen as subcategory of (leisure time) physical activity and is sometimes used interchangeably with vigorous physical activity in literature (Dionigi & Gard, 2018).

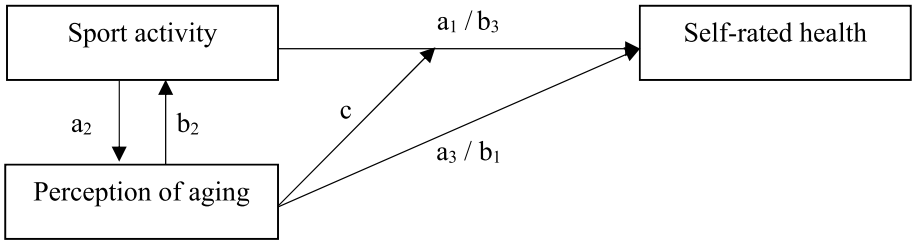

Fig. 1. Conceptual model of the relation of perception of aging, sport activity and self-rated health.

activity (World Health Organization, 2010) and are considered as confounder, which allows to focus on the effect of sport activity more specifically.

Based on the conceptual framework, the following assumptions are derived to be tested via the empirical analyses (Fig. 1).

a) Sport activity affects self-rated health directly (a_1) and indirectly ($a_2 + a_3$), whereby perception of aging acts as mediator in the relation between sport activity and self-rated health.
b) Perception of aging affects self-rated health directly (b_1) and indirectly ($b_2 + b_3$), whereby sport activity acts as mediator in the relation between perception of aging and self-rated health.
c) Perception of aging acts as moderator in the relation between sport activity and self-rated health.

For the analysis of these assumptions, the models are controlled for retirement, gender, age, partner, education, income, physical diseases, gardening and walking.[3]

Materials and methods

Data sample

We collect individual-level panel data from the German Ageing Survey (DEAS), which were publicly released by the Research Data Centre for the German Centre of Gerontology (DZA) (Klaus et al., 2017). DEAS is a representative survey of the German population in the second half of life, which covers various topics such as health-related behavior, social and family networks, and individual economic situations (Klaus et al., 2017). Data from five waves is used (1996, 2002, 2008, 2011 and 2014), and individuals who participated in the survey for at least two waves are included in the construction of the panel dataset. 232 individual (1705 cumulated) observations with missing values were excluded to ensure equal sample size for all blockwise models (Table 2). The unbalanced panel data contains 1027 individual (3269 cumulated) observations of middle- and older-aged persons from 40 to 95 years old ($\bar{x} = 63.90$, SD = 11.19)[4] of which 44.97 per cent are female.

Variables

In the DEAS, self-rated health is measured by a five-item scale where respondents can rate their health as 'very good', 'good', 'fair', 'poor' or 'very poor'.[5] For the analysis, a dummy variable was generated, which equals a value of *1* if the original variable representing self-rated health reports 1 'very good' or 2 'good', otherwise it has a value of *0*, (see Balia & Jones, 2008; Contoyannis & Jones, 2004; Oftedal et al., 2019). Sport activity was reported by respondents on a six-item scale with the categories 1 'daily', 2 'several times a week', 3 'once a week', 4 'one to three times a month', 5 'infrequent' or 6 'never' (Deutsches Zentrum für Altersfragen, 2015). A binary variable covering regular sport activity was generated taking the value *1* if sport activity is equal to 1 'daily', 2 'several times a week' or 3 'once a week', and *0* otherwise; we assume that one to three times participation in a month or less is not regular activity.[6] The variable 'perception of aging' represents the averaged items 'age: health bad', 'age: compensate physical impairments worse' and 'age: less vital and fit' (Cronbach's $\alpha = 0.74$). Perception of aging refers to an individual attitude towards/concept of aging and in this case, covers the approval to the stereotype of aging being associated with a decline in health and physical functioning.[7] The four answer categories range from 1 'applies exactly' to 4 'does not apply at all'; a higher value equals a more positive perception of aging. The variable 'perception of aging' was standardized (min. = -2.15, max. = 2.86). The variable 'retirement' indicates if a person is actively employed '0' or retired '1'. 'Gender' (0 'male', 1 'female'), 'age' (log-transformed), 'partner', which indicates if an individual has a steady life partner (0 'no', 1 'yes'), education (0 'low', 1 'middle', 2 'high') and the continuous variable 'income' (log--transformed monthly household income) are used as demographic and socio-economic control variables. Objective health status is represented by the binary variable 'physical diseases', taking the value *1* if an individual states two or more physical diseases[8] and *0* otherwise. As other dimensions of leisure-time physical activity, the binary variables 'walking' (0 'no', 1 'yes') and 'gardening' (0 'no', 1 'yes') were included. Both variables took the value *1* if an individual denotes being active 1 'daily', 2 'several times a week' or 3 'once a week'. The variable 'wave' indicates each specific wave (1–5) and was included as time-fixed effects. The interaction term 'sport activity*perception of aging' was generated to investigate a moderating effect.

