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Sociodemographic correlates of physical activity and sport among adults in Germany: 1997–2018

Introduction

In light of persistently high levels of physical inactivity in adult populations globally (Guthold, Stevens, Riley, & Bull, 2018) and growing evidence on the negative health effects of physical inactivity (Lee et al., 2012; Lippi & Sanchis-Gomar, 2020), the promotion of physical activity (PA) remains a key strategy to prevent noncommunicable diseases (NCDs). Recent years have seen the launch of both global (WHO, 2018) and European efforts (WHO/Europe, 2015) to promote PA, and data collected jointly by the European Commission and the World Health Organization (WHO) suggest growing interest in PA by national governments (Breda et al., 2018; Gelius et al., 2020). While policies are often based on the broad concept of health-enhancing PA (Foster, 2000), there is an ongoing debate on the potentially pronounced benefits of leisure-time PA and sports (as a subset of PA). Some studies have already identified differences in health effects by PA domain (Abu-Omar & Rütten, 2008; Lechner, 2009). However, it also needs to be considered that different sport disciplines come with varying health effects, but also with varying risks of sport injuries (Oja et al., 2015).

In Germany, efforts to promote PA have increased since around 2007/2008 (Bundesministerium für Ernährung,

Landwirtschaft und Verbraucherschutz, & Bundesministerium für Gesundheit, 2008) and were further strengthened in 2015 with the adoption of a law to increase health prevention efforts (Präventionsgesetz PräVG, 2015) and the publication of the German National PA and PA promotion recommendations in the following year (Abu-Omar et al., 2018). A common theme of these policy initiatives is the development of actions for PA promotion, in particular among disadvantaged/vulnerable population groups. This is warranted by evidence of persistent health and risk factor inequalities among adults in Germany (Lampert, Hoebel, Kuntz, Müters, & Kroll, 2017).

Internationally, a number of large-scale studies, commonly based on data collected by national health surveillance systems, have reported on population prevalence rates (Guthold et al., 2018; Løyen et al., 2016) and correlates (Koyanagi, Stubbs, & Vancampfort, 2018) of PA. A recent review on this topic also identified 78 studies that had investigated the correlates and determinants of cardiorespiratory fitness in adults (Zeiger et al., 2019), and a similar analysis has been conducted for Germany (Zeiger et al., 2020). However, a comprehensive analysis of correlates of PA over time is currently lacking for Germany. In particular it would be valuable to investigate the success of policy actions to promote PA among vulnerable groups

in Germany through an examination of trends in the distribution of correlates (and inequalities over time). Available studies using data from Germany have investigated some correlates of PA over time and show that, between 1990 and 2011, the prevalence of a healthy lifestyle increased and the cardiometabolic risk profile of adults improved (Finger et al., 2016; Finger et al., 2019). Another study has looked at educational inequalities in sport participation, finding that sporting inactivity was more prevalent in less-educated groups (Hoebel et al., 2017). None of these studies, however, focused specifically on PA and its sociodemographic determinants. An important reason for this dearth of research is that Germany does not have a single national PA and sports monitoring system in place, although efforts to establish one have been stepped up.

In order to gain deeper insights into PA gradients for specific target groups in Germany and to monitor potential shifts in such gradients over time, it is useful to pool available national cross-sectional data sets. The resulting sample sizes are sufficiently large to analyze specific target groups that are only represented with a few cases in the single data sets. It also allows for combining data sets from different time periods in order to perform a meaningful national-level comparison of correlates over time. The Robert Koch Institute (RKI), the Fed-

Year(s) data were collected	Survey	Institution collecting the data (reference)	Age range of respondents	Sample size
1997–1999	BGS 1998	Robert Koch Institute (2016)	18–79	7124
1998	Allbus 1998	Leibniz Institute for the Social Sciences (GESIS, 2012)	18+	3234
2003	GSTel03	Robert Koch Institute (2014d)	18+	8318
2004	Allbus 2004	Leibniz Institute for the Social Sciences (GESIS, 2011)	18+	2946
2006	NBS 2006	GfK Nürnberg (Rütten, Abu-Omar, Adlwarth, & Meierjürgen, 2007)	10+	10,554
2008–2011	DEGS1 2011	Robert Koch Institute (2015)	18–79	7987
2009	GEDA 2009	Robert Koch Institute (2014a)	18+	21,262
2010	GEDA 2010	Robert Koch Institute (2014b)	18+	22,050
2012	GEDA 2012	Robert Koch Institute (2014c)	18+	19,294
2013	SHARE-WAVE 5	Max Planck Institute for Social Law and Social Policy (Börsch-Supan, 2019; Börsch-Supan et al., 2013; Malter & Börsch-Supan, 2015)	50+	5752
2013–2018	GESIS Panel 2018	Leibniz Institute for the Social Sciences (GESIS, 2018b)	18+	7599
2014	Allbus 2014	Leibniz Institute for the Social Sciences (GESIS, 2018a)	18+	3471
2014	GEDA 2014	Robert Koch Institute (2018)	18+	24,016

eral government's institute responsible for health surveillance in Germany, has explicitly encouraged researchers to do so (Lange et al., 2015). The study at hand presents pooled data from 13 individual data sets collected between 1997 and 2018 to investigate whether correlates/determinants of PA have changed over time. To our best of knowledge, this is the first attempt to compile and analyze these data for Germany, which could contribute to monitoring progress in PA among vulnerable groups in recent years and to re-frame future interventions and policies.

