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Physical activity, self-rated fitness and stress among 55,185 men and women in the Danish Capital Region Health survey 2017

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ABSTRACT

Previous studies have indicated that both low physical activity and low physical fitness are associated with a higher level of stress but the influence of age and health status on the associations is unknown. This was examined in a cross-sectional study based on data from the Danish Capital Region Health Survey 2017. Among all adults ≥ 16 years residing in the largest of five regions in Denmark 1. January 2017 a random sample of 104,950 was invited to participate. Hereof, 55.185 responded (52,6%). Physical activity during leisure time, fitness, self-rated health and stress (Cohens Perceived Stress Scale) was self-reported by questionnaire. Logistic regression weighted for size of municipality and non-response was used. Age modified the associations. In all age-groups odds ratio (OR) for a high level of stress was increasingly higher the lower the level of physical activity. The association was strongest among the 16–24-year-olds and persisted after adjustment for self-rated health, that otherwise attenuated the associations to an increasing extent the older the age-group. Similar models investigating the modifying effect of age on the association between self-rated fitness and stress showed the same patterns and tendencies. This study showed that physical activity and self-rated fitness were both associated with stress. The OR for a high level of stress was increasingly higher the lower the level of physical activity or self-rated fitness. This was found in all age-groups, but most pronounced among the 16–24-year-olds. Furthermore, findings suggest that health condition explains the associations to an increasing extent with increasing age.

1. Introduction

Mental health problems such as stress, depression and anxiety, are major public health challenges that cost over EUR 600 billion each year and affect more than one in six in the European Union (OECD, 2018). Stress is a condition that occurs when demands are perceived to exceed the adaptive capacity of an individual (Cohen et al., 2007); it is associated with poor psychological well-being and can lead to various physical health problems as well as other mental health problems (Cohen et al., 2007). In 2017, one quarter of the citizens in Denmark above 16 years of age reported a high level of stress, but the prevalence of high stress differed by age and was most prevalent among younger women (Jensen et al., 2017). In accordance, a US national survey found the highest level of stress among women and among young adults (American Psychological Association, 2013).

Evidence of a beneficial association between a high level of physical activity and lower risk of depression (Bennie et al., 2020; Mammen and Faulkner, 2013; Choi et al., 2019; Rethorst et al., 2009), anxiety symptoms (Herring et al., 2010) and general mental health (Chekroud et al., 2018; White et al., 2017; Biddle, 2016) has been established in studies including *meta*-analyses and systematic reviews of prospective studies and intervention studies. Correspondingly, an association between a high level of physical activity or physical fitness and a lower level of stress has been suggested in adult and adolescent populations but evidence regarding this specific relationship is less well-established (Schnohr et al., 2005; Aldana et al., 1996; Gerber et al., 2014; Moljord et al., 2011; VanKim and Nelson, 2013; Jonsdottir et al., 2010; Herbert et al., 2020; Soares et al., 2019; Algren et al., 2018).

Leisure time physical activity is instrumental in health promotion and prevention of multiple chronic diseases and premature death at any

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age (Wen et al., 2011; Warburton et al., 2006; Löllgen and Papadopoulou, 2018). Furthermore, a recent study showed an association between adherence to physical activity guidelines and prevalence of twelve common chronic health conditions such as cardiovascular diseases, COPD, cancer and arthritis and clustering of these health conditions (Bennie et al., 2019;16(1):34.). Exercise training leads to adaptations of the neuroendocrine system and to a reduced level of circulating stress hormone levels (Hackney, 2006). Observational and experimental studies suggest that individuals who exercise or have a high level of physical fitness may have a lower physiological response to stress (Scully et al., 1998; Rimmele et al., 2007; Klaperski et al., 2014; Gerber et al., 2017). This suggests a stress-buffering effect of exercise and high physical fitness where reduced stress reactivity may constitute a mechanism of action for the beneficial effects of exercise in maintaining mental health (Zschucke et al., 2015). A reverse direction of the association has also been suggested based on findings from prospective studies indicating that stress may lead to a lower level of physical activity (Stults-Kolehmainen and Sinha, 2014).

A high level and intensity of physical activity may lead to improved fitness, but they are fundamentally different constructs. While physical activity is a multidimensional behavior (Caspersen et al., 1985), physical fitness is a characteristic of the individual that is partly genetically determined (Caspersen et al., 1985; Bouchard, 2012) and they may have different associations with stress.