Empirical analyses

When using observational data, explanatory variables are likely to be affected by unobserved factors, and therefore, correlated with the error term (Wooldridge, 2013). If this endogeneity problem is not addressed well, biased estimators from systematic errors would be produced. Thus, valid evidence regarding the relation between explanatory variables and the outcome are not feasible without treating this issue well.[9]

Regarding the relation between sport activity and self-rated health, decisions on sport activity are likely to be endogenous due to unobserved individual heterogeneity that could affect both self-rated health as well as sport activity (Humphreys et al., 2014). Here, unobserved individual heterogeneity can be related to individual (leisure) time preferences, individual value of health, health literacy, attitudes regarding sport activities or status-specific values that influence individual decision-making

[3] More information on this is given in the materials and methods section.
[4] This age range is used since the effect of retirement is also of interest in this study.
[5] For more information regarding the variables used for the analysis, see Table 4 in the appendice.
[6] Here we refer to physical activity guidelines for middle and older age groups (World Health Organization, 2010).
[7] It should be noted that this variable covers only one dimension of attitudes on/concepts of aging, other dimensions are, for example, social isolation or loss of autonomy (Huy et al., 2010; Massie & Meisner, 2019).
[8] For example, cancer, cardiovascular diseases, visual impairments or diabetes.
[9] It should be noted that omitted variables are not the only source of endogeneity (Wooldridge, 2013).

(Bourdieu, 1978; Humphreys et al., 2014; Jenkin et al., 2017). Individual previous experiences of sport activity or other corresponding contextual factors, such as the access to and the number of sport facilities or the offer of health sport courses in the residential area, can be further examples of the source of endogeneity (Hallmann, Wicker, Breuer, & Schönherr, 2012; Jenkin et al., 2017; Yen, Michael, & Perdue, 2009). To address this endogeneity problem, a blockwise fixed effects logistic regression model and two recursive bivariate probit models were conducted.

Empirical analysis I - fixed effects regression models

Using fixed effects regression allows us to control for individual specific time-invariant unobserved heterogeneity by applying the within transformation to eliminate the individual time-invariant error (Allison, 2009; Wooldridge, 2013). Here, individual variation in the variables is focused, rather than differences between individuals. Our fixed effects logistic regression model can be described as[10]:

$$\begin{aligned}\text{SELF}-\text{RATED HEALTH}_{(it)} = \beta_0 \; & +\beta_1 \text{ SPORT ACTIVITY}_{(it)} + \beta_2 \text{ PERCEPTION OF AGING}(it) \\ & +\beta_3 \text{ RETIREMENT}_{(it)} + \beta_4 \text{ GENDER}_{(i)} + \beta_5 \text{ AGE}_{(it)} \\ & +\beta_6 \text{ PARTNER}_{(it)} + \beta_7 \text{ EDUCATION}_{(i)} + \beta_8 \text{ INCOME}_{(it)} \\ & +\beta_9 \text{ PHYSICAL DISEASES}_{(it)} + \beta_{10} \text{ GARDENING}_{(it)} \\ & +\beta_{11} \text{ WALKING}_{(it)} + \beta_{12} \text{ SPORT ACTIVITY*PERCEPTION OF AGING}_{(it)} \\ & +\lambda_{(t)} + u_{\text{SELF-RATED HEALTH}(it)}, \\ & u_{\text{SELF-RATED HEALTH}(it)} = \eta_{(i)} + \varepsilon_{\text{SELF-RATED HEALTH}(it)}\end{aligned} \tag{1}$$

where SELF-RATED HEALTH$_{(it)}$ is the health outcome of individual *i* at time *t*. $\lambda_{(t)}$ captures the time-fixed effects, *u* is the error term, $\eta_{(i)}$ indicates the individual fixed effects and $\varepsilon_{(it)}$ is an error term. For first insights into mediation and moderation effects regarding perception of aging, a blockwise fixed effects logistic regression model is constructed as shown in Table 2.[11] After investigating the effect of sport activity on self-rated health while adjusting for confounder in Model 1, 'perception of aging' is included (Model 2). In Model 3, the interaction term 'sport activity*perception of aging' was included to identify a moderation effect, and Model 4 includes the time-fixed effects.

Empirical analysis II – recursive bivariate probit model

Even though the fixed effects regression model controls for individual specific time-invariant unobserved heterogeneity, time-variant variations might exist and generate endogeneity. Apart from mediation and moderation effects regarding perception of aging in the fixed effects model, further indirect pathways from sport activity to self-rated health may exist. Identifying these pathways is crucial to clarify the underlying mechanisms between sport activity and self-rated health.