Methods

Data sets

■ **Table 1** provides an overview of the national and population-representative data sets that were utilized for the analysis. All data sets assessed physical activity/exercise or sport participation among adults. Data sets were from the following sources: Robert Koch Institute (National Public Health Institute of Germany) (Robert Koch Institute, 2014a,

2014b, 2014c, 2014d, 2015, 2016, 2018), GESIS Leibniz Institute for the Social Sciences (GESIS, 2011, 2012, 2018a, 2018b), Max Planck Institute for Social Law and Social Policy (Börsch-Supan, 2019; Börsch-Supan et al., 2013; Malter & Börsch-Supan, 2015), and the GfK corporation (Rütten, Abu-Omar, Adlwarth, & Meierjürgen, 2007). With one exception, all data sets were obtained as public-use files. Data for the German Survey of Sedentary Adults (Nicht-Beweger Studie, NBS) were collected jointly with the GfK corporation and belonged to the research team that conducted the data analysis. The data sets are based on random samples that were commonly drawn from municipal population registers. All intend to be representative for the German adult population. In some data sets, adults living in former East Germany are overrepresented (BGS 1998, Allbus 1998, Allbus 2004, Allbus 2014). Additionally, one needs to consider that migrants might be underrepresented in most datasets since German language skills were required for study participation.

Assessment of physical activity and sport across data sets

■ **Table 5** in the Appendix indicates how PA and sport participation were assessed in the different data sets and the cut-off points that were utilized to identify people as not having engaged in vigorous PA in the last week. This is a highly relevant indicator as any vigorous PA is useful for health (Gebel et al., 2015) and, in most data sets, questions regarding PA focused on vigorous PA only (BGS 1998, GEDA 2009, 2010, 2012, SHARE 5, DEGS1). In NBS 2006 and GEDA 2014, questions included vigorous and moderate PA. Respondents were identified as being less physically active if they reported to “never” engage in vigorous activities (BGS 1998, NBS 2006). For SHARE 5, respondents were coded as being physically inactive if they reported to “almost never or never” engage in vigorous PA. Respondents to GEDA 2009, GEDA 2010, GEDA 2012 and DEGS1 were coded as being physically inactive if they stated that they had engaged in “no vigorous PA in the past week”.

Respondents were identified as not engaging in sports if they reported that they “never” engage in sports in the Allbus 1998, Allbus 2004, Allbus 2014, NBS 2006, and GESIS panel 2018 data sets. For BGA 1998, GSTel 2003, GEDA 2009, GEDA 2010, GEDA 2012, GEDA 2014 and DEGS1, respondents were identified as not engaging in sport if they said they had not done so “in the last 3 months”.

Assessment of sociodemographic variables

All data sets used comparable measures of the sociodemographic and socioeconomic status of respondents. This includes age, gender marital status, educational attainment, income and migrant background (e.g., nationality, country of origin). Some of this information was not available in all data sets.

Data analysis

Data analysis was restricted to respondents aged 18 and older. The exceptions being SHARE data that were restricted to

respondents aged 50 and older (SHARE is limited to collecting data in older adults) and NBS data that were restricted to adults aged 20 and older (NBS data did not allow identification of adults aged 18 or 19).

Data were analyzed in two stages: In the first step, data sets were kept separate in order to explore social gradients of PA and sport. In the second step, data sets were pooled, demographic factors harmonized and binary logistic regressions were conducted. The pooling of the data in the second step of the analysis represents a meta-analysis, although results are presented for two rather than one time interval. As sample sizes vary between the different data sets, the analysis represents only a crude comparison of PA correlates and determinants over time. The GEDA 2014 data showed prevalence and correlates that were quite different to every other data set, including GEDA 2010 and 2012, the latter two data sets being quite concordant. For this reason, GEDA 2014 was not included in the pooled data set. GEDA 2014 data were derived by the comparably new European Health Interview Survey—Physical Activity Questionnaire (EHIS-PAQ) questionnaire (Finger et al., 2015) that differs considerably from all other questionnaires utilized.

Separate regressions for physical inactivity and sport participation were computed. Correlates used were age, education, income quintile, migrant background, suffering from hypertension or diabetes mellitus. For the latter two variables, regression analysis was limited to people over the age of 50 in order to avoid bias from chronically ill younger people.

For the investigation of correlates and determinants over time, data were pooled based on the main year the survey was conducted. The early period of surveys ranged from 1998–2009 (Allbus 1998, BGS 1998, GSTel 2003, Allbus 2004, NBS 2006, DEGS1 2008, GEDA 2009) and the more recent period from 2010–2018 (GEDA 2010, GEDA 2012, Share5 2013, Allbus 2014, Geda 2014, GesisPanel 2018).