The relative importance of physical activity and fitness for preventing stress may be stronger among younger than among older people. The prevalence of many chronic diseases and disability increases with age and these may be strong determinants for both a low level of physical activity and for a high level of stress. Therefore, health condition is an important confounder to consider in an investigation of the relationships between physical activity and physical fitness and stress in different age-groups. To the best of our knowledge it has not previously been systematically investigated whether the relationship between physical activity or physical fitness and stress is moderated by age, or how poor health affects the relationships in different age groups.

1.1. Aims

The aim of this large cross-sectional study was to investigate the association between physical activity and stress and between physical fitness and stress. Secondly, to investigate whether age modified these associations taking the role of physical health into account.

Our hypothesis is that both a low level of physical activity and poor physical fitness is associated with a high level of stress in all age groups but that the strength of the association may differ in different age-groups. Further, we hypothesize that physical health explains the associations to an increasing extent with increasing age.

2. Methods

2.1. Study population

The cross sectional survey The Danish Capital Region Health Survey 2017 (DK-CRHS) was part of The Danish National Health Survey (DNHS). The aim of these studies is to monitor the status and trends in physical and mental health, health behavior and morbidity in the adult (⩾16 years) Danish population (Christensen et al., 2020). Denmark is diveded into five regions, of which the largest is the Capital Region. Among all adults ≥ 16 years residing in the Capital Region 1. January 2017, 104,950 adults were extracted as a random sample drawn from the Danish Civil Registration System by a personal identification number (CPR number) and were invited to fill in a questionnaire. The CPR number was also used to link to data on sex, age and socioeconomic status from central registers. The response rate was 52,6% corresponding to 55,185 respondents. Written informed consent was given by the participants when returning the questionnaires.

2.2. Main exposure variables

Physical activity during leisure time: one question on total time spent in physical activity of moderate and vigorous intensity (MVPA) during leisure time *and* commuting in hours and minutes per week (question one) and one question on how much of this time is spent specifically in vigorous intensity physical activity (VPA) (question two). Information about time spent in VPA was retrieved from question two and time spent in moderate intensity physical activity (MPA) was calculated from both questions. Based on WHO's recommendation of minimum 150 min per week in moderate physical activity or minimum 75 min in vigorous physical activity per week or equivalent combinations hereof, the respondents were categorized in four categories according to whether the WHO recommendations were met: Physically inactive (0 min MPA and VPA time), insufficiently physically active (sum of MPA/150 and VPA/75 is > 0 and < 1), sufficiently physically active (sum of MPA/150 and VPA/75 is >=1 and < 2), optimally physically active (sum of MPA/150 and VPA/75 >=2)

Self-rated fitness: a single question: "how do you rate your physical fitness?" with 5 response categories: very good, good, moderate, fair or poor. These were collapsed into three categories: very good/good, moderate and fair/poor

The questions have been validated (Sagelv et al., 2020; Danquah et al., 2016; Jensen et al., 2018).

2.3. Outcome

Stress (perceived psychological stress (PSS)) was assessed by the ten-question version of Cohens Perceived Stress Scale (Cohen et al., 1983) that asseses to which extent everyday life was considered stressful (unpredictable, uncontrollable or overloaded) for the last four weeks with 5 categories: (0 = never, 1 = almost never, 2 = sometimes, 3 = fairly often, 4 = very often). The theoretical range of the score is from 0 to 40 (Cohen et al., 1983). The cut-point of high stress was based on the level of PSS in DNHS of men and women in 2010 and defined as the highest scoring quintile (≥18) (Jensen et al., 2017).

2.4. Covariates

2.4.1. From the self-administered questionnaire:

Smoking status: one question categorised as daily/occasional smoker yes/no.

Alcohol intake: average intake of alcohol each day of the week. Alcohol intake was categorised according to recommendation from the Danish Health Authorities as weekly intake of beer, wine and spirits: low (0-7 units for women and 0-14 units for men), moderate (8–14 units for women and 15–21 units for men); overuse (>14 units for women and > 21 units for men).

BMI (kg/m^2): self-reported height and weight categorised as ≤ 18.5; 18.5 < BMI < 25; 25 ≤ BMI < 30; 30 and above according to WHO.