To address the above-mentioned issues, the recursive bivariate probit model approach is applied (see Greene, 2008), where two equations, one for self-rated health and one for sport activity, are estimated simultaneously, as shown in Table 3.[12] Here, endogeneity of sport activity can be taken into account since the errors of the self-rated health equation and the sport activity equation are allowed to correlate (Balia & Jones, 2008; Greene, 2008; Humphreys et al., 2014). Our recursive bivariate probit model with time-fixed effects can be written as:

$$\begin{aligned}\text{SELF}-\text{RATED HEALTH}_{(it)} = \beta_0 \; & +\beta_1 \text{ SPORT ACTIVITY}_{(it)} + \beta_2 \text{ PERCEPTION OF AGING}_{(it)} \\ & +\beta_3 \text{ RETIREMENT}_{(it)} + \beta_4 \text{ GENDER}_{(i)} + \beta_5 \text{ AGE}_{(it)} \\ & +\beta_6 \text{ PARTNER}_{(it)} + \beta_7 \text{ EDUCATION}_{(i)} + \beta_8 \text{ INCOME}_{(it)} \\ & +\beta_9 \text{ PHYSICAL DISEASES}_{(it)} + \beta_{10} \text{ GARDENING}_{(it)} \\ & +\beta_{11} \text{ WALKING}_{(it)} + \eta_{(t)} + u_{\text{SELF-RATED HEALTH}(it)}\end{aligned} \tag{2}$$

$$\begin{aligned}\text{SPORT ACTIVITY}_{(it)} = \gamma_0 \; & +\gamma_1 \text{ PERCEPTION OF AGING}_{(it)} + \gamma_2 \text{ RETIREMENT}_{(it)} \\ & +\gamma_3 \text{ GENDER}_{(i)} + \gamma_4 \text{ AGE}_{(it)} + \gamma_5 \text{ PARTNER}_{(it)} \\ & +\gamma_6 \text{ EDUCATION}_{(i)} + \gamma_7 \text{ INCOME}_{(it)} + \gamma_8 \text{ PHYSICAL DISEASES}_{(it)} \\ & +\lambda_{(t)} + u_{\text{SPORT ACTIVITY}(it)}\end{aligned} \tag{3}$$

This recursive equation estimation allows us to observe direct as well as indirect effects regarding the outcome. The model is called 'recursive' since sport activity appears on the left-hand side of equation *3* and also as an explanatory variable on the right-hand side of equation *2*. Equation *2* uses the same variables as equation *1*, which were used for the fixed effects regression models.[13]

Changing an individual behavior or attitude may not affect self-rated health immediately; rather, there could be a lag between behavior change and its impact.[14] To address this issue, one-period lagged

[10] Since gender and education are individual specific and time invariant, which are captured in individual fixed effects, both variables were omitted, and effects of these variables can not be estimated in the fixed effects model.

[11] Only 1702 observations (506 individual groups) are used since 1567 observations (521 individual groups) were dropped from the analysis due to a non-varying outcome (see Greene, 2008).

[12] The different sample size used in the two recursive bivariate models occurs due to the use of lagged variables in the second model. Here, information on one period (wave) is lost, which leads to a decrease of observations.

[13] Time-invariant variables, such as gender and education, are captured by using fixed effects regression.

[14] This assumption refers to theories of health behavior change (for an overview, see Schwarzer & Luszczynska, 2008).

explanatory variables[15] are included in the second recursive bivariate probit model (equations *4* and *5*). Including lagged variables also allows the temporal sequence of exposure and outcome to be addressed; this can be seen as a way to consider reverse causation, thus yielding more robust information. Our recursive bivariate probit model with time-fixed effects and lagged explanatory variables can be written as:

$$\begin{aligned}\text{SELF}-\text{RATED HEALTH}_{(it)} = \beta_0 \quad & +\beta_1 \text{ SPORT ACTIVITY}_{(it-1)} + \beta_2 \text{ PERCEPTION OF AGING}_{(it-1)} \\ & +\beta_3 \text{ RETIREMENT}_{(it-1)} + \beta_4 \text{ GENDER}_{(i)} + \beta_5 \text{ AGE}_{(it)} \\ & +\beta_6 \text{ PARTNER}_{(it-1)} + \beta_7 \text{ EDUCATION}_{(i)} + \beta_8 \text{ INCOME}_{(it-1)} \\ & +\beta_9 \text{ PHYSICAL DISEASES}_{(it-1)} + \beta_{10} \text{ GARDENING}_{(it-1)} \\ & +\beta_{11} \text{ WALKING}_{(it-1)} + \lambda_{(t)} + u_{\text{SELF-RATED HEALTH}(it)}\end{aligned} \tag{4}$$

