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POOR SELF-RATED HEALTH IS ASSOCIATED WITH LOW- GRADE INFLAMMATION IN 43,481 LATE ADOLESCENT MEN OF THE GENERAL POPULATION

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10 **GRADE INFLAMMATION IN 43,481 LATE ADOLESCENT MEN**
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13 **OF THE GENERAL POPULATION**
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10 Self-rated health and inflammation in adolescent men
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Abstract

Objective

Self-rated health is a powerful predictor of long-term health and mortality, hence the importance of a better understanding of its biological determinants. Previous studies have shown that low-grade inflammation is associated with poor self-rated health in clinical and healthy populations, but the evidence is sparse in men and lacks completely for men in late adolescence.

The aim of this study was to investigate the association between low-grade inflammation and self-rated health in a very large population of late adolescent men.

Design

Data from 49,321 men (18-21 years) conscribed to military service in 1969 and 1970 was used.

Inflammation had been measured through erythrocyte sedimentation rate (ESR). Self-rated health had been self-assessed on a five-point scale. Data from 43,481 conscripts with subclinical levels of ESR remained after exclusion of those with ESR <1 and >11. Associations were calculated using logistic regression analyses and Ordinary Least Square (OLS) regression.

Adjustments were made for body mass index (BMI), socioeconomic position (SEP), inflammatory disease, emotional control, smoking, risky use of alcohol and physical activity.

Results

The odds of having Poor/Very poor self-rated health was 66 % higher for conscripts with elevated ESR levels ($\geq 7 < 11$) (OR:1.66; 95%CI:1.29-2.14).

Conclusion

This study adds to the evidence of an association between low-grade inflammation and poor self-rated health across the life span in both men and women, providing further support for

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3 inflammation as part of a general psychobiological process that underpins subjective health
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5 perception.
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10 **Strengths and limitations of this study**

- 11 • This is the first study to investigate the association between low-grade
12 inflammation and self-rated health in a large sample (n=49,321) of late adolescent
13 men.
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- 15 • Using data from the national military conscription register, encompassing nearly
16 all Swedish men born in 1949-1951, eliminates selection bias.
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- 18 • Adjustments were made for life-style patterns, demographic factors and
19 psychological disposition.
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- 21 • The cross-sectional design precludes conclusions about causality.
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29 **What is already known on this subject?** Further knowledge of biological correlates to self-
30 rated may provide a better understanding of the mechanisms behind the predictive properties of
31 poor self-rated health. The association between inflammatory markers and self-rated health has
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33 so far mainly been investigated in women. The current study investigates such an association in
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35 late adolescent men.
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42 **What this study adds?** The results from the present study suggests that inflammatory factors
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44 may be relevant for the biological underpinnings of self-rated health also in men of late
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46 adolescence and hence further support inflammation as a general factor in the psychobiological
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48 processes that underpin subjective health perception across the adult life span.
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INTRODUCTION

Self-rated health is a single-item measure of an individual's perceived health status. A number of studies show that poor self-rated health predicts future adverse health outcomes, such as cardiovascular events [1] and healthcare utilization [2], and is coupled to a near two-fold risk of premature mortality [3-5]. The predictive qualities of self-rated health remain after controlling for objective health and social and demographic risk factors [4].

Although the mechanisms that link self-rated health to future objectively verified ill-health are largely unknown, recent studies point at inflammation as an important determinant of how an individual perceives her global health status [6-8]. As part of the inflammatory response to acute infection or injury, pro-inflammatory cytokines such as interleukin (IL)-1 β , IL-6 and tumor necrosis factor (TNF)- α drive the acute phase response by increasing levels of acute phase proteins [9]. One of these proteins, fibrinogen, is a coagulation factor and is reflected by erythrocyte sedimentation rate (ESR). When inflammation is present, the fibrinogen causes erythrocytes to clot in rolls, thus sinking faster through a test tube, resulting in an increased ESR [10, 11]. Compared to other tests of inflammation, ESR is a simple and cost efficient way of establishing the presence of the acute phase reactants, and, indirectly, the activity of pro-inflammatory cytokines [9] making it a suitable marker of inflammation when collecting large amount of data.

One hypothesis to explain the observed association between low-grade inflammation and poor self-rated health is that inflammation related signals reach areas in the brain, including the insular cortex and the anterior cingulate cortex [12, 13], i.e. areas that are important in interpretation of bodily state and homeostatic changes [14]. As part of co-ordination of a sickness response, shifts in motivation and alterations of behaviors that promote healing and

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3 recovery are thereby induced [15]. Symptoms of such inflammation-induced sickness behaviors
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5 include anhedonia, fatigue and increased sensitivity to pain, which are also determinants of
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7 subjective health perception [16]. Since low-grade inflammation is part of the pathology in major
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9 causes of premature mortality, such as cardio-vascular disease (see e.g. [17, 18]), type-2 diabetes
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11 [19], obesity [20] and certain types of cancer [21, 22] low-grade inflammation could be one
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13 factor linking poor self-rated health with future adverse health outcomes.
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18 In order to investigate whether low-grade inflammation may be implicated in subjective
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20 health perception, a row of recent studies have examined the link between increased levels of
21
22 pro-inflammatory cytokines and poor self-rated health [6-8, 16, 23, 24]. Other studies have
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24 examined the association between self-rated health and fibrinogen [25], ESR [26] and of another
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26 acute phase reactant, C-reactive protein (CRP)[7, 23, 27, 28]. So far, the evidence of a link
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28 between low-grade inflammation and self-rated health is more robust for women as compared to
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30 men [6-8, 16, 27], and the strength of the association has been indicated to increase with age [6,
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32 16]. For instance, among 347 women 45 to 90 years old of the general population there was a
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34 significant association between IL-6 and poor self-rated health, particularly among those 65
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36 years old and above [6]. In another study, 174 female primary health care patients of 18 years
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38 and older who were divided into three age groups, higher TNF- α was significantly associated
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40 with poor self-rated health in all groups, and higher IL-1 β and IL-1 receptor antagonist was
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42 associated with poor self-rated health in those over 65 years old [16]. Moreover, in 235 middle-
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44 aged and elderly women with coronary heart disease, high levels of CRP and IL-6 were
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46 associated with poor self-rated health in those over 65 years old [16]. Moreover, in 235 middle-
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48 aged and elderly women with coronary heart disease, high levels of CRP and IL-6 were
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50 associated with poor self-rated health [7].
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54 Among the studies including both men and women, only two have performed sex-based
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56 stratified analyses [8, 27] and one study examined the interaction effect of sex and inflammation
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3 on self-rated health [28]. A study of 170 female and 89 male primary health care patients showed
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5 a significant independent association between higher IL-1 β and TNF- α and poor self-rated
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7 health only in women [8], but the lack of association in men could be due to small sample size
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9 and low power. Among 11,000 women and 5,000 men, a significant association between CRP
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11 and self-rated health remained only in women after adjustment for control factors [27]. However,
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13 in a population of 13,236 young adults aged 24-34 years, high sensitivity CRP above 3 mg/L was
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15 significantly associated with lower ratings of self-rated health after adjustment for health
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17 behaviors, self-reported illness and medication in both men and women. Inclusion of BMI fully
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19 attenuated the association between CRP and self-rated health in the women whereas a small but
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21 significant association remained in men [28].
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27 The remaining studies encompassing both men and women reported significant
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29 associations between IL-6 and self-rated health [23, 24], and between fibrinogen and self-rated
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31 health [25] but as these studies are only adjusted for sex it is not clear if this association would
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33 be found in the male or female strata only.
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36 The present study aims at investigating low-grade inflammation and subjective health
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38 perception in a very large, young and healthy population mainly free from medical conditions.
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40 We hypothesized that conscripts with elevated ESR levels had rated their health as poorer in this
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42 population of late adolescent men, a group that has not yet been investigated in this context.
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51 **METHODS**

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55 **Participants**

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3 This study was based on data collected in 1969 to 1970 when 49,321 Swedish men born
4 between 1949 and 1951 (aged 18-21 years) underwent a compulsory 2-day screening procedure
5 prior to military service. During this time period, only 2-3 % of men eligible for military services
6 were exempted from conscription, mainly due to severe disabilities or severe congenital
7 disorders. All conscripts had answered questionnaires about social background, habits,
8 psychological factors, social adjustment and health status and had been structured-interviewed by
9 a psychologist. Finally, a physician examined all conscripts, and any somatic or psychiatric
10 disorders were diagnosed according to the Swedish version of the International Classification of
11 Disorders, version 8 (ICD-8). The present study was approved by the regional ethics board.
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27 Measures

31 Self-Rated Health

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34 The conscripts had been asked to assess their health, answering the question: “*In general,*
35 *would you say your health right now is: Very good, Good, Fair, Poor or Very poor*”? The
36 answers had been rated on a 5-point scale where 1=“Very good”, 2=“Good”, 3=“Fair”, 4=“Poor”
37 and 5=“Very poor”. Due to low numbers in the categories “Poor” and “Very poor”, these were
38 combined into one category in the logistic regression analyses.
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48 Erythrocyte Sedimentation Rate

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50 At physical examination, blood samples had been taken and ESR had been measured
51 according to standard laboratory procedures (Westergren method)[9]. The ESR is affected by the
52 hematocrit (Htc, i.e. the proportion of whole blood made up by erythrocytes), we therefore
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corrected the ESR values for the hematocrit according to the formula $ESR * Htc / 45$ [29]. Htc-corrected ESR values are used in all analyses and presentations of ESR values. Despite plausible inter-individual genetic variations [30], the upper limit of the normal range of ESR has, on group level, been found to correspond to the age in years divided by two [31]. The age span of the men included in this study ranged from 18 to 21 years. Based on the highest age included, the normal range was rounded off to < 11 mm/hr. Thus, the 3.7 % of the participants with $ESR \geq 11$ mm/hr ($n=3,937$) were excluded from the analyses. Those with $ESR < 1$ mm/hr ($N=1,903$) were also excluded in order to reduce error of misclassifications [32]. The remaining 88.2 percent % of the ($N=43,481$) conscripts had ESR levels $> 1 < 11$ mm/hr and were included in the analyses.

Body Mass Index

The conscripts' height and weight had been measured at the physical examination. Body mass index (BMI) is determined by calculating the ratio of weight to height squared (kg/m^2). Obesity and underweight as measured by very high or very low BMI have independently been associated with poorer self-rated health [33].

