Smoking status and physical fitness during initial military training

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Smoking Status and Physical Fitness during Initial Military Training

Abstract

Background: Habitual smoking is prevalent in military populations, but whether smoking status influences physical fitness development during training is not clear.

Aims: We investigated the effect of smoking status on physical fitness parameters during initial British Army Infantry training.

Methods: Routine measures of physical fitness (2.4 km run time and maximum number of press ups and sit ups in two minutes) were obtained in 1,182 male recruits (mean ± SD: age 20 ± 3 y, body mass 70.6 ± 9.8 kg, height 1.77 ± 0.07 m; 58% smokers) at weeks 1, 14 and 24 of initial military training. A linear mixed model was used to identify differences in performance between smokers and non-smokers over time.

Results: Non-smokers performed significantly better than smokers in all performance tests ($P<0.01$), but rates of improvement during training were similar ($P>0.05$). Run performance improved by 7% in non-smokers (estimated marginal means with 95% confidence limits; 612 (608-616) s to 567 (562-572) s) and 8% in smokers (622 (619-625) s to 571 (568-575) s). Press up performance improved by 18% in non-smokers (48.3 (47.1-49.4) to 57.0 (55.6-58.3)) and 23% in smokers (44.1

(43.2-45.1) to 54.5 (53.3-55.6)) and sit up performance by 15% in non-smokers (57.3 (56.3-58.2) to 66.0 (64.9-67.2)) and 18% in smokers (53.8 (53.0-54.6) to 63.3 (62.3-64.3)).

Conclusions: Smokers exhibited lower muscular and cardiorespiratory endurance performance than non-smokers. Unexpectedly however, no significant differences in improvement in performance indices were demonstrated between smokers and non-smokers during military training.

Key words: Smoking; Military; Physical training; Exercise; Physical fitness

Introduction

Habitual smoking is typically more prevalent in military populations than in the general population [1]. It has been reported to affect both cardiorespiratory fitness and muscular strength; compared to non-smokers, habitual smokers exhibit poorer back extensor strength [2] and lower aerobic capacity [3]. The number of cigarettes smoked per day is also negatively related to aerobic capacity [4]. Furthermore, smoking has been reported to be predictive of poorer physical readiness for military duty [5], and to adversely affect run performance during, and at completion of, military training [6,7]. Lower physical fitness in habitual smokers at entry to military training could be explained, in part, by smokers typically engaging in less physical activity compared to non-smokers [8,9]. However, it is not clear whether habitual smoking affects improvement in physical fitness during a progressive training programme.

The only published study investigating whether smoking affects the development of fitness reported that a combined performance score from a battery of physical tests (press ups, pull ups, standing jump, 2.4 km run time) was significantly greater in non-smokers than smokers at the end of a six month officer training programme, despite comparable performance between groups at baseline [10]. However, a comparison of only a cumulative performance score was made between groups, and solely at entry and exit. Further research is needed, examining performance tests individually, and employing more statistically appropriate repeated measures analysis. Initial military training provides a suitable environment to examine the effect of lifestyle behaviours, such as smoking, on physical fitness development. Large cohorts of healthy individuals, with a relatively high prevalence of smoking, complete physically arduous, long-term, standardised training

programmes incorporating regular physical fitness testing. This study therefore aims to explore whether habitual smoking impairs improvement in performance of military physical fitness tests during 24 weeks of initial training in British Army Infantry recruits.

Methods

Questionnaire and physical performance data were collected from male recruits (*n*= 1,182) aged 18-33 y undertaking British Infantry training between 2009 and 2011. At the physical training induction on the first day of training, participants were given a short verbal brief by a designated member of military staff and a full written brief before giving written consent to take part in the study. Participants were assured that data would not be seen by military staff and their military training/careers would not be influenced in any way. The study was approved by the Ministry of Defence Research Ethics Committee (Protocol number 0805/160).