Results

Comparison of social gradients of PA and sport across data sets

Figures 1 and 2 provide an overview of the social gradients of sports participation. Across data sets, prevalence estimates for never/almost never engaging in sport range between 10–30% for the youngest age group and 60–85% for the oldest age group (Fig. 1). Prevalence estimates for never/almost never engaging in sport range between 30–60% for the poorest quintile and 10–30% for the richest quintile (Fig. 2).

Social gradients of age and income appear to be mostly linear.

Compared to sport, fewer data sets assessed vigorous physical activity (Figs. 3 and 4). In general, prevalence estimates vary greatly between data sets. For age, other than data sets NBS 2006 and GEDA 2014 (both indicate no relationship between age and engaging in vigorous PA), a more curvilinear relationship between age and not engaging in vigorous PA can be observed (Fig. 3). The prevalence of no vigorous PA ranged from 10–60% for the youngest age group to 55–70% for the oldest age group. Participation in vigorous PA does not seem to be strongly related to income across data sets (Fig. 4).

Correlates/determinants of engaging in sport across data sets

Table 2 depicts the binary logistic regression on never/almost never engaging in sport in 12 data sets. In all, 11 of the 12 data sets indicated that older people were more likely than younger people to report no/almost no sport-related activity. The highest odds ratios were observed in the three Allbus (1998, 2004, 2014) data sets (OR 9.26, OR 6.27, OR 3.34) for people aged 60 or older compared to the youngest group. In all data sets, those with lower levels of education were more likely to report to almost never/never engage in sport compared to those with the highest level of education. Odds ratios ranged from 1.81 (NBS 2006) to 3.70 (Allbus 2014), while Nagelkerke's pseudo R^2 ranged from 0.04 (NBS 2006) to 0.29 (Allbus 2014). Across

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Sociodemographic correlates of physical activity and sport among adults in Germany: 1997–2018

Abstract

Introduction. Promoting physical activity (PA) is a key strategy to prevent noncommunicable diseases worldwide. In order to monitor physical activity levels in Germany, several large-scale studies have reported on prevalence rates and correlates. However, a comprehensive analysis of correlates of PA over time is currently lacking for Germany.

Methods. For the analysis, 13 national cross-sectional data sets were utilized. Data analysis was restricted to respondents aged 18 and older. In a first step, data sets were kept separate in order to explore social gradients of PA and sport. In the second step, data sets were pooled, demographic factors harmonized and binary logistic regressions were conducted.

Results. Regarding sports participation, different data sets indicate comparable social gradients. People with a higher age, lower income, lower levels of education, or a migrant background consistently have a higher risk of not engaging in sports. Compared to sports participation, social gradients are less pronounced for engaging in vigorous PA. Higher age, lower education, and lower income are also markers for an increased risk of not engaging in vigorous PA.

Discussion. The study confirms that factors of age, income, education and migrant background continue to contribute to differentials in sport and vigorous PA participation in Germany. For policy-making, this implies that PA promotion should focus on systems-based actions that might reduce population-wide inequalities. Future research might focus on pooling single studies with smaller samples in order to investigate PA and sports participation in specific disadvantaged target groups.

Keywords

Social gradients · Vigorous physical activity · Sport participation · Pooled data analysis · Correlates over time

Fig. 1 ◀ Percentage reporting to never/almost never engage in sport by age across 12 cross-sectional data sets collected in Germany between 1997 and 2018

Fig. 2 ◀ Percentage reporting to never/almost never engage in sport by income quintile across 12 cross-sectional data sets collected in Germany between 1997 and 2018

all data sets, those in the lowest income quintile were more likely to almost never/never engage in sports compared to those in the highest quintile. All ten data sets that assessed migrant background showed that migrants were more likely to report almost never/never engaging in sports compared to nonmigrants. Results for relationships between sport participation and suffering from hypertension or diabetes were less consistent.

Correlates/determinants of engaging in vigorous physical activity across data sets

Eight of the data sets permitted analysis of the correlates/determinants of participation in vigorous PA (Table 3). In six of these (the exceptions being BGS 1998 and GEDA 2014), older people aged 60+ had a higher probability of not engaging in vigorous PA than younger people (age 18–39). Also, in six data sets, those with lower levels of education were more likely

to report to almost never/never engage in vigorous PA compared to those with the highest level of education. For the lowest income quintile, five out of the eight data sets showed a higher odds of not reporting any vigorous PA compared to the highest income quintile. Being a migrant was associated with not engaging in vigorous PA in four data sets. Nagelkerke's pseudo R^2 ranged from 0.007 (GEDA 2014) to 0.08 (GEDA 2009).

