Introduction: The health and physical fitness of adolescents and young adults are important not just to the individuals concerned, but also to society as a whole. Many studies from many different countries have dealt with the prevalence of overweight, the risk factors for it, and the morbidity it causes, but no more than a few have addressed the effects of unhealthy lifestyles on physical fitness. In this study, we show that young adults’ physical performance depends on the number of risk factors they possess. We also compare the young adults’ physical performance with that of adolescents aged 10 to 17.

Methods: We obtained cross-sectional data on the weight, smoking status, athletic activity, time to run 1 km, and ability to perform a chin-up on a horizontal bar of 8048 subjects aged 10 to 25. The young adults were divided into groups depending on the number of risk factors they possessed from the following list: overweight, smoking, and lack of exercise.

Results: 28.4% of the men and 35.4% of the women aged 18 to 25 had none of these risk factors and exhibited the best physical performance. The more risk factors were present, the worse physical performance became. The 24- and 25-year-olds performed at the same level as the 14- and 15-year-olds.

Discussion: Unhealthy lifestyles can impair physical fitness even before any chronic disease arises. Possession of even a single risk factor is associated with significantly worse performance. Unless comprehensive and effective interventions are introduced in school and at work, the further cementation and worsening of unhealthy lifestyles will be hard to stop.

### TABLE 1

<table>
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<th>Male study participants</th>
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<td>Age (years)</td>
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### TABLE 2

<table>
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<td>Age (years)</td>
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<td>Total</td>
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billion euros, accounted for more than 11% of the gross domestic product and is continuing to rise (19).

With the focus on the overall costs it has remained mostly unacknowledged that loss of physical power and decreased resilience occur even before chronic diseases develop. In people in gainful employment who are thus afflicted, this may mean an impaired ability to work, decreased productivity, a higher likelihood of making mistakes, and an increased risk of accidents. Morbidity, prevalence, and risk factors of overweight have been the focus of numerous studies (20), but their relation with physical fitness has rarely been investigated. This is particularly true for adolescents and young adults, who are still at the start or in the initial stages of their careers, and whose fitness is of enormous future relevance for the economy and society in general.

The transition between school and career is the main focus of the “Fit fürs Leben” [Fit for Life] study (www.dshs-koeln.de/fitfuersleben), in which more than 19 000 persons have participated so far. The target groups are children/adolescents and young adults aged 6 to 25. In cross sectional serial examinations, data are collected on health, leisure time/working habits, anthropometric parameters, and physical fitness as measured by standardized equipment and motor performance (12, 21).

The present study compared physical fitness in young adults who differed with respect to health risk factors. Participants were categorized into four groups based on the risk factors overweight, smoking, and lack of exercise, ranging from persons without risk factors to persons with three risk factors. Measures of physical fitness were the times achieved in running a distance of 1000 meters (endurance) and doing chin-ups (strength). Comparisons with 10- to 17-year olds are, furthermore, intended to assess changes in physical fitness that are primarily related to growth and puberty.

**Methods**

The Fit for Life study was presented by the data protection officer for Rhineland-Palatinate and North Rhine–Westphalia and approved by the ethics committee of the German Sport University Cologne. Studies in schools were approved by the respective school authorities.

**Study participants**

We evaluated data from 10- to 25-year-old subjects (N = 8048, 10- to 17-year-olds n = 2053, 18- to 25-year-olds n = 5995), who were surveyed as well as anthropometrically examined, and who had completed at least one motor-performance test. Study participants were students at general-education schools (23.8%), apprentices (9.4%) in the commercial/technical and service sectors from Rhineland-Palatinate and North Rhine–Westphalia, and soldiers (66.8%) from locations all over Germany. The members of the armed forces (conscripts as well as short-service volunteers and career soldiers) underwent the examinations in the context of the evaluation of the basic fitness tests that was introduced in Germany’s Armed Forces (Bundeswehr) in 2010 (21). This test was developed as a joint civilian-military research project by the German Sport University Cologne and the Bundeswehr’s Joint Medical Service in Koblenz (Zentrales Institut des Sanitätsdienstes der Bundeswehr Koblenz). Participation in the serial examinations conducted in 2006 to 10 was voluntary. Subjects received standardized written information and gave their consent in writing. Underage subjects required the signature of a parent or person in loco parentis.
Investigation procedures

—Anonymized written questionnaire surveys: In addition to sociodemographic data, the questionnaire collected data on leisure time activities, sports/exercise, and health using pre-defined answers on graded scales (12).