Upon gaining consent, participants were asked to complete the Military Pre-training Questionnaire (MPQ; Robinson et al. 2010) to determine individual smoking characteristics. The MPQ was designed to assess risk factors for training-related injury and, using a comparable sample, was previously found to have good agreement in test-retest scores [11]. The MPQ recorded smoking status, smoking history and smoking behaviour prior to joining the Army. Upon exit from training (whether by completion or military discharge), participants completed a shortened version of the questionnaire to determine whether smoking status had changed or was inconsistent during training. Questionnaire items allowed clear distinctions between habitual current smokers (> 1 cigarette per day) and non-smokers. Non-smokers were defined as those who had either never smoked a cigarette, or currently did not smoke and had

never smoked regularly. Participants who failed to answer all appropriate questions, gave conflicting answers or altered smoking status during training could not be characterised into a smoking group and were not included in analysis. Respondents were also asked to rate their physical activity prior to entry to training relative to men of the same age from 1 (much less active) to 5 (much more active) [12].

At weeks 1, 14 and 24 of training, participants performed a standardised battery of military physical fitness tests. Data were collated by military staff during physical training lessons. Tests consisted of a competitive, timed best effort 2.4 km run, and the maximum number of press ups and sit ups completed within two minutes for each exercise. Tests were self-paced, in a standardised order, and participants could rest (during the tests) at any time. A sample of fitness tests were observed by a member of the research team at regular intervals to ensure identical test administration and practice. At the time of data collection, the standards for entry into basic training were a 2.4 km run time of 12:45 min (765 s), 44 push ups and 50 sit ups in two minutes. By the end of training recruits were expected to perform the 2.4 km run in 10:30 min (630 s). The British Army Infantry training course is composed of a wide variety of demanding physical training including running, strength and endurance exercise, circuit training and loaded marching where both the mass carried and distance covered is progressively increased over the training duration. Physical training sessions are completed multiple times per week in combination with military drill (e.g. weapons handling) and extended tactical field exercises in preparation for combat and war deployment.

Statistical analyses were completed using SPSS 18.0 for Windows (IBM, New York, US). A linear mixed model was used to identify any significant differences between groups and main effects of time and/or interaction (in this case,

whether the change in performance in smokers and non-smokers is different from one another over time). Linear mixed modelling uses all observations at all time points to model a temporal relationship of the whole population sample while also simultaneously modelling each individual participant response as a "random" effect to produce estimated marginal means. This has been shown to be an appropriate statistical means to account for missing data in longitudinal study designs [13], such as, in this case, recruit drop out. Since some drop out from training would not be at random, a first order auto-regressive structure (AR(1)) was chosen to model time-variance and produced the lowest Akaike Information Criterion, demonstrating the best fit for the data in comparison to unstructured linear mixed models. This structure accommodates having less data at later time-points by the model allowing data to become less correlated over time. Estimated marginal means were produced for each variable for weeks 1, 14 and 24. Self-rated physical activity prior to training was compared between groups by independent t-test. Statistical significance was identified at $P<0.05$. Population characteristics are presented as mean ± SD, and performance data as estimated marginal means with 95% confidence limits (CL).

Results

Physical performance data were obtained in week 1 (n=1182), comprising non-smokers (n=475, age 20 ± 3 y, body mass 71.8 ± 10.5 kg, height 1.77 ± 0.07 m) and smokers (n=707, age 20 ± 3 y, body mass 70.0 ± 9.4 kg, height 1.77 ± 0.08 m). In smokers, number of years smoked was 6.0 ± 3.2 y and average number of cigarettes smoked was 11.7 ± 5.7 per day.

After week 1, each consecutive time point contained fewer participants (week 14, n=896 (529 smokers); week 24, n=755 (421 smokers). Military discharge

accounted for the loss of 310 participants (203 smokers), comprising 132 by voluntary discharge, 100 whose services were deemed no longer required, 37 unsuitable for Army service, 36 medically unfit for service and five were dismissed on legal grounds or by defection. Physical performance data were missing for a further 117 participants, resulting in total missing data for 427 participants. Thirty-nine individuals altered their smoking status during training and were not included in analyses. Exact sample numbers used in statistical analyses for each performance variable are presented in Table 1.