Fig. 3 ◀ Percentage reporting to never/almost never engage in (vigorous) PA by age across 8 cross-sectional data sets collected in Germany between 1997 and 2014

Fig. 4 ◀ Percentage reporting to never/almost never engage in (vigorous) PA by income across 8 cross-sectional data sets collected in Germany between 1997 and 2014

Correlates/determinants of physical activity and sport over time

■ **Table 4** shows the pooled data grouped by time period. Regarding the odds of never/almost never engaging in sport, most gradients appeared to remain rather stable over time. With respect to migrant background, the social gradient might have diminished somewhat over time. Also, no clear trends emerge regarding not engaging in vigorous PA. Overall,

social gradients for not engaging in sport seem to be more pronounced compared to social gradients for not engaging in vigorous PA.

Discussion

Summary

This paper has compared major available data sets regarding the correlates and determinants of PA and sports participation in Germany, and has conducted

a pooled data analysis of these data sets in order to gain a deeper insight into the development of these correlates over time, thus monitoring the progress in PA promotion and informing future policy and intervention design. Regarding sports participation, different data sets indicate comparable social gradients. People with a higher age, lower income, lower levels of education, or a migrant background consistently have a higher risk of not engaging in sports. Compared to sports participation, social gradients are less pronounced

OR (95% CI)	Allbus 1998	BGS 1998	GSTel 2003	Allbus 2004	NBS 2006	GEDA 2009	GEDA 2010	DEGS1 2011	GEDA 2012	Allbus 2014	GEDA 2014	GESIS Panel 2018
Women	1.13 (0.94–1.37)	1.10 (0.97–1.24)	0.92 (0.82–1.03)	1.10 (0.91–1.33)	0.91 (0.83–1.00)	0.91 (0.86–0.97)	0.90 (0.85–0.96)	0.97 (0.86–1.09)	0.89 (0.83–0.95)	1.07 (0.89–1.29)	0.89 (0.84–0.95)	0.98 (0.85–1.13)
Men	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Age 60+	9.26 (7.06–12.14)	1.83 (1.52–2.20)	1.33 (1.11–1.58)	6.27 (4.65–8.46)	1.65 (1.46–1.87)	1.54 (1.40–1.69)	1.49 (1.35–1.64)	1.25 (1.04–1.51)	1.86 (1.67–2.06)	3.34 (2.49–4.50)	0.81 (0.74–0.89)	2.17 (1.76–2.67)
Age 40–59	2.80 (2.20–3.56)	1.21 (1.05–1.39)	1.12 (0.97–1.29)	2.27 (1.76–2.93)	1.15 (1.03–1.28)	1.26 (1.17–1.37)	1.26 (1.16–1.37)	1.21 (1.03–1.41)	1.44 (1.30–1.59)	1.82 (1.39–2.39)	0.94 (0.87–1.01)	1.85 (1.54–2.21)
Age 18–39	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Education low	2.35 (1.78–3.09)	2.29 (1.95–2.68)	1.91 (1.65–2.20)	3.41 (2.54–4.58)	1.81 (1.60–2.04)	2.16 (1.99–2.33)	2.37 (2.19–2.57)	1.87 (1.56–2.25)	2.34 (2.16–2.55)	3.70 (2.86–4.78)	2.16 (2.00–2.33)	3.51 (2.89–4.27)
Education medium	1.20 (0.90–1.61)	1.34 (1.12–1.62)	1.35 (1.16–1.57)	2.33 (1.72–3.17)	1.58 (1.42–1.76)	1.30 (1.20–1.41)	1.50 (1.38–1.62)	1.26 (1.05–1.50)	1.49 (1.36–1.62)	2.03 (1.56–2.63)	1.44 (1.33–1.56)	1.87 (1.51–2.31)
Education high	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Income bottom 20%	2.59 (1.87–3.60)	2.23 (1.79–2.77)	1.79 (1.48–2.18)	3.34 (2.41–4.63)	1.66 (1.43–1.94)	1.68 (1.51–1.87)	1.83 (1.64–2.04)	2.33 (1.87–2.92)	1.79 (1.59–2.01)	3.06 (2.21–4.24)	1.95 (1.76–2.16)	2.67 (2.05–3.47)
Income 20–40%	2.01 (1.48–2.72)	1.78 (1.46–2.17)	1.41 (1.16–1.71)	2.51 (1.83–3.45)	1.34 (1.15–1.55)	1.35 (1.21–1.50)	1.56 (1.41–1.73)	1.86 (1.49–2.31)	1.78 (1.59–1.99)	1.57 (1.14–2.17)	1.79 (1.62–1.97)	2.28 (1.76–2.96)
Income 40–60%	1.55 (1.14–2.10)	1.49 (1.23–1.81)	1.50 (1.24–1.82)	1.87 (1.36–2.56)	1.23 (1.07–1.41)	1.22 (1.10–1.35)	1.31 (1.18–1.44)	1.70 (1.35–2.15)	1.42 (1.28–1.58)	1.41 (1.02–1.95)	1.45 (1.31–1.60)	1.59 (1.23–2.05)
Income 60–80%	1.46 (1.09–1.97)	1.28 (1.05–1.57)	1.20 (0.99–1.47)	1.22 (0.89–1.68)	1.16 (1.00–1.34)	1.10 (0.99–1.23)	1.17 (1.05–1.31)	1.39 (1.11–1.74)	1.20 (1.07–1.35)	1.26 (0.91–1.74)	1.23 (1.11–1.36)	1.38 (1.04–1.82)
Income top 20%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Migrant	2.09 (1.35–3.26)	1.78 (1.30–2.43)	1.63 (1.21–2.20)	2.38 (1.63–3.46)	N/A	1.36 (1.14–1.62)	1.34 (1.13–1.58)	N/A	1.23 (0.99–1.54)	2.40 (1.67–3.46)	1.45 (1.23–1.71)	1.66 (1.31–2.11)
No migrant	1.00	1.00	1.00	1.00	N/A	1.00	1.00	N/A	1.00	1.00	1.00	1.00
Diabetes yes	N/A	1.14 (0.66–1.89)	1.32 (1.00–1.73)	1.05 (0.71–1.55)	N/A	1.66 (1.45–1.91)	1.81 (1.58–2.07)	1.65 (1.32–2.07)	1.61 (1.43–1.82)	2.10 (1.51–2.94)	1.56 (1.38–1.76)	N/A
Diabetes no	N/A	1.00	1.00	1.00	N/A	1.00	1.00	1.00	1.00	1.00	1.00	N/A
Hypertension yes	N/A	1.23 (1.03–1.48)	0.89 (0.76–1.06)	1.38 (1.05–1.81)	N/A	1.32 (1.21–1.45)	1.23 (1.13–1.35)	1.09 (0.94–1.26)	1.20 (1.11–1.31)	1.34 (1.06–1.70)	1.22 (1.13–1.32)	N/A
Hypertension no	N/A	1.00	1.00	1.00	N/A	1.00	1.00	1.00	1.00	1.00	1.00	N/A

