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Injury proneness in infantry conscripts undergoing a physical training programme: smokeless tobacco use, higher age, and low levels of physical fitness are risk factors

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Musculoskeletal injuries represent an adverse event of strenuous physical activity. The aim of the present study was to identify pretraining factors that may predispose to such injuries. Risks of injury according to age, body composition, previous physical activity, physical fitness, use of smokeless tobacco (moist snuff) and smoking habits were determined in a population of 480 male conscripts in the army. Data were obtained by questionnaire, height and weight measurements, and from a 3000–metre run test prior to a 10-week period of basic military and physical training. Injuries were registered by doctors attached to the training camp. Every fourth conscript sustained one or more musculoskeletal injuries during the training period. Low back pain, overuse knee injuries, Achilles tendinitis, and sprains of joint capsules or ligaments were the most frequent diagnosis groups. Subjects aged 22 years and more, the least active persons before call-up, those who thought they were less fit than the average, the slowest one-third in the 3000–metre run test, smokers of more than 10 cigarettes a day, and snuff-takers suffered more injuries according to univariate analyses. Multiple logistic regression analysis showed that age, self-assessed physical fitness and snuff-taking were mutually independent risk factors of high statistical significance.

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Key words: overuse injuries; exercise; physical activity; military personnel; smoking; smokeless tobacco; logistic models.

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Benefits of physical activity, such as improved cardiorespiratory and muscular fitness (1) and decreased morbidity and mortality (2, 3), are firmly established. On the other hand, musculoskeletal injuries occur frequently in connection with physical activity (4, 5), showing that physical activity also entails health risks and potential loss of productivity. Knowledge of risk factors is essential to the injury prevention.

The amount of training is the best documented risk factor where injuries among recreational or competitive runners are concerned (6, 7). There is also consistent epidemiological support for a greater risk of future injuries associated with previous running injury, while several postulated risk factors have either not been identified on multivariate analysis or the results of different studies have been conflicting (6–8). In military populations of recruits doing basic training, it is normal for women to sustain more injuries than men (9–11), and for individuals who have had low levels of physical activity before call-up to sustain more injuries than the recently more active ones (9, 12, 13). With reference to military research there is also some evidence for the inclusion of low running capacity (9, 13, 14) and a high body mass index (9, 11, 14) as injury risk factors. It is suggested that the uniformity and consistency of military recruit training provide natural controls for selection bias due to individual modifications in the character of physical activity, and for confounding associations between physical training and other potential injury risk factors (7, 8). Nevertheless, the evidence for the aetiological role of several postulated risk factors is still inconclusive where injuries among military recruits are concerned. Thus, age is positively related to the incidence of injuries in two studies (13, 14), but not in another (11). In one study the previous participation in competitive sport is associated with fewer injuries (11), but this is not confirmed in a couple of others (9, 13). Smoking is found to be a risk factor in one study (13), but not in another (11).

Studies regarding the role of smokeless tobacco use upon injury risk, on the other hand, have to our knowledge not been available. Smokeless tobacco has gained high popularity in some sports milieus. Among young Norwegian men, regular use of moist snuff is positively correlated with physical activity (15); and in the USA, a high prevalence of smokeless tobacco use has been reported in professional baseball players (16) and varsity athletes (17).

The primary purpose of this study was to document the impact of past physical activity, current fitness, and lifestyle on the risks for musculoskeletal injuries in a population of Norwegian conscripts undergoing basic infantry training. Basic training includes regular physical activity (18); musculoskeletal injuries occur frequently (19); and a wide range in the distribution of individual qualifications was expected. Risk factors of interest included previous physical activity and sports participation, physical fitness, age, body composition, smoking and the use of moist snuff. (Use of other smokeless tobacco products, i.e. chewing tobacco, is negligible in Norway, particularly among young people (National Council on Tobacco and Health, personal communication).)