[TABLE 1 HERE]

Significant main effects of smoking were observed such that non-smokers performed better than smokers in all physical performance measures independent of time ($P<0.01$). Military training improved press up performance (Figure 1; $P<0.01$) by 18% in non-smokers (estimated marginal means with 95% CL; 48.3 (47.1, 49.4) to 57.0 (55.6, 58.3)) and 23% in smokers (44.1 (43.2, 45.1) to 54.5 (53.3, 55.6)) and sit up performance (Figure 2; $P<0.01$) by 15% in non-smokers (57.3 (56.3, 58.2) to 66.0 (64.9, 67.2)) and 18% in smokers (53.8 (53.0, 54.6) to 63.3 (62.3, 64.3)). Run performance improved (Figure 3; $P<0.01$) by 7% in non-smokers (612 (608, 616) s to 567 (562, 572) s) and 8% in smokers (622 (619, 625) s to 571 (568, 575) s). While change scores in performance indices were larger, in absolute terms, in smokers than non-smokers during training, no interaction effects were observed ($P>0.05$), meaning rates of improvement in performance were similar between groups.

[INSERT FIGURES 1 TO 3 HERE]

Rating of physical activity relative to peers prior to training was significantly higher in non-smokers (3.47 ± 1.05) than smokers (3.16 ± 1.03) in this population (P=0.02).

Discussion

The aim of this study was to determine whether habitual smoking affects training adaptation by examining physical fitness test performance during 24 weeks of initial military training. Independent of time, participants who smoked were significantly less fit than non-smokers. However, training elicited significant improvements in press up, sit up and 2.4 km run performance that were similar in both non-smokers (18%, 15% and 7%, respectively) and smokers (23%, 18% and 8%, respectively), indicating that cigarette smoking did not impact on the development of physical fitness.

A high prevalence of smoking in individuals engaged in arduous physical training is unique to the military. This study improves on existing literature by quantifying improvement in physical fitness of smokers and non-smokers to a standardised training programme. The only published study investigating this previously indicated that smoking may attenuate adaptation during long term training, but examined only a composite score of a battery of fitness tests using a basic statistical approach [10]. By applying more robust statistical analysis to individual performance tasks, the present study improves on these limitations and demonstrates, for the first time, no difference in the progression of physical fitness between young male smokers and non-smokers following identical training programmes. Participants following the same training regime removes a potential confounding factor, after baseline, of smokers and non-smokers typically having

different physical activity levels [8]. Since infantry training is designed to prepare recruits for the physically demanding role of a trained soldier, improvements in fitness parameters were expected. Given the effectiveness of the physical training regime was significant for all performance parameters, any deleterious effect of smoking may have been too small to be measurable by comparison.

Challenges inherent in undertaking research during military training may have prevented the identification of different adaptive responses between smoking groups. A linear mixed model corrects for missing data by simultaneously modelling each individual alongside population means. However, recruits who reached weeks 14 and 24 of training may have contained a higher proportion of those that adapted more positively to training, potentially resulting in an unintentionally biased sample. This is noteworthy given the combinations of lifestyle factors that predict injury risk in recruit training[14] and the higher proportion of smokers lost to training in the present study. The model could then be skewed by the improvement of the fitter 'survivors'. Unfortunately, data on discharge categories alone are not sufficient to determine if the sample contained bias, particularly since recruits could be discharged or have missing data for reasons distinct from failure on a fitness test and information could only be collected on those who remained part of the military cohort. Therefore, a structure of mixed model was chosen to account for participants being lost both randomly and non-randomly. Separately, the opportunity for fitter individuals to improve fitness may be hindered in the mixed-ability training environment. Since all recruits must achieve a minimum physical performance standard, most military physical tasks are completed as a group at a set pace meaning recruits work at different relative intensities and fitter individuals may not perform maximally if successful performance is assured. In a more easily-controlled laboratory-based study

some of these limitations could be mitigated by matching pairs of smokers and non-smokers for fitness at baseline or blinding performance standards, but would be challenging and unrealistic in the military training environment. Despite the discussed issues, the large sample size and control achieved by standardised testing and training mean the present study maintained ecological ('real world') validity and lends confidence that any meaningful impairment in the adaptation of physical fitness resulting from smoking in this population would still have been apparent.