OR > 1 indicate a higher risk of reporting not to engage in sport
OR odds ratio, CI confidence interval, N/A not available

Table 3 Logistic regression on dependent variable engaging in (vigorous) physical activity (PA)

OR (95% CI)	BGS 1998	NBS 2006	GEDA 2009	GEDA 2010	DEGS1 2011	GEDA 2012	SHARE 5 2013	GEDA 2014
Women	1.30 (0.94–1.80)	0.89 (0.80–0.98)	1.37 (1.27–1.48)	1.25 (1.16–1.35)	1.41 (1.26–1.59)	1.36 (1.26–1.47)	1.58 (1.21–2.05)	0.96 (0.90–1.01)
Men	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Age 60+	1.00 (0.58–1.70)	1.46 (1.27–1.66)	2.77 (2.48–3.08)	2.58 (2.31–2.87)	1.95 (1.61–2.35)	3.01 (2.67–3.39)	1.33 (1.03–1.73)	1.00 (0.97–1.12)
Age 40–59	1.19 (0.84–1.69)	1.18 (1.05–1.33)	1.28 (1.16–1.42)	1.30 (1.18–1.43)	1.44 (1.22–1.69)	1.49 (1.32–1.67)	1.00	1.04 (0.97–1.12)
Age 18–39	1.00	1.00	1.00	1.00	1.00	1.00	N/A	1.00
Education low	1.51 (1.01–2.27)	1.97 (1.74–2.25)	1.56 (1.42–1.71)	1.46 (1.33–1.60)	1.48 (1.23–1.79)	1.51 (1.37–1.65)	1.19 (0.87–1.63)	1.08 (1.00–1.16)
Education medium	1.17 (0.73–1.88)	1.68 (1.49–1.89)	1.07 (0.97–1.18)	1.10 (1.00–1.20)	1.15 (0.96–1.38)	1.09 (0.98–1.20)	1.03 (0.75–1.40)	1.02 (0.95–1.09)
Education high	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Income bottom 20%	1.27 (0.72–2.26)	1.21 (1.02–1.43)	1.37 (1.21–1.55)	1.41 (1.25–1.60)	2.31 (1.84–2.89)	1.40 (1.23–1.59)	1.08 (0.70–1.68)	0.99 (0.68–0.90)
Income 20–40%	1.70 (1.02–2.80)	1.10 (0.93–1.29)	1.20 (1.06–1.35)	1.25 (1.11–1.41)	1.74 (1.39–2.17)	1.25 (1.11–1.41)	0.84 (0.54–1.30)	0.90 (0.83–0.99)
Income 40–60%	1.50 (0.93–2.40)	1.02 (0.88–1.19)	1.15 (1.03–1.29)	1.17 (1.04–1.30)	1.56 (1.23–1.98)	1.18 (1.05–1.33)	0.76 (0.50–1.17)	0.95 (0.86–1.03)
Income 60–80%	1.05 (0.62–1.76)	1.06 (0.90–1.24)	1.12 (1.00–1.27)	1.03 (0.92–1.17)	1.48 (1.18–1.86)	1.09 (0.96–1.25)	1.00 (0.66–1.52)	0.99 (0.89–1.08)
Income top 20%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Migrant	0.96 (0.42–2.18)	N/A	1.72 (1.42–2.09)	1.76 (1.47–2.12)	N/A	1.68 (1.33–2.11)	1.95 (1.15–3.31)	0.98 (0.84–1.15)
No migrant	1.00	N/A	1.00	1.00	N/A	1.00	1.00	1.00
Diabetes yes	N/A	N/A	1.48 (1.28–1.72)	1.35 (1.17–1.56)	1.25 (1.00–1.56)	1.24 (1.09–1.41)	1.70 (1.13–2.52)	0.90 (0.80–1.01)
Diabetes no	N/A	N/A	1.00	1.00	1.00	1.00	1.00	1.00
Hypertension yes	N/A	N/A	1.04 (0.94–1.15)	1.16 (1.05–1.28)	1.02 (0.88–1.18)	1.00 (0.91–1.09)	1.50 (1.16–1.92)	1.01 (0.93–1.88)
Hypertension no	N/A	N/A	1.00	1.00	1.00	1.00	1.00	1.00