Socioeconomic Position

Parental socioeconomic position (SEP) was used as an indicator of childhood socioeconomic circumstances. Information about socioeconomic circumstances of the conscripts at 9 to 11 years of age was obtained from the National Population and Housing Census from 1960. The conscripts and the head of the household, usually the father, were linked through their personal identification number by Statistics Sweden. Based on the occupation of the head of the household seven socioeconomic groups were identified: (a) unskilled workers, (b) skilled

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3 workers, (c) assistant non-manual employees, (d) non-manual employees at intermediate level,
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5 (e) non-manual employees at higher level, (f) farmers, and (g) those not classified into a
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7 socioeconomic group. Self-employed persons could not be identified in the census from 1960
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9 where such persons were classified as employed according to occupation. Previous research have
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11 shown that childhood SEP is associated with markers of inflammation in adults [34, 35], and a
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13 previous study from this sample found a significant association between ESR and SEP [36], why
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15 SEP is included in the analyses.
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20 21 22 Inflammatory Disease

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24 Presence of one or more of the following medical conditions as registered for each
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26 conscript by a physician according to ICD-8 was adjusted for in the analyses: infectious disease,
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28 malignancies, lymphatic and haemotopoetic tumors, diabetes mellitus, asthma, gastrointestinal
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30 inflammation, hay fever, infection and inflammation in skin, arthritis and rheumatoid arthritis.
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35 36 37 Emotional Control

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39 The combined questionnaire and interview data had been used by a psychologist to
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41 evaluate emotional control rated on 5-point scale, based on self-reported anxiety, stress-
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43 tolerance, nervous problems, capacity for emotional commitment and control over aggression (a
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45 score of 1 to 2 represent *Low* emotional control). A previous study has shown that low emotional
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47 control was a confounding factor in the association between poor self-rated health and mortality
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49 [5] and was for that reason included in the analyses.
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54 55 56 Smoking

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3 Tobacco smoking has been associated with increased systemic inflammation in men [37,
4 38]. Smoking has also been associated with poor self-rated health [6, 39, 40] and was therefore
5 included in the analyses. The self-reported number of cigarettes smoked per day had been rated
6 on a 4-point scale where 1>20, 2=11-20, 3=1-10 cigarettes per day and 4=non-smoker.
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17 Risky use of alcohol was estimated based upon questions on high consumption of alcohol:
18 none vs. at least one of the following indicators– consumption of at least 250 g 100 % alcohol
19 per week; use of alcohol to alleviate a hangover; having been apprehended for drunkenness;
20 being drunk often.
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29 30 Physical activity

31 We used active membership in sport clubs as a proxy for physical activity.
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36 37 Statistics

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39 To calculate the association between ESR and self-rated health, logistic regression analysis
40 was used with ESR as the independent variable and self-rated health as the outcome variable
41 (Table 2). In the logistic regression analyses, the group was dichotomized into those with ESR
42 <7 mm/hr (n=41,064), and those with ESR \geq 7 mm/hr (n=2,417), a cut-off used in previous
43 analyses on this study sample [36].
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51 Self-rated health was classified into four groups: 1=Very good, 2=Good, 3=Fair, or
52 4=Poor/Very poor. The effects of having elevated ESR serum levels (\geq 7 mm/hr) on the odds of
53 having Good, Fair, or Poor rather than Very good (= reference) self-rated health was calculated.
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As a second step, the association between ESR serum levels and self-rated health was adjusted separately for background variables BMI, SEP, presence of inflammatory disease, emotional control, smoking, risky use of alcohol and physical activity. Third, in the full model, the association between ESR levels and self-rated health was adjusted for all background variables together.

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The association between ESR and self-rated health was also estimated using Ordinary Least Square (OLS) regression, in both univariate and multivariate models. In the adjusted models, the association between ESR and self-rated health was estimated adjusting for the effect of BMI, SEP, presence of inflammatory disease, emotional control, smoking, risky use of alcohol and physical activity. An α -value of .05 was used to test for statistical significance. All analyses were performed using SPSS statistics software version 21.

34 35 36 37 38 **RESULTS**

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Participant characteristics in total and separated for those with lower (<7 mm/hr) and those with higher (\geq 7 mm/hr) ESR are shown in Table 1. The majority of participants had ESR below 7 mm/hr (91.2 %) and reported their health as Very good or Good (82.4 %). Conscripts with elevated ESR levels tended to have poor self-rated health and farmer background with higher frequency. Conscripts with lower ESR levels tended to have good self-rated health and non-manual SEP background with higher frequency.

Table 1. Participant characteristics separately for those with ESR < 7 (n = 41,064) and ESR ≥ 7 (n = 2,417). Group differences in frequencies have been tested with Chi Square test and differences in means with t-tests.

Variable/category	ESR<7	ESR≥7	χ^2	Variable/category	ESR<7	ESR≥7	χ^2
Self-rated health (%)				SEP Father 1960 (%)			
Very good	41.1	34.8	22.17*	Worker, unskilled	33.3	35.6	3.42
Good	41.4	45.2	7.43*	Worker, skilled	21.5	21.7	0.07
Fair	13.8	14.6	1.01	Non-manual, assistant	10.1	9.5	0.88
Poor/Very poor	3.7	5.3	17.05*	Non-manual, intermed.	16.9	13.9	12.09*
Smoking per day (%)				Non-manual, higher	5.2	3.8	9.44 [†]
> 20 cigarettes	3.7	3.4	0.31	Farmer	10.7	13.2	13.05*
11-20 cigarettes	23.4	22.4	0.85	Non-classified	2.3	2.4	0.07
1-10 cigarettes	31.9	32.2	0.04	Year of Birth (%)			
Non smoker	41.1	41.9	0.36	1949	5.4	4.6	2.36
Inflammatory disease (%)	9.0	9.6	1.29	1950	17.3	16.2	1.75
Low emotional control (%)	30.3	30.0	0.12	1951	77.3	79.2	1.06
Risky use of alcohol (%)	15.7	16.6	1.23	Self-rated health, M (SD)	1.80 (0.82)	1.91 (0.85)	-5.90*

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Physical activity (%)	36.4	36.7	0.07	BMI, M (SD)	21.00 (2.57)	20.96 (2.80)	0.62
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* $p < .001$; † $p < .05$

BMI=body mass index, ESR= erythrocyte sedimentation rate, SEP=socioeconomic position.

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Table 2. Crude and adjusted odds ratio of reporting Good, Fair and Poor SRH as compared to Very good SRH (reference) in those with ESR ≥ 7 .

Adjusted for	Good	Fair	Poor
Crude	1.29 (1.17-1.41)	1.25 (1.10-1.42)	1.72 (1.42-2.09)
BMI	1.29 (1.17-1.41)	1.25 (1.10-1.42)	1.71 (1.41-2.08)
SEP	1.27 (1.16-1.40)	1.24 (1.09-1.41)	1.74 (1.43-2.11)
Inflammatory disease	1.29 (1.17-1.41)	1.25 (1.10-1.42)	1.75 (1.44-2.13)
Emotional control	1.29 (1.18-1.42)	1.24 (1.08-1.43)	1.69 (1.36-2.10)
Smoking	1.30 (1.19-1.43)	1.27 (1.11-1.44)	1.79 (1.46-2.19)
Risky use alcohol	1.25 (1.12-1.38)	1.22 (1.06-1.40)	1.58 (1.27-1.97)
Physical activity	1.29 (1.18-1.42)	1.24 (1.09-1.41)	1.72 (1.41-2.09)
All above	1.26 (1.13-1.40)	1.25 (1.07-1.46)	1.66 (1.29-2.14)

BMI=body mass index, SEP=socioeconomic position.

There was a dose-response pattern between self-rated health and ESR (Table 2). The poorer rating of health, the higher the odds of having ESR above 7, and, consequently, conscripts with ESR ≥ 7 mm/hr had significantly higher odds of rating their health as less than Very good than did conscripts with ESR < 7 mm/hr. The size of the association and the level of significance were largely unaffected by adjustments for BMI, SEP, inflammatory diseases, emotional control, smoking, risky use of alcohol and physical activity.

Ordinary Least Square (OLS) regression with 95% CI of the association between ESR and self-rated health is presented in Table 3. High levels of ESR were associated with poor self-rated health independent of BMI, SEP, presence of inflammatory disease, emotional control, smoking, risky use of alcohol and physical activity.

Table 3. Crude and adjusted associations between ESR and self-rated health calculated with Ordinary Least Square (OLS) regression presented as OLS coefficient with 95% confidence intervals and beta coefficients.

Adjusted for	Intercept	B	95% CI	beta	R ²
Crude	1.763	.016	.012-.020	.040	.002
BMI	1.966	.016	.012-.020	.039	.003
SEP	1.857	.016	.012-.020	.039	.002
Inflammatory disease	1.728	.016	.012-.020	.039	.021
Emotional control	1.595	.016	.013-.020	.040	.098
Smoking	1.657	.018	.014-.021	.043	.034
Risky use alcohol	1.738	.016	.012-.020	.039	.011
Physical activity	1.849	.016	.013-.020	.040	.022
All above	1.707	.017	.013-.021	.042	.133

BMI=body mass index, SEP=socioeconomic position.

DISCUSSION

The aim of this study was to investigate if there is an association between higher level of the inflammatory marker ESR and poor self-rated health in late adolescent men. The odds of having poor rather than very good self-rated health was elevated by approximately 70 % among individuals with higher (≥ 7 mm/hr) as compared with lower (< 7 mm/hr) ESR levels.

This pattern was stable when relevant confounders (BMI, SEP, presence of inflammatory disease, emotional control, smoking, risky use of alcohol and physical activity) were controlled for. Hence, the present result is consistent with our hypothesis and adds to previous findings by indicating that low-grade inflammation is associated with lower self-ratings of health, also in late adolescent men.

The results of the present study are in contrast with the lack of association between inflammatory markers and self-rated health in men in the studies by Lekander and coworkers [8] and Tanno and coworkers [27]. In comparison to the present study, those studies are based on dissimilar methods and populations, with older participants (mean age 59 and 58 years, respectively, compared to 18-21 years in the present study). The study the study by Lekander and coworkers had a considerably smaller sample size and Tanno and coworkers (27) had an Asian population. However, the present results are in concordance with a previous study that demonstrated a small but significant association between CRP and self-rated health in young adult men 24 to 34 years old [28].

