Smoking status: effects on the dietary intake, physical activity, and body fat of adult men

Robert C Klesges, Linda H Eck, Terry R Isbell, William Fulliton, and Cindy L Hanson

ABSTRACT This investigation evaluated the relationship between smoking status and body fatness, dietary intake, and physical activity in adults. Subjects were 210 males who were either regular cigarette smokers (n = 35) or nonsmokers (n = 175). Estimated body fat and waist-to-hip (girth) measurements were carefully obtained. Additionally, a sensitive assessment of long-term dietary intake and a multifactorial approach to the assessment of physical activity were made. Results indicated that smokers had lower estimated body fat as calculated by multiple skinfold thickness assessments. In contrast, smokers reported the same total energy intakes as nonsmokers and their levels of physical activity were significantly lower than those of nonsmokers. The differences in intake and expenditure in smokers and the role of metabolism as a possible determinant of the fat differences in smokers vs nonsmokers are discussed. Am J Clin Nutr 1990:51:784-9.

KEY WORDS Smoking, body fat, intake, activity

Introduction

Smoking is causally related to > 350 000 deaths from cardiovascular disease, cancer, and chronic obstructive lung disease in the United States each year (1, 2). One-third of heavy smokers aged 35 y will die before age 85 y of diseases caused by their smoking (3). The estimated cost of health problems associated with smoking, including medical care, absenteeism, decreased work productivity, and accidents, is estimated to be $56 billion per year (1).

Given the consistent demonstration of dose-dependent relationships between smoking and disease, evidence of reductions in health risks after smoking cessation, and experimental studies documenting carcinogenic effects of tobacco smoke in animals, few scientists question the causal nature of the relationships between smoking and illness. Despite knowledge of the health consequences of cigarette smoking, 26.5% of the adults in the United States continue to smoke (1). Unfortunately, few effective or economical programs for smoking cessation have been developed.

The potential success of smoking cessation efforts is impeded by the fact that many of the advantages of continuing smoking are immediate (eg, stimulation from nicotine, learned associations of smoking with pleasant events) (4) whereas the disadvantages of smoking (eg, cancer, heart disease) are delayed and probabilistic. One immediate consequence of quitting smoking is weight gain (1, 5). The use of smoking as a weight-control strategy by the average smoker appears to be a powerful motivator for continued smoking and, perhaps, smoking initiation (6). Its role in relapse is less clear however (5).

The perception that smoking controls body weight is backed by strong empirical support. There is now overwhelming evidence that cigarette smokers weigh less than comparably aged nonsmokers (7, 8); individuals who start smoking lose weight (9), and many smokers who quit smoking gain weight (10–13). The 1988 Surgeon General's Report (1) summarized the results of 28 cross-sectional evaluations of smoking and body weight as well as 43 studies in which smoking and body weight status were evaluated over time. Of the 71 studies evaluated, 62 (87%) collectively indicated that smokers weigh less than nonsmokers and that people who quit smoking gain weight. For the cross-sectional studies it was reported that smokers weighed an average of 3.23 kg less (range 1.07–6.79 kg) than nonsmokers. Smokers who quit in the longitudinal studies gained an average of 2.79 kg (range 0.79–8.19 kg) after cessation. Another recent quantitative review of the smoking and body weight literature reached similar conclusions (5).

Despite the obvious importance of documenting the mechanisms of weight change in subjects who smoke, it may be surprising that very few studies examining this issue in humans have been published. In the research on energy balance changes (viz, changes in dietary intake, physical activity, and metabolic rate) among smokers who quit, there are only a few investigations and these studies are limited by small sample sizes, short follow-up periods, and crude measures of dietary intake, physical activity, and metabolic rate. Although the extant literature is both inconclusive and incomplete, it appears that dietary intake (particularly of sweet-tasting simple carbohydrates and fats) may increase and resting metabolic rate may decrease after smoking cessation (see 1 and 5 for a review). In contrast, it
appears that physical activity does not change (or may even increase) after cessation (5).