$$\begin{aligned}\text{SPORT ACTIVITY}_{(it-1)} = \gamma_0 \quad & +\gamma_1 \text{ PERCEPTION OF AGING}_{(it-1)} + \gamma_2 \text{ RETIREMENT}_{(it-1)} \\ & +\gamma_3 \text{ GENDER}_{(i)} + \gamma_4 \text{ AGE}_{(it)} + \gamma_5 \text{ PARTNER}_{(it-1)} \\ & +\gamma_6 \text{ EDUCATION}_{(i)} + \gamma_7 \text{ INCOME}_{(it-1)} + \gamma_8 \text{ PHYSICAL DISEASES}_{(it-1)} \\ & +\lambda_{(t)} \quad + u_{\text{SPORT ACTIVITY}(it)}\end{aligned} \tag{5}$$

For the fixed effects logistic regression, odds ratios (OR) as well as average marginal effects (AME)[16] are displayed. For the recursive bivariate probit models, average marginal effects (AME) (marginal success probability of y = 1) are presented. Clustered standard errors at the individual level were estimated, and multicollinearity was tested for all regression models (VIF < 5).[17] All estimated regression models are significant ($p < 0.05$).[18] Microsoft R Open 3.5.2 (*base*) was used for data management, and all analyses were carried out using STATA 14.2.

Results

Descriptive results

Table 1 summarizes all variables, which are differentiated by self-rated health.[19] Fifty-seven per cent of the sample report (very) good

Table 1
Summary of variables differentiated for self-rated health (German Ageing Survey (DEAS) 1996–2014, N = 3269 cumulated observations).

Predictor	Self-rated health (0 = Poor)	Self-rated health (1 = Good)	Total	*p*
Sport activity (N; %)				
0 No	840 (49.04)	873 (50.96)	1713 (52.40)	< 0.05[a]
1 Yes	569 (36.57)	987 (63.43)	1556 (47.60)	
Perception of aging (M; SD)	2.05 (0.53)	2.46 (0.58)	2.29 (0.60)	< 0.05[b]
Retirement (N; %)				
0 No	424 (31.78)	910 (68.22)	1334 (40.81)	< 0.05[a]
1 Yes	985 (50.90)	950 (49.10)	1935 (59.19)	
Gender (N; %)				
0 Male	782 (43.47)	1017 (56.53)	1799 (55.03)	0.64[a]
1 Female	627 (42.65)	843 (57.35)	1470 (44.97)	
Age (M; SD)	66.52 (10.96)	61.91 (10.96)	63.90 (11.19)	< 0.05[b]
Partner (N; %)				
0 No	293 (47.64)	322 (52.36)	615 (18.81)	< 0.05[a]
1 Yes	1116 (42.05)	1538 (57.95)	2654 (81.19)	
Education (N; %)				
0 Low	127 (56.70)	97 (43.30)	224 (6.85)	< 0.05[a]
1 Middle	763 (44.62)	947 (55.38)	1710 (52.31)	
2 High	519 (38.88)	816 (61.12)	1335 (40.84)	
Income (M; SD)	2399.34 (1439.80)	2843.47 (1885.62)	2652.04 (1721.66)	<0.05[b]
Physical diseases (N; %)				< 0.05[a]
0 Less than two	212 (19.67)	866 (80.33)	1078 (32.98)	
1 Two and more	1197 (54.63)	994 (45.37)	2191 (67.02)	
Walking (N; %)				0.66[a]
0 No	460 (42.55)	621 (57.45)	1081 (33.07)	
1 Yes	949 (43.37)	1239 (56.63)	2188 (66.93)	
Gardening (N; %)				< 0.05[a]
0 No	469 (48.00)	508 (52.00)	977 (29.89)	
1 Yes	940 (41.01)	1352 (58.99)	2292 (70.11)	

Note: p = P-value for statistical tests. N = Frequency. % = Percentage. M = Mean. SD = Standard deviation. [a] = χ^2 - test. [b] = Kruskal-Wallis equality-of-populations rank test.

[15] This does not refer to time-invariant variables as well as 'age'.

[16] When using logit or probit models, average marginal effects allow better comparison and interpretation, especially when using nested models (Brzoska, Sauzet, & Breckenkamp, 2017).

[17] According to the literature, VIF (variance inflation factor) values > 10 indicate multicollinearity (see Wooldridge, 2013).

[18] Likelihood ratio (LR) chi-square test.

[19] All presented group differences are significant ($p < 0.05$).

health. Forty-eight per cent participate regularly in sport activity, of which 63 % state a (very) good self-rated health. The mean of unstandardized 'perception of aging' is 2.29 (SD = 0.60), and the group with (very) good self-rated health has a higher mean than the other ($\bar{x} = 2.46$, SD = 0.58). Fifty-nine per cent of the sample are retired, of which 49 % stated a (very) good self-rated health. Individuals with a (very) good self-rated health are younger than others on average ($\bar{x} = 61.91$, SD = 10.96). Sixty-one per cent of individuals with (very) good self-rated health report a high educational attainment, and they also state that they have a higher household income ($\bar{x} = 2632.31$, SD = 1435.98).