Material and methods

Study population

Conscripts beginning a 10-week period of basic training at an army training camp (Sessvollmoen, January 1991) were asked to participate in the study. Of 558 recruits, 480 volunteered and completed a questionnaire about their physical fitness and previous lifestyle. The sample consisted of male recruits from 19 to 28 years of age (median 21, 94% within the 20–22 age range). Height and weight measurements were obtained prior to the training, and body mass index (BMI) was calculated as weight $\cdot$ height^{-2}. A 3000-m run test was carried out by 449 of the subjects (94%) in the sample at the beginning of the training period. According to the dates of entry and transfer of each serviceman, the total time at risk was 1130 conscripts-months. The study was approved by the local ethics committee.

Questionnaire

The questionnaire was completed by every recruit in the presence and with the advice of an instructor. The recruits were asked to describe their levels of physical activity over the past 2 years compared to those of other men of the same age. Assessments were on a 5-point scale (1=much less active, 3=average, 5=much more active). A question similar to this one was validated by Washburn et al. (20), suggesting that self-assessment may provide useful indices of physical activity for epidemiological research. Individuals were also asked to estimate for how many hours per week on average they had been engaged in some form of physical activity at school, work or in their spare time during the past year. Physical activity was defined as any bodily movement caused by the contraction of skeletal muscles so much that it resulted in a noticeable increase in ventilation, heart rate or heat production (sweat). The recruits were also asked whether in their spare time during the past year they had engaged in competitive sport, had taken exercise repetitively for pleasure or to keep fit (without going in for competitive sport), or engaged in no regular athletic activities or exercise at all. Individuals were also asked how they would describe their physical fitness level compared to that of other men of the same age. Here, too, a 5-point scale was used (1=much poorer, 3=average, 5=much better). Physical fitness was defined as the ability to perform physically demanding tasks such as fast pace walking uphill, riding a bicycle uphill and running. The recruits were asked whether they had smoked, and if so how many cigarettes per day on average they had smoked during the last month before call-up. Finally they were asked whether they were using moist snuff regularly (usually every day). The completion rate for individual questions was 99–100%.

Physical activity

The training programme included 4 hours a week of basic physical training. In addition, the conscripts carried out 1 hour per week of march training, 2 hours per week of infantry running, 3 hours per week of close order drill and 3–4 hours per week of open order and battle technique.

Registration of injuries

Injuries were registered as they occurred by doctors attached to the training camp. An injury was defined as a pain, inflammation or functional disorder which (a) involved the musculoskeletal or soft tissues; (b) was serious enough for the conscript to seek and obtain a medical consultation; and (c) could have occurred entirely or in part as a consequence of an external trauma or strain sustained during the period of basic training. For every consultation concerning an injury, the doctor entered the date, whether the injury had been registered previously, the diagnosis and anatomical site and the tentative aetiology. The assessment of cause formed the basis of defining a subgroup of injuries that in the doctor's opinion was

Table 1. Relative risks (RR) of musculoskeletal injuries with 95% confidence intervals (CI) according to univariate analyses for age, body mass index, previous physical activity, fitness and lifestyle variables

Risk factor	*n* (% of 480)	Injuries per 100 recruit-months	RR	95% CI	*P*-value
Age (years)					
19–20	228 (47)	10.4	1.00	0.69–1.45	–
21	181 (38)	12.2	1.17	0.80–1.70	NS
22–28	71 (15)	19.7	1.89	1.23–2.91	<0.01*
BMI ($kg \cdot m^{-2}$)					
Low (17.41–21.35	160 (33)	15.3	1.60	1.06–2.43	<0.05
Middle (21.37–23.58)	160 (33)	9.5	1.00	0.63–1.59	–**
High (23.59–33.88)	159 (33)	12.4	1.30	0.85–2.01	NS
Past activity					
More active	170 (35)	9.9	1.00	0.65–1.55	–
Average	183 (38)	12.1	1.22	0.81–1.84	NS
Less active	126 (26)	16.7	1.69	1.11–2.56	<0.05**
Weekly hours of past activity					
>10	111 (23)	10.7	1.00	0.59–1.69	–
3–10	250 (52)	12.7	1.19	0.77–1.84	NS
0–2	114 (24)	13.9	1.31	0.80–2.13	NS
Sport participation					
Competitive sport	125 (26)	11.5	1.00	0.62–1.61	–
Sport for exercise	196 (41)	11.3	0.98	0.64–1.51	NS
No sport	154 (32)	15.0	1.31	0.85–2.01	NS
Self-assessed physical fitness					
More fit	114 (24)	8.2	1.00	0.55–1.81	–
Average	270 (56)	11.6	1.41	0.88–2.28	NS
Less fit	93 (19)	20.9	2.56	1.54–4.27	<0.01*
Initial 3000-m run (min:sec)					
Fast (10:23–13:17)	150 (31)	9.4	1.00	0.62–1.62	–
Middle (13:18–14:45)	150 (31)	9.4	1.00	0.62–1.62	NS
Slow (14:46–23:14)	149 (31)	13.9	1.49	0.96–2.31	NS**
Smoking (cigarettes $\cdot d^{-1}$)					
0	235 (49)	10.7	1.00	0.70–1.43	–
1–10	104 (22)	11.4	1.07	0.68–1.68	NS
>10	141 (29)	16.3	1.53	1.06–2.21	<0.05**
Snuff-dipping					
No	404 (84)	11.1	1.00	0.76–1.31	–
Yes	72 (15)	19.5	1.75	1.18–2.58	<0.01