—Anthropometrics: Height/weight and waist circumference were measured using standardized instruments (anthropometer, calibrated scales) according to the handbook of ergonomics and DIN/EN/ISO 15535 2003–10. In order to quantify the prevalence of overweight persons body mass index (BMI) was calculated. Adult study participants with a BMI $\geq 25$ kg/m$^2$ were classified as overweight. For persons younger than 18, the age-specific and sex-specific BMI classification from the International Obesity Task Force (IOTF) was used (22).

—Health risk factors: in accordance with the WHO criteria, the presence or frequency of the health risk factors overweight, smoking, and lack of exercise for 18- to 25-year-olds were calculated by using the data on everyday habits and the anthropomorphic measures. The risk factors were defined as follows:

  - Overweight (BMI $\geq 25$/IOTF limit or waist circumference [men $> 102$ cm, women $> 88$ cm]).
  - Smoking (yes)
  - Lack of exercise (category “never” or “rarely” as response to the question on how often subject exercises).

Based on these criteria, subjects were categorized into four groups (persons without risk factors and groups of persons with 1, 2, or 3 risk factors).

—Physical fitness: In order to obtain measures of fitness for endurance and strength, two motor-performance tests were used (1000 meter run and chin-ups), which enable precise assessment of performance without requiring complicated infrastructural adjustments. For the chin-ups (palms facing towards the subject), subjects were required to remain for as long as possible in the final position of a pull-up. Both test disciplines are elements of the Basis-Fitness-Test (BFT) (21). For further evaluation, the times achieved (in seconds) were used.

—Calculation of performance score: The two motor-performance tests were used to calculate a performance score. The achieved times were ranked for each year of birth and separated by sex and then translated into a points system on the basis of the performance quartile. According to whether a subject was assigned to the high-performing first quartile to the lowest-performing fourth quartile, 1 to 4 points were awarded per discipline. The range was therefore 2 points (= the highest-performing group) to 8 points (= lowest-performing group).

Data presentation and statistics

We used IBM$^\text{TM}$ SPSS$^\text{TM}$ Statistics 19.0 and STATISTICA$^\text{TM}$ 7.1 for our statistical analyses. Means, standard deviations, standard error, and percentiles ($5^\text{th}$, $25^\text{th}$, $50^\text{th}$, $75^\text{th}$, $95^\text{th}$) were calculated as descriptive measures for location, spread, and range. Differences in means were examined using analysis of variance (main factors sex, age, number of risk factors). Dichotomous parameters were evaluated using the chi square test and/or binary logistic regression (outcome variable: risk factor). For binary logistic regression, odds ratios (OR) and the 95% confidence interval (CI) are reported. Associations were determined using hierarchical regression (outcome variable: performance score). Within the regression procedure, we dummy-coded ordinal and nominal scaled variables. We assumed a p-value of $<0.01$ as the significance limit for random and systematic effects.
Results

Anthropometrical data

Until the 12th or 13th year of life, mean values and development of body height and weight in girls and boys are almost identical (Tables 1, 2). In subsequent years, sex-specific differences occur; boys gain greater height and weight (p<0.0001). Although length growth in both sexes is as good as completed after the 18th year of life, body mass in men continues to increase, by about 1 kg per year.