Results from fixed effects logistic regression models

Table 2 summarizes the results for the fixed effects regression model. Here, by applying fixed effects regression, 'within variation' is analyzed, contrary to 'between variation' in random effects models or by using cross-sectional data. In Model 1, a positive effect of 'sport activity' is found (OR = 1.479, AME = 0.001), which decreases after including 'perception of aging' in Model 2 (OR = 1.352, AME = 0.001). A more positively rated perception of aging increases the likelihood of a good self-rated health (OR = 1.960, AME = 0.002). A positive effect of being retired is found in all models. Model 3 includes the interaction term of sport activity and perception of aging, whereby a moderating effect of perception of aging in the relation between sport activity and self-rated health is found (OR = 1.400, AME = 0.001). Perception of aging, retirement as well as the interaction term are significant in Model 4 with time-fixed effects, but no effect of sport activity is found. A McFadden Pseudo-R^2 of 0.183 is found for the full model.

Results from recursive bivariate probit models

Table 3 shows summaries for the two recursive bivariate probit models. Significant rho-values of -0.521 ($p < 0.05$) for the first bivariate probit model and -0.930 ($p < 0.05$) for the second bivariate probit model with lagged explanatory variables indicate that using the bivariate probit model approach is necessary for unbiased estimators. Since the error terms of both models are correlated, unobserved individual heterogeneity is detected, which affects both self-rated health and sport activity (see Greene, 2008; Humphreys et al., 2014). Positive effects of sport activity (AME = 0.317) and perception of aging (AME = 0.100) as well as a negative effect of being retired (AME = -0.058) are found in the model for self-rated health in the first bivariate probit model. No effect of education and income is found. For the sport activity model, a positive effect of perception of aging is found (AME = 0.044). Furthermore, positive effects of being retired (AME = 0.117) and income (AME = 0.162) can be revealed.

Since a recursive system was estimated, identifying indirect effects is possible. Here, the direct effects in the sport activity model simultaneously represent indirect effects on self-rated health. Here, we first focus on indirect effects over sport activity ($x \rightarrow$ sport activity $\rightarrow$ self-rated health, where x is an explanatory variable in the sport activity equation). Indirect effects of perception of aging (0.014), retirement (0.037) and income (0.051) on self-rated health are found[20]. Regarding perception of aging ($x \rightarrow$ perception of aging $\rightarrow$ self-rated health), indirect effects of retirement (0.012) and income (0.016) on self-rated health are found. In the second recursive bivariate probit model, which includes t_{-1} lagged explanatory variables, positive effects of sport activity (AME = 0.448), perception of aging (AME = 0.031) and a

Table 2
Summary of fixed effects logistic regression model predicting self-rated health (German Ageing Survey (DEAS) 1996–2014).

Predictor	Model 1: Sport activity		Model 2: Perception of aging		Model 3: Interaction		Model 4: Time-fixed Effects	
	OR	AME	OR	AME	OR	AME	OR	AME
Sport activity								
0 No	*Ref*		*Ref*		*Ref*		*Ref*	
1 Yes	1.479**	0.001**	1.352*	0.001	1.362*	0.001*	1.345	0.000
	[0.218]	[0.000]	[0.207]	[0.001]	[0.210]	[0.001]	[0.209]	[0.002]
Perception of aging	–	–	1.960***	0.002***	1.700***	0.002***	1.690***	0.000
			[0.172]	[0.000]	[0.184]	[0.000]	[0.184]	[0.003]
Retirement								
0 No	*Ref*		*Ref*		*Ref*		*Ref*	
1 Yes	1.635*	0.001*	1.610*	0.002*	1.623*	0.002*	1.652*	0.000
	[0.325]	[0.000]	[0.337]	[0.001]	[0.340]	[0.001]	[0.345]	[0.003]
Income	1.269	0.000	1.248	0.001	1.236	0.001	1.258	0.000
	[0.266]	[0.000]	[0.270]	[0.001]	[0.263]	[0.001]	[0.273]	[0.001]
Sport activity*	–	–	–	–	1.401*	0.001*	1.417*	0.000
Perception of aging					[0.217]	[0.001]	[0.221]	[0.002]
N cases	1702		1702		1702		1702	
N groups	506		506		506		506	
McFadden- Pseudo-R^2	0.117		0.176		0.180		0.183	

Note: OR = Odds Ratio. AME = Average Marginal Effect. Clustered standard errors in parantheses. Included variable 'wave' for time-fixed effects not presented. All models are adjusted for the variables '*age*', '*partner*', '*physical diseases*', '*gardening*' and '*walking*'. Time invariant variables '*gender*' and '*education*' are captured by individual fixed effects. *$p < .05$. **$p < .01$. ***$p < .001$.