P-values pertain to a two-sample comparison of injury risk between the respective risk group and a reference group (RR=1.00).
* Significantly different also when compared with each of the other groups ($P<0.05$).
** Significantly different (also) when compared with the other groups combined ($P<0.05$).

causally related directly to organized service activities, thereby making an alternative to the more comprehensive definition that included all injuries in which strain could have been a contributing factor. In the event of more than one consultation for the same injury, the injury was only counted once.

Analysis of data

The distribution of the answers to the questions about previous physical activity and self-assessments of physical fitness showed very few responders choosing the most extreme alternatives. For both questions, therefore, the two alternatives on either side of the average group were merged. Risk groups according to continuous variables (height, weight, BMI, and run time) were formed by ranking the recruits according to their measurements and dividing them consecutively into three equally large groups (tertiles).

Incidence rates were expressed as injuries per 100 conscript-months. Relative risks with 95% confidence intervals were calculated using injuries per subject and time at risk, assuming a model with constant intensity of injuries (21). Statistical comparisons between groups were made using a chi-square test based on the same model (21). A corresponding chi-square test for trend (21) was used to examine the association between cigarette consumption (numbers of cigarettes) and the risk of injury.

In addition, logistic regression analysis was carried out on the proportion of recruits with at least one injury versus the proportion of recruits with no injuries. This was done in order to examine the significance of each parameter adjusted for the effects of the others (multivariate analysis). The logistic regression analysis was based on the linear log odds ratio model: log(odds ratio)$=a+b_1x_1+b_2x_2+..+b_px_p$. The antilogarithm of the regression coefficient b_1 is the estimated odds ratio of factor x_1, adjusted for the variables $x_2...x_p$. Odds ratio is the odds of an event for a group of people (injuried versus non-injuried) with a high level of a risk factor divided by the same odds for the group of people with a low level of that risk factor. Variables were alternately put in and out of the model to study adjustment effects. The same variables, with the same division into risk groups as in the univariate analyses, were used. Finally, stepwise multiple logistic regression analysis with backward elimination was carried out to obtain the statistically most powerful set of independent variables. Limits for removal and re-entry were set at $P=0.10$ and $P=0.05$, respectively. The term mutually independent statistical variables was used if the regression coefficient as well as odds ratio of each risk factor changed less than 10% by inclusion or exclusion of other risk factors in the model. All tests were two-tailed, and differences were considered significant if $P<0.05$.

Table 2. Risk factors for musculoskeletal injuries in general remaining after stepwise backwards elimination by multiple regression analysis. Comparative injury risks are given as adjusted odds ratios (OR) with 95% confidence intervals (CI)

Risk factor	OR	95% CI	*P*-value
Age (years)			
19–22	1.00	–	–
≥22	2.21	1.20–4.06	=0.01
Self-assessed physical fitness			
Average or more fit	1.00	–	–
Less fit	2.05	1.02–4.12	<0.05
Initial 3000-m run			
Average or fast tertiles	1.00	–	–
Slow tertile	1.72	1.02–2.91	<0.05
Past activity (hours · week^{-1})			
>2	1.00	–	–
0–2	0.49	0.25–0.96	<0.05
Snuff-dipping			
No	1.00	–	–
Yes	2.50	1.38–4.50	<0.01

P-values indicate that OR differs from 1.00.
Linear odds ratio equation remaining after backwards elimination: Log (odds ratio)$=-1.74+0.79x_1$(age) $+0.72x_2$(self-assessed fitness) $+0.54x_3$(run time) $-$ $0.71x_4$(past activity) $+0.92x_5$(snuff), x=0 for reference groups and x=1 for comparison groups.