Health risk factors

The proportion of overweight male study participants is notably higher than in female participants (35.9% vs 26.6%; p<0.0001) (Tables 1, 2). The relative frequencies rise over the age-group levels in men (OR 1.06; 95% CI 1.04 to 1.08; p<0.0001) and fall in women (OR 0.95; 95% CI 0.92 to 0.98; p = 0.0011). Consequently, more men aged 18 to 25 are overweight than 10- to 17-year-old boys (37.4% vs 30.6%; p<0.0001), whereas 18- to 25-year-old women are less overweight compared with 10- to 17-year-old girls (23.0% vs 29.3%; p = 0.0125).

The survey about sports activity showed almost identical proportions of male and female study participants who never exercised or did so only rarely (22.0% vs 23.7%; P=0.1747, Tables 1, 2). The likelihood of never or rarely exercising increased by age-group level in men (OR 1.11; 95% CI 1.09 to 1.13; p<0.0001) and women (OR 1.07; 95% CI 1.04 to 1.10; p=0.0001). Compared with 10- to 17-year-old subjects, the proportions of non-exercisers rose in 18- to 25-year-old men (11.1% vs 24.3%; p<0.0001) and women (20.2% vs 29.7%; p<0.0001).

For the risk factor smoking, a strong age-associated development dynamic existed that was almost identical for both sexes (men: OR 1.28; 95% CI 1.25 to 1.30; p=0.0001; vs women: OR 1.30; 95% CI 1.25 to 1.34; p<0.0001). Compared with 10- to 17-year-olds, the proportion of smokers among 18- to 25-year-old men was notably higher (12.8% vs 46.3%, p<0.0001), and the same was true for women (8.7% vs 41.7%; p<0.0001).

Most of the male (71.6%) and female (64.6%) 18- to 25-year-olds had at least one of the three risk factors (Figure 1b). 30.2% of male adults and 24.6% of female adults had two or even three risk factors. Figure 1a shows a clear association with age: The proportion of study participants without cardiovascular risk factors falls notably after the 15th and 16th year of age.

Physical performance

The times for the 1000 meter run and the chin-up (Figure 2) showed better scores (p<0.0001) for male study participants (262.0s±51.4s and 46.7s±23.2s) compared to female subjects (345.9s±70.5s and 24.2s±19.2s). This also applied to the age-group level specific change in performance (p<0.0001); only the times for chin-ups among 10- to 12-year-old boys and girls hardly differed.

In male study participants, the puberal age groups showed notable improvements in performance (p<0.0001). The best times for chin-ups were achieved by 19-year-olds and in the 1000 meter run by 17-year-old subjects. An almost continual decline was observed for the subsequent age-group levels. The performances of 24- to 25-year-old men were at the level of 14- to 15-year-old adolescents.

The age-associated improvements of performance in female study participants were clearly less pronounced: The achieved times for chin-ups and 1000 meter run in 24- to 25-year-old women corresponded to the
performance level achieved by 14- to 15-year-old girls and 11- to 12-year-old boys.

**Association between physical fitness and number of risk factors**

The best performance results for chin-ups and the 1000 meter run (Figures 3, 4) were achieved by subjects without risk factors; this was the case for both men and women. Performance notably deteriorated with the presence of risk factors, and particularly for a rising number of risk factors (p<0.0001). The association between physical fitness and risk factors is made clear by the calculated performance score (Figure 5): Only very few persons with more than one risk factor made it into the highest-achieving group (performance score 2). Conversely, participants without risk factors were rare among those with poorer performance scores. At some 60%, they constituted the highest proportion of the highest-performing subjects.

Overall the performance score increased—and therefore performance deteriorated—with each additional risk factor, and is explained statistically by means of the characteristics under investigation to a proportion of 26% (Table 3).

**Discussion**

Worldwide, numerous epidemiological studies have described the large increases in lack of exercise, overweight, obesity, and associated diseases (2–4, 23, 24). Conversely, the effects of unfavorable lifestyle habits on physical fitness have been investigated comparatively rarely. The limited data can be explained partly by the difficulties in recruiting a sufficiently large number of volunteers for tests that are often time consuming and physically challenging. The comparability of existing studies is limited, because the performance tests that were used differed widely (25).

