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Reduction of physical activity in daily life and its determinants in smokers without airflow obstruction

KARINA COUTO FURLANETTO, LEANDRO CRUZ MANTOANI, GIANNA BISCA, ANDREA AKEMI MORITA, JULIANA ZABATIERO, MAHARA PROENÇA, DEMÉTRIA KOVELIS AND FABIO PITTA

Laboratory of Research in Respiratory Physiotherapy (LFIP), Department of Physiotherapy, State University of Londrina (UEL), Londrina, Brazil

ABSTRACT

Background and objective: **In smokers without airflow obstruction, detailed, objective and controlled quantification of the level of physical inactivity in daily life has never been performed. This study aimed to objectively assess the level of physical activity in daily life in adult smokers without airflow obstruction in comparison with matched non-smokers, and to investigate the determinants for daily physical activity in smokers.**

Methods: **Sixty smokers (aged 50 (39–54) years) and 50 non-smokers (aged 48 (40–53) years) matched for gender, age, anthropometric characteristics, educational level, employment status and seasons of the year assessment period were cross-sectionally assessed regarding their daily physical activity with a step counter, besides assessment of lung function, functional exercise capacity, quality of life, anxiety, depression, self-reported comorbidities carbon monoxide level, nicotine dependence and smoking habits.**

Results: **When compared with non-smokers, smokers walked less in daily life (7923 ± 3558 vs 9553 ± 3637 steps/day, respectively), presented worse lung function, functional exercise capacity, quality of life, anxiety and depression. Multiple regression analyses identified functional exercise capacity, Borg fatigue, self-reported motivation/physical activity behaviour and cardiac disease as significant determinants of number of steps/day in smokers (partial r^2 = 0.10, 0.12, 0.16 and 0.05; b = 15, −997, 1207 and −2330 steps/day, respectively; overall fit of the model R^2 = 0.38; P < 0.001).**

Conclusions: **Adult smokers without airflow obstruction presented reduced level of daily physical activity. Functional exercise capacity, extended fatigue sensation, aspects of motivation/physical activity behaviour and self-reported cardiac disease are significant determinants of physical activity in daily life in smokers.**

SUMMARY AT A GLANCE

This is the first study to show that smokers are less physically active than non-smokers matched for the main factors influencing daily physical activity. Significant determinants of daily physical activity objectively assessed in smokers are: functional exercise capacity, fatigue sensation and self-reported motivation/physical activity behaviour and cardiac disease.

Key words: exercise, monitoring, motor activity, smoking, tobacco.

Abbreviations: 6MWT, 6-min walk test; COPD, chronic obstructive pulmonary disease; Mot/Be.PA, motivation/behaviour physical activity.

INTRODUCTION

The association between physical inactivity and smoking has been increasingly discussed in the literature. Tobacco smoking has been shown to be the most important risk factor for developing chronic obstructive pulmonary disease (COPD).[1,2] There is also abundant evidence demonstrating that physical inactivity is a feature of COPD.[3–5] Interestingly, a few questionnaire-based studies[6–8] have already shown that physical activity level in smokers is an important factor associated with the disease, even before the diagnosis of COPD. A landmark cohort study[6] demonstrated that higher levels of regular physical activity are associated with reduced lung function decline and lower risk of developing COPD among smokers. A case–control study found an inverse association between lifelong physical activity and the risk of COPD and breathlessness.[7] Furthermore, it has recently been suggested that the reduction of daily physical activity is the first feature in the time-course development of COPD, and perhaps cigarette smoking had a deleterious effect on physical activity even before the onset of the disease.[8]

Correspondence: Fabio Pitta, Departamento de Fisioterapia—CCS, Hospital Universitário de Londrina, Av. Robert Koch, 60—Vila Operaria, 86038-350—Londrina, Paraná, Brazil. Email: fabiopitta@uol.com.br

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However, a specific study design comparing objectively measured physical activity of smokers and non-smokers matched for various important factors influencing daily physical activity has not yet been performed.