Table 3. Risk factors for musculoskeletal injuries with tentative causes related to service activities, remaining after stepwise backwards elimination by multiple logistic regression analysis. Comparative injury risks are given as adjusted odds ratios (OR) with 95% confidence intervals (CI)

Risk factor	OR	95% CI	*P*-value
Age (years)			
19–22	1.00	–	–
≥22	2.33	1.21–4.50	=0.01
Self-assessed physical fitness			
Average or more fit	1.00	–	–
Less fit	3.33	1.29–8.59	=0.01
Initial 3000-m run			
Average or fast tertiles	1.00	–	–
Slow tertile	1.83	1.01–3.31	<0.05
Past activity			
Average or more active	1.00	–	–
Less active	0.41	0.16–1.07	=0.07
Snuff-dipping			
No	1.00	–	–
Yes	2.44	1.30–4.57	<0.01

P-values indicate that OR differs from 1.00.
Linear odds ratio equation remaining after backwards elimination: Log (odds ratio)$=-2.21+0.85x_1$(age) $+1.20x_2$(self-assessed fitness) $+0.61x_3$(run time) $-$ $0.89x_4$(past activity) $+0.89x_5$(snuff), x=0 for reference groups and x=1 for comparison groups.

Results

A total of 141 injuries sustained by 117 of the 480 conscripts (24%) was registered, corresponding to an incidence of 12.5 injuries per 100 recruit-months. The injuries were primarily located in the lower limbs (60%), followed by the back (24%). The most frequently used diagnosis groups were, in the order mentioned, low back pain (20%); overuse knee injuries (14%); Achilles tendinitis (11%); and sprains of joint capsules or ligaments (9%). In 68% of the injuries, a tentative cause was directly related to organized service activities. Marching and infantry running were regarded as the causes of most injuries.

Both univariate and multivariate analysis showed a higher risk of injury among recruits aged 22 years and over than among younger recruits (Tables 1 and 2).

The one-third with the lowest BMI ran a higher risk of injury than the middle third according to the chi-square test (Table 1). For their part, those in the middle BMI group sustained fewer injuries than all the others put together. However, the differences never appeared to be significant using logistic regression. Height and weight were not associated with risks of injury.

Recruits who believed that their physical activity had been below the average for men of their age sustained more injuries than the others (Table 1). This difference was eliminated by logistic regression analysis when adjusted for self-assessed physical fitness or 3000-m run times. The time devoted to physical activ-

Table 4. Odds ratios (OR) of musculoskeletal injuries with 95% confidence intervals (CI) for age, self-assessed physical fitness and smokeless tobacco use. Each OR has been adjusted for effects of the other two risk factors by multiple logistic regression analysis. Both musculoskeletal injuries in general and the subgroup of injuries with causes tentatively related to service activities are concerned

Risk factor	Injuries in total			Injuries attributed to service activities		
	OR	95% CI	*P*-values	OR	95% CI	*P*-values
Age (years)						
19–22	1.00	–	–	1.00	–	–
≥22	2.06	1.18–3.59	=0.01	2.15	1.18–3.93	=0.01
Physical fitness						
Average or more fit	1.00	–	–	1.00	–	–
Less fit	2.09	1.26–3.46	<0.01	2.32	1.34–3.01	<0.01
Snuff-dipping						
No	1.00	–	–	1.00	–	–
Yes	2.31	1.34–3.99	<0.01	2.30	1.26–4.19	<0.01

P-values indicate that OR differs from 1.00.
Linear odds ratio equations (x=0 for reference groups and x=1 for comparison groups): injuries in total: Log (odds ratio) $=-1.56+0.72x_1$(age) $+0.74x_2$(physical fitness) $+0.84x_3$(snuff); service activities: Log (odds ratio) $=-2.05+0.77x_1$(age) $+0.84x_2$(physical fitness) $+0.83x_3$(snuff).

ity prior to military service was not significantly associated with risk of injury using univariate analysis (Table 1). In multivariate analysis, on the other hand, the recruits who had spent the least time on physical activities showed the lowest risk of injury if corrections were made for 3000-m run times (Table 2).