[20] Using marginal effects allows indirect effects to be calculated by multiplying the estimated values in both equations.

Table 3
Summary of recursive bivariate probit models predicting self-rated health (German Ageing Survey (DEAS) 1996–2014).

Recursive bivariate probit model						Recursive bivariate probit model with lagged independent variables					
Equation I: Self-rated health			Equation II: Sport activity			Equation I: Self-rated health			Equation II: Sport activity$_{(t-1)}$		
Predictor	AME	SE	Predictor	AME	SE	Predictor	AME	SE	Predictor	AME	SE
Sport activity			–			Sport activity$_{(t-1)}$			–		
0 No	*Ref*		–			0 No	*Ref*		–		
1 Yes	0.317***	0.070	–			1 Yes	0.448***	0.011	–		
Perception of aging	0.100***	0.016	Perception of aging	0.044***	0.010	Perception of aging$_{(t-1)}$	0.031**	0.010	Perception of aging$_{(t-1)}$	0.034**	0.013
Retirement			Retirement			Retirement$_{(t-1)}$			Retirement$_{(t-1)}$		
0 No	*Ref*		0 No	*Ref*		0 No	*Ref*		0 No	*Ref*	
1 Yes	-0.058*	0.026	1 Yes	0.117***	0.031	1 Yes	-0.083**	0.030	1 Yes	0.100*	0.043
Education			Education			Education			Education		
0 Low	*Ref*		0 Low	*Ref*		0 Low	*Ref*		0 Low	*Ref*	
1 Middle	0.038	0.034	1 Middle	0.023	0.048	1 Middle	0.043	0.044	1 Middle	-0.010	0.067
2 High	0.043	0.037	2 High	0.049	0.049	2 High	0.044	0.046	2 High	0.046	0.068
Income	0.023	0.026	Income	0.162***	0.025	Income$_{(t-1)}$	-0.025	0.021	Income$_{(t-1)}$	0.152***	0.032
N cases	3269					N cases	1649				
N groups	1027					N groups	855				
Rho	-0.521*					Rho	-0.930***				

Note: AME = Average Marginal Effect (marginal success probability of y = 1). SE = Clustered standard error. All models are adjusted for the variables '*age*', '*gender*', '*partner*', '*physical diseases*' and '*wave*' (time-fixed effects). Self-rated health models are additionally adjusted for the variables '*gardening*' and '*walking*'. *p < .05. **p < .01. ***p < .001.

negative effect of being retired (AME = -0.083) are found in the self-rated health model. For the sport activity model, positive effects of perception of aging (AME = 0.034), retirement (AME = 0.100) and income (AME = 0.152) are found. Indirect effects similar to those in the model without lagged variables are found. Compared to the model without t_{-1} lagged explanatory variables, an increase in the effect size of sport activity on self-rated health and a decrease in the effect size of perception of aging on self-rated health are found.

Discussion

Given the evidence that aging is associated with individual physical and health changes (Robert Koch-Institut, 2009), aging societies have to face major health and sociopolitical challenges. Due to the increased share of older people in several European countries such as Germany, ensuring healthy aging is a collective concern. Since perception of aging has been shown as relevant for health behavior, such as sport activity (e.g. Andrews et al., 2017), the present study analyzed the influence of the health-specific perception of aging in relation to sport activity and self-rated health in middle and older age in a longitudinal perspective. To gain a deeper knowledge of the underlying mechanisms, mediating and moderating effects are focused upon via a blockwise fixed effects logistic regression model and two recursive bivariate probit models. Here, more robust information is provided since our empirical methods attempt to address endogeneity as much as possible. The previous literature, which fails to address this issue may over- or underestimate influencing factors on health, or it may identify spurious relations, which is critical, especially with respect to the implications for health policy strategies (see also Glass, Goodman, Hernán, & Samet, 2013).

In line with previous research (e.g. Daskalopoulou et al., 2017; Gayman et al., 2017) and the derived assumptions of the conceptual framework, a positive effect of sport activity on self-rated health is found. Evidence that supports the assumption of perception of aging as a mediator and moderator in the relation between sport activity and self-rated health is found, as shown by the decreased coefficient of sport activity in Model 2 of the fixed effects model (partial mediation), and the significant interaction effect 'sport activity*perception of aging' (Table 2). The assumption of sport activity as mediator is supported by the significant effect of perception of aging in the sport activity models and the significant effects of sport activity and perception of aging in the self-rated health models of the recursive bivariate probit models (Table 3). The analyses reveal that both sport activity as well as perception of aging can be considered as crucial pillars of self-rated health in middle and older age.[21]