Despite the importance of this issue, physical activity level and its negative correlation with smoking habits in this 'at-risk' population of smokers have been mostly studied with questionnaires to assess daily physical activity,[9] while it is known that highly accurate information about daily physical activity is more likely to be obtained with objective assessment than with questionnaires.[10] Walking is the most common form of performing moderate-intensity physical activity in daily life, and pedometers are valid devices[11–13] that are able to count the number of steps/day and consequently estimate physical activity levels.[14]

Therefore, in view of the scarce literature concerning objective assessment of physical activity in daily life to study the deleterious association of decrease in physical activity and smoking, we hypothesized that smokers with not-yet-clinical-nor-spirometrical COPD are less physically active than non-smokers matched for factors known to be possible contributors to the level of physical activity in daily life. The objectives of the present study were: (i) to objectively assess the level of physical activity in daily life in adult smokers without airflow obstruction and compare it with non-smokers matched for potential factors influencing physical activity; and (ii) to investigate determinants of physical activity level in smokers.

METHODS

Study design and subjects

This cross-sectional study included 116 subjects who were evaluated at the Laboratory of Research in Respiratory Physiotherapy from the State University of Londrina (Brazil). Sixty-five smokers without airflow obstruction (forced expiratory volume in the 1 s/forced vital capacity > 0.7)[15] were assessed before being included in an interventional program of physical activity promotion, previously described elsewhere.[16] The inclusion criteria for smokers were: to be a current smoker, aged over 18 years, without lung function impairments and pathological conditions that could impair daily physical activity. Individuals were excluded if they were unable to understand or cooperate during the assessments or if they reported not having worn the pedometer for a minimum of 12 h/day during 6 days. A group of 51 non-smokers were recruited and matched for gender, age, anthropometric characteristics, educational level, employment status and seasons of the year in which the assessment period was undertaken. They were never smokers and had never been exposed to passive smoking. The study was approved by the institution's Ethics in Research Committee, and patients' data and information were kept confidential.

Assessments

Physical activity in daily life was assessed using a pedometer Yamax Digiwalker SW-200 (Yamax, Inc., Tokyo, Japan).[11–13] All subjects were asked to wear it for 6 consecutive days, from Sunday to Friday. The average step count of the 6 days was calculated, and for analysis purposes, the smokers' group was subdivided into physically active or inactive subgroups according to their physical activity level (≥8000 or <8000 steps/day, respectively).[14,17] Additionally, the profile of physical activity was expressed based on the five classifications proposed by Tudor-Locke and Bassett[18] according to the number of steps/day: sedentary, low active, somewhat active, active and high active (Appendix S1 in the supporting information).

A simple question about self-reported motivation and physical activity behaviour (scale 1–5) was also applied. The question was an adaptation of a previously proposed five-stage categorization[19–21] (Appendix S1 in the supporting information). As for the results of this study, this question is from now on referred as motivation/behaviour physical activity (Mot/Be.PA).

Besides the assessment of physical activity in daily life and self-reported Mot/Be.PA, all participants underwent assessment of lung function (spirometry), exercise capacity (6-min walk test, 6MWT), health-related quality of life (36-item short-form health survey); permission for use granted by copyright owners), anxiety (State-Trait Anxiety Inventory; permission for use granted by copyright owners), depression (Beck Depression Inventory), self-reported comorbidities and medication use. For smokers, expired carbon monoxide level, smoking habits and nicotine dependence (Fagerström Tolerance Questionnaire) were also assessed. Specific details are provided in the Appendix S1 in the supporting information.