No significant differences were found in risk of injury according to whether the recruits had participated in competitive sports, sport for exercise, or no sport at all (Table 1). Self-assessment by recruits of their own physical fitness, on the other hand, did relate clearly to the frequency of injuries. Those who estimated that they were less fit than the average sustained more injuries than those who thought they were in average or above-average condition. The difference was significant using both univariate and multivariate analysis (Tables 1 and 2).

Where the introductory 3000-m test was concerned, the slowest third of the recruits sustained more injuries than the rest (Table 1). When logistic regression was applied, the difference was eliminated by adjustment for physical fitness only, but reappeared if adjustments were made at the same time for weekly hours of past activity (Table 2).

Smokers who smoked over 10 cigarettes a day ran higher risks of injury than non-smokers (Table 1). The risk increased with the number of cigarettes smoked ($P<0.01$). In multivariate analysis, however, the statistical differences disappeared when adjusted for self-asssessed physical fitness or 3000-m run time. Snuff-taking, on the other hand, was associated with increased risk of injury in both univariate and multivariate analysis (Tables 1 and 2).

The inclusion of only those injuries with causes directly related to service activities resulted in insignificant changes. Recruits aged 22 years and over ($P<0.05$), the least active recruits ($P<0.05$), those who thought they were less fit than the average ($P<0.01$), the slowest third in the 3000-m run ($P<0.05$), and snuff-dippers ($P<0.05$) showed higher risk of such injuries according to univariate analysis. For these injuries, too, there was a positive relationship between cigarette consumption (the number of cigarettes) and the risk of injury. After backward elimination with multiple logistic regression, age, poor physical condition, slow 3000-m run times and the use of snuff still remained as significant risk factors (Table 3).

In both the multivariate models, the one comprising all musculoskeletal injuries in the training period (Table 2) and the one covering injuries causally related to service activities (Table 3), age, self-assessed physical fitness and snuff-taking emerged as mutually independent statistical variables. Times for the 3000-m run and past physical activity, on the other hand, were closely negatively intercorrelated (highly significant association since the 95% confidence intervals of mean run time in different activity groups showed no overlaps (data not shown)); they were mutually dependent of each other as contributory factors in the models, and even then were only marginally significant. The presentation of a multivariate model exclusively based on age, self-estimation of physical fitness and snuff-taking was therefore justified (Table 4).

Discussion

In this study we identified the following risk factors for musculoskeletal injuries: higher age, low levels of previous physical activity, low levels of self-assessed physical fitness, low running capacity, smoking and snuff-taking. Of these, age, physical fitness and snuff-taking were found to be mutually independent statistical variables.

The study was carried out on Norwegian conscripts who undergo basic training under general compulsory military service. Accordingly, the sample might be more representative for the general male population than in similar studies that drew subjects from participants in road races (22, 23), members of a sports clinic (24), or even military servicemen in countries where enlistment is voluntary (9, 11–13). Both the incidence of injuries and the distribution of types of injury and anatomical injury sites were very similar to those reported for a larger population of Norwegian infantry conscripts (19) as well as for American army recruits doing basic training (9).

We have decided to consider risk factors both in relation to all musculoskeletal injuries in the training period and in relation to the subgroup of injuries with causes directly related to organized service activities, because the latter was supposed to give a more specific and reliable representation of training-related injuries. The service-related injuries may, on the other hand, be underestimated because the inclusion in this category presupposed an opinion on the part of the doctor of the sequence of events leading to the injury. The two samples showed no difference, however, with regard to significant risk factors.