OR > 1 indicating a higher risk of reporting no vigorous PA

OR odds ratio, CI confidence interval, N/A not available

for engaging in vigorous PA. Higher age, lower education, and lower income are also markers for an increased risk of not engaging in vigorous PA.

Results in context of other findings/studies

The analysis confirms findings from single German studies on social gradients related to sport and PA (Finger, Mensink, Lange, & Manz, 2017). Likewise, reviews have indicated that these gradients can be observed in many studies (Choi, Lee, Lee, Kang, & Choi, 2017) and can also be observed for other dependent variables, e.g., engagement in voluntary work (Simonson & Hameister, 2017). It has also been reported that

being a migrant (Caperchione, Kolt, & Mummery, 2009) and being at increased NCD risk with hypertension (Cascino et al., 2019) or diabetes mellitus (Adeniyi, Anjana, & Weber, 2016) are associated with increased physical inactivity. A study from Norway has investigated time trends in correlates of PA. In this study, lower levels of education remained persistently associated with lower participation rates in leisure-time physical activity (Morseth, Jacobsen, Emaus, Wilsgaard, & Jørgensen, 2016). While our analysis showed that variables such as being a migrant and having lower levels of education have separate effects on PA and sports participation, it cannot be ruled out that there are interaction effects that would

put people with multiple risk factors at an even higher risk of being inactive.

Since age, income and education represent important social gradients in our analysis, it is also important to point to the barriers to being physically active for these target groups. For older adults in Germany, studies have identified poor health, lack of company and lack of interest as main barriers (Moschny, Platen, Klaaßen-Mielke, Trampisch, & Hinrichs, 2011). For low-income groups, a study from the United Kingdom has identified high costs, lack of childcare, lack of time and low awareness of the health benefits of PA as important barriers for engaging in PA programs (Withall, Jago, & Fox, 2011). For some migrants, a lack of language skills has also been described

Table 4 Logistic regression on dependent variable engaging in sport and vigorous physical activity (PA)

OR (95% CI)	Sport		Vigorous PA	
	1998–2009	2010–2018	1998–2009	2010–2018
Women	0.94 (0.89–0.98)	0.92 (0.88–0.97)	1.36 (1.27–1.46)	1.30 (1.24–1.38)
Men	1.00	1.00	1.00	1.00
Age 60+	1.59 (1.49–1.70)	1.66 (1.56–1.77)	2.69 (2.43–2.98)	2.77 (2.57–2.99)
Age 40–59	1.22 (1.15–1.30)	1.29 (1.22–1.37)	1.26 (1.15–1.38)	1.39 (1.29–1.49)
Age 18–39	1.00	1.00	1.00	1.00
Education low	2.40 (2.27–2.55)	2.32 (2.20–2.45)	1.61 (1.48–1.76)	1.47 (1.38–1.57)
Education medium	1.35 (1.27–1.44)	1.45 (1.38–1.53)	1.08 (0.99–1.18)	1.10 (1.03–1.17)
Education high	1.00	1.00	1.00	1.00
Income bottom 20%	1.73 (1.60–1.87)	1.83 (1.70–1.97)	1.30 (1.15–1.46)	1.40 (1.28–1.52)
Income 20–40%	1.43 (1.33–1.55)	1.60 (1.49–1.72)	1.16 (1.03–1.30)	1.23 (1.14–1.34)
Income 40–60%	1.32 (1.23–1.42)	1.35 (1.26–1.44)	1.15 (1.03–1.28)	1.16 (1.07–1.26)
Income 60–80%	1.16 (1.07–1.26)	1.18 (1.10–1.27)	1.11 (0.99–1.25)	1.07 (0.98–1.17)
Income top 20%	1.00	1.00	1.00	1.00
Migrant	1.56 (1.38–1.76)	1.38 (1.23–1.55)	1.71 (1.42–2.06)	1.80 (1.58–2.06)
No migrant	1.00	1.00	1.00	1.00
Diabetes yes	1.40 (1.26–1.55)	1.66 (1.53–1.80)	1.43 (1.25–1.64)	1.29 (1.18–1.40)
Diabetes no	1.00	1.00	1.00	1.00
Hypertension yes	1.23 (1.16–1.30)	1.24 (1.17–1.30)	0.99 (0.90–1.07)	1.07 (1.00–1.13)
Hypertension no	1.00	1.00	1.00	1.00