A positive relation between perception of aging and self-rated health is found, and this suggests that individuals with a positive perception of aging develop proactive health-related behavior. Therefore, they are more likely to participate in health check-ups or health-promoting behavior such as a sport activity (see Andrews et al., 2017; Beyer et al., 2015; Wurm et al., 2010). Hence, the results suggest that those individuals have a stronger desire to maintain their current physical and health status, are more convinced that they can actually change something about their current life situation and believe that their health status is, to a certain extent, also their own responsibility (see Huy & Thiel, 2009). The interaction effect between sport activity and perception of aging indicates, that a positive perception of aging leads to a stronger relation between sport activity and self-rated health. This means, that individuals with more positive perception of aging benefit more from the health promoting effect of sport activity. This might be explained by that fact, that individuals with a positive perception of aging are more aware of the (health) benefits and value of sport activity for their self-rated health status, which plays an important role regarding individual resource allocation choices (i.e. in the individual concept of health care, sport activity seems to be a valuable investment).

Regarding retirement, while a positive effect is found in the fixed effects regression, a negative effect on self-rated health and a positive effect on sport activity is found in the recursive bivariate probit models. The positive effect in the fixed effects regression model may occur due to the positive relation between retirement and sport activity, which can be seen in the sport activity equation of the recursive bivariate probit

[21] Since different analytical approaches were applied, additionally, for further support of the assumptions of mediation effects of both perception of aging and sport activity, the Karlson-Holm-Breen decomposition was applied (Karlson, Holm, & Breen, 2012; Kohler, Karlson, & Holm, 2011). The method was carried out for different model types, whereby results of the main analyses are confirmed. Since this is not part of the main empirical strategy, the results are not presented, but are available upon request.

models, and therefore, the positive indirect effect (retirement → sport activity → self-rated health). Only indirect effects of individual resources (income) are found, which differs from previous findings (e.g. Huisman, Read, Towriss, Deeg, & Grundy, 2013). This could be traced back to insufficient within or between variation due to the characteristics of the middle and older age group. Additionally, by using t_{-1} lagged variables, reverse causation was considered and partly addressed; similar findings as those in the models before are confirmed.

Even though the study provides more differentiated and helpful insights regarding the complex relation between perception of aging, sport activity and self-rated health for middle- and older-aged adults in Germany, the limitations of the study should be considered when interpreting the results. (1) Since only a small share of respondents participated in every wave of the German Ageing Survey ($N < 400$), an unbalanced panel was used, which includes individuals that have participated at least two times. This can be problematic for the fixed effects regression since the observation time may be too short to observe substantial 'within' variations. (2) Since the largest proportion of the sample stated a middle or high educational attainment (low educational attainment = 6.85 %), which does not correspond to the distribution of the educational level of older people in Germany (Statistisches Bundesamt, 2018), a sampling bias may exist (sample-selection, see Heckman, 1979). Since education is positively associated with health behavior (Demarest et al., 2013), the participants may also have a higher awareness of health (behavior) or health literacy. Even though we control for education, the sample selection may generate bias in our estimators if it exists. This problem is also found in other panel surveys, whereby participants with lower education are more likely to drop out (Klaus et al., 2017). Furthermore, our sample consists of a disproportionately high share of male participants (55.03 %). Since influencing factors of sport activity and healthy lifestyle behaviors differ gender-specific (Downward et al., 2014) and men usually state higher self-rated health (Szende, Janssen, & Cabases, 2014), our sample may consist of participants with more health-oriented lifestyles and better baseline health outcome. Furthermore, in middle and older age, panel survey participants are more likely to report good (self-rated) health compared to non-participants (Barreto, 2012). Therefore, generalization of results needs to be done with caution. (3) Although we applied fixed effects regression and recursive bivariate probit models to address the problem of endogeneity, our estimators may still be biased due to unobserved heterogeneity. This problem is common in health literature with observational (non-experimental) data. To deal with this issue, qualitative studies, which could be triangulated with quantitative models are needed to further develop health policy strategies in a more differentiated manner. Here, factors such as past experiences regarding health-promoting programs (see Griffin, 2017; Phoenix & Bell, 2019), (social) status-specific dispositions or values (see Bourdieu, 1978; Tulle & Dorrer, 2012) or the corresponding contextual background (e.g. neighborhood effects) (see Yen et al., 2009) should also be considered in future research.

Conclusion

This study contributes to a deeper understanding and provides more robust and differentiated information about the relation between sport activity and self-rated health in middle and older age by focusing on the health-specific perception of aging as a crucial factor and by showing the complexity of the mechanisms via recursive models. Our findings show that both sport activity as well as perception of aging are proven to be important, which indicates that public health policy should not solely focus on physical activity and its different dimensions (e.g. sport activity). Rather, it should include group-specific strategies to shape individual perceptions of aging towards a more positive view of aging (Beyer et al., 2019; Massie & Meisner, 2019), in order to consider the heterogeneity of middle and older age groups adequately.