Although changes in performance did not differ between smokers and non-smokers, on average smokers exhibited significantly lower performance in all tests. Previous research supports that smoking has adverse effects on the cardiorespiratory system [15–17] and muscular endurance [18–21] . Taken together, the results of the present study might be taken to support the assertion that habitual smoking adversely affects overall physical fitness [4,7]. On balance, however, smokers exhibiting fewer health-promoting lifestyle choices is also proposed to contribute to lower physical fitness levels typically observed [8], potentially explaining, in part, the differences in performance observed between smokers and non-smokers at baseline. This is supported by significantly higher self-reported activity level (prior to training) in non-smokers. Separately, this suggests the training regime may have been a more potent stimulus/intervention for adaptation in smokers. This larger change in lifestyle may explain the unexpected observation that absolute change in physical performance indices (while not significantly different) were greater in smokers than non-smokers.

The performance measures in the current study are used by the military as indicators of physical fitness relative to age and sex. Despite statistical significance, the absolute differences observed between smokers and non-smokers ranged between 1% and 6%, such that the average physical fitness of smokers in the present study

was still sufficient to pass military physical fitness standards during initial training (630 s 2.4 km run, 44 press ups, 50 sit ups). It may be that the cumulative harmful effects of smoking on physical fitness would be more discernible in different population such as older, or less physically active, groups or when examining baseline fitness-matched pairs of non-smokers and heavy smokers.

The findings of the current study demonstrate that, during a standardised military training programme resulting in significant improvements in cardiorespiratory and muscular endurance, there was no evidence of an impact of habitual smoking on the development of physical fitness in the short term. On average, however, habitual smokers exhibited lower physical fitness than non-smokers, independent of time in training. This was likely a consequence of lower habitual physical activity in smokers prior to training. These data support previous research that smokers typically have lower cardiorespiratory fitness than non-smokers, but may also extend to reduced performance in muscular endurance tasks. Whether this is a product of smoking itself impairing physical fitness or smokers partaking in less physical training in a free living environment, however, remains to be confirmed.

Key points:

- Military training elicited similar significant improvements in physical performance indices in smoking and non-smoking recruits, suggesting habitual smoking has little to no impact on improvement in physical fitness.
- On average, smokers were less fit than non-smoking counterparts during initial military training, which may be related to smoking status or be explained by

lower physical activity level than non-smokers prior to commencement of training.

- A high prevalence of smoking combined with standardised progressive physical training is unique to the military, and it is not clear if these same results would be observed in an older and/or less physically-active population.

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Conflict of Interest: All authors declare that they have no conflict of interest.

Abbreviations: MPQ: Military Pre-training Questionnaire; NS: Non-smoker; S: Habitual smoker; CL: Confidence limits

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Table. 1 Number of non-smokers (NS) and smokers (S) with physical fitness test data entered in linear mixed model analysis

	Week 1		Week 14		Week 24		
Variable	NS	S	NS	S	NS	S	Total Observations
Press up	475	707	367	528	301	423	2801
Sit up	475	707	367	529	302	424	2804
Run	472	701	334	493	334	421	2755

Fig. 1 Total number of press ups completed in two minutes by non-smokers (△) and smokers (▲) at weeks 1, 14 and 24 of initial Infantry training (estimated marginal means with 95% CL). Horizontal parenthesis denotes main effect of time. Vertical parenthesis denotes main effect of smoking.