However, the available data would seem to support the view that physical fitness among adolescents and young adults has deteriorated over the past decades (25–29).

The present study analyzed the association between physical fitness and cardiovascular risk factors (overweight, lack of exercise, smoking). In spite of the limitations of the cross-sectional study design, the notably higher proportion of male study subjects, selection bias (voluntary participation), and information bias (responses from questionnaire surveys), and without claiming to be representative for Germany in its entirety, it is obvious that significantly poorer performance results were observed even when one single risk factor was present. The results deteriorated further with each additional risk factor. Poorer physical fitness might also result from a higher affinity for certain leisure-time habits or risk behaviors. Independently of such a possibility, at this point the empirical proof of the association between risk factors and performance is of crucial importance.

The results indicate that after the primary growth–related pubertal performance improvement, many adolescents and young adults already display a performance loss, which may be caused by unfavorable everyday lifestyle habits and lack of exercise. The performance results of 25-year-olds are at the same level as those of 14- to 15-year-olds. The US National Health and Nutrition Examination Survey (NHANES) has reached the same conclusions; among other findings, the maximum oxygen intake (VO_{2max}) in 18- to 19-year-old women was below the comparison values of 12- to 13-year-old girls (30).

The increasingly earlier adoption of unhealthy or inactive lifestyle habits is being held responsible for the decrease in fitness and the wide spread of risk factors (7, 27, 28, 31–33). This trend has been developing for...
several decades and has apparently accelerated in the past 20 years (10, 13, 29, 34–36). A meta-analysis of data from 161 000 adolescents from 1961 to 2000 shows that physical fitness has been deteriorating since the 1970s (25). According to studies from the 1980s and 1990s, the reduction in aerobic fitness in adolescents (over a period of 10 years) was between 2.4% and 18.3% (37, 38). In young adults, a clear drop in fitness was also noted (13, 26, 29). Running performance over 12 minutes in Finnish conscripts have been deteriorating since the 1980s (Figure 6). These results reported by Santtila et al (29) are based on data from 387 000 men, which means that 95% of all Finnish men aged 20 were tested.

Dyrstad et al. (26) compared VO\textsubscript{2max} and BMI in Norwegian conscripts between 1980 and 2002. They also found a clear negative trend (VO\textsubscript{2max} 8% drop, BMI 6% increase) and explained this with an increasing lack of physical activity/exercise. According to studies of the physical activity of more than 70 000 adolescents from 34 countries, only 24% of the boys aged 13 to 15 and 15.4% of the girls of the same age exercised enough (39), according to WHO recommendations (40). Even if other studies have found that notably more adolescents are actively participating in sports, the number of non-athletes and persons who do not exercise at all rises in older adolescents and young adults (10, 12, e1, e2). Compared with the group of 10- to 17-year-olds, in our

![Figure 5](https://example.com/figure5.png)

**FIGURE 5**

Proportions of 18- to 25-year-old study participants with 0, 1, 2, and 3 risk factors in the individual point classes of the performance score (left: men n = 4653, right: women n = 369), which ranges from 2 (= highest-performing group) to 8 (= lowest-performing group)

![Table 3](https://example.com/table3.png)

**TABLE 3**

Determining the association between the risk factors weight status, smoking, and frequency of exercise and performance score in 18- to 25-year-olds by using hierarchical multiple linear regression in men (n = 4611; R\textsuperscript{2} = 0.266) and women (n = 358; R\textsuperscript{2} = 0.258)