Self-rated health: "In general, would you say that your health is excellent, very good, good, fair or poor?" Categorised as excellent/very good/good or fair/poor. As a marker of physical health, poor self-rated health is well-known to be independently associated with both chronic disease and mortality (Latham and Peek, 2013; DeSalvo et al., 2006).

2.4.2. From central registers:

Sex and age: the Danish Civil Registration System. Age was categorised in seven categories: 16–24, 25–34, 35–44, 45–54, 55–64, 65–79, 80+.

Socioeconomic status (SES) was assessed as neighbourhood socioeconomic status. A score based on the distribution in quartiles of the educational level, employment status and mean gross income of the residents was calculated and a composite measure was formed, allocating each of the 29 municipalities of the Capital Region of Denmark and 10 districts of Copenhagen into one of four municipality social

groups (MSG). Information was collected from the Danish Population's Education Register (PER) and the Employment Classification Module (AKM) and the Income Statistics Register (Bernsdorf et al., 2016).

2.5. Ethics

Approval from the Danish Health Research Ethics Committee System was not required according to Danish law, as the research project was purely based on data from questionnaires and National registers.

2.6. Statistical methods

Survey design weights were used to adjust for size of municipality and furthermore weights to account for possible differential non-response were applied based on the following factors: sex, age, ethnicity, education, income, work status, civil status, visits in general practice, admissions to hospital and ownership of property. Weights were calculated by Statistics Denmark. Survey methods were used in all analyses.

In the descriptive analyses, the distribution of variables in the total study population and according to sex was calculated.

The correlation between physical activity and self-rated fitness was explored by Goodman and Kruskals gamma.

Exposure variables and all covariates were kept as categorical variables. The outcome: a high level of stress was dichotomized in the logistic regression analyses.

Survey logistic regression was used. From among available covariates, potential confounders were selected a priori based on current knowledge from the literature (Jensen et al., 2017; Algren et al., 2018; Scully et al., 1998; Tavolacci et al., 2013; Noble et al., 2015; Meader et al., 2016). The basic model 1 was adjusted for sex and age. Model 2 was additionally adjusted for smoking, alcohol, BMI and SES. Model 3 was model 2 further adjusted for self-rated health. Model 2.1 was model 2 with mutual adjustment for physical activity and self-rated fitness respectively.

Interaction between age and physical activity or self-rated fitness respectively, was investigated in separate models including their product terms (age*physical activity or age*self-rated fitness). In a secondary analysis interaction with sex was correspondingly investigated in models including the interaction terms: (sex*physical activity or sex*self-rated fitness), as it has previously been recommended to also take sex differences into account (Scully et al., 1998).

The models including an interaction term are reported as model 1a, 2a and 3a for the association between physical activity and stress and as 1b, 2b and 3b for the association between self-rated fitness and stress.

Statistical analyses were performed using the statistical package Statistical Analysis System (SAS) version 9.4. In all analyses, $p < 0.05$ was considered statistically significant.

3. Results

Table 1 shows the number of respondents, number of missing and the weighted percentages among 55,185 men and women participating in the survey. The prevalence of a high level of stress was 25.7% among all participants, 29.8% among women and 21.4% among men.

Table 2 shows a statistically significant association between level of self-reported physical activity and stress and between self-rated physical fitness and stress among all respondents. In the basic model OR of having a high level of stress increased with decreasing level of physical activity and with decreasing level of self-rated fitness. Adjustment for covariates in model 2 only reduced the estimates slightly and the estimates remained statistically significant. Further, mutually adjusting for physical activity and self-rated fitness attenuated the estimates for the association between physical activity and stress, while the association between self-rated health and stress was only slightly changed (model 2.1, Table 2).

Table 1
Characteristics (number and weighted percentage) among all 55,185 men and women in the Danish Capital Region Health Survey 2017 and according to sex.