Statistical analysis

The statistical software SPSS Statistics 17.0 (SPSS Inc., Chicago, IL, USA) was used. Normality in data distribution was checked with the Kolmogorov–Smirnov test. Data were expressed as mean (standard deviation) or median (interquartile range 25–75%). For continuous variables, unpaired *t*-test or Mann–Whitney test were used to compare smokers and non-smokers, or the subgroups of physically active or inactive smokers. For categorical variables, the chi-square test was used to compare groups and to compare the proportion of subjects classified according to physical activity level.[18] Pearson's or Spearman's coefficients were used to analyse correlations. Variables that were significantly related to the number of steps/day in the single correlation (continuous variables) or showed significant differences in the number of steps/day between categories (dichotomous variables) were selected to be included in the multivariate model. Multiple stepwise regression was performed to identify independent contributors to the variance in daily activity of smokers. A $P < 0.05$ was set for statistical significance.

Table 1 Characteristics of the subjects matched for factors known to be possible contributors to physical activity level

	Smokers (n = 60)	Non-smokers (n = 50)
Gender, M/F (%)	24/36 (40/60)	19/31 (38/62)
Age (years)	50 (39–54)	48 (40–53)
BMI (kg.m^2)	25 (22–29)	26 (24–29)
Educational level, CU/IU/CHS/IHS/CMS/IMS (%)	24/5/19/3/5/3 (40/8/32/5/8/5)	20/8/16/1/4/0 (40/16/32/2/8/0)
Employment status, FE/S/H/R (%)	41/2/13/4 (68/3/22/7)	34/1/10/5 (68/2/20/10)
Seasons of the year, SS/AW (%)	31/29 (52/48)	29/21 (58/42)
Initiation of smoking, years	16 (14–19)	NA
Cigarettes/day	20 (11–24)	NA
Pack-years	23 (15–43)	NA
Nicotine dependence	5 (3–7)	NA

The values of categorical variables were described as frequency (percentage) as well as the numeric variables were described as median (interquartile range 25–75%) according to the normality in data distribution. Nicotine dependence: Fagerström Tolerance Questionnaire to nicotine dependence level (score 0–10). There were no differences between the groups ($P > 0.05$ for all).

AW, assessed on autumn or winter; BMI, body mass index; CHS, complete high school; CMS, complete middle school; CU, complete university; FE, formally employed; H, housewife; IHS, incomplete high school; IMS, incomplete middle school; IU, incomplete university; M/F, male/female; NA, not applicable; R, retired; S, student; SS, assessed on summer or spring.

RESULTS

Profile of physical activity in smokers and comparison with non smokers

Five smokers and one non-smoker were excluded from the study because they did not complete the physical activity assessment; therefore, 60 smokers and 50 non-smokers were included in the analysis. Smokers and non-smokers were matched for potential factors known to be possible contributors to level of physical activity in daily life. These factors were: gender, age, anthropometric characteristics, educational level, employment status and season of the year in which the assessment period was undertaken (Table 1). Besides presenting worse lung function, exercise capacity, quality of life, and symptoms of anxiety and depression, smokers also walked less than non-smokers in daily life (Table 2 and Fig. 1).

The pattern of physical activity in daily life of the smokers and non-smokers groups, based on the classification proposed by Tudor-Locke and Bassett,[18] is shown in Figure 2. When comparing physically inactive (n = 34) and active (n = 26) smokers (cut-off of 8000 steps/day), despite the fact that the average distance achieved in the 6MWT was not significantly different between the subgroups (565 ± 74 vs 584 ± 69 m, respectively; P = 0.39), there were statistical differences in fatigue both immediately after the test (Borg scores: 2.5 (0–3.25) vs 0.5 (0–2), respectively; P = 0.03) and at 2 min of recovery after the end of the test (0.75 (0–2) vs 0 (0–0.13), respectively; $P < 0.008$), that is, physically inactive smokers reported a higher perceived exertion of fatigue than physically active smokers. No other intergroup differences were found.

Self-reported comorbidities and medication use

The proportion of smokers and non-smokers with self-reported comorbidities is presented in Table 3. In general, smokers reported more comorbidities than non-smokers, although with no statistically significant differences except for stable cardiac disease. Thirty smokers (50%) reported daily medication use against 21 non-smokers (42%) (P = 0.44).