Data sets grouped by period(s) of data collection

The periods of data collection were 1998–2009 (1998 Allbus, BGS 1998, GSTel2003, Allbus 2004, NBS 2006, DEGS1 2008, GEDA 2009) and 2010–2018 (GEDA 2010, GEDA 2012, Share5 2013, Allbus 2014, GesisPanel 2018)

OR > 1 indicating a higher risk of reporting (1) not to engage in sport, and (2) no vigorous PA

OR odds ratio, CI confidence interval

as a barrier (Lopez-Quintero, Berry, & Neumark, 2010).

Implications for PA promotion in Germany

Our analysis confirms that factors of age, income, education and migrant background continue to contribute to differentials in sport and vigorous PA participation in Germany. For policy-making at the national, regional and local level, this implies that PA promotion should focus on systems-based actions that might reduce population-wide inequalities. Even

though policies and interventions that promote PA among vulnerable groups were implemented in Germany in the past (BZgA, 2021), these efforts apparently did not succeed in diminishing existing social gradients at population level: This pertains to differences in health, life expectancy as well as PA (Lampert, Kroll, Kuntz, & Hoebel, 2018). Potentially, this is due to the fact that behavior-oriented programs are widespread in Germany, but rather reach people with a medium to high socioeconomic status (Jordan, Weiß, Krug, & Mensink, 2012). Additionally, the fragmented structures of PA

promotion in Germany might pose another barrier for the scaling-up of successful interventions (Gohres & Kolip, 2017). In order to reduce such inequalities, countries, regions and cities could start by implementing the recommendations of the “Health 2020” policy framework to set common objectives between health and other sectors, to address social inequalities and to take action on the social and environmental determinants of health (WHO/Europe, 2013). However, it has to be recognized that the reduction of inequalities is a rather chronic health policy problem (Peters, 2005; Rütten, Abu-Omar, Gelius, & Schow, 2013).

In the field of PA promotion, policy actions such as transport infrastructure improvements, modifications to the built environment, or school-based programs might benefit more people than offering individual PA/exercise programs. In addition, there may be a need for funding specific PA programs that explicitly target vulnerable groups. Decision-makers and program planners should identify the specific needs of these populations, as this is considered a main good practice characteristic of PA policies and interventions (Horodyska et al., 2015). For assessing target group needs, participatory planning mechanisms can be used during project design and implementation (Rütten, Abu-Omar, Frahsa, & Morgan, 2009).

With respect to sport, Germany’s sport club system has been traditionally supported by high levels of volunteerism and extensive government support, thus helping it to keep membership fees low for large segments of the population. However, our results suggest an ongoing need and a large potential to increase sports participation among socially disadvantaged population groups, either within the German sport club system or by providing novel incentives that help engage those most in need of PA and sports participation.

At the level of national public health policy, the dearth of large-scale surveillance data for PA and sport in Germany and the added value of our pooled data set underline the need for a consistent, standardized nationwide health/PA surveillance

lance system that includes the use of sensor-based objective data.

Methodological limitations

When interpreting our results, one should bear in mind that our pooled data analysis comes with a number of methodological limitations. For one, prevalence estimates vary widely across the individual studies due to different self-report measures of PA and sport utilized. It is well known that PA self-reports have limited reliability and validity (Steenen-Johannessen et al., 2016).

In comparison to the other data sets, in GEDA 2014 a domain-specific PA questionnaire was used and information on work-related, transportation-related and leisure-time PA was considered when constructing the vigorous PA indicator. This methodological difference may explain the substantially different prevalence estimates this data set yields (Finger et al., 2015). We thus decided to not utilize the data set in the pooled analysis.

Furthermore, most monitoring systems focus on vigorous PA and thus might underestimate light and moderate PA, which are also highly relevant for health-related outcomes (Füzéki, Engeroff, & Banzer, 2017). This might have led to an underestimation of PA in selected samples. Additionally, the data indicate neither short bouts of activity (less than 10 min) nor sitting behavior. This information would also be relevant, in particular as there is a growing body of evidence on the health benefits of avoiding long periods of sitting (Bailey & Locke, 2015; Peddie et al., 2013).

Finally, societal changes and cohort effects have taken place in the timespan during which the data were collected. Such cohort effects might have affected PA and sedentary behaviors, at least in some population groups. They could be caused by digitalization or changing attitude towards the importance of sport and PA for health across birth cohorts. The current study did not account for such potential cohort effects.