Demographic factors and life-style patterns have been associated with both low-grade inflammation and to poor self-rated health; factors that may constitute possible confounders in the association between ESR and self-rated health, such as aging [41], obesity [42], low SEP

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3 [36], and smoking [6, 38]. Adjustments for BMI, SEP, inflammatory disease, emotional control,
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5 smoking, risky alcohol use, and physical activity did not, however, change the association
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7 between ESR and self-rated health in the present study. Also, individuals with a higher degree of
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9 inflammation did not introduce bias, as all conscripts with an ESR equal to or above 11 mm/hr
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11 were excluded. Unfortunately, data on diet was not available in the present study, which is a
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13 factor to take into account in future studies.
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17 Our study sample consisted of 43,431 conscripts encompassing the majority of all Swedish
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19 men born in 1949 to 1951. Having a study sample that represents such a large percentage of the
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21 population is obviously advantageous in terms of power, but also eliminates the risk for selection
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23 bias. In the present material of late adolescent men, the majority of participants were, as
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25 expected, healthy. Altogether 82.6 % rated their health as Good or Very good, and 82.7 % had
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27 ESR values ≥ 1 and < 7 mm/hr. It cannot be excluded that in a current-day sample of young men
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29 the included factors would be differently distributed, and that e.g. low-grade inflammation would
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31 be more prevalent as obesity, which has been linked with low-grade inflammation [43, 44],
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33 almost doubled in prevalence between 1971 and 1993 among Swedish military conscripts [45].
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35 However, the association between ESR and self-rated health in the present study was
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37 independent of background factors such as BMI and there is little reason to expect that the
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39 putative underlying biological mechanism by which inflammation is associated with subjective
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41 health perception would have changed.
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48 Concerning validity, some discordance between ESR and other inflammatory markers has
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50 been documented. For instance ESR has been shown to rise and decrease slower than CRP (see
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52 e.g. [46]). However, the dose-responsive and independent relation between self-rated health and
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3 ESR in the present study suggests that ESR is a marker for self-rated health, not merely
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5 reflecting manifest disease or chronic conditions.
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8 In conclusion, the present study showed for the first time, a significant association between
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10 a measure of inflammation and self-rated health in late adolescent men. Although its
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12 observational and cross-sectional design precludes any conclusions about causality, evidence is
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14 here provided to further support inflammation as a general factor in the psychobiological
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16 processes that underpin subjective health perception across the adult life span.
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21 **Contributors** ML, TH, BM, AA conceived of the study. CW drafted the manuscript.
22

23
24 KS and TH performed the statistical analyses. All authors were involved in the discussion of the
25
26 data and revised the manuscript for intellectual content.
27

28
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35 **Data sharing statement** The study uses data from the Swedish conscription cohort which
36
37 includes assessments of the physical and mental health status of all conscripts. Please contact the
38
39 corresponding author for further information on data availability.
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41

42 43 44 **References**

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POOR SELF-RATED HEALTH IS ASSOCIATED WITH LOW- GRADE INFLAMMATION IN 43,481 LATE ADOLESCENT MEN OF THE GENERAL POPULATION

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4 **POOR SELF-RATED HEALTH IS ASSOCIATED WITH LOW-**
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7 **GRADE INFLAMMATION IN 43,481 LATE ADOLESCENT**
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10 **MEN OF THE GENERAL POPULATION**
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3 Self-rated health and inflammation in adolescent men
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5 *Key words: self-rated health, erythrocyte sedimentation rate, low-grade inflammation,*
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7 *military conscripts*
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Abstract

Objective

Self-rated health is a powerful predictor of long-term health and mortality, hence the importance of a better understanding of its biological determinants. Previous studies have shown that low-grade inflammation is associated with poor self-rated health in clinical and healthy populations, but the evidence is sparse in men and lacks completely for men in late adolescence. The aim of this study was to investigate the association between low-grade inflammation and self-rated health among conscripts. It was hypothesized that high levels of inflammatory factors would be associated with poor self-rated health.

Design

Data from 49,321 men (18-21 years) conscribed to military service in 1969 and 1970 was used. Inflammation had been measured through erythrocyte sedimentation rate (ESR). Self-rated health had been assessed on a five-point scale and was dichotomized into *Good* ("Very good"/"Good"/"Fair") versus *Poor* ("Poor"/"Very poor"). Data from 43,481 conscripts with normal levels of ESR remained after exclusion of those with ESR <1 and >11 mm/hr. Associations were calculated using logistic regression analyses. Adjustments were made for body mass index, socioeconomic position, inflammatory disease, emotion regulation, smoking, risky use of alcohol and physical activity.

Results

High levels of ESR was associated with a higher odds for poor self-rated health (OR:1.077 for each unit mm/hr increase in ESR, 95% confidence interval: 1.049-1.105).

Conclusion

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3 The present study shows for the first time, a significant association between a marker of
4 inflammation and self-rated health in late adolescent men providing evidence of an
5 association between low-grade inflammation and poor self-rated health also in men, providing
6 further support for inflammation as part of a general psychobiological process that underpins
7 subjective health perception.
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13 14 15 16 **Strengths and limitations of this study**

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18 • This is the first study to investigate the association between low-grade
19 inflammation and self-rated health in a large sample (n=49,321) of late
20 adolescent men.
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- 22 • Using data from the national military conscription register, encompassing
23 nearly all Swedish men born in 1949-1951, eliminates selection bias.
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- 25 • Adjustments were made for life-style patterns, demographic factors and
26 psychological disposition.
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- 28 • The cross-sectional design precludes conclusions about causality.
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35 **What is already known on this subject?** Further knowledge of biological correlates to self-
36 rated may provide a better understanding of the mechanisms behind the predictive properties
37 of poor self-rated health. The association between inflammatory markers and self-rated health
38 has so far mainly been investigated in women. The current study investigates such an
39 association in late adolescent men.
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48 **What this study adds?** The results from the present study shows an association between a
49 marker of inflammation and self-rated health also in men of late adolescence providing further
50 support for inflammation as part of a general psychobiological processes that underpin
51 subjective health perception across the adult life span in both men and women.
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INTRODUCTION

Self-rated health is a single-item measure of an individual's perceived health status. A number of studies show that poor self-rated health predicts future adverse health outcomes, such as cardio-vascular events [1] and healthcare utilization [2], and is coupled to a near two-fold risk of premature mortality [3-5]. The predictive qualities of self-rated health remain after controlling for objective health and social and demographic risk factors [4].

Although the mechanisms that link self-rated health to future objectively verified ill-health are largely unknown, recent studies point at inflammation as an important determinant of how an individual perceives her global health status [6-8]. As part of the inflammatory response to acute infection or injury, pro-inflammatory cytokines such as interleukin (IL)-1 β , IL-6 and tumor necrosis factor (TNF)- α drive the acute phase response by increasing levels of acute phase proteins [9]. One of these proteins, fibrinogen, is a coagulation factor and is reflected by erythrocyte sedimentation rate (ESR). When inflammation is present, the fibrinogen causes erythrocytes to clot in rolls, thus sinking faster through a test tube, resulting in an increased ESR [10, 11]. Compared to other tests of inflammation, ESR is a simple and cost efficient way of establishing the presence of the acute phase reactants, and, indirectly, the activity of pro-inflammatory cytokines [9] making it a suitable marker of inflammation when collecting large amount of data.

One hypothesis to explain the observed association between low-grade inflammation and poor self-rated health is that inflammation related signals reach areas in the brain, including the insular cortex and the anterior cingulate cortex [12, 13], i.e. areas that are important in interpretation of bodily state and homeostatic changes [14]. As part of co-ordination of a sickness response, shifts in motivation and alterations of behaviors that

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3 promote healing and recovery are thereby induced [15]. Symptoms of such inflammation-
4 induced sickness behaviors include anhedonia, fatigue and increased sensitivity to pain, which
5 are also determinants of subjective health perception [16]. Since low-grade inflammation is
6 part of the pathology in major causes of premature mortality, such as cardio-vascular disease
7 (see e.g. [17, 18]), type-2 diabetes [19], obesity [20] and certain types of cancer [21, 22] low-
8 grade inflammation could be one factor linking poor self-rated health with future adverse
9 health outcomes.
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12 In order to investigate whether low-grade inflammation may be implicated in subjective
13 health perception, a row of recent studies have examined the link between increased levels of
14 pro-inflammatory cytokines and poor self-rated health [6-8, 16, 23, 24]. Other studies have
15 examined the association between self-rated health and fibrinogen [25], ESR [26] and of
16 another acute phase reactant, C-reactive protein (CRP)[7, 23, 27, 28]. So far, the evidence of a
17 link between low-grade inflammation and self-rated health is more robust for women as
18 compared to men [6-8, 16, 27], and the strength of the association has been indicated to
19 increase with age [6, 16]. For instance, among 347 women 45 to 90 years old of the general
20 population there was a significant association between IL-6 and poor self-rated health,
21 particularly among those 65 years old and above [6]. In another study, 174 female primary
22 health care patients of 18 years and older who were divided into three age groups, higher
23 TNF- α was significantly associated with poor self-rated health in all groups, and higher IL-1 β
24 and IL-1 receptor antagonist was associated with poor self-rated health in those over 65 years
25 old [16]. Moreover, in 235 middle-aged and elderly women with coronary heart disease, high
26 levels of CRP and IL-6 were associated with poor self-rated health [7].
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52 Among the studies including both men and women, only two have performed sex-based
53 stratified analyses [8, 27] and one study examined the interaction effect of sex and
54 inflammation on self-rated health [28]. A study of 170 female and 89 male primary health
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3 care patients showed a significant independent association between higher IL-1 β and TNF- α
4 and poor self-rated health only in women [8], but the lack of association in men could be due
5 to small sample size and low power. Among 11,000 women and 5,000 men, a significant
6 association between CRP and self-rated health remained only in women after adjustment for
7 control factors [27]. However, in a population of 13,236 young adults aged 24-34 years, high
8 sensitivity CRP above 3 mg/L was significantly associated with lower ratings of self-rated
9 health after adjustment for health behaviors, self-reported illness and medication in both men
10 and women. Inclusion of BMI fully attenuated the association between CRP and self-rated
11 health in the women whereas a small but significant association remained in men [28].
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23 The remaining studies encompassing both men and women reported significant
24 associations between IL-6 and self-rated health [23, 24], and between fibrinogen and self-
25 rated health [25] but as these studies are only adjusted for sex it is not clear if this association
26 would be found in the male or female strata only.
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32 The present study aims at investigating low-grade inflammation and subjective health
33 perception in a very large, young and healthy population, mainly free from medical
34 conditions. The hypothesis was that conscripts with elevated ESR levels had rated their health
35 as poorer in this population of late adolescent men, a group that has not yet been investigated
36 in this context.
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47 **METHODS**

51 **Participants**

52 This study was based on data collected in 1969 to 1970 when 49,321 Swedish men born
53 between 1949 and 1951 (aged 18-21 years) underwent a compulsory 2-day screening
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3 procedure prior to military service. During this time period, only 2-3 % of men eligible for
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5 military services were exempted from conscription, mainly due to severe disabilities or severe
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7 congenital disorders. All conscripts had answered questionnaires about social background,
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9 habits, psychological factors, social adjustment and health status and had been structured-
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11 interviewed by a psychologist. Finally, a physician examined all conscripts, and any somatic
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13 or psychiatric disorders were diagnosed according to the Swedish version of the International
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15 Classification of Disorders, version 8 (ICD-8). The present study was approved by the
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17 regional ethics board.
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20 21 22 23 **Measures**

24 25 26 27 **Self-Rated Health**

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29 The conscripts had been asked to assess their health, answering the question: “*In*
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31 *general, would you say your health right now is: Very good, Good, Fair, Poor or Very*
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33 *poor*”? The answers had been rated on a 5-point scale where 1=“Very good”, 2=“Good”,
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35 3=“Fair”, 4=“Poor” and 5=“Very poor” and was dichotomized into *Good* (1-3) and *Poor* (4
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37 and 5) self-rated health.
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40 41 42 43 **Erythrocyte Sedimentation Rate**

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45 At physical examination, blood samples had been taken and ESR had been measured
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47 according to standard laboratory procedures (Westergren method)[9]. The ESR is affected by
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49 the hematocrit (Htc, i.e. the proportion of whole blood made up by erythrocytes), we therefore
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51 corrected the ESR values for the hematocrit according to the formula $ESR * Htc / 45$ [29]. Htc-
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53 corrected ESR values are used in all analyses and presentations of ESR values. Despite
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55 plausible inter-individual genetic variations [30], the upper limit of the normal range of ESR
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3 has, on group level, been found to correspond to the age in years divided by two [31]. The age
4 span of the men included in this study ranged from 18 to 21 years. Based on the highest age
5 included, the normal range was rounded off to <11 mm/hr. Thus, the 3.7 % of the participants
6 with ESR \geq 11 mm/hr (n=3,937) were excluded from the analyses. Those with ESR <1 mm/hr
7 (n=1,903) were also excluded in order to reduce error of misclassifications [32]. The
8 remaining 88.2 percent % (n=43,481) of the conscripts had ESR levels $>1 < 11$ mm/hr and
9 were included in the analyses.
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20 21 Body Mass Index