Determinants of physical activity behaviour in smokers

Based on the results of single correlation analyses and comparisons between different levels of dichotomous variables, the following five parameters were included in the multivariate model: body mass index (r = –0.29), distance achieved in the 6MWT (m) (r = 0.31), Borg fatigue scale's score 2 min after the end of the 6MWT (or extended fatigue) (r = 0.32), self-reported Mot/Be.PA (r = 0.31) and cardiac disease (r = –0.29). Gender, age and season of the year in which assessment period was undertaken, educational level, employment status, lung function, nicotine dependence, smoking habits, anxiety, depression and quality of life were not significantly related to number of steps/day in this sample and therefore were not included in the multivariate analysis. The model of stepwise multiple regression showed that distance achieved in the 6MWT, extended fatigue, self-reported Mot/Be.PA and cardiac disease emerged as significant determinants of daily number of steps. Altogether, these variables explained 38% of the variance in the number of steps/day achieved by smokers (adjusted R^2 = 0.378; $P < 0.001$). Beta coefficients, 95% confidence interval, part correlation and statistical significance are shown in Table 4. Multiple regression analyses including the other factors that were hypothesized to be related to physical activity were also performed (Appendix S1 and Table S1 in the supporting information); however, the same four variables remained as the significant ones in the regression model (adjusted R^2 = 0.377). Finally, the sample was pooled (smokers and non-smokers), and forced expiratory volume in the 1 s and smoking status (yes/no) were included in the regression model; as a result,

Table 2 Comparison between the groups concerning the measurements of physical activity, functional exercise capacity, expired carbon monoxide level, lung function, health-related quality of life, anxiety and depression

	Smokers (n = 60)	Non-smokers (n = 50)
Steps/day	7923 ± 3558*	9553 ± 3637
6MWT (m)	574 ± 72*	631 ± 64
6MWT, %pred	84 ± 9*	93 ± 8
COexh, level	3 (2–5)*	1 (1–1)
COexh (ppm)	18 (13–30)*	6 (6–6)
COexh, %COHb	3.6 (2.6–5.4)*	0.8 (0.8–0.8)
Spirometry		
FVC (L)	3.18 (2.7–4.1)	3.43 (2.9–4.2)
FVC, %pred	86 ± 13*	95 ± 14
FEV_1 (L)	2.6 (2.3–3.3)**	3 (2.5–3.6)
FEV_1, %pred	91 (78–97)*	99 (92–105)
FEV_1/FVC	83 ± 6*	85 ± 5
$FEF_{25–75}$ (L/s)	3.1 ± 1.1*	3.5 ± 0.9
$FEF_{25–75}$, %pred	104 (116–143)*	116 (99–131)
MVV (L/min)	114 ± 35*	133 ± 41
MVV, %pred	91 ± 21*	100 ± 21
PEF (L/s)	6.5 (5.2–8.8)**	6.9 (5.9–9.9)
PEF, %pred	79 ± 15*	91 ± 12
HRQoL questionnaire		
Physical functioning	90 (75–95)*	95 (85–100)
Physical role	100 (75–100)*	100 (100–100)
Bodily pain	72 (51–84)*	74 (62–100)
General health	72 (57–82)*	87 (77–92)
Vitality	65 (45–80)*	78 (70–85)
Social role functioning	87 (50–100)*	100 (88–100)
Emotional role functioning	100 (33–100)*	100 (92–100)
Mental health	64 (44–84)*	84 (76–92)
Anxiety questionnaire		
STAIT-T	39 (32–49)*	33 (30–40)
Depression questionnaire		
BDI	10 (5–17)*	4 (2–8)

* $P < 0.05$ in comparison with non-smokers; ** $0.05 < P < 0.1$ in comparison with non-smokers.

The values were described as mean ± standard deviation or median (interquartile range 25–75%) according to the normality in data distribution.