The finding that older recruits were more exposed to injury is consistent with similar studies of American (13) and Norwegian recruits (14), while another study was unable to confirm that the age of recruits was associated with injury risk (11). A study of civilian participants starting a walking, running, or jogging programme also showed increasing risk of injury with increasing age (25). Reports on studies of habitual runners, however, have concluded either that age is not associated with injury (22, 24, 25) or that the frequency of injury declines with increasing age (23). Apart from the possible selection of injury-resistant individuals, i.e. that only those runners who remain free of injuries continue to run, it should also be pointed out that individuals in civilian populations are freer than military recruits to choose their own intensities and quantities of training. In any case, it is somewhat surprising that an effect of age can be demonstrated within the narrow age range of this and other military recruit populations (13, 14). It may thus not be the age in itself that is the decisive factor, but rather some characteristics of the conscripts who do their military service at a later time (14). One can speculate on the importance of having the youth closely proceeding as opposed to older recruits who have had an adult lifestyle for some more years. Childhood and adolescence is in all likelihood the period in life that contains most varied physical activities, including much walking. Even though many adults continue to be physically active in adulthood, can it be that these activities are more planned and limited in time and place, that they are less all-round, and that everyday life comprises largely of more sedentary activities?

The contradiction between our findings, showing a high incidence of injury with low BMI, and some earlier studies reporting a higher risk of injury with high BMI (9, 11, 14) need be no more than apparent. One of the studies that pointed to high BMI as a risk factor (9) also noted that recruits, at least male recruits, with low BMI tended to show an increased incidence of injuries, resulting in a U-curve. In a study of overexertional back pain among Israeli infantry recruits (26), low BMI was likewise a risk factor for low back pain. It may accordingly be the case that both high and low BMI could indicate a higher risk of injury than the intermediate values: high because overweight increases the strain of such weightbearing activities as running and marching; low because persons with lower muscle mass may tire more easily, especially during infantry training when military equipment has to be carried. The data should be interpreted cautiously, however, since logistic regression analysis did not confirm the differences shown in the chi-square test, whether univariate or in multivariate combinations.

Our results confirm reports that low levels of previous physical activity are a cause of greater risk of injury among recruits (9, 12, 13). This fits in with a theory that physical activity may result in an adaptation of the musculoskeletal system and thereby help to prevent injuries when the individual is later subjected to new strains. The observed effect was masked, however, if adjustments were made for physical fitness or running capacity, since previous physical activity appeared to be correlated with both. In fact variants of low levels of past activity turned out to be associated with less rather than greater risk of injury when adjusted for running capacity (Tables 2 and 3). This may mean that recruits with relatively good running capacity despite little past training are well equipped to withstand injury, whereas recruits who are poor runners despite substantial training are more exposed.

We were not able to confirm a recent report to the effect that previous participation in competitive sport was associated with fewer injuries (11), which places our study alongside others in which no association has been found between previous participation in sports and the risk of injury (9, 13). However one objection to the present and similar studies (9, 13) may be that they do not discriminate between different sports. It has, for instance, been reported previously that recruits who had been runners were less exposed to stress fractures (27).

It seems reasonable to assume that relatively unfit individuals undergo relatively more strain than those with better physical capacity when going through a physically demanding programme, and that they will therefore be more exposed to injury. Self-assessment of physical fitness has increased in importance in the Norwegian armed forces since the discontinuation a few years ago of physical tests as part of the selection procedure by conscription boards. Classification of physical condition is at present based on conscripts' own information about themselves. Physical fitness has been defined as the ability to perform physically demanding tasks, and its elements include muscular strength and endurance, cardiorespiratory fitness and also to a certain degree motor skills. These are elements that can be operationalized and studied using more objective methods. It has thus been shown that lower levels of muscular endurance could entail a higher risk of training injuries (9, 13). The present and similar studies (9, 13, 14) have, moreover, demonstrated that low running capacity can be a risk factor. Self-assessed physical fitness offers the advantage, however, that it is easy to measure by means of a questionnaire, comprises a wide range of skills, and appears to be a good means of discriminating between recruits who are more or less likely to sustain injuries. It may thus form a simple basis for differentiating training loads according to individual capabilities.