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23 The conscripts' height and weight had been measured at the physical examination. Body
24 mass index (BMI) is determined by calculating the ratio of weight to height squared (kg/m^2).
25 Obesity and underweight as measured by very high or very low BMI have independently been
26 associated with poor self-rated health [33] and obesity has been associated with inflammation
27 [34]. BMI was categorized into 4 groups: underweight (BMI<18.5), normal weight (BMI:
28 18.5-25), overweight (BMI: 25-30) and obesity (BMI>30) and normal weight was used as
29 reference in the logistic regression analyses.
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41 Socioeconomic Position

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43 Parental socioeconomic position (SEP) was used as an indicator of childhood
44 socioeconomic circumstances. Information about socioeconomic circumstances of the
45 conscripts at 9 to 11 years of age was obtained from the National Population and Housing
46 Census from 1960. The conscripts and the head of the household, usually the father, were
47 linked through their personal identification number by Statistics Sweden. Based on the
48 occupation of the head of the household seven socioeconomic groups were identified: (a)
49 unskilled workers, (b) skilled workers, (c) assistant non-manual employees, (d) non-manual
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3 employees at intermediate level, (e) non-manual employees at higher level, (f) farmers, and
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5 (g) those not classified into a socioeconomic group. Self-employed persons could not be
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7 identified in the census from 1960 where such persons were classified as employed according
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9 to occupation. Previous research have shown that childhood SEP is associated with markers
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11 of inflammation in adults [35, 36], and a previous study from this sample found a significant
12
13 association between ESR and SEP [37], why SEP is included in the analyses.
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16 17 18 Inflammatory Disease

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20 Presence of one or more of the following medical conditions as registered for each
21
22 conscript by a physician according to ICD-8 was adjusted for in the analyses: infectious
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24 disease, malignancies, lymphatic and haemotopoetic tumors, diabetes mellitus, asthma,
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26 gastrointestinal inflammation, hay fever, infection and inflammation in skin, arthritis and
27
28 rheumatoid arthritis.
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31 32 33 Emotion Regulation

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35 The combined questionnaire and interview data had been used by a psychologist to
36
37 evaluate emotion regulation (then termed 'emotional control') was rated on 5-point scale,
38
39 based on self-reported anxiety, stress-tolerance, nervous problems, capacity for emotional
40
41 commitment and control over aggression (a score of 1 to 2 represent *Low* emotion regulation).
42
43 In a previous study, based on data from the same population, low emotion regulation was a
44
45 confounding factor in the association between poor self-rated health and mortality [5] and it
46
47 was also the covariate with the most prominent difference between conscripts with poor SRH
48
49 and conscripts with good SRH. Persistent negative affect such as anger, anxiety and
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51 depression has been associated with inflammation and disease [38, 39, 40], hence the
52
53 inclusion of emotion regulation in the analyses.
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Smoking

Tobacco smoking has been associated with increased systemic inflammation in men [41, 42]. Smoking has also been associated with poor self-rated health [6, 43, 44] and was therefore included in the analyses. The self-reported number of cigarettes smoked per day had been rated on a 4-point scale where 1>20, 2=11-20, 3=1-10 cigarettes per day and 4=non-smoker.

Risky use of alcohol

Risky use of alcohol has been associated with elevated markers of inflammation [45]. Risky use of alcohol was estimated based upon questions on high consumption of alcohol: none vs. at least one of the following indicators– consumption of at least 250 g 100 % alcohol per week; use of alcohol to alleviate a hangover; having been apprehended for drunkenness; being drunk often.

Physical activity

We used active membership in sport clubs as a proxy for physical activity. Exercise has been shown to have anti-inflammatory effects [46], and low physical activity has been associated with worse self-rated health [47].

Statistics

To calculate the association between ESR and self-rated health, logistic regression analysis was used with ESR as the independent variable and self-rated health as the outcome variable. As a second step, the association between ESR serum levels and self-rated health was adjusted separately for background variables BMI, SEP, presence of inflammatory

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3 disease, emotion regulation, smoking, risky use of alcohol and physical activity. Third, in the
4
5 full model, the association between ESR levels and self-rated health was adjusted for all
6
7 background variables together. The background variables were treated as categorical variables
8
9 in the analyses.

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11 An α -value of .05 was used to test for statistical significance. All analyses were performed
12
13 using SPSS statistics software version 21.
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16 17 18 19 20 21 **RESULTS**

22
23 Participant characteristics for conscripts with poor and conscripts with good self-rated health
24
25 are presented in Table 1. The majority of the conscripts reported their self-rated health as
26
27 good (96.2 %). Overall, conscripts with poor self-rated health were more likely to report poor
28
29 health behaviors such as smoking and risky alcohol use and had a higher frequency of low
30
31 health behaviors such as smoking and risky alcohol use and had a higher frequency of low
32
33 emotion regulation than conscripts with good self-rated health.

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35 was associated with a higher odds for poor self-rated health (OR=1.066 for each unit mm/hr
36
37 increase in ESR, Table 2). The size of the association and the level of significance were
38
39 largely unaffected by adjustments for BMI, SEP, inflammatory diseases, emotion regulation,
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41 smoking, risky use of alcohol and physical activity (OR=1.077).
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48 49 **DISCUSSION**

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52 The aim of this study was to investigate if there is an association between higher level of the
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54 inflammatory marker ESR and poor self-rated health in late adolescent men. The results of
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3 this study show that the odds of having poor rather than good self-rated health was elevated
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5 by approximately 7 % per for each unit mm/hr increase in ESR.
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8 This pattern was stable when relevant confounders (BMI, SEP, presence of
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10 inflammatory disease, emotion regulation, smoking, risky use of alcohol and physical
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12 activity) were controlled for. Hence, the present result is consistent with the hypothesis that
13
14 inflammation is part of a general factor in the psychobiological processes that underpin
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16 subjective health perception also in late adolescent men, although the cross-sectional design
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18 of the present study precludes conclusions about causality.
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21 The results of the present study are in contrast with the lack of association between
22
23 inflammatory markers and self-rated health in men in the studies by Lekander and coworkers
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25 [8] and Tanno and coworkers [27]. In comparison to the present study, those studies are based
26
27 on dissimilar methods and populations, with older participants (mean age 59 and 58 years,
28
29 respectively, compared to 18-21 years in the present study). The study the study by Lekander
30
31 and coworkers had a considerably smaller sample size and Tanno and coworkers [27] had an
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33 Asian population. However, the present results are in concordance with a previous study that
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35 demonstrated a small but significant association between CRP and self-rated health in young
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37 adult men 24 to 34 years old [28].
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41 Demographic factors and life-style patterns have been associated with both low-grade
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43 inflammation and with poor self-rated health; factors that may constitute possible confounders
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45 in the association between ESR and self-rated health, such as aging [48], obesity [49], low
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47 SEP [37], and smoking [6, 42]. Adjustments for BMI, SEP, inflammatory disease, emotion
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49 regulation, smoking, risky alcohol use, and physical activity did not, however, change the
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51 association between ESR and self-rated health in the present study suggesting that the
52
53 association is not dependent on any of the confounding variables. No assessments of sickness
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55 behavior were available in the present study and further studies are needed to investigate
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3 sickness behavior as a mediating factor linking inflammatory factors and poor self-rated
4 health. Also, individuals with a higher degree of inflammation did not introduce bias, as all
5 conscripts with an ESR equal to or above 11 mm/hr had been excluded. Unfortunately, data
6 on diet was not available in the present study, which is a factor to take into account in future
7 studies.
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14 Our study sample consisted of 43,431 conscripts encompassing the majority of all
15 Swedish men born in 1949 to 1951. Having a study sample that represents such a large
16 percentage of the population is obviously advantageous in terms of power, but also eliminates
17 the risk for selection bias. In the present material of late adolescent men, the majority of
18 participants were, as expected, healthy; altogether 82.6 % rated their health as “Good” or
19 “Very good”. It cannot be excluded that in a current-day sample of young men the included
20 factors would be differently distributed, and that e.g. low-grade inflammation would be more
21 prevalent as obesity, which has been linked with low-grade inflammation [50, 51], almost
22 doubled in prevalence between 1971 and 1993 among Swedish military conscripts [52].
23 However, the association between ESR and self-rated health in the present study was
24 independent of background factors such as BMI and there is little reason to expect that the
25 putative underlying biological mechanism by which inflammation is associated with
26 subjective health perception would have changed.
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45 Concerning validity, there is some discordance between ESR and other inflammatory
46 markers. For instance ESR has been shown to rise and decrease slower than CRP (see e.g.
47 [53]). However, the dose-responsive and independent relation between self-rated health and
48 ESR in the present study suggests that ESR is a marker for self-rated health, not merely
49 reflecting manifest disease or chronic conditions.
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3 In conclusion, the present study shows for the first time, a significant association
4 between a marker of inflammation and self-rated health in late adolescent men providing
5 evidence of an association between low-grade inflammation and poor self-rated health also in
6 men, as previously demonstrated in women. Data is here provided to further support
7 inflammation as a general factor in the psychobiological processes that underpin subjective
8 health perception across the adult life span.
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18 **Contributors** ML, TH, BM, AA conceived of the study. CW drafted the manuscript.

19
20 KS and TH performed the statistical analyses. All authors were involved in the discussion of
21 the data and revised the manuscript for intellectual content.
22
23

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25
26 **Competing interests** None declared.
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29 **Data sharing statement** No additional data available.
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BMJ Open

IS POOR SELF-RATED HEALTH ASSOCIATED WITH LOW- GRADE INFLAMMATION IN A CROSS-SECTIONAL STUDY OF 43,110 LATE ADOLESCENT MEN OF THE GENERAL POPULATION?

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5 Self-rated health and inflammation in adolescent men
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7 *Key words: self-rated health, erythrocyte sedimentation rate, low-grade inflammation,*
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9 *military conscripts*
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ABSTRACT

Objective

Self-rated health is a powerful predictor of long-term health and mortality, hence the importance of a better understanding of its biological determinants. Previous studies have shown that low-grade inflammation is associated with poor self-rated health in clinical and healthy populations, but the evidence is sparse in men and lacks completely for men in late adolescence. The aim of this study was to investigate the association between low-grade inflammation and self-rated health among conscripts. It was hypothesized that high levels of inflammatory factors would be associated with poor self-rated health.

Design

Data from 49,321 men (18-21 years) conscribed to military service in 1969 and 1970 was used. Inflammation had been measured through erythrocyte sedimentation rate (ESR). Self-rated health had been assessed on a five-point scale and was dichotomized into *Good* (“Very good”/“Good”/“Fair”) versus *Poor* (“Poor”/“Very poor”). Data from 43,110 conscripts with normal levels of ESR and who reported self-rated health remained after exclusion of those with ESR <1 and >11 mm/hr. Associations were calculated using logistic regression analyses. Adjustments were made for body mass index, socioeconomic position, inflammatory disease, emotion regulation, smoking, risky use of alcohol and physical activity.