6MWT, 6-min walk test; BDI, Beck Depression Inventory; COexh, carbon monoxide level in the exhaled air; COHb, carboxyhaemoglobin; FEF, forced expiratory flow; FEV_1, forced expiratory volume in the 1 s; FVC, forced vital capacity; HRQoL, health-related quality of life; MVV, maximum voluntary ventilation; PEF, peak expiratory flow; STAIT-T, State-Trait Anxiety Inventory.

steps/day was significantly explained only by being a smoker (b = −1730 steps; P = 0.01; adjusted R^2 = 0.05).

DISCUSSION

To our best knowledge, this is the first study that has demonstrated a reduction in the objectively measured level of physical activity in daily life of adult smokers compared with matched non-smokers. It is also the first study to outline the profile and determinant factors of daily physical activity of smokers without spirometric diagnose of airflow obstruction. Several potential factors of participation in daily activity such as employment status,[22] educational level,[22,23] seasonal variation throughout the year[24,25] and anthropometric characteristics[26,27] were controlled by having matched non-smoking participants.

The present study has clearly shown that smokers performed significantly less steps/day than non-smokers. Inactivity in smokers is not a surprising finding on itself. Others have used different tools to suggest that smokers are less active in daily life; however, conflicting results are found in the

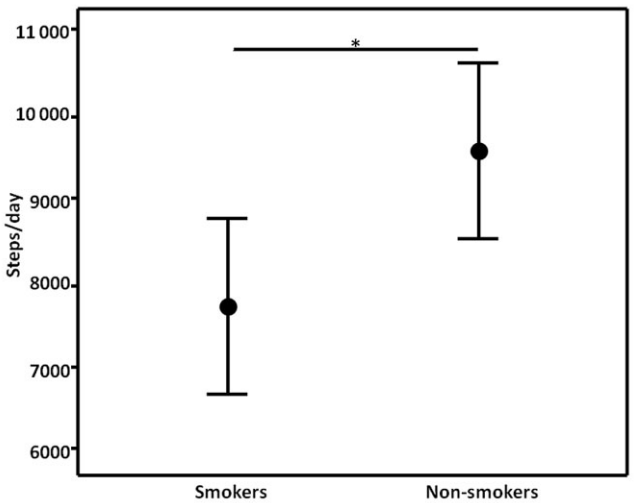

Figure 1 Number of steps/day in smokers and non-smokers. Error bar with the mean score and 95% confidence interval (95% confidence interval) for both groups. Smokers: 7923 (7004–8842); non-smokers: 9553 (8520–10587) steps/day. *P = 0.02.

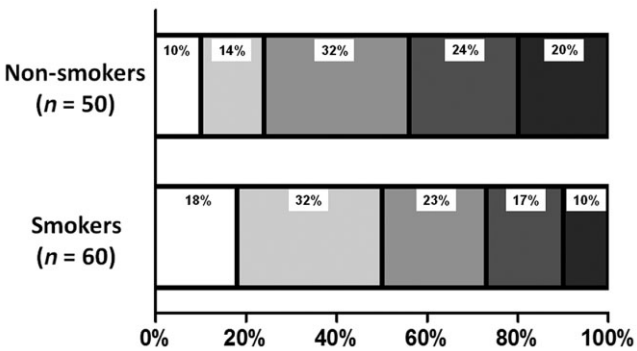

Figure 2 Profile of physical activity in daily life of smokers and non-smokers. Sedentary (Sed): <5000 steps/day; low active (L. Act.): between 5000 and 7499 steps/day; somewhat active (Sw-Act.): between 7500 and 9999 steps/day; active (Act): between 10 000 and 12 499 steps/day; high active: >12500 steps/day. *P < 0.05 between the proportion of low-active subjects in the groups of smokers (32%) and non-smokers (14%). (▭) Sed; (▭) L.Act.; (▭) Sw-Act.; (▭) Act.; (▭) H.Act.

literature.[9,28,29] A Brazilian study[28] involving undergraduate students found that both smokers and non-smokers presented similar pattern of physical inactivity, and no association was found between smoking and physical inactivity. Nevertheless, physical activity level was self-reported, and the subjects' age was considerably lower in comparison with the present study. Conversely, a study that assessed physical activity levels of adults with an accelerometer[29] demonstrated that smokers had significantly lower levels of physical activity than their non-smoking counterparts. However, groups were not matched for the main factors that could influence daily physical activity level. The lack of a matched group of non-smokers might be a source of bias, as differences in potential determinants of physical activity could act as confounding factors.