The proportion of our sample who took snuff (15%) was the same, while the proportion of smokers (51%) was higher, than in an extensive survey of the use of stimulants among conscripts in the Norwegian armed forces (28). The observed risk effect of smoking resembles the result of an American study that also showed greater risk of injury among recruits who smoked more than 10 cigarettes a day than among non-smokers (13). In contrast to that study we found that smoking habits were associated with both physical fitness and running capacity in such a way that the effect of smoking was masked in the multivariate analysis. The smokers were much better represented among the slower or less-fit subjects. A corresponding intercorrelation did not exist, however, with regard to snuff-taking, which was just as widespread among the fastest or more fit subjects as among the other recruits.

Snuff-users had, when adjustments were made for other risk factors, a twofold increase in the risk of injury. Causality could hypothetically be attributed to a number of different conditions, such as the inhibiting effect of nicotine on neuromuscular transmission (29), reduced regional blood flow to the working tissues (30), dysregulation of the microcirculation (31), changes in metabolism (32, 33), or the acting of free radicals on vulnerable tissue (34). Some of these effects might be able to increase the relative burdens of exercise on the musculoskeletal system or retard the process of recovering from exertion, resulting in increased risk of injury. Adverse effects of snuff-dipping in sports and exercise strongly contrast with the marketing strategies by tobacco companies that link smokeless tobacco with athletic performance and virility (35), and with the exceptional high prevalences of smokeless tobacco use in some sports milieus (16, 17).

The existence of risk factors that make certain individuals more exposed to musculoskeletal injuries than others underlines the practical importance of making the appropriate individual adaptations to training and physically demanding tasks. Documentation of such risk factors as smoking and snuff-taking also gives grounds for recommending a changed lifestyle as part of injury prevention. In the present study, we have especially emphasized three factors that independently predict increased risk of injury: low levels of self-assessed physical fitness, higher age, and snuff-taking.

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References

1. American College of Sports Medicine. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. Position stand. Med Sci Sports Exerc 1990: 22: 265–74.
2. Blair SN, Kohl HW, Gordon NF, Paffenbarger RS. How much physical activity is good for health? Ann Rev Public Health 1992: 13: 99–126.
3. Blair SN, Powell KE (chairmen). Physical activity and public health: a symposium in honor of Dr Ralph S. Paffenbarger's 70th birthday. Med Sci Sports Exerc 1994: 26: 807–65.
4. Koplan JP, Siscovick DS, Goldbaum GM. The risks of exercise: a public health view of injuries and hazards. Public Health Rep 1985: 100: 189–95.
5. Kraus JF, Conroy C. Mortality and morbidity from injuries in sports and recreation. Ann Rev Public Health 1984: 5: 163–92.
6. Hoeberigs JH. Factors related to the incidence of running injuries: a review. Sports Med 1992: 13: 408–22.
7. Macera CA. Lower extremity injuries in runners: advances in prediction. Sports Med 1992: 13: 50–7.
8. Jones BH, Cowan DN, Knapik JJ. Exercise, training and injuries. Sports Med 1994: 18: 202–14.
9. Jones BH, Bovee MW, Harris JM, Cowan DN. Intrinsic risk factors for exercise-related injuries among male and female army trainees. Am J Sports Med 1993: 21: 705–10.
10. Reinker KA, Ozburne S. A comparison of male and female orthopaedic pathology in basic training. Mil Med 1979: 144: 532–6.
11. Ross J, Woodward A. Risk factors for injury during basic military training. Is there a social element to injury pathogenesis? J Occup Med 1994: 36: 1120–6.