Results

High levels of ESR was associated with a higher odds for poor self-rated health (OR:1.077 for each unit mm/hr increase in ESR, 95% confidence interval: 1.049-1.105).

Conclusion

The present study shows for the first time, a significant association between a marker of inflammation and self-rated health in late adolescent men providing evidence of an association between low-grade inflammation and poor self-rated health also in men, providing further support for inflammation as part of a general psychobiological process that underpins subjective health perception.

Strengths and limitations of this study

- This is the first study to investigate the association between low-grade inflammation and self-rated health in a large sample of late adolescent men.
- Using data (n=43,110) from the national military conscription register, encompassing nearly all the Swedish men born in 1949-1951, eliminates selection bias.
- Adjustments were made for life-style patterns, demographic factors and psychological disposition.
- The cross-sectional design precludes conclusions about causality.

INTRODUCTION

Self-rated health is a single-item measure of an individual's perceived health status. A number of studies show that poor self-rated health predicts future adverse health outcomes, such as cardio-vascular events [1] and healthcare utilization [2], and is coupled to a near two-fold risk of premature mortality [3-5]. The predictive qualities of self-rated health remain after controlling for objective health and social and demographic risk factors [4].

Although the mechanisms that link self-rated health to future objectively verified ill-health are largely unknown, recent studies point at inflammation as an important determinant of how an individual perceives her global health status [6-8]. As part of the inflammatory response to acute infection or injury, pro-inflammatory cytokines such as interleukin (IL)-1 β , IL-6 and tumour necrosis factor (TNF)- α drive the acute phase response by increasing levels of acute phase proteins [9]. One of these proteins, fibrinogen, is a coagulation factor and is reflected by erythrocyte sedimentation rate (ESR). When inflammation is present, the fibrinogen causes erythrocytes to clot in rolls, thus sinking faster through a test tube, resulting in an increased ESR [10, 11]. Compared to other tests of inflammation, ESR is a simple and cost efficient way of establishing the presence of the acute phase reactants, and, indirectly, the activity of pro-inflammatory cytokines [9] making it a suitable marker of inflammation when collecting large amount of data.

One hypothesis to explain the observed association between low-grade inflammation and poor self-rated health is that inflammation related signals reach areas in the brain, including the insular cortex and the anterior cingulate cortex [12, 13], i.e. areas that are important in interpretation of bodily state and homeostatic changes [14]. As part of co-ordination of a sickness response, shifts in motivation and alterations of behaviours that promote healing and recovery are thereby induced [15]. Symptoms of such inflammation-

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3 induced sickness behaviours include anhedonia, fatigue and increased sensitivity to pain,
4 which are also determinants of subjective health perception [16]. Since low-grade
5 inflammation is part of the pathology in major causes of premature mortality, such as cardio-
6 vascular disease (see e.g. [17, 18]), type-2 diabetes [19], obesity [20] and certain types of
7 cancer [21, 22] low-grade inflammation could be one factor linking poor self-rated health
8 with future adverse health outcomes.
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11 In order to investigate whether low-grade inflammation may be implicated in subjective
12 health perception, a row of recent studies have examined the link between increased levels of
13 pro-inflammatory cytokines and poor self-rated health [6-8, 16, 23, 24]. Other studies have
14 examined the association between self-rated health and fibrinogen [25], ESR [26] and of
15 another acute phase reactant, C-reactive protein (CRP)[7, 23, 27, 28]. So far, the evidence of a
16 link between low-grade inflammation and self-rated health is more robust for women as
17 compared to men [6-8, 16, 27], and the strength of the association has been indicated to
18 increase with age [6, 16]. For instance, among 347 women 45 to 90 years old of the general
19 population there was a significant association between IL-6 and poor self-rated health,
20 particularly among those 65 years old and above [6]. In another study, 174 female primary
21 health care patients of 18 years and older who were divided into three age groups, higher
22 TNF- α was significantly associated with poor self-rated health in all groups, and higher IL-1 β
23 and IL-1 receptor antagonist was associated with poor self-rated health in those over 65 years
24 old [16]. Moreover, in 235 middle-aged and elderly women with coronary heart disease, high
25 levels of CRP and IL-6 were associated with poor self-rated health [7].
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50 Among the studies including both men and women, only two have performed sex-based
51 stratified analyses [8, 27] and one study examined the interaction effect of sex and
52 inflammation on self-rated health [28]. A study of 170 female and 89 male primary health
53 care patients showed a significant independent association between higher IL-1 β and TNF- α
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3 and poor self-rated health only in women [8], but the lack of association in men could be due
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5 to small sample size and low power. Among 11,000 women and 5,000 men, a significant
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7 association between CRP and self-rated health remained only in women after adjustment for
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9 control factors [27]. However, in a population of 13,236 young adults aged 24-34 years, high
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11 sensitivity CRP above 3 mg/L was significantly associated with lower ratings of self-rated
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13 health after adjustment for health behaviours, self-reported illness and medication in both men
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15 and women. Inclusion of BMI fully attenuated the association between CRP and self-rated
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17 health in women whereas a small but significant association remained in men [28].
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21 The remaining studies encompassing both men and women reported significant
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23 associations between IL-6 and self-rated health [23, 24], and between fibrinogen and self-
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25 rated health [25] but as these studies are only adjusted for sex it is not clear if this association
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27 would be found in the male or female strata only.
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30 The present study aims at investigating low-grade inflammation and subjective health
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32 perception in a very large, young and healthy population, mainly free from medical
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34 conditions. The hypothesis was that conscripts with elevated ESR levels had rated their health
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36 as poorer in this population of late adolescent men, a group that has not yet been investigated
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38 in this context.
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46 METHODS

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Study design

This cross-sectional study was based on data collected in 1969 to 1970 when 49,321 Swedish men born between 1949 and 1951 (aged 18-21 years) underwent a compulsory 2-day

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3 screening procedure prior to military service. During this time period, only 2-3 % of men
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5 eligible for military services were exempted from conscription, mainly due to severe
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7 disabilities or severe congenital disorders. All conscripts had answered questionnaires about
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9 social background, habits, psychological factors, social adjustment and health status and had
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11 been structured-interviewed by a psychologist. Finally, a physician examined all conscripts,
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13 and any somatic or psychiatric disorders were diagnosed according to the Swedish version of
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15 the International Classification of Disorders, version 8 (ICD-8). The present study was
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17 approved by the regional ethics board.
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25 26 27 28 29 Self-Rated Health

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31 The conscripts had been asked to assess their health, answering the question: “*In*
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33 *general, would you say your health right now is: Very good, Good, Fair, Poor or Very*
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35 *poor*”? The answers had been rated on a 5-point scale where 1=“Very good”, 2=“Good”,
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37 3=“Fair”, 4=“Poor” and 5=“Very poor” and was dichotomized into *Good* (1-3) and *Poor* (4
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39 and 5) self-rated health.
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44 45 46 47 48 Erythrocyte Sedimentation Rate

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50 At physical examination, blood samples had been taken and ESR had been measured
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52 according to standard laboratory procedures (Westergren method)[9]. The ESR is affected by
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54 the hematocrit (Htc, i.e. the proportion of whole blood made up by erythrocytes), we therefore
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56 corrected the ESR values for the hematocrit according to the formula $ESR * Htc / 45$ [29]. Htc-
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58 corrected ESR values are used in all analyses and presentations of ESR values. Despite
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60 plausible inter-individual genetic variations [30], the upper limit of the normal range of ESR

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3 has, on group level, been found to correspond to the age in years divided by two [31]. The age
4 span of the men included in this study ranged from 18 to 21 years. Based on the highest age
5 included, the normal range was rounded off to <11 mm/hr. Thus, the 3.7 % of the participants
6 with ESR \geq 11 mm/hr (n=3,937) were excluded from the analyses out of whom 168 had rated
7 their self-rated health as poor, 3,655 had rated their self-rated health as good, and 114 had
8 missing self-rated health values. Those with ESR <1 mm/hr (n=1,903) were also excluded in
9 order to reduce error of misclassifications [32] out of whom 148 had rated their self-rated
10 health as poor, 1,739 as good, and 16 had missing values. A total of 43,110 out of the
11 remaining 43,481 conscripts with ESR levels \geq 1 and < 11 mm/hr had data on self-rated health
12 and were included in the analyses.
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24 25 26 27 Body Mass Index

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29 The conscripts' height and weight had been measured at the physical examination. Body
30 mass index (BMI) is determined by calculating the ratio of weight to height squared (kg/m^2).
31 Obesity and underweight as measured by very high or very low BMI have independently been
32 associated with poor self-rated health [33] and obesity has been associated with inflammation
33 [34]. BMI was categorized into 4 groups: underweight (BMI<18.5), normal weight (BMI:
34 18.5-25), overweight (BMI: 25-30) and obesity (BMI>30) and normal weight was used as
35 reference in the logistic regression analyses.
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48 Socioeconomic Position

49 Parental socioeconomic position (SEP) was used as an indicator of childhood
50 socioeconomic circumstances. Information about socioeconomic circumstances of the
51 conscripts at 9 to 11 years of age was obtained from the National Population and Housing
52 Census from 1960. The conscripts and the head of the household, usually the father, were
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3 linked through their personal identification number by Statistics Sweden. Based on the
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5 occupation of the head of the household seven socioeconomic groups were identified: (a)
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7 unskilled workers, (b) skilled workers, (c) assistant non-manual employees, (d) non-manual
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9 employees at intermediate level, (e) non-manual employees at higher level, (f) farmers, and
10
11 (g) those not classified into a socioeconomic group. Self-employed persons could not be
12
13 identified in the census from 1960 where such persons were classified as employed according
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15 to occupation. Previous research have shown that childhood SEP is associated with markers
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17 of inflammation in adults [35, 36], and a previous study from this sample found a significant
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19 association between ESR and SEP [37], why SEP is included in the analyses.
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25 Inflammatory Disease

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27 Presence of one or more of the following medical conditions as registered for each
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29 conscript by a physician according to ICD-8 was adjusted for in the analyses: infectious
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31 disease, malignancies, lymphatic and haemotopoetic tumors, diabetes mellitus, asthma,
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33 gastrointestinal inflammation, hay fever, infection and inflammation in skin, arthritis and
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35 rheumatoid arthritis.
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41 Emotion Regulation

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43 The combined questionnaire and interview data had been used by a psychologist to rate
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45 emotion regulation (then termed 'emotional control') on 5-point scale, based on self-reported
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47 anxiety, stress-tolerance, nervous problems, capacity for emotional commitment and control
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49 over aggression (a score of 1 to 2 represent *Low* emotion regulation). In a previous study,
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51 based on data from the same population, low emotion regulation was a confounding factor in
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53 the association between poor self-rated health and mortality [5] and it was also the covariate
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55 with the most prominent difference between conscripts with poor and conscripts with good
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3 self-rated health. Persistent negative affect such as anger, anxiety and depression has been
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5 associated with inflammation and disease [38, 39, 40], hence the inclusion of emotion
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7 regulation in the analyses.
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10 11 Smoking