Table 3 Self-reported comorbidities and comparison between smokers and non-smokers

Comorbidities	Smokers (n = 60)	Non-smokers (n = 50)	P-value
Systemic hypertension	11 (19%)	5 (10%)	0.28
Arthritis	6 (10%)	4 (8%)	0.75
Peripheral vascular disease	8 (14%)	3 (6%)	0.34
Stable cardiac disease	8 (14%)	1 (2%)	0.04
Diabetes mellitus	5 (8%)	3 (6%)	0.72
Osteoporosis	2 (3%)	1 (2%)	1.00
Thyroid disorders	4 (7%)	2 (4%)	0.68
Allergy	25 (41%)	13 (27%)	0.16

The values were described as frequency (percentage). The total number of subjects reporting any comorbidities in each group were 41 (68%) of smokers and 25 (50%) of non-smokers. The median (interquartile range 25–75%) of the number of comorbidities for the subjects reporting comorbidities in each group were 1 (1–2) of smokers and 1 (1–2) of non-smokers (P = 0.13).

Further interesting findings from the present study were the differences in exercise capacity, lung function, quality of life, anxiety, and depression between the groups of smokers and non-smokers. These results confirmed different aspects of health impairment among smokers and added new information to previous literature findings. It is known that smoking leads to a lifelong reduction in spirometric values such as reduction in forced expiratory volume in the 1 s, which has been associated with increased all-cause mortality in smokers.[30] Furthermore, previous research shows that smokers present peripheral muscle alterations,[31] worse exercise tolerance,[32] higher levels of anxiety[33] and depression,[33] and consequently more impaired quality of life[34] than non-smokers. Pertaining to worse lung function, one could speculate that inactivity among smokers could be due to ventilatory limitation as observed in mild COPD during exercise;[35] however, steps/day was not correlated with any spirometric variable and in the regression model with the pooled sample, forced expiratory volume in the 1 s did not significantly explain steps/day. All these differences between smokers and non-smokers, specifically the novel physical inactivity aspect brought by the present study, corroborate previous studies, encouraging not only smoking cessation but also physical activity promotion programs for smokers.[6–8,16,36] Differences between physically active and inactive smokers are discussed in the Appendix S1 in the supporting information.

This is potentially the first study that has investigated the determinants of objectively assessed physical activity in smokers. Exercise capacity, extended fatigue, self-reported Mot/Be.PA and cardiac disease explained 38% of the variability in the number of steps/day performed by smokers. It has been suggested that causal effects of health behaviour, such as social and physical environment, are determinants of physical activity, while individual-level factors such as age, gender, health status, self-efficacy and previous physical activity are only associated with it. Further; although being infrequently assessed,[26] the combination of favourable psychosocial and environmental

Table 4 Multiple regression analysis with the number of steps/day as the dependent variable

	Unstandardized coefficients (B)	Standard error	Standardized coefficients (beta)	95% CI for B	P-value	Part correlation
Constant	5672.061	981.471	NA	3704.331 to 7639.790	NA	NA
Mot/Be PA†	1206.742	321.107	0.394	562.962 to 1850.523	0.001	0.389
Extended fatigue‡	−997.224	317.379	−0.334	−1633.530 to −360.919	0.003	−0.325
6MWT (m)§	15.293	5.264	0.309	4.704 to 25.845	0.005	0.301
Cardiac disease¶	−2329.705	1103.121	−0.226	−4541.329 to −118.082	0.039	−0.219

† Mot/Be PA = answers about motivation and physical activity behaviour (score 1–5).