Similarly, little is known about the factors that maintain the body-weight differences between smokers and nonsmokers. Most investigations in this area also have serious methodological difficulties such as short-term measures of diet and exercise (eg, 24 h); inadequate evaluations of dietary intake, physical activity, and body weight (eg, a single self-report question on how active a subject thinks he or she is); and highly selected samples (eg, female smokers who regularly exercise heavily (5). Many of these studies did not primarily investigate the effects of smoking on dietary intake, physical activity, and body weight and, as such, often did not provide analyses of the effects of smoking on energy balance and body weight.

Given the available literature on what maintains body-weight differences between smokers and nonsmokers, it is not surprising that there is little consistency in the reported findings. If diet and exercise accounted for the body-weight differences between smokers and nonsmokers, one would need to observe either lower dietary intakes and/or higher levels of physical activity. Interestingly, this has never been reported. To date, studies have reported that the dietary intakes of smokers are either the same as (8, 14–17) or higher (18–21) than nonsmokers. Studies assessing physical activity in smokers vs nonsmokers have reported that smokers’ levels of physical activity are either the same as (20, 22, 23) or lower (16) than nonsmokers. These findings were observed despite the fact that of the studies that also evaluated differences between body weight or body fat, 100% reported that smokers had lower body weight or body fat than nonsmokers.

Given the methodological problems of the studies assessing the effects of smoking status on dietary intake, physical activity, and body weight or body fat, it is clear that an investigation of these important issues is both highly warranted and needed. Thus, the purpose of this investigation was to conduct a thorough, careful, and simultaneous evaluation of the effects of smoking status on sensitive measures of dietary intake, physical activity, and body fat composition.

Methods

Subjects

Subjects were 215 adult Caucasian males varying in degree of cardiovascular risk (as measured by obesity status and family history of cardiovascular disease) who are participating in a longitudinal assessment of cardiovascular-risk-factor acquisition in adults and their young children. Average age of participants was 34.7 ± 4.91 y (X ± SD) (range 23–52 y). The sample was subdivided on the basis of self-reported smoking status. Of those reporting, 175 were nonsmokers and 40 were regular cigarette smokers. On the basis of previous research on smoking status and body weight (21), only smokers reporting an average of at least seven cigarettes per day were included in the sample. Intermittent smokers (n = 5) reporting six cigarettes per day or less were dropped from the analyses, leaving a sample size of 210 (175 nonsmokers, 35 smokers). Average daily intake of smokers was 25.9 ± 13.76 cigarettes per day (X ± SD) (range 7–70 cigarettes). All subjects signed informed consent forms, and the research protocol was approved by the Memphis State University Human Subjects Review Board.

Procedure

Subjects were recruited by means of response forms distributed to local physicians’ offices, day-care centers, and churches. Subjects were also recruited by advertisements placed in local newspapers and on local radio stations and by recommendations from subjects already participating in the study. Upon agreeing to participate in the study, individuals were mailed various self-report questionnaires (see below) and a consent form to be filled out and signed. Subjects then participated in a laboratory assessment during which time skinfold thickness and girth measurements were obtained.

Measures

Body composition. Three skinfold thickness measurements were taken on the right side of the body with a Lange skinfold caliper (Cambridge Scientific Industries, Cambridge, MD). The triceps skinfold thickness was measured halfway between the acromion and the olecranon, and the chest skinfold thickness measurement was taken diagonally halfway between the anterior axillary line and the nipple. The subscapular skinfold thickness measurement was taken just below the tip of the inferior angle of the scapula. Triplicate measurements at each site were obtained and the value recorded was the average of the three measurements, according to recommendations for a standardized protocol (24). All measurements were taken by an experienced exercise physiologist. The average of these three skinfold thickness measurements was then used to estimate a percent body fat, based on the tables by Jackson and Pollock (25).