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13 Tobacco smoking has been associated with increased systemic inflammation in men
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15 [41, 42]. Smoking has also been associated with poor self-rated health [6, 43, 44] and was
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17 therefore included in the analyses. The self-reported number of cigarettes smoked per day had
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19 been rated on a 4-point scale where 1>20, 2=11-20, 3=1-10 cigarettes per day and 4=non-
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21 smoker.
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24 25 Risky use of alcohol

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27 Risky use of alcohol has been associated with elevated markers of inflammation [45].
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29 Risky use of alcohol was estimated based upon questions on high consumption of alcohol:
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31 none vs. at least one of the following indicators– consumption of at least 250 g 100 % alcohol
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33 per week; use of alcohol to alleviate a hangover; having been apprehended for drunkenness;
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35 being drunk often.
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42 43 Physical activity

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45 We used active membership in sport clubs as a proxy for physical activity. Exercise has
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47 been shown to have anti-inflammatory effects [46], and low physical activity has been
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49 associated with worse self-rated health [47].
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52 53 Statistics

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55 To calculate the association between ESR and self-rated health, logistic regression
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57 analysis was used with ESR as the independent variable and self-rated health as the outcome
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3 variable. As a second step, the association between ESR serum levels and self-rated health
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5 was adjusted separately for background variables BMI, SEP, presence of inflammatory
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7 disease, emotion regulation, smoking, risky use of alcohol and physical activity. Third, in the
8
9 full model, the association between ESR levels and self-rated health was adjusted for all
10
11 background variables together. The background variables were treated as categorical variables
12
13 in the analyses. Data from 43,110 conscripts with self-rated health data and normal levels of
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15 ESR were included in the analyses. Missing values for background variables were excluded
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17 listwise.
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21 An α -value of .05 was used to test for statistical significance. All analyses were
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23 performed using SPSS statistics software version 21.
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30 31 RESULTS

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35 Participant characteristics for conscripts with poor and conscripts with good self-rated health
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37 are presented in Table 1. The majority of the conscripts reported their self-rated health as
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39 good (96.2 %). Overall, conscripts with poor self-rated health were more likely to report poor
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41 health behaviors such as smoking and risky alcohol use and had a higher frequency of low
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43 emotion regulation than conscripts with good self-rated health.
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Table 1. Participant characteristics separately for men with poor self-rated health and men with good self-rated health. Group differences in frequencies have been tested with Chi Square test and differences in means with t-tests.

Variable/category	Self-rated health		χ^2
	Poor n=1,618	Good n=41,492	
BMI			
<18.5	18.2	13.4	31.01*
18.5-25.0	74.4	80.0	29.32*
25.0-30.0	6.5	5.8	1.32
>30.0	0.8	0.8	0.00
Socioeconomic position (%)			
Worker, unskilled	32.6	33.5	0.61
Worker, skilled	21.9	21.5	0.21
Non-manual, assistant	10.0	10.1	0.03
Non-manual, intermediate	18.5	16.7	3.80
Non-manual, higher	5.7	5.1	1.26
Farmer	8.3	10.9	10.48*
Non-classified	2.9	2.2	3.04
Inflammatory disease (%)	22.6	8.5	377.98*
Low emotion regulation (%)	71.2	28.6	1313.11*
Smoking (%)			
> 20 cigarettes/day	14.5	3.2	555.13*
11-20 cigarettes/day	31.7	23.0	64.63*

1-10 cigarettes/day	25.1	32.2	35.34*
Non smoker	28.7	41.6	104.82*
Risky use of alcohol (%)	29.3	15.2	191.76*
Physical activity (%)	24.7	37.0	102.49*
			<i>t</i>
ESR, M (SD)	2.98 (2.19)	2.70 (1.98)	5.58*
BMI, M (SD)	20.79 (2.73)	21.00 (2.57)	-3.26*

* $p < .001$

BMI: body mass index, ESR: erythrocyte sedimentation rate.

High levels of ESR was associated with a higher odds for poor self-rated health (OR=1.066 for each unit mm/hr increase in ESR, Table 2). The size of the association and the level of significance were largely unaffected by adjustments for BMI, SEP, inflammatory diseases, emotion regulation, smoking, risky use of alcohol and physical activity (OR=1.077).

Table 2. Crude and adjusted effects of ESR on the odds to have very poor/poor rather than fair/good/very good self-rated health.

	Odds ratio (95% CI)	N
Crude	1.066 (1.043-1.091)	43,110
Adjusted for individual background variables		
<i>BMI</i>	1.064 (1.040-1.088)	43,067
<i>Socioeconomic position</i>	1.069 (1.045-1.093)	43,110
<i>Inflammatory disease</i>	1.066 (1.042-1.091)	43,110
<i>Emotion regulation</i>	1.070 (1.046-1.096)	42,930
<i>Smoking</i>	1.071 (1.047-1.096)	42,555
<i>Risky use of alcohol</i>	1.066 (1.039-1.093)	35,801
<i>Physical activity</i>	1.067 (1.043-1.091)	43,110
Adjusted for all background variables	1.077 (1.049-1.105)	35,553

ESR: erythrocyte sedimentation rate, BMI: body mass index.

DISCUSSION

The aim of this study was to investigate if there is an association between higher level of the inflammatory marker ESR and poor self-rated health in late adolescent men. The results of this study show that the odds of having poor rather than good self-rated health was elevated by approximately 7 % per for each unit mm/hr increase in ESR.

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3 This pattern was stable when relevant confounders (BMI, SEP, presence of
4 inflammatory disease, emotion regulation, smoking, risky use of alcohol and physical
5 activity) were controlled for. Hence, the present result is consistent with the hypothesis that
6 inflammation is part of a general factor in the psychobiological processes that underpin
7 subjective health perception also in late adolescent men, although the cross-sectional design
8 of the present study precludes conclusions about causality.
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12 The results of the present study are in contrast with the lack of association between
13 inflammatory markers and self-rated health in men in the studies by Lekander and co-workers
14 [8] and Tanno and co-workers [27]. In comparison to the present study, those studies are
15 based on dissimilar methods and populations, with older participants (mean age 59 and 58
16 years, respectively, compared to 18-21 years in the present study). The study by Lekander and
17 co-workers had a considerably smaller sample size and Tanno and co-workers [27] had an
18 Asian population. However, the present results are in concordance with a previous study that
19 demonstrated a small but significant association between CRP and self-rated health in young
20 adult men 24 to 34 years old [28].
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36 Demographic factors and life-style patterns have been associated with both low-grade
37 inflammation and with poor self-rated health; factors that may constitute possible confounders
38 in the association between ESR and self-rated health, such as aging [48], obesity [49], low
39 SEP [37], and smoking [6, 42]. Adjustments for BMI, SEP, inflammatory disease, emotion
40 regulation, smoking, risky alcohol use, and physical activity did not, however, change the
41 association between ESR and self-rated health in the present study suggesting that the
42 association is not dependent on any of the confounding variables. No assessments of sickness
43 behaviour were available in the present study and further studies are needed to investigate
44 sickness behaviour as a mediating factor linking inflammatory factors and poor self-rated
45 health. Also, individuals with a higher degree of inflammation did not introduce bias, as all
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3 conscripts with an ESR equal to or above 11 mm/hr had been excluded. Unfortunately, data
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5 on diet was not available in the present study, which is a factor to take into account in future
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7 studies.
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10 Our study sample consisted of 43,110 conscripts encompassing the majority of all
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12 Swedish men born in 1949 to 1951. Having a study sample that represents such a large
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14 percentage of the population is obviously advantageous in terms of power, but also eliminates
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16 the risk for selection bias. In the present material of late adolescent men, the majority of
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18 participants were, as expected, healthy; altogether 82.6 % rated their health as “Good” or
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20 “Very good”. It cannot be excluded that in a current-day sample of young men the included
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22 factors would be differently distributed, and that e.g. low-grade inflammation would be more
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24 prevalent as obesity, which has been linked with low-grade inflammation [50, 51], almost
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26 doubled in prevalence between 1971 and 1993 among Swedish military conscripts [52].
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28 However, the association between ESR and self-rated health in the present study was
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30 independent of background factors such as BMI and there is little reason to expect that the
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32 putative underlying biological mechanism by which inflammation is associated with
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34 subjective health perception would have changed.
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41 Concerning validity, there is some discordance between ESR and other inflammatory
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43 markers. For instance ESR has been shown to rise and decrease slower than CRP (see e.g.
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45 [53]). However, the independent relation between self-rated health and ESR in the present
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47 study suggests that ESR is a marker for self-rated health, not merely reflecting manifest
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49 disease or chronic conditions.
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52 In conclusion, the present study shows for the first time, a significant association
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54 between a marker of inflammation and self-rated health in late adolescent men providing
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56 evidence of an association between low-grade inflammation and poor self-rated health also in
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3 men, as previously demonstrated in women. Data is here provided to further support
4 inflammation as a general factor in the psychobiological processes that underpin subjective
5 health perception across the adult life span.
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10 Contributors: ML, TH, BM, AA conceived of the study. CW drafted the manuscript. KS and
11 TH performed the statistical analyses. All authors were involved in the discussion of the data
12 and revised the manuscript for intellectual content.
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20 Competing interests: None declared.
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23 Data sharing statement: No additional data available.
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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1 OK	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2 OK	Explain the scientific background and rationale for the investigation being reported
Objectives	3 OK	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4 OK	Present key elements of study design early in the paper
Setting	5 OK	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 OK	(a) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7 OK	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8* OK	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 OK	Describe any efforts to address potential sources of bias
Study size	10 OK	Explain how the study size was arrived at
Quantitative variables	11 OK	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 OK	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses
Results		
Participants	13* OK	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14* OK	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest
Outcome data	15* OK	Report numbers of outcome events or summary measures
Main results	16 OK	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
	OK	
Discussion		
Key results	18	Summarise key results with reference to study objectives
	OK	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
	OK	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
	OK	
Generalisability	21	Discuss the generalisability (external validity) of the study results
	OK	
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
	OK	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

IS POOR SELF-RATED HEALTH ASSOCIATED WITH LOW- GRADE INFLAMMATION IN 43,110 LATE ADOLESCENT MEN OF THE GENERAL POPULATION?: A CROSS-SECTIONAL STUDY

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5 Self-rated health and inflammation in adolescent men
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7 *Key words: self-rated health, erythrocyte sedimentation rate, low-grade inflammation,*
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ABSTRACT

Objective

Self-rated health is a powerful predictor of long-term health and mortality, hence the importance of a better understanding of its biological determinants. Previous studies have shown that low-grade inflammation is associated with poor self-rated health in clinical and healthy populations, but the evidence is sparse in men and lacking completely for men in late adolescence. The aim of this study was to investigate the association between low-grade inflammation and self-rated health among conscripts. It was hypothesized that high levels of inflammatory factors would be associated with poor self-rated health.

Design

Data from 49,321 men (18-21 years) conscripted for military service in 1969 and 1970 was used. Inflammation had been measured through erythrocyte sedimentation rate (ESR). Self-rated health had been assessed on a five-point scale and was dichotomized into *Good* ("Very good"/"Good"/"Fair") versus *Poor* ("Poor"/"Very poor"). Data from 43,110 conscripts with normal levels of ESR and who reported self-rated health remained after exclusion of those with ESR <1 and >11 mm/hr. Associations were calculated using logistic regression analyses. Adjustments were made for body mass index, socioeconomic position, inflammatory disease, emotion regulation, smoking, risky use of alcohol and physical activity.