‡ Extended fatigue: Borg scale of fatigue after 2 min of recovery of the 6MWT (score 0–10).

§ Walking distance in the 6MWT (m).

¶ Self-reported cardiac disease (yes/no).

Partial r^2 = 0.16, 0.12, 0.10 and 0.05, respectively. Overall fit of the model R^2 = 0.378; $P < 0.001$. Based on the results of single correlation analyses (Pearson or Spearman coefficient) the following five parameters were entered into the multivariate model with r = BMI: −0.29; 6MWT (m): 0.31; Borg fatigue scale 2 min after the end of the 6MWT: 0.32, self-reported Mot/Be.PA: 0.31; cardiac disease: −0.29. Continuous variables (BMI and 6MWT) were centred.

6MWT, 6-min walk test; BMI, body mass index; CI, confidence interval; Mot/Be.PA, motivation/behaviour physical activity; NA, not applicable.

variables should improve prediction of high physical activity level. It is unclear whether functional exercise capacity affects physical activity or the latter affects the former. This is a tricky chicken-and-egg situation that deserves further investigation. Identifying exercise capacity as a determinant factor of physical activity in smokers is in line with previous findings in patients with COPD.[3] However, the predictive value of the 6MWT's distance in the regression model was lower in smokers than in patients with COPD (R^2 = 0.10 and R^2 = 0.56, respectively). This is likely to occur due to the much more pronounced variability of the number of steps/day in smokers when compared with patients with COPD.[37] As previously discussed, the presence of fatigue sensation assessed by the Borg scale also explained part of the physical activity variance, which might reflect muscle alterations in smokers.[31] Motivation is believed to help individuals to initiate and maintain healthy behaviour.[38] Not surprisingly, adults who report higher enjoyment and preference for physical activity have been shown to report higher levels of activity.[39] This study demonstrated that Mot/Be.PA was another independent determinant of physical activity. However, our assessment of motivational and behavioural aspects was limited to a simple question based on the transtheoretical model of readiness to change, developed to investigate change in health behaviour.[19,20] Finally, cardiac disfunction is also recognized as a determinant of physical inactivity in patients with COPD;[40] moreover, the association between cardiovascular disease, smoking and physical inactivity may be present in adult smokers.[41] Therefore, the fact that cardiovascular comorbidity determines physical activity in smokers is not surprising.

Despite our efforts, some limitations are found in the study. Variables that could explain part of the variance in daily physical activity of smokers have not been assessed, such as ethnicity, food intake behaviour and marital status. However, as the groups were recruited from the same region and matched by age and educational level, we do not believe that there are marked differences between the groups in these outcomes. Further, the addition of single-breath diffusing capacity for carbon monoxide could have provided useful information to the intergroup results' interpretation.[42] Finally, self-reporting of comorbidities could also be considered a limitation. However, this method of reporting comorbidities is largely used and was the same in the two present groups. Therefore, an eventual underreport would happen in both groups. Furthermore, comorbidities are related to physical activity even considering certain degree of misclassification, justifying their investigation as determinants of physical activity.

In summary, smokers with no spirometric diagnosis of airflow obstruction presented a reduced level of daily physical activity and worse exercise capacity, lung function, anxiety, depression and quality of life in comparison with matched non-smokers. Functional exercise capacity, extended fatigue sensation, aspects of motivation/physical activity behaviour and self-reported cardiac disease are significant determinants of daily physical activity in smokers.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix S1 Supporting information: Methods, Results and Discussion.

Table S1 Multiple regression analysis with the number of steps/day as the dependent variable and the following variables as independent variables: (i) BMI, (ii) 6MWT (metres), (iii) Borg fatigue scale 2 min after the end of the 6MWT, (iv) self-reported Mot/Be.PA, (v) self-reported cardiac disease, (vi) gender, (vii) season of the year, (viii) age, (ix) educational level and (x) social-economical status.