12. Gardner LI, Dziados JE, Jones BH, et al. Prevention of lower extremity stress fractures: a controlled trial of a shock absorbent insole. Am J Public Health 1988: 78: 1563–7.
13. Jones BH, Cowan DN, Tomlinson JP, Robinson JR, Polly DW, Frykman PN. Epidemiology of injuries associated with physical training among young men in the army. Med Sci Sports Exerc 1993: 25: 197–203.
14. Heir T, Eide G. Age, body composition, aerobic fitness, and health condition as risk factors for musculoskeletal injuries in conscripts. Scand J Med Sci Sports 1996: 6: 222–7.
15. Schei E, Fønnebø V, Aarø LE. Use of smokeless tobacco among conscripts: a cross-sectional study of Norwegian army conscripts. Prev Med 1990: 19: 667–74.
16. Siegel D, Benowitz N, Ernster VL, Grady DG, Hauck WW. Smokeless tobacco, cardiovascular risk factors, and nicotine and cotinine levels in professional baseball players. Am J Public Health 1992: 82: 417–21.
17. Walsh MM, Hilton JF, Ernster VL, Masouredis CM, Grady DG. Prevalence, patterns, and correlates of spit tobacco use in a college athlete population. Addict Behav 1994: 19: 411–27.
18. Norwegian Ministry of Defence. Physical education in the Norwegian Armed Forces. Service instructions, gr.43. Oslo: Norwegian Ministry of Defence, 1993 (in Norwegian).
19. Heir T, Glomsaker P. Epidemiology of musculoskeletal injuries among Norwegian conscripts undergoing basic military training. Scand J Med Sci Sports 1996: 6: 186–91.
20. Washburn RA, Adams LL, Haile GT. Physical activity assessment for epidemiologic research: the utility of two simplified approaches. Prev Med 1987: 16: 636–46.
21. Andersen PK, Væth M. Statistical analysis of survival data in medical research. Copenhagen: FADL's forlag, 1984 (in Danish).
22. Koplan JP, Powell KE, Sikes RK, Shirley RW, Campbell CC. An epidemiologic study of the benefits and risks of running. JAMA 1982: 248: 3118–21.
23. Marti B, Vader JP, Minder CE, Abelin T. On the epidemiology of running injuries: the 1984 Bern Grand-Prix study. Am J Sports Med 1988: 16: 285–94.
24. Macera CA, Jackson KL, Hagenmaier GW, Kronenfeld JJ, Kohl HW, Blair SN. Age, physical activity, physical fitness, body composition and incidence of orthopedic problems. Res Q Exerc Sports 1989: 60: 225–33.
25. Blair SN, Kohl HW, Goodyear NN. Rates and risks for running and exercise injuries: studies in three populations. Res Q Exerc Sport 1987: 58: 221–8.
26. Milgrom C, Finestone A, Lev B, Wiener M, Floman Y. Overexertional lumbar and thoracic back pain among recruits: a prospective study of risk factors and treatment regimens. J Spinal Disord 1993: 6: 187–93.
27. Greaney RB, Gerber FH, Laughlin RL, et al. Distribution and natural history of stress fractures in US marine recruits. Radiology 1983: 146: 339–46.
28. Headquarters Defence Command Norway. Annual report of intoxicants in the Norwegian armed forces. Oslo: Headquarters Defence Command Norway, 1994 (in Norwegian).
29. Lester MJ, Jacobson BH, Edwards SW. Effect of ingestion of smokeless tobacco on motor distal latency of the median nerve. Perceptual Motor Skills 1988: 67: 283–90.
30. Hucabee KD, Barnes T, Williams AG, Fan WL, Downey HF. Effects of snuff on regional blood flow to the cheek and tongue of anesthetized dogs. Oral Surg Oral Med Oral Pathol 1993: 76: 729–35.
31. Battistel M, Plebani M, Di-Mario F, Jocic M, Lippe IT, Holzer P. Chronic nicotine intake causes vascular dysregulation in the rat gastric mucosa. Gut 1993: 34: 1688–92.
32. Colberg SR, Casazza GA, Horning MA, Brooks GA. Increased dependence on blood glucose in smokers during rest and sustained exercise. J Appl Physiol 1994: 76: 26–32.
33. Van Duser BL, Raven PB. The effects of oral smokeless tobacco on the cardiorespiratory response to exercise. Med Sci Sports Exerc 1992: 24: 389–95.
34. Przyklenk K. Nicotine exacerbates postischemic contractile dysfunction of 'stunned' myocardium in the canine model. Possible role of free radicals. Circulation 1994: 89: 1272–81.
35. Connolly GN, Orleans CT, Blum A. Snuffing tobacco out of sport. Am J Public Health 1992: 82: 351–3.