Additionally, girth measurements were taken at both the waist and hips. The largest circumference at the waist and hips was taken, following the recommendations of Lapidus et al (26). A waist-to-hip ratio was then calculated, which has shown to be an independent risk factor for cardiovascular disease (26, 27).

Dietary intake. Long-term assessment of dietary intake was obtained by the Willett Food Frequency Questionnaire (28, 29), a 4-page, 61-item, self-administered questionnaire. The decided advantage of a long-term food frequency measure is its provision to evaluate long-term dietary intake to overcome week-to-week and seasonal variations in dietary intake. Moreover, the Willett questionnaire strongly correlates to repeated dietary recalls (29) as well as daily dietary records administered for an entire year (28). Administration of this measure is very straightforward and subjects were able to ask trained nutritionists about specific items. Upon completion of the food frequency questionnaire, all items were checked so that missing data were eliminated. Subjects who failed to complete any items were recontacted and missing items were completed. All data were verified and then analyzed by use of nutrient data tapes provided by the Willett research group.

Physical activity. Following the recommendations of LaPorte et al (30, 31), multiple measures of physical activity were obtained in the present investigation. Specifically, the Paffenbarger scale (32), the Baecke physical-activity questionnaire (33), and the Studies of Children’s Activity and Nutrition (SCAN) Energy Balance Questionnaire (Klesges RC, Fulliton W, Isbell T, Eck LH, Hanson CL, unpublished observation, 1989) were all administered.

The Paffenbarger questionnaire (32) is a self-report activity
survey that assesses three specific types of activities: 1) flights of stairs climbed each day, 2) number of city blocks (or equivalent) walked each day, and 3) light, moderate, and vigorous activities for the previous week for both weekdays and weekend days. Responses are weighted to yield the number of kilocalories burned in physical activity each day. The Paffenbarger questionnaire has been shown to independently predict cardiovascular disease morbidity and mortality (32), has been shown to predict hypertension (34), and has acceptable reliability and validity coefficients (31, 35).

The Baecke questionnaire (33) is a factor-analyzed scale comprising 16 items representing physical activity at work, sport, and nonsport leisure-time physical activity. The question relating to sports participation is open-ended whereas the remaining questions are based on 5-point, Likert-type scales. The items are then scored (sports participation is given a value ranging from 0.5 to 4.5 depending on intensity and duration of the activity) yielding values ranging from 16 (highly sedentary) to 70 (highly active in work, sport, and nonsport leisure-time activity). The Baecke questionnaire has been used extensively in recent years and has demonstrated a highly acceptable degree of reliability and construct validity (33, 35, 36).

The SCAN Energy Balance Questionnaire follows the recommendations of physical-activity epidemiologists who suggest that the most reliable assessments of physical activity may be simple, often single-item questions that assess vigorous and aerobic activities (eg, stairs climbed per week, minutes of exercise that make one sweat or winded) (30, 31). A question format that appears promising is to have the person rate his or her level of physical activity relative to their age- and sex-matched peers (30, 31). The SCAN Energy Balance Questionnaire is a series of three questions that ask individuals to rate 1) work activities, 2) leisure time activities, and 3) aerobic activities compared with other individuals of their age and sex. In a recent large-scale epidemiologic investigation (Klesges RC, Fullerton W, Isbell T, Eck LH, Hanson CL, unpublished observation, 1989), levels of physical activity assessed by the Energy Balance Questionnaire strongly correlated (negatively) to the cardiovascular risk factors of systolic and diastolic blood pressure, heart rate, relative weight, and body fat.

Statistical analysis

Data were analyzed with smoking status as the independent variable and measures of body composition, dietary intake, and physical activity as the dependent variables. Analysis of variance was used to test potential differences between smokers and nonsmokers on the outcome variables (37).