	All (n = 55,185)	Men (n = 24,895)	Women(n = 30,290)
	n	(% of all men) #	(% of all women) #
Age			
16–24	5461	13.4	15.2
25–34	6832	18.3	18.6
35–44	8241	17.2	16.5
45–54	10,217	17.4	16.2
55–64	9325	13.8	12.6
65–79	12,428	15.8	15.6
80	2683	4.1	5.3
Level of physical activity			
Physically inactive	3706	7.8	8.2
Insufficiently physically active	8961	17.3	18.4
Sufficiently physically active	10,285	19.2	21.6
Optimally physically active	25,295	55.6	51.8
Missing	6938		
Self-rated fitness			
Fair/poor	12,979	21.5	26.6
Moderate	21,074	36.9	39.7
Very good/good	19,982	41.6	33.7
Missing	1150		
BMI			
Underweight (BMI ≤ 18.5)	1269	1.4	4.1
Normal weight (18.5 < BMI < 25)	26,875	47	58
Overweight (25 ≥ BMI < 30)	17,868	38.1	24.9
Obese (BMI ≥ 30)	7712	13.5	13
Missing	1461		
Smoking status			
Yes	10,704	26.1	20.8
No	43,421	73.9	79.2
Missing	1060		
Alcohol intake per week			
No/low	41,141	79.3	78.5
Moderate*	7022	10.7	14.7
High**	4432	10	6.8
Missing	2590		
Self-rated health			
Very good/good	46,866	86.5	83.4
Fair/poor	8,101	13.4	16.5
Missing	218		
Socioeconomic status (Neighbourhood SES)			
1 Highest			
2 High middle	13,927	21	21.6
3 Low middle	13,956	31.7	32.2
4 Lowest	14,115	21.4	21.3
	13,187	25.9	24.9

*Moderate: 8-14U/week for women and 15–21 U/week for men.
**High: > 14U/week for women and > 21 U/week for men.
#The percentages displayed are weighted for non-response and stratified sampling and can therefore not be calculated from the number of respondents.

The correlation between level of physical activity and self-rated fitness was investigated, showing a gamma coefficient of −0.5931 ($p < 0.001$).

Interaction was found between age and both physical activity and self-rated fitness when adjusted for age and sex (model 1a and 1b) as well as lifestyle and SES (model 2a and 2b). Neither in the basic model 1a and 1b nor in the further adjusted model 2a and 2b statistically significant interaction was seen between sex and neither physical activity nor self-rated fitness.

Figures show OR for a high level of stress according to level of physical activity (Fig. 1) and self-rated fitness (Fig. 2) in each of the different age-groups. The reference group is 16–24-year-olds with optimal level of physical activity and very good/good self-rated fitness, respectively.

In Fig. 1A for physical activity (and Table A.1 in appendix) the same

Table 2
Odds ratio (OR) and 95% confidence interval (CI) for a high level of stress according to level of physical activity and self-rated fitness among 55,185 men and women in the Danish Capital Region Health Survey 2017.

	No[#]	Basic model 1[§] OR	95% CI	Model 2[§§] OR	95% CI	Model 2.1[§§§] OR	95% CI
Level of physical activity							
Optimal	25,295	1		1		1	
Sufficient	10,285	1.14	1.06 – 1.23	1.11	1.03 – 1.19	0.85	0.79 – 0.92
Insufficient	8961	1.63	1.52 – 1.75	1,51	1.40 – 1.63	0.96	0.89 – 1.04
Inactive	3706	2.47	2.25 – 2.71	2.24	2.02 – 2.46	1.28	1.15 – 1.42
Self-rated fitness							
Very good/ good	19,982	1		1		1	
Moderate	21,074	1.76	1.65 – 1.88	1.71	1.59 – 1.83	1.75	1.62 – 1.89
Fair/poor	12,074	4.05	3.78 – 4.33	3.78	3.51 – 4.08	3.71	3.39 – 4.06

[§] Basic model 1: Adjusted for sex and age. [§§]Model 2: Adjusted for sex, age, smoking, alcohol consumption, BMI and SES (neighbourhood SES). [§§§]Model 2.1: Adjusted for sex, age, smoking, alcohol consumption, BMI, SES (neighbourhood SES) and mutual adjustment for level of physical activity and self-rated fitness. [#]These numbers are unweighted.

pattern was seen in all age-groups both in the basic model 1a and further adjusted model 2a: compared to those 16–24 of age with optimal physical activity, OR of a high level of stress increased with decreasing level of physical activity. However, there was a tendency of a reduced OR for a high level of stress with increasing age-group at all levels of physical activity, except among those physically inactive.

In Fig. 1B (and in Table A.1 in appendix) it is seen that that further adjusting for self-rated health in model 3a attenuated the associations, but to an increasing degree with increasing age-group up till age 80 + and most pronounced in the least physically active group. However, the same tendency, that OR of having a high level of stress increased with decreasing level of physical activity, was still visible in most age-groups.