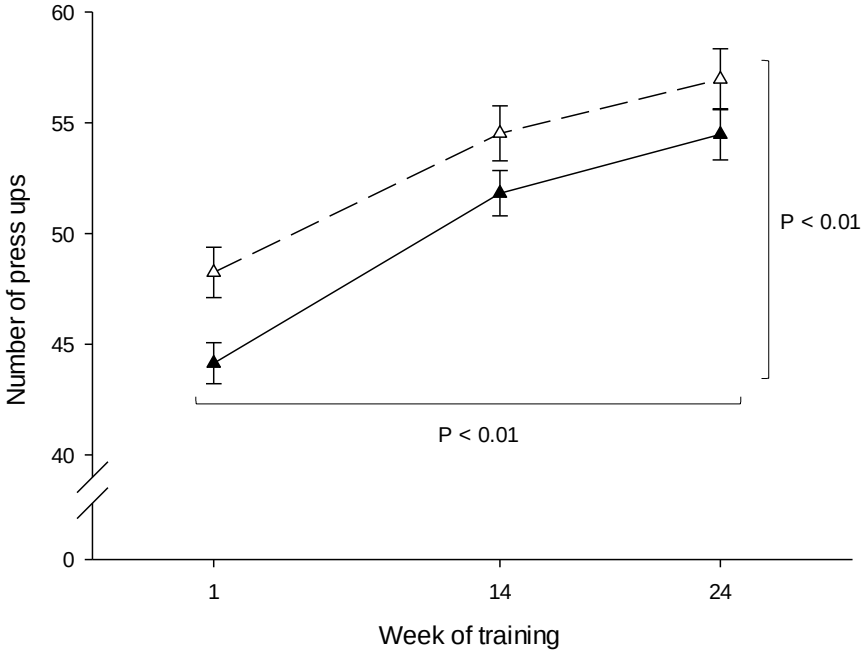

Fig. 2 Total number of sit ups completed in two minutes by non-smokers (△) and smokers (▲) at weeks 1, 14 and 24 of initial Infantry training (estimated marginal means with 95% CL). Horizontal parenthesis denotes main effect of time. Vertical parenthesis denotes main effect of smoking.

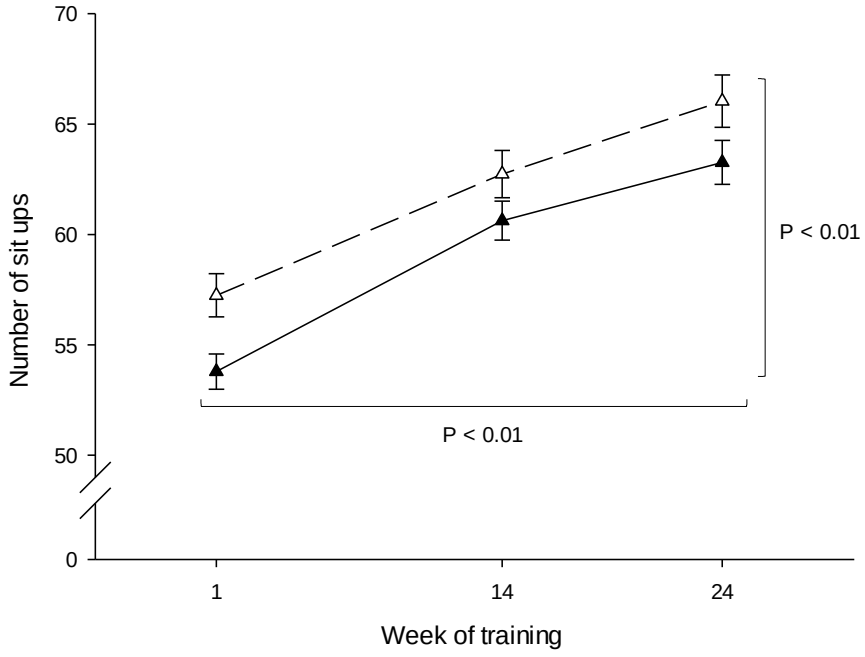

Fig. 3 Average 2.4km run performance in non-smokers (△) and smokers (▲) at weeks 1, 14 and 24 of initial Infantry training (estimated marginal means with 95% CL). Horizontal parenthesis denotes main effect of time. Vertical parenthesis denotes main effect of smoking.