Results

Data reduction

Body composition was measured on the subject’s tricep, chest, and subscapular sites. These three skinfold thickness measurements were used to determine a body fat percentage as outlined above. Waist, hip, and waist-to-hip ratio were also evaluated as dependent variables. The measure of dietary intake yields an average intake of total kilocalories per day along with dietary components (eg, percent of total kilocalories from protein, carbohydrates, and fats).

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Body composition by smoking status*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Smokers (n = 35)</td>
</tr>
<tr>
<td>Total body fat (%)</td>
<td>18.39 ± 6.88</td>
</tr>
<tr>
<td>Triceps skinfold thickness (mm)</td>
<td>12.84 ± 6.56</td>
</tr>
<tr>
<td>Subscapular skinfold thickness (mm)</td>
<td>18.12 ± 8.10</td>
</tr>
<tr>
<td>Chest skinfold thickness (mm)</td>
<td>15.45 ± 7.81</td>
</tr>
<tr>
<td>Hip measurement (cm)</td>
<td>102.69 ± 5.62</td>
</tr>
<tr>
<td>Waist measurement (cm)</td>
<td>94.33 ± 12.31</td>
</tr>
</tbody>
</table>

* x ± SD.
† Significantly different from smokers, p < 0.05 (two-tailed test).
‡ Significantly different from smokers, p < 0.01 (two-tailed test).
§ Marginally different from smokers, p < 0.10 (two-tailed test).

To evaluate levels of physical activity, a principal components factor analysis was conducted on the 13 subtests comprising the three measures of physical activity. Five highly reliable (ie, no eigenvalues < 1.1) factors emerged, explaining 66% of the total variance: 1) a leisure time and aerobic activity factor (eigenvalue = 2.82, 22% of variance accounted for); 2) an anaerobic (vigorous activity) factor during leisure activities (eigenvalue = 1.90, 15% of variance accounted for); 3) a work-related factor or physical activities engaged in during work (eigenvalue = 1.61, 12% of variance accounted for); 4) an anaerobic (vigorous activities) factor of activities in nonleisure and sports activities (eg, stair climbing; eigenvalue = 1.16, 9% of variance accounted for); and 5) a moderate activities factor (eg, walking, gardening, light housework; eigenvalue = 1.10, 8% of variance accounted for). Previous research has shown that the leisure time and aerobic activity factor (factor 1) strongly predicts blood pressure, heart rate, and obesity (negatively) in both men and women whereas factors 2 through 5 do not appear to relate to either obesity or blood pressure (Klesges RC, Fulliton W, Isbell T, Eck LH, Hanson CL, unpublished observation, 1989).

Body composition results

Results of the body composition analyses are presented in Table 1. Inspection of Table 1 revealed a significant main effect on total body fat (F1[1,201] = 5.69, p < 0.03), with smokers having a lower estimated total body fat (x̄ = 18.39%) than nonsmokers (x̄ = 21.19%). Of the three skinfold thickness measurements making up the total body fat analysis, triceps skinfold thickness was much smaller (x̄ = 12.84 mm) in smokers than in nonsmokers (x̄ = 16.58, F1[1,201] = 7.61, p < 0.008) and both subscapular (F1[1,201] = 3.47, p = 0.06) and chest (F1[1,201] = 3.10, p = 0.08) were in the predicted direction. Additionally, smokers had marginally smaller (x̄ = 101.7 cm) hip measurements than did nonsmokers [x̄ = 105.16 cm, F1[185] = 3.55, p = 0.06]. Neither the waist nor the waist-to-hip ratio was reliably different (F values < 1.9).