Conclusions

The study pooled different surveys that featured different ways of assessing PA and sports participation, as well as different methodologies for data collection to identify time trends in correlates and determinants. While it is important to acknowledge these limitations, the consistency of the pattern of correlates provides a strength to the veracity of their persistence. For future research, pooling single studies with smaller samples might allow researchers to investigate PA and sports participation in other specific disadvantaged population groups (e.g., single parents of young children, people with obesity class 2 or 3), even if their number is too small for a meaningful analysis in each of the individual surveys.

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Declarations

Conflict of interest. K. Abu-Omar, S. Messing, M. Sarshar, P. Gelius, S. Ferschl, J. Finger and A. Bauman declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies performed were in accordance with the ethical standards indicated in each case.

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Appendix

Table 5 Sport- and physical activity (PA)-related questions and answer categories in data sets				
Survey/Year	PA question	Answer categories	Sport question	Answer categories
Allbus 1998 2004 2014	–	–	Please tell me here too, how often do you do the following in your leisure time: Do sports	– Never – Less often – At least once a month – At least once a week – Every day
GESIS Panel 2018	–	–	How often do you do sports in your leisure time? Please only think about active physical exercise	– Never – Less than once a month – At least once a month – Several times a month – More than once a week – Daily
BGS 1998	When answering the questions (...), please only think about the last 3 months. In your leisure time, how often do you engage in sport or other physically demanding activities that make you sweat or lose your breath?	– Daily – 3–6 times per week – 1–2 times per week – Less often, about once a month – Never	When answering the questions (...), please only think about the last 3 months. How often do you play sport?	– No sport-related activity – Less than 1 h per week – Regularly, 1–2 h per week – Regularly, 2–4 h per week – Regularly more than 4 h per week
GEDA 2009 2010 2012	On how many days per week are you physically active to an extent that makes you sweat or lose your breath? Note: Please consider an average week	Number of days 0	Think about the last 3 months: Did you play sports?	– Yes – No
	And on these days, for how long are you physically active on average?	– 60 min and more – 30 min to less than 60 min – 10 min to less than 30 min – Less than 10 min	And roughly for how many hours per week did you do so?	– More than 4 h – Up to 4 h – Up to 2 h – Up to 1 h – Or less
GEDA 2014	In a typical week, on how many days do you bicycle for at least 10 min continuously in order to get to and from places?	Number of days 0	In a typical week, on how many days do you carry out sports, fitness or recreational (leisure) activities for at least 10 min continuously?	Number of days 0
	When you are working, which of the following best describes what you do?	– Mostly sitting or standing – Mostly walking or tasks of moderate physical effort – Mostly heavy labor or physically demanding work – Not performing any working tasks	–	–
GSTel 2003	–	–	Think about the last 3 months: Did you play sports?	– Yes – No
	–	–	And roughly for how many hours per week did you do so?	– Up to 1 h – Up to 2 h – Up to 3 h – Up to 4 h

Table 5 (Continued)

Survey/Year	PA question	Answer categories	Sport question	Answer categories
NBS 2006	<i>The following question pertains to your everyday physical activity that makes you lose your breath at least a little, e.g., during work, traveling from place to place, or as part of your household chores or garden work (e.g., speedy walking, speedy biking, garden work, household chores). For the following statements, please only check the one that applies best to you (please only check one)</i>	– No physical activity and no intention to start in the next 6 months – No physical activity but intention to start in the next 6 months – Some physical activity, but not regular (i.e., less than 5 times per week for at least 30 min) – Some regular physical activity (i.e., less than 5 times per week for at least 30 min), but only started in the last 6 months – Some regular physical activity (i.e., less than 5 times per week for at least 30 min), started longer than 6 months ago	<i>The following questions are about how much sport you play in your leisure time, and about your fitness. How often do you play sport?</i>	– Regularly, more than 4 h per week – Regularly, 2–4 h per week – Regularly, 1–2 h per week – Less than 1 h per week – I don't play sport
SHARE 5 2013	We would like to know about the type and amount of physical activity you do in your daily life. How often do you engage in vigorous physical activity, such as sports, heavy housework, or a job that involves physical labor?	– More than once a week – Once a week – One to three times a month – Hardly ever, or never	–	–
DEGS1 2011	<i>When answering the questions (...), please only think about the last 3 months. On how many days per week are you physically active to an extent that makes you sweat or lose your breath? Please consider an average week</i> <i>And on these days that your physical activity makes you sweat or lose your breath, for how long are you physically active on average?</i>	Number of days 0 – Less than 10 min – 10 to less than 30 min – 30 to less than 60 min – More than 60 min	<i>When answering the questions (...), please only think about the last 3 months. How often do you play sport?</i>	– No sport-related activity – Less than 1 h per week – Regularly, 1–2 h per week – Regularly, 2–4 h per week – Regularly, more than 4 h per week

For surveys listed in *italics*, no official English translation was available. The questions and answers for these surveys were translated by the authors

The categories used to identify respondents who reported no sport activity or no (vigorous) PA are marked in **bold**

The cut-off points we used to identify inactive respondents are indicated in **bold**

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