Fig. 2 shows the results of a similar model investigating the association between level of self-rated fitness and stress, taking the interaction between self-rated fitness and age into account. This showed an even stronger association but otherwise the same patterns and tendencies as for the association between physical activity and stress both in the basic model 1b and the further adjusted model 2b (Fig. 2A and Table B.1 in appendix).

Further adjustment for self-rated health in model 3b also attenuated the associations, especially among those with the lowest level of fitness, and to an increasing degree with increasing age-group up till age 80+ (Fig. 2B and Table B.1 in appendix).

An analysis of the association between age and level of stress in a model adjusted for sex showed that the OR of a high level of stress was highest among the 16–24-year-olds (reference group) and became less pronounced with increasing age-group from age 25–34: (OR 0.87 95% confidence interval (CI) 0.80–0.95) to age 65–79: (OR 0.49 95% CI 0.45–0.53).

4. Discussion

A low level of physical activity and poor self-rated fitness, respectively, was associated with a high level of stress in this large population-based survey of + 16-year-old, Danish men and women. This finding is in accordance with previous studies finding similar associations (Schnohr et al., 2005; Aldana et al., 1996; Gerber et al., 2014; Moljord et al., 2011; VanKim and Nelson, 2013; Jonsdottir et al., 2010; Herbert et al., 2020; Soares et al., 2019; Algren et al., 2018). This indicates that a high level of physical activity may prevent stress.

The novel finding of this study is the different associations in different age-groups, that the associations seems to be most significant in the younger age-groups and the finding that health status may explain much of the associations in the older age-groups. These findings emphasize the importance of taking age and health status into account in future studies of the associations between physical activity or fitness and stress and in the interpretation of results from studies in selected age-groups.

In all age-groups the same pattern indicating that the OR of having a high level of stress increased with decreasing level of physical activity or

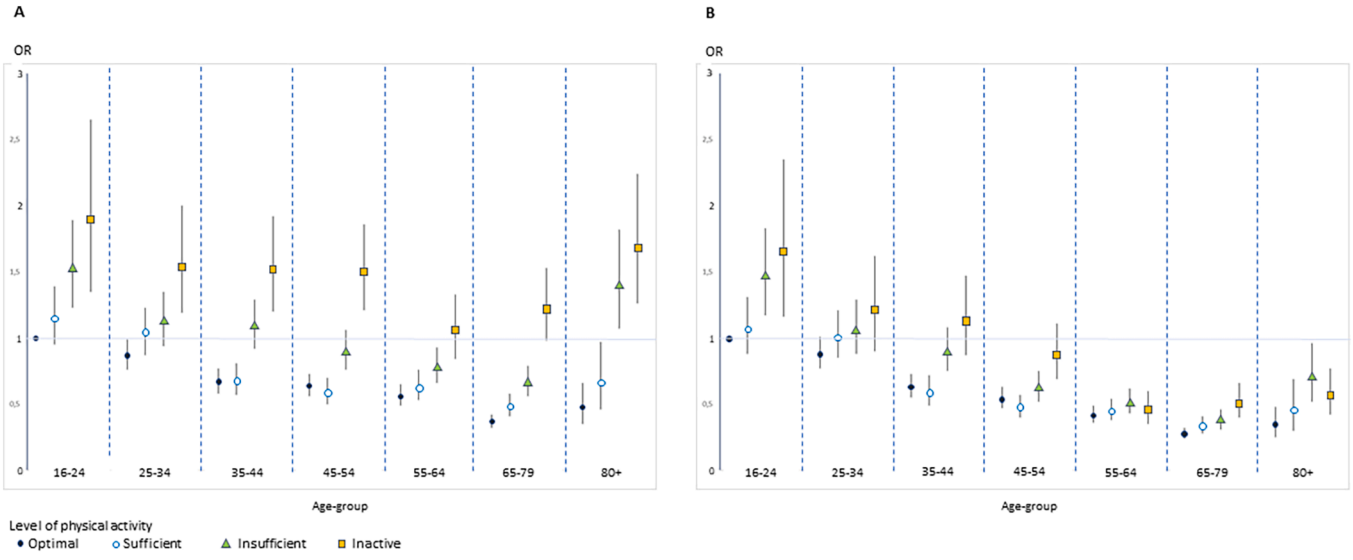

Fig. 1. Odds Ratio and 95% confidence interval for a high level of stress according to different combinations of age and level of physical activity compared to 16–24-year-olds with optimal level of physical activity, in two adjusted analyses shown in A and B. 55,185 men and women in the Danish Capital Region Health Survey 2017.