Dietary intake. Table 2 presents the results of the dietary intake analysis by smoking status. Inspection of Table 2 indicates that, despite significantly lower percent body fat, smokers were
TABLE 2
Dietary components by smoking status*

<table>
<thead>
<tr>
<th></th>
<th>Smokers (n = 35)</th>
<th>Nonsmokers (n = 175)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total intake (kcal)</td>
<td>2137.9 ± 491.9</td>
<td>2088.0 ± 731.1</td>
</tr>
<tr>
<td>Protein (% of diet)</td>
<td>15.3 ± 2.9</td>
<td>16.3 ± 2.9†</td>
</tr>
<tr>
<td>Total fat (% of diet)</td>
<td>36.3 ± 7.0</td>
<td>36.2 ± 6.1</td>
</tr>
<tr>
<td>Saturated fatty acids (% of diet)</td>
<td>13.5 ± 2.6</td>
<td>13.3 ± 2.7</td>
</tr>
<tr>
<td>Polyunsaturated fatty acids (% of diet)</td>
<td>6.8 ± 2.2</td>
<td>7.0 ± 1.6</td>
</tr>
<tr>
<td>Monosaturated fatty acids (% of diet)</td>
<td>13.9 ± 3.1</td>
<td>13.9 ± 2.8</td>
</tr>
<tr>
<td>Total carbohydrates (% of diet)</td>
<td>45.5 ± 8.5</td>
<td>46.8 ± 7.7</td>
</tr>
<tr>
<td>Sucrose (% of diet)</td>
<td>17.7 ± 10.0</td>
<td>15.0 ± 7.7†</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>1829.1 ± 588.5</td>
<td>1817.9 ± 682.0</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>16.1 ± 4.7</td>
<td>18.8 ± 7.5‡</td>
</tr>
</tbody>
</table>

* ± SD. As is true with many computerized nutrient databases, components of the diet do not add up to 100% because of rounding errors and incomplete data within the database.
† Marginally different from smokers, p < 0.10 (two-tailed test).
‡ Significantly different from smokers, p < 0.05 (two-tailed test).

eating amounts similar to nonsmokers. The components of the diet appear to be somewhat different, with smokers reportedly eating marginally higher intakes of sucrose (F[1,209] = 3.2, p = 0.07) marginally lower protein intake (F[1,209] = 3.4, p = 0.07), and significantly lower amounts of fiber intake (F[1,209] = 4.11, p < 0.05).

Physical activity

Given that socioeconomic status (38) significantly correlated to some of the measures of physical activity (factors 1 and 3) and smoking status, analysis of covariance (with SES as the covariate) was conducted. The results of the physical-activity analyses are presented in Table 3.

As indicated in Table 3, results of the analyses on physical activity revealed that on factor 1, smokers reported significantly lower (Z score = −0.56 ± 0.80) levels of physical activity in sports, leisure time, and aerobic activities than did nonsmokers (Z = 0.09 ± 0.98; F[1,174] = 9.23, p < 0.005). No other differences were observed across the other four factors of physical activity. Finally, analyses were also conducted utilizing the individual subtests of the physical-activity questionnaire in favor of the factor analytic results. Analyses indicated an identical pattern of results as was found with the factor analytic findings; that is, smokers reported significantly lower levels of sports, leisure, and aerobic activities relative to nonsmokers. In contrast, smokers did not differ from nonsmokers in other types of activities.

Discussion

The results of this investigation, consistent with the findings of previous studies that generally used more crude measures of adiposity (1), indicate that smokers have significantly lower levels of body fat than do nonsmokers. However, despite these lower levels of body fat, smokers reported identical dietary intakes and significantly lower levels of aerobic and leisure time activity. It is interesting to note that a recent study (Klesges RC, Fullerton W, Isbell T, Eck LH, Hanson CL, unpublished observations, 1989) using the same factors utilized in the current investigation reported that aerobic and leisure time activities were significantly negatively correlated to weight, relative weight, and body fat. No other factor measured was reportedly associated with measures of body fat (Klesges RC, Fullerton W, Isbell T, Eck LH, Hanson CL, unpublished observations, 1989). Thus, smokers report that they have significantly lower levels of a type of activity that has been shown previously to relate to higher body fat. With this smoking sample, however, these lower levels of activity were observed concurrently with lower levels of body fat. Assuming that smokers are not systematically biased in their reports of dietary intake and physical activity, a mechanism other than dietary intake or physical activity is serving to maintain the levels of lower body fat in smokers.