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Ethics approval

Ethical approval and written consent were not required for this type of study.

Declarations of competing interest

None.

Availability of data and materials

The [survey] data that support the findings of this study are available in [Research Data Centre (FDZ-DZA)] with the identifier(s) ["DOI 10.5156/DEAS.1996.M.004", "DOI 10.5156/DEAS.2002.M.003", "DOI 10.5156/DEAS.2008.M.003", "DOI 10.5156/DEAS.2011.M.002" and "DOI 10.5156/DEAS.2014.M.001"].

CRediT authorship contribution statement

Eric Faß: Conceptualization, Methodology, Formal analysis, Software, Writing - original draft, Writing - review & editing. **Hyunwoong Pyun:** Methodology, Formal analysis, Software, Writing - review & editing. **Torsten Schlesinger:** Conceptualization, Writing - review & editing, Supervision.

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Appendix

Table 4
Description of variables used in the analysis (German Ageing Survey (DEAS) 1996–2014.

Variable	Scaling	Corresponding question	Additional information
Self-rated health (original)	1 'Very good', 2 'Good', 3 'Fair', 4 'Poor', 5 'Very poor'	How do you rate your current state of health? (translated by the author)	–
Self-rated health (binary)	0 'Poor'; 1 'Good'	–	–
Sport activity (original)	1 'Daily', 2 'Several times a week'; 3 'Once a week'; 4 'One to three times in a month'; 5 'Infrequent'; 6 'Never'	How often do you do sports, e.g. hiking, football, gymnastics or swimming? (translated by the author)	–
Sport activity (binary)	0 'No'; 1 'Yes'	–	–
Walking (original)	1 'Daily', 2 'Several times a week'; 3 'Once a week'; 4 'One to three times in a month'; 5 'Infrequent'; 6 'Never'	How often do you go for walks? (translated by the author)	No information on distance or number of steps in official questionnaire provided.
Walking (binary)	0 'No'; 1 'Yes'	–	–
Gardening (original)	1 'Daily', 2 'Several times a week'; 3 'Once a week'; 4 'One to three times in a month'; 5 'Infrequent'; 6 'Never'	How often do you garden during the summer months? (translated by the author)	No information on length or type of work/activity in official questionnaire provided.
Gardening (binary)	0 'No'; 1 'Yes'	–	–
Age: health bad	1 'Applies exactly'; 2 'More likely'; 3 'Not applicable'; 4 'Does not apply at all'	Please indicate to what extent the following statements apply to you personally. (translated by the author)	Individuals should indicate, whether they agree with the statements, that, when getting older, health will get bad, physical impairments can be compensated worse and one is less vital and fit.
Age: compensate physical impairments worse	See previous	See previous	
Age: less vital and fit	See previous	See previous	
Perception of aging (mean score)	–	–	A perception of aging – score, consisting of the averaged items 'age: health bad', 'age: compensate physical impairments worse' and 'age: less vital and fit', was created to represent an individual's attitude towards future age-specific developments of health/physical functioning. Since the variable represents a mean score with a total of ten data points, the variable was treated as continuous.
Retirement	0 'No', 1 'Yes'	–	
Gender	0 'Male', 1 'Female'	–	
Age	40–95	Please tell me your date of birth first.	For the analysis, the variable was log-transformed.
Partner	0 'No', 1 'Yes'		–
Education	0 'Low'; 1 'Middle'; 2 'High'		Refers to the International Standard Classification of Education (ISCED) scale. 'Low' = 'No completed vocational training and at most completed secondary modern school or POS'. 'Middle' = completed vocational training (incl. advanced further training) or (technical) higher education entrance qualification. 'High' = university degree. Education was only measured when an individual first appeared in the survey, thus creating missing values in the variable 'education' in following waves. Missing values caused this way were replaced by the previous value in this variable.
Income		–	Household income – For the analysis the variable was log-transformed
Physical diseases	0 'Less than two', 1 'Two and more	Which of the following diseases or health problems do you have? (translated by the author)	Binary variable indicating an individual's physical diseases. Covers the following diseases: cancer, cardiovascular diseases, circulatory disorder, back or bone problems, respiratory diseases, visual or hearing impairments, diabetes, gastroenteritis, mental disorder (e.g. anxiety, depression, lack of concentration, exhaustiveness), headaches/migraine, sleep disorder, bladder trouble, biliary/liver or kidney disease.
Wave	1–5	–	Dummy variable indicates each specific wave.
Sport activity*Perception of aging	–	–	Interaction term of variables 'sport activity' and 'perception of aging'

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