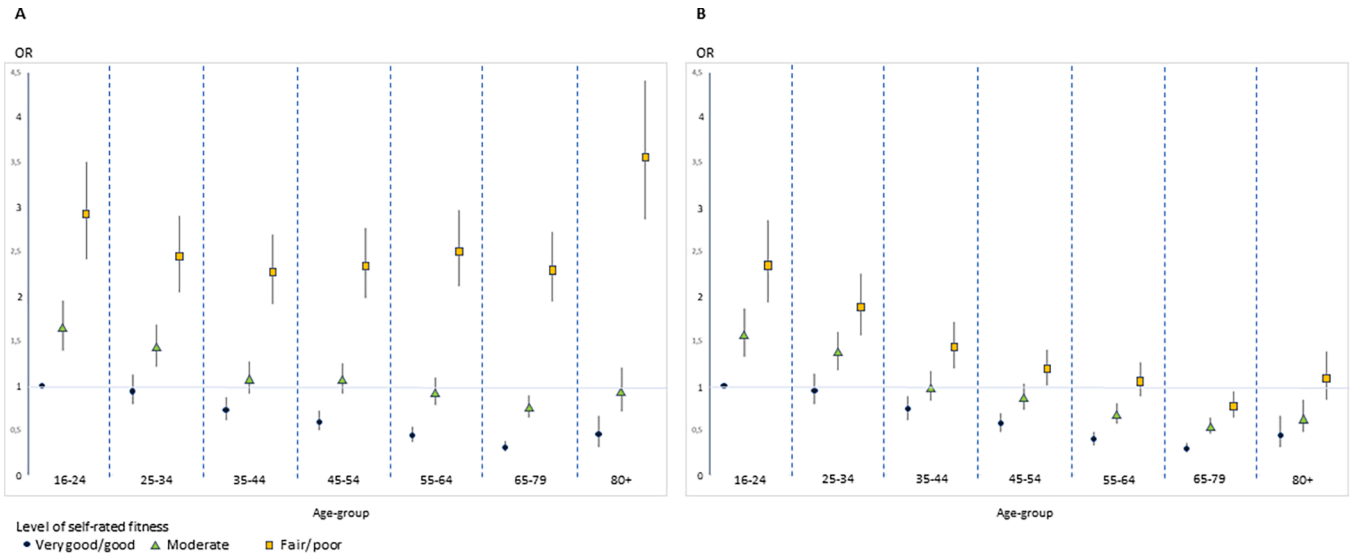

Fig. 2. Odds Ratio and 95% confidence interval for a high level of stress according to different combinations of age and level of self-rated fitness compared to 16–24-year-olds with very good/good self-rated fitness, in two adjusted analyses shown in A and B. 55,185 men and women in the Danish Capital Region Health Survey 2017.

self-rated fitness was observed. However, the strongest associations were found in the youngest age-groups especially among the 16–24-year-olds. A tendency of decreasing ORs for a high level of stress with increasing age was seen at any level of physical activity and self-rated fitness except among those least physically active or fit. This decrease may be partly explained by the finding of decreasing OR for a high level of stress with older age. However, it may also indicate that being physically active or having good physical fitness is relatively more important for prevention of stress in the young than in the older age-groups. And alternatively, if stress may also lead to physical inactivity, a high level of stress could be a more important determinant for physical inactivity in the youngest age-groups while poor health may be more important in older age-groups. In accordance, a study on physical activity and depressive symptoms suggested that while physical activity may prevent depressive symptoms at all ages, depressive symptoms seemed to be a barrier to physical activity only in young adults before midlife (Pinto Pereira et al., 2014). Adolescence is a time where individuals are particularly vulnerable to stress (Chrousos, 2009). As stress may have prolonged health effects, young adults are an important target-group in future studies on the impact of physical activity or fitness for prevention of stress.