Results

High levels of ESR were associated with higher odds for poor self-rated health (OR: 1.077 for each unit mm/hr increase in ESR, 95% confidence interval: 1.049-1.105).

Conclusion

The present study shows for the first time, a significant association between a marker of inflammation and self-rated health in late adolescent men, adding to evidence of an association between low-grade inflammation and subjective health perception also in men, as previously demonstrated in women. Further support for inflammation as part of a general psychobiological process that underpins subjective health perception is hereby provided.

Strengths and limitations of this study

- This is the first study to investigate the association between low-grade inflammation and self-rated health in a large sample of late adolescent men.
- Using data (n=43,110) from the national military conscription register, encompassing nearly all the Swedish men born in 1949-1951, eliminates selection bias.
- Adjustments were made for life-style patterns, demographic factors and psychological disposition.
- The cross-sectional design precludes conclusions about causality.

INTRODUCTION

Self-rated health is a single-item measure of how an individual subjectively perceives her health status. A number of studies show that poor self-rated health predicts future adverse health outcomes, such as cardio-vascular events [1] and healthcare utilization [2], and is coupled with a near two-fold risk of premature mortality [3-5]. The predictive qualities of self-rated health remain after controlling for objective health, social and demographic risk factors [4].

Although the mechanisms that link self-rated health to future objectively verified ill-health are largely unknown, recent studies point at inflammation as an important determinant of subjective health perception [6-8]. As part of the inflammatory response to acute infection or injury, pro-inflammatory cytokines such as interleukin (IL)-1 β , IL-6 and tumour necrosis factor (TNF)- α drive the acute phase response by increasing levels of acute phase proteins [9]. One of these proteins, fibrinogen, is a coagulation factor and is reflected by erythrocyte sedimentation rate (ESR). When inflammation is present, the fibrinogen causes erythrocytes to clot in rolls, thus sinking faster through a test tube, resulting in an increased ESR [10, 11]. Compared to other tests of inflammation, ESR is a simple and cost efficient way of establishing the presence of the acute phase reactants and, indirectly, the activity of pro-inflammatory cytokines [9], making it a suitable marker of inflammation when collecting large amount of data.

One hypothesis to explain the observed association between low-grade inflammation and poor self-rated health is that inflammation related signals reach areas in the brain, including the insular cortex and the anterior cingulate cortex [12, 13], i.e. areas that are important in interpretation of bodily state and homeostatic changes [14]. As part of the co-ordination of a sickness response, shifts in motivation and alterations of behaviours that

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3 promote healing and recovery are thereby induced [15]. Symptoms of such inflammation-
4 induced sickness behaviours include anhedonia, fatigue and increased sensitivity to pain,
5 which are also determinants of subjective health perception [16]. Since low-grade
6 inflammation is part of the pathology in major causes of premature mortality, such as cardio-
7 vascular disease (see e.g. [17, 18]), type-2 diabetes [19], obesity [20] and certain types of
8 cancer [21, 22], low-grade inflammation could be one factor linking poor self-rated health
9 with future adverse health outcomes.
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14 In order to investigate whether low-grade inflammation may be implicated in subjective
15 health perception, a row of recent studies have examined the link between increased levels of
16 pro-inflammatory cytokines and poor self-rated health [6-8, 16, 23, 24]. Other studies have
17 examined the association between self-rated health and fibrinogen [25], ESR [26] and of
18 another acute phase reactant, C-reactive protein (CRP)[7, 23, 27, 28]. So far, the evidence of a
19 link between low-grade inflammation and self-rated health is more robust for women
20 compared to men [6-8, 16, 27], and the strength of the association has been indicated to
21 increase with age [6, 16]. For instance, among 347 women 45 to 90 years old of the general
22 population there was a significant association between IL-6 and poor self-rated health,
23 particularly among those 65 years old and above [6]. In another study, in 174 female primary
24 health care patients of 18 years and older who were divided into three age groups, higher
25 TNF- α was significantly associated with poor self-rated health in all three age groups,
26 whereas higher levels of IL-1 β and IL-1 receptor antagonist were associated with poor self-
27 rated health in those over 65 years old [16]. Moreover, in 235 middle-aged and elderly women
28 with coronary heart disease, high levels of CRP and IL-6 were associated with poor self-rated
29 health [7].
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34 Among the studies including both men and women, only two have performed sex-based
35 stratified analyses [8, 27] and one study examined the interaction effect of sex and
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3 inflammation on self-rated health [28]. A study of 170 female and 89 male primary health
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5 care patients showed a significant independent association between higher IL-1 β and TNF- α
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8 and poor self-rated health only in women [8], but the lack of association in men could be due
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10 to small sample size and low statistical power. Among 11,000 women and 5,000 men, a
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12 significant association between CRP and self-rated health remained only in women after
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14 adjustment for control factors [27]. However, in a population of 13,236 young adults aged 24-
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16 34 years, high sensitivity CRP above 3 mg/L was significantly associated with lower ratings
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18 of self-rated health after adjustment for health behaviours, self-reported illness and
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20 medication in both men and women. Inclusion of BMI fully attenuated the association
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22 between CRP and self-rated health in women whereas a small but significant association
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24 remained in men [28].
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29 The remaining studies encompassing both men and women reported significant
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31 associations between IL-6 and self-rated health [23, 24], and between fibrinogen and self-
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33 rated health [25]. As these studies were only adjusted for sex it is not clear if this association
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35 would be found in the male or female strata only.
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38 The present study aims to investigate low-grade inflammation and subjective health
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40 perception in a very large, young and healthy population, mainly free from medical
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42 conditions. The hypothesis was that conscripts with elevated ESR levels had poorer self-rated
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44 health. This population of late adolescent men is a group that has not yet been investigated in
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46 this context.
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54 METHODS

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Study design

This cross-sectional study was based on data collected in 1969 to 1970 when 49,321 Swedish men born between 1949 and 1951 (aged 18-21 years) underwent a compulsory 2-day screening procedure prior to military service. During this time period only 2-3 % of men eligible for military services were exempted from conscription, mainly due to severe disabilities or severe congenital disorders. All conscripts had answered questionnaires about social background, habits, psychological factors, social adjustment and health status and had been structured-interviewed by a psychologist. Finally, a physician examined all conscripts, and any somatic or psychiatric disorders were diagnosed according to the Swedish version of the International Classification of Disorders, version 8 (ICD-8). The present study was approved by the regional ethics board.

Measures

Self-Rated Health

The conscripts had been asked to assess their health, answering the question: “*In general, would you say your health right now is: Very good, Good, Fair, Poor or Very poor*”? The answers had been rated on a 5-point scale where 1=“Very good”, 2=“Good”, 3=“Fair”, 4=“Poor” and 5=“Very poor” and were dichotomized into *Good* (1-3) and *Poor* (4 and 5) self-rated health.

Erythrocyte Sedimentation Rate

At physical examination, blood samples had been taken and ESR had been measured according to standard laboratory procedures (Westergren method) [9]. The ESR is affected by the hematocrit (Htc, i.e. the proportion of whole blood made up by erythrocytes), we therefore

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3 corrected the ESR values for the hematocrit according to the formula $ESR * Htc / 45$ [29]. Htc-
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5 corrected ESR values are used in all analyses and presentations of ESR values. Despite
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7 plausible inter-individual genetic variations [30], the upper limit of the normal range of ESR
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9 has, on group level, been found to correspond to the age in years divided by two [31]. The age
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11 span of the men included in this study ranged from 18 to 21 years. Based on the highest age
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13 included, the normal range was rounded off to < 11 mm/hr. Thus, the 3.7 % of the participants
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15 with $ESR \geq 11$ mm/hr ($n=3,937$) were excluded from the analyses out of whom 168 had rated
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17 their self-rated health as poor, 3,655 had rated their self-rated health as good, and 114 had
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19 missing self-rated health values. In order to reduce misclassifications errors those with ESR
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21 < 1 mm/hr ($n=1,903$) were also excluded [32], out of whom 148 had rated their self-rated
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23 health as poor, 1,739 as good, and 16 had missing values. A total of 43,110 out of the
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25 remaining 43,481 conscripts with ESR levels ≥ 1 and < 11 mm/hr had data on self-rated health
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27 and were included in the analyses.
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33 34 Body Mass Index

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36 The conscripts' height and weight had been measured at the physical examination. Body
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38 mass index (BMI) is determined by calculating the ratio of weight to height squared (kg/m^2).
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40 Obesity and underweight as measured by very high or very low BMI have independently been
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42 associated with poor self-rated health [33] and obesity has been associated with inflammation
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44 [34]. BMI was categorized into four groups: underweight (BMI <18.5), normal weight (BMI:
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46 18.5-25), overweight (BMI: 25-30) and obesity (BMI >30). Normal weight was used as
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48 reference in the logistic regression analyses.
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53 54 Socioeconomic Position

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3 Parental socioeconomic position (SEP) was used as an indicator of childhood
4 socioeconomic circumstances. Information about socioeconomic circumstances of the
5 conscripts at 9 to 11 years of age was obtained from the National Population and Housing
6 Census from 1960. A conscript and the head of the household, usually the conscript's father,
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8 were linked through their personal identification number by Statistics Sweden. Based on the
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10 occupation of the head of the household seven socioeconomic groups were identified: (a)
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12 unskilled workers, (b) skilled workers, (c) assistant non-manual employees, (d) non-manual
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14 employees at intermediate level, (e) non-manual employees at higher level, (f) farmers, and
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16 (g) those not classified into a socioeconomic group. Self-employed persons could not be
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18 identified in the census from 1960 when such persons were classified as employed according
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20 to occupation. Previous research have shown that childhood SEP is associated with markers
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22 of inflammation in adults [35, 36], and a previous study from this sample found a significant
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24 association between ESR and SEP [37], why SEP is included in the analyses.
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35 Inflammatory Disease

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37 Presence of one or more of the following medical conditions as registered for each
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39 conscript by a physician according to ICD-8 was adjusted for in the analyses: infectious
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41 disease, malignancies, lymphatic and haemotopoetic tumors, diabetes mellitus, asthma,
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43 gastrointestinal inflammation, hay fever, infection and inflammation in skin, arthritis and
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45 rheumatoid arthritis.
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50 Emotion Regulation

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52 The combined questionnaire and interview data had been used by a psychologist to rate
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54 emotion regulation (then termed 'emotional control') on a 5-point scale, based on self-
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56 reported anxiety, stress-tolerance, nervous problems, capacity for emotional commitment and
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3 control over aggression (a score of 1 to 2 represent *Low* emotion regulation). In a previous
4 study, based on data from the same population, low emotion regulation was a confounding
5 factor in the association between poor self-rated health and mortality [5] and it was also the
6 covariate with the most prominent difference between conscripts with poor self-rated health
7 and conscripts with good self-rated health. Persistent negative affect, such as anger, anxiety
8 and depression, has been associated with inflammation and disease [38, 39, 40], hence the
9 inclusion of emotion regulation in the analyses.
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20 Smoking

21 Tobacco smoking has been associated with increased systemic inflammation in men
22 [41, 42]. Smoking has also been associated with poor self-rated health [6, 43, 44] and was
23 therefore included in the analyses. The self-reported number of cigarettes smoked per day had
24 been rated on a 4-point scale where 1=>20, 2=11-20, 3=1-10 cigarettes per day and 4=non-
25 smoker.
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36 Risky use of alcohol

37 Risky use of alcohol has been associated with elevated markers of inflammation [45].
38 Self-reported use of alcohol was categorised as risky when consumption exceeded 250 g 100
39 % alcohol per week; alcohol was used to alleviate a hangover; having been apprehended for
40 drunkenness; or being drunk often.
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50 Physical activity

51 We used active membership in sport clubs as a proxy for physical activity. Exercise has
52 been shown to have anti-inflammatory effects [46], and low physical activity has been
53 associated with worse self-rated health [47].
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Statistics

To calculate the association between ESR and self-rated health, logistic regression analysis was used with ESR as the independent variable and self-rated health as the outcome variable. As a second step, the association between ESR serum levels and self-rated health was adjusted separately for background variables BMI, SEP, presence of inflammatory disease, emotion regulation, smoking, risky use of alcohol and physical activity. Thirdly, in the full model, the association between ESR levels and self-rated health was adjusted for all background variables together. The background variables were treated as categorical variables in the analyses. Data from 43,110 conscripts with self-rated health data and normal levels of ESR were included in the analyses. Missing values for background variables were excluded listwise.