The only known mechanism left to explain the lower body weight and body fat among smokers is some type of increased metabolism (39). Metabolic rate is an important and often overlooked variable in energy imbalances because ~75% of total energy expenditure comes in the form of metabolism (40, 41). However, those few studies that have evaluated metabolic changes in response to smoking cessation in humans have produced inconclusive results with some investigations finding support for metabolic changes in cigarette smokers (42-46), and others (47-49) failing to find a metabolic change. Thus, direct evidence supporting a metabolic contribution to postcessation weight gain has been elusive. Although acute (typically ≤2 h) metabolic responses to smoking and nicotine administration have been extremely well documented (45, 46, 50, 51), chronic changes in metabolic rate, long thought to be an important prerequisite to documenting a relationship between metabolism and postcessation weight gain (52), have not been observed (48). However, as suggested in a recent review of the literature on smoking and body weight (53), multiple exposure to an agent that acutely increases metabolic rate, such as smoking (50) and exercise (54), may alone be sufficient to produce a

TABLE 3
Physical-activity factor scores by smoking status*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Smokers (n = 35)</th>
<th>Nonsmokers (n = 175)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1: leisure time, aerobics, and sports (Z score)</td>
<td>−0.56 ± 0.80</td>
<td>0.09 ± 0.98†</td>
</tr>
<tr>
<td>Factor 2: anaerobic (vigorous) activity during leisure (Z score)</td>
<td>0.23 ± 1.24</td>
<td>−0.06 ± 0.95</td>
</tr>
<tr>
<td>Factor 3: physical activity at work (Z score)</td>
<td>0.42 ± 1.29</td>
<td>−0.10 ± 0.91</td>
</tr>
<tr>
<td>Factor 4: anaerobic (vigorous) activity during nonleisure activity</td>
<td>−0.06 ± 0.82</td>
<td>−0.01 ± 0.97</td>
</tr>
<tr>
<td>Factor 5: moderate activities (Z score)</td>
<td>−0.12 ± 1.01</td>
<td>0.04 ± 1.01</td>
</tr>
</tbody>
</table>

* ± SD. Z scores are standard scores with a sample mean of 0 and a standard deviation of 1.
† Significantly different from smokers, p < 0.005 (two-tailed test).
significant change in body weight and body fat. Future research should evaluate these, as well as other important possible metabolic differences in smokers.

Despite the strengths of the current investigation (eg, thorough and simultaneous evaluation of body fat, dietary intake, and physical activity), the results should be viewed with some degree of caution. First, the sample comprised all men. It appears that females may enjoy more of the weight control benefits of smoking than do males (5). Given the large number of dietary (55) and activity (31) differences between males and females, future research should focus on possible sex differences in energy balance of smokers vs nonsmokers. A second weakness involves the assessment of smoking status. The current investigation evaluated smoking status based on the responses to a self-report of whether subjects smoke and the number of cigarettes per day. The vast majority of studies on smoking and body weight rely on self-reports of smoking (5); nonetheless, it is possible that some falsification of smoking status was present.

It has been concluded, however, that for assessment studies, such as the current investigation in which the research question is whether or not someone smokes cigarettes (also the case with the current study), self-reports of smoking status are highly accurate (56). However, future studies should carefully biochemically validate smoking status and focus on possible metabolic differences between smokers and nonsmokers. Only a complete evaluation of the energy balance equation (viz, dietary intake, physical activity, and metabolic rate) will fully explain the body weight and body fat differences between these two groups. A thorough understanding of the mechanisms of body-weight differences between smokers and nonsmokers will contribute substantially to preventing a major obstacle to smoking cessation, namely postcessation weight gain.

References


31. LaPorte RE, Montoye HJ, Casper CN. Assessment of physical