With increasing age, self-rated health explained the association between level of physical activity and stress and between self-rated fitness and stress to an increasing extent, especially among those with the lowest level of physical activity and fitness. The prevalence of chronic disease and disability increases with age, and this may lead to inability to be physically active and to a decline in physical fitness. This may be especially reflected among those with the lowest levels of physical activity or fitness. Furthermore, there is an association between chronic disease and disability and stress (Vancampfort et al., 2017). This could partly explain why the associations were increasingly explained by confounding from poor health with increasing age.

We investigated the independent relationships between physical activity and stress and between self-rated fitness and stress and found similar patterns for the associations, albeit with a stronger association with physical fitness. Fitness seemed to explain much of the association between physical activity and stress whereas the association between self-rated fitness and stress was not explained by physical activity. Although there is a correlation between physical activity and fitness and that fitness can be improved by a high level and intensity of physical activity, this could imply that fitness is most important in relation to stress. There are important differences in their properties that could explain the findings. Physical activity is a multidimensional behavior (Caspersen et al., 1985) whereas physical fitness is a characteristic of the individual (Caspersen et al., 1985; Bouchard, 2012), that is also determined by genetics (Bouchard, 2012). Furthermore, physical activity may have a social component where social interaction and interpersonal communication can act as coping strategies that may decrease perceived stress. It has been suggested that the beneficial effect of physical activity and fitness on mortality may act through different mechanisms (Bahls et al., 2018). Whether there may also be different mechanisms for physical activity and fitness in relation to stress, remains to be examined in future studies.

4.1. *Strengths and limitations*

The large size of this population-based survey allows for an investigation of the associations in different age groups and with adjustment for important confounders including self-rated health. The response rate was just over 50% but to account for possible bias due to differential non-response we used survey design weights based on sex, age, ethnicity, education, income, work status, civil status, visits in general practice, admissions to hospital and ownership of property.

A cross-sectional study as the present does not allow for establishment of causality or determination of the direction of the found associations. This must be further investigated in future longitudinal studies.

A strength of the present study is the assessment of stress by a validated scale with high consistency over the last decades (Cohen et al., 1983). There is, however, no predefined cut-point for PSS-defined stress and individuals classified as having a high level of stress do not necessarily perceive themselves as having a high level of stress. Physical activity and fitness as well as height, weight and thereby BMI were self-reported which may lead to misclassification. Although both physical activity and fitness are self-reported it is unlikely that they capture the same construct. Fitness is assessed by one global question of how persons rate their own level of fitness. The question has been shown to have moderate correlation with measured cardiorespiratory fitness (Jensen et al., 2018). Physical activity is assessed by two questions on the time

spent in moderate and vigorous physical activity and is categorized according to the recommendations of WHO (Danquah et al., 2016). Both questionnaire-based assessment of physical activity and assessment of fitness by a single-item question has been shown to be useful for ranking individuals in categories of physical activity and level of cardiorespiratory fitness in epidemiological studies (Sagelv et al., 2020; Petersen et al., 2021).

Another strength is the use of neighbourhood SES as a marker of SES. It includes information on educational level, employment status and income in the municipality and may furthermore indirectly reflect access to sports facilities and whether it is common to be physically active. A sensitivity analysis adjusted for individual educational level instead of neighbourhood SES showed the same results and tendencies (results not shown).

As physical activity may have a social component, the role of social relations (quality and quantity) would have been relevant to investigate. Likewise, duration and quality of sleep may be associated with both physical activity and stress or modify the association (Gerber et al., 2013) and may be an important confounder or effect-modifier to include in future studies.

5. Conclusions

In all age-groups, a low level of physical activity and poor self-rated fitness, respectively, was associated with a high level of stress. The OR of having a high level of stress increased with decreasing level of physical activity or self-rated fitness. Novel findings of this study were that the associations between physical activity or fitness and stress differed across age-groups and was most pronounced among those 16–24 of age, and that health condition seemed to explain the association to an increasing extent with increasing age.

Although causal effects and the direction of the associations cannot be established in a cross-sectional study, the results support the importance of being physically active and maintaining physical fitness for mental health especially among younger adults.

CRediT authorship contribution statement

Karen Allesøe: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing- review & editing, Visualization. **Cathrine Juel Lau:** Conceptualization, Methodology, Writing- review & editing. **Lone Prip Buhelt:** Conceptualization, Methodology, Writing- review & editing. **Mette Aadahl:** Conceptualization, Methodology, Writing- review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2021.101373.

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