An α -value of .05 was used to test for statistical significance. All analyses were performed using SPSS statistics software version 21.

RESULTS

Participant characteristics for conscripts with poor self-rated health and conscripts with good self-rated health are presented in Table 1. The majority of the conscripts reported their self-rated health as good (96.2 %). Overall, conscripts with poor self-rated health were more likely to report poor health behaviours such as smoking and risky use of alcohol and had a higher frequency of low emotion regulation than conscripts with good self-rated health.

Table 1. Participant characteristics separated for men with poor self-rated health and men with good self-rated health. Group differences in frequencies have been tested with Chi Square test and differences in means with t-tests.

Variable/category	Self-rated health		χ^2
	Poor n=1,618	Good n=41,492	
BMI			
<18.5	18.2	13.4	31.01*
18.5-25.0	74.4	80.0	29.32*
25.0-30.0	6.5	5.8	1.32
>30.0	0.8	0.8	0.00
Socioeconomic position (%)			
Worker, unskilled	32.6	33.5	0.61
Worker, skilled	21.9	21.5	0.21
Non-manual, assistant	10.0	10.1	0.03
Non-manual, intermediate	18.5	16.7	3.80
Non-manual, higher	5.7	5.1	1.26
Farmer	8.3	10.9	10.48*
Non-classified	2.9	2.2	3.04
Inflammatory disease (%)	22.6	8.5	377.98*
Low emotion regulation (%)	71.2	28.6	1313.11*
Smoking (%)			
> 20 cigarettes/day	14.5	3.2	555.13*
11-20 cigarettes/day	31.7	23.0	64.63*

1-10 cigarettes/day	25.1	32.2	35.34*
Non smoker	28.7	41.6	104.82*
Risky use of alcohol (%)	29.3	15.2	191.76*
Physical activity (%)	24.7	37.0	102.49*
			<i>t</i>
ESR, M (SD)	2.98 (2.19)	2.70 (1.98)	5.58*
BMI, M (SD)	20.79 (2.73)	21.00 (2.57)	-3.26*

* $p < .001$

BMI: body mass index, ESR: erythrocyte sedimentation rate.

Elevated levels of ESR were associated with higher odds for poor self-rated health (OR=1.066 for each unit mm/hr increase in ESR, Table 2). The size of the association and the level of significance were largely unaffected by adjustments for BMI, SEP, inflammatory diseases, emotion regulation, smoking, risky use of alcohol and physical activity (OR=1.077).

Table 2. Crude and adjusted effects of ESR on the odds to have very poor/poor rather than fair/good/very good self-rated health.

	Odds ratio (95% CI) ¹	N
Crude	1.066 (1.043-1.091)	43,110
Adjusted for individual background variables		
<i>BMI</i>	1.064 (1.040-1.088)	43,067
<i>Socioeconomic position</i>	1.069 (1.045-1.093)	43,110
<i>Inflammatory disease</i>	1.066 (1.042-1.091)	43,110
<i>Emotion regulation</i>	1.070 (1.046-1.096)	42,930
<i>Smoking</i>	1.071 (1.047-1.096)	42,555
<i>Risky use of alcohol</i>	1.066 (1.039-1.093)	35,801
<i>Physical activity</i>	1.067 (1.043-1.091)	43,110
Adjusted for all background variables	1.077 (1.049-1.105)	35,553

ESR: erythrocyte sedimentation rate, BMI: body mass index.

¹ Odds ratio for each unit mm/hr increase in ESR

DISCUSSION

The aim of this study was to investigate if there is an association between higher level of the inflammatory marker ESR and poor self-rated health in late adolescent men. The results of this study show that the odds of having poor rather than good self-rated health were elevated by approximately 7 % per for each unit mm/hr increase in ESR.

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3 This pattern was stable when relevant confounders (BMI, SEP, presence of
4 inflammatory disease, emotion regulation, smoking, risky use of alcohol and physical
5 activity) were controlled for. Hence, the present result is consistent with the hypothesis that
6 inflammation is part of a general factor in the psychobiological processes that underpin
7 subjective health perception also in late adolescent men, although the cross-sectional design
8 of the present study precludes conclusions about causality.
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11 The results of the present study are in contrast with the lack of association between
12 inflammatory markers and self-rated health in men in the studies by Lekander and co-workers
13 [8] and Tanno and co-workers [27]. In comparison to the present study, those studies are
14 based on dissimilar methods and populations, with older participants (mean age 59 and 58
15 years, respectively, compared to 18-21 years in the present study). The study by Lekander and
16 co-workers had a considerably smaller sample size, and Tanno and co-workers [27] had an
17 Asian population. However, the present results are in concordance with a previous study that
18 demonstrated a small but significant association between CRP and self-rated health in young
19 adult men 24 to 34 years old [28].
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23 Demographic factors and life-style patterns have been associated with both low-grade
24 inflammation and with poor self-rated health; factors that may constitute possible confounders
25 in the association between ESR and self-rated health, such as aging [48], obesity [49], low
26 SEP [37], and smoking [6, 42]. Adjustments for BMI, SEP, inflammatory disease, emotion
27 regulation, smoking, risky alcohol use, and physical activity did not, however, change the
28 association between ESR and self-rated health in the present study suggesting that the
29 association is not dependent on any of the confounding variables. Also, individuals with a
30 higher degree of inflammation did not introduce bias, as all conscripts with an ESR equal to
31 or above 11 mm/hr had been excluded. No assessments of sickness behaviour were available
32 in the present study and further studies are needed to investigate sickness behaviour as a
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3 mediating factor linking inflammatory factors and poor self-rated health. Unfortunately, data
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5 on diet was not available in the present study, which is a factor to take into account in future
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7 studies.
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10 Our study sample consisted of 43,110 conscripts encompassing the majority of all
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12 Swedish men born in 1949 to 1951. The large sample size allows for a more accurate estimate
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14 of the association between high levels of ESR and poor self-rated health. Having a study
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16 sample that represents such a large percentage of the population also eliminates the risk for
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18 selection bias. In the present material of late adolescent men, the majority of participants
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20 were, as expected, healthy; altogether 82.6 % rated their health as “Good” or “Very good”. It
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22 cannot be excluded that in a current-day sample of young men the included factors would be
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24 differently distributed, and that e.g. low-grade inflammation would be more prevalent since
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26 obesity, which has been linked with low-grade inflammation [50, 51], almost doubled in
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28 prevalence between 1971 and 1993 among Swedish military conscripts [52]. However, the
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30 association between ESR and self-rated health in the present study was independent of
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32 background factors such as BMI and there is little reason to expect that the putative
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34 underlying biological mechanism by which inflammation is associated with subjective health
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36 perception would have changed.
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42 Concerning validity, there is some discordance between ESR and other inflammatory
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44 markers. For instance ESR has been shown to rise and decrease slower than CRP (see e.g.
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46 [53]). However, the independent relation between self-rated health and ESR in the present
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48 study suggests that ESR is a marker for self-rated health, not merely reflecting manifest
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50 disease or chronic conditions.
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53 In conclusion, the present study shows for the first time a significant association
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55 between elevated levels of ESR and poor self-rated health in late adolescent men, providing
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57 evidence of an association between low-grade inflammation and subjective health perception
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3 also in men, as previously demonstrated in women. Data is here provided to further support
4 inflammation as a general factor in the psychobiological processes that underpin subjective
5 health perception across the adult life span.
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10 Contributors: ML, TH, BM, AA conceived of the study. CW drafted the manuscript. KS and
11 TH performed the statistical analyses. All authors were involved in the discussion of the data
12 and revised the manuscript for intellectual content.
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20 Competing interests: None declared.
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23 Data sharing statement: No additional data available.
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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1 OK	(a) Indicate the study's design with a commonly used term in the title or the abstract
	(a) Title, page 3	(b) Provide in the abstract an informative and balanced summary of what was done and what was found
	(b) Page 3	
Introduction		
Background/rationale	2 OK	Explain the scientific background and rationale for the investigation being reported
	Pages 5-7	
Objectives	3 OK	State specific objectives, including any prespecified hypotheses
	Page 7	
Methods		
Study design	4 OK	Present key elements of study design early in the paper
	Title, pages 3, 7-8	
Setting	5 OK	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
	Pages 7-8	
Participants	6 OK	(a) Give the eligibility criteria, and the sources and methods of selection of participants
	Pages 7-8	
Variables	7 OK	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
	Pages 8-11	
Data sources/measurement	8* OK	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
	8-11	
Bias	9 OK	Describe any efforts to address potential sources of bias
	Pages 7-8	
Study size	10 OK	Explain how the study size was arrived at
	Pages 7-9	
Quantitative variables	11 OK	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
	Pages 8-12	
Statistical methods	12 OK	(a) Describe all statistical methods, including those used to control for confounding
	(a) Pages 11-12	(b) Describe any methods used to examine subgroups and interactions
	(b) Table 1	(c) Explain how missing data were addressed
	(c) Pages 9,12	(d) If applicable, describe analytical methods taking account of sampling strategy
	(d) n/a	(e) Describe any sensitivity analyses
	(e) n/a	
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
	OK	
	(a) Pages 8-9 and Table 2	(b) Give reasons for non-participation at each stage
	(b) Pages 8-9	(c) Consider use of a flow diagram

Descriptive data	14*OK (a) Table 1 (b) Table 2	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest
Outcome data	15* OK Table 1.	Report numbers of outcome events or summary measures
Main results	16 OK (a) Page 15, 8-11, Table 2 (b) Pages 9 (c) n/a	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17 OK n/a	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18 OK Page 15-16	Summarise key results with reference to study objectives
Limitations	19 OK Page 17	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 OK Pages 15-18	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 OK Page 17	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22 OK Page 18	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.