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<th>Men</th>
<th></th>
<th></th>
<th>Women</th>
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<tbody>
<tr>
<td></td>
<td>B</td>
<td>β</td>
<td>∆ R\textsuperscript{2}</td>
<td>p</td>
<td>B</td>
<td>β</td>
</tr>
<tr>
<td>Intercept</td>
<td>5.188</td>
<td>–0.047</td>
<td>&lt;0.0001</td>
<td>5.322</td>
<td>0.223</td>
<td>0.060</td>
</tr>
<tr>
<td>Frequency of exercise (reference: never)</td>
<td>0.091</td>
<td>0.5284</td>
<td>0.0450</td>
<td>0.384</td>
<td>0.2104</td>
<td></td>
</tr>
<tr>
<td>– Rare/irregularly</td>
<td>–0.211</td>
<td>–0.047</td>
<td>0.1778</td>
<td>–0.261</td>
<td>–0.062</td>
<td>0.5284</td>
</tr>
<tr>
<td>– 1–2 times per week</td>
<td>–0.834</td>
<td>–0.214</td>
<td>&lt;0.0001</td>
<td>–0.817</td>
<td>–0.215</td>
<td>0.0450</td>
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<tr>
<td>– 3–4 times per week</td>
<td>–1.382</td>
<td>–0.355</td>
<td>&lt;0.0001</td>
<td>–1.402</td>
<td>–0.328</td>
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<td>– More than 4 times per week</td>
<td>–1.691</td>
<td>–0.253</td>
<td>&lt;0.0001</td>
<td>–1.992</td>
<td>–0.271</td>
<td>&lt;0.0001</td>
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<tr>
<td>Smoking (reference: non-smoking)</td>
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<td>0.004</td>
<td>0.2104</td>
<td>0.147</td>
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<tr>
<td>– Smoking</td>
<td>0.426</td>
<td>0.115</td>
<td>&lt;0.0001</td>
<td>0.223</td>
<td>0.060</td>
<td>0.2104</td>
</tr>
<tr>
<td>Weight status (reference: not overweight)</td>
<td>0.157</td>
<td>0.147</td>
<td>0.2104</td>
<td>0.147</td>
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<tr>
<td>– Overweight</td>
<td>1.517</td>
<td>0.397</td>
<td>&lt;0.0001</td>
<td>1.705</td>
<td>0.384</td>
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study the proportion of inactive persons doubled in young men and increased by a factor of 1.5 in 18- to 25-year-old women. The drastic drop in physical activities during the transition into young adulthood was also noted in one of the rare longitudinal studies, the Amsterdam Growth and Health Longitudinal Study (c3).

In view of the further decreases in physical activity/exercise (for example, because of the rising consumption of digital media among adolescents) the described negative trends are likely to come to a head. The present study results indicate that even if a single risk factor is present—in spite of a short period of exposition—drastic losses in fitness can be expected. Each additional risk factor further increases these losses. Without extensive and effective interventions in schools and companies unhealthy lifestyles will further become embedded and spread, and this cannot be stopped. Young adulthood is a “preventive window” for the manifestation of chronic diseases (12, e2).

**KEY MESSAGES**

- Unfavorable everyday habits, especially physical inactivity, are widespread and have become established among many adolescents and young adults.
- Everyday habits that are adverse to health can lead to fitness loss, reduced resilience, and loss in productivity, even before diseases manifest.
- The sole presence of one of the investigated risk factors (overweight, lack of exercise, smoking) is associated with significant losses in fitness in young adults.
- Any further risk factors result in further fitness impairments.
- In view of the costs incurred to a country’s economy by health-adverse lifestyles, extensive and effective prevention campaigns for adolescents and young adults are urgently needed.

**Conflict of interest statement**

Professor Leyk, Dr Rüther, Professor Blettner, Ms Moedl (holder of a diploma in sports science), Mr Sievert (diploma in sports teaching), Professor Hackforth, and Dr Witzki declare that no conflict of interest exists.

Professor Lötig has received reimbursement for travel and hotel expenses from the German Society of Internal Medicine (DGIM).

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**REFERENCES**


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For eReferences please refer to: www.aerzteblatt-international.de/ref4412
Physical Fitness, Weight, Smoking, and Exercise Patterns in Young Adults

Dieter Leyk, Thomas Rüther, Alexander Witzki, Alexander Sievert, Anne Moedl, Maria Blettner, Dieter Hackfort, Herbert Löllgen

eReferences