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Ultralight Cigarettes: Activity, Cardiovascular, Dietary, and Subjective Parameters

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JACOBER, A., M. HASENFRATZ AND K. BÄTTIG. *Ultralight cigarettes: Activity, cardiovascular, dietary, and subjective parameters.* PHARMACOL BIOCHEM BEHAV **47**(1) 187–195, 1994.—In a field study, 24-h heart rate, physical activity, and cigarette consumption were continuously recorded, whereas resting heart rate, blood pressure, dietary intake, and subjective parameters were assessed six times per day. Smoking habitual and ultralight cigarettes for two days each was compared in a sample of 48 smokers, consisting of 24 office and 24 nonoffice workers of both sexes. Nonoffice workers smoked more and revealed higher respiratory CO and Fagerstrom index values, whereas other group differences were unrelated to smoking or its effects. Switching to ultralight cigarettes with four- to eightfold lower nicotine yields than the habitual cigarettes significantly decreased respiratory CO by 5 ppm, saliva cotinine by 30%, resting heart rate by 2.5 bpm, systolic blood pressure by 3.5 mmHg, and diastolic blood pressure by 3.0 mmHg, but increased fat intake by about 400 kJ, whereas activity and subjective well-being were not affected. Thus, the reduction in saliva cotinine was considerably smaller than the reduction in nicotine yield, and the effects on physiological parameters therefore were rather modest.

Heart rate   Blood pressure   Physical activity   Dietary intake   Ultralight cigarette   Saliva cotinine
Office vs. nonoffice work   Field study

RESEARCH on switching from high to low nicotine–low tar cigarettes has involved so far mainly the analysis of acute or semichronic changes in nicotine intake, effects on cardiovascular parameters, and compensation mechanisms. The picture derived from these studies suggests that reducing nicotine yield four- to fivefold to levels between 0.1 and 0.3 mg decreases nicotine intake and cotinine at best by about 50% (49,51), whereas switching between cigarette brands yielding more than about 1 mg nicotine had little influence on blood nicotine levels (4). As compensation mechanisms, increased puff volumes (16,24), more puffs per cigarette (16,51), shorter puffing intervals (51), or none of these (44), and only minimally increased or unchanged cigarette consumption (22) have been described. This only partial compensation revealed concomitantly reduced boosts in heart rate and blood pressure after smoking (18,41). Consistent with these findings from switching studies, designs comparing smokers habituated to cigarettes with different nicotine yields also revealed a reduction in nicotine intake of only about 40% in smokers habituated to ultralight cigarettes yielding less than 0.3 mg nicotine as compared with smokers of cigarettes yielding four- to fivefold more nicotine (21). Furthermore, no differences in blood nicotine levels of smokers of cigarettes with different yields above about 1 mg nicotine were observed (43). In smokers of ultralight cigarettes as compared with smokers of stronger cigarettes a marginally higher smoking rate of about two cigarettes per day was reported (38), and compensation mechanisms and cardiovascular responses analogous to those described above (21). On the whole, the effects revealed by these kinds of studies are quite subtle, and the relevance of these predominantly laboratory findings for the everyday life situation remains open. Better answers to these questions can be expected from field designs using sophisticated portable measuring devices that allow the frequent or continuous collection of psychophysiological and smoking behavior data under field conditions.

With respect to smoking-induced effects on dietary patterns, most studies have compared smokers, ex-smokers, and nonsmokers rather than switchers from high to low nicotine cigarettes or smokers of different cigarette types. Results suggest for smokers as compared with nonsmokers a lower intake of dietary fibres (12,23,25,32,47), vegetables (25,29,32), unsaturated fatty acids (32,46), different minerals and vitamins (7,12,20), and a higher intake of alcohol and caffeine (25,29,32,47), as recently reviewed (33). After quitting smoking, a transient increase in caloric intake has been reported (17,28), and for those subjects remaining abstinent for more than a year a change to the dietary habits of nonsmokers (46). However, changes in dietary patterns after quitting smoking may not only be affected by the termination of nicotine intake but may also be a function of factors like changes in taste perception (40,42), habituation to food cues (10), or different endog-

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enous dietary habits of successful quitters (46). Therefore, results from smoking cessation studies may not be extrapolated to the situation of switching from high to low nicotine-low tar cigarettes.

The purpose of the present study was to investigate under field conditions, for both sexes and for occupational groups with different physical load changes in smoking behavior, physical activity, cardiovascular, dietary, and subjective parameters occurring during the first two days after switching to ultralight cigarettes, thus studying acute effects observed in laboratory experiments under field conditions and linking them to chronic effects found in epidemiologic studies. A previously described device (2,19) was used to assess cigarette consumption, 24-h heart rate, and physical activity, whereas a new blood pressure monitor and a new self-developed electronic diary were used to assess resting heart rate and blood pressure as well as diet and subjective parameters.

MATERIALS AND METHODS

Subjects

Forty-eight smokers of both sexes were recruited through a newspaper advertisement. Eligible subjects smoked at least 15 cigarettes per day with a minimal nicotine delivery of 0.7 mg and were allocated to one of four subgroups of 12 each according to sex and job. The criterion for classification into one of two occupational groups was the physical demand of the job. Thus, sedentary office workers were differentiated from more active nonoffice workers, working typically as craftsman, salesperson, operative, or housewife with children. As expected, significant sex differences were obtained for body weight, males 69.6 ± 7.2 kg, females 58.6 ± 6.7 kg, $F(1, 44) = 29.4, p < 0.001$; body height, males 175.6 ± 5.0 cm, females 167.6 ± 6.1 cm, $F(1, 44) = 24.7, p < 0.001$; and body mass index, males 22.6 ± 2.3 kg/m^2, females 20.8 ± 1.8 kg/m^2, $F(1, 44) = 8.7$ $p < 0.01$. Quetelet's index (weight in kg/height in m^2) was used as body mass index. Nonoffice workers scored on Fagerstrom's Tolerance Questionnaire (11) significantly higher as compared with office workers, nonoffice 6.1 ± 1.5 points, office 5.2 ± 1.5 points, $F(1, 44) = 4.7, p < 0.05$. The questionnaire was presented in a translated German version. No significant group differences were found for age (28.3 ± 6.7 years), self-reported daily cigarette consumption (27.7 ± 9.6 cigarettes/day), nicotine yield (0.948 ± 0.157 mg), and condensate (11.8 ± 2.6 mg). Subjects were paid 200 SFr for delivering a complete data set.

Monitoring Equipment

Subjects were equipped with a self-developed, combination actometer/heart rate counter, an automatic digital OMRON blood pressure monitor (Model HEM-815-F, OMRON Corporation, Tokyo), and a PSION Organiser II pocket computer (Model LZ64, PSION PLC, London). The actometer/heart rate counter has been described in detail in earlier reports (2,19). Briefly, heart rates were assessed from R-peaks of the ECG, detected by three electrodes placed on the chest, and physical activity was measured as electrical impulses induced in a coil by a freely moving magnetic ball. Thirty-second sums of these parameters were stored in an exchangeable memory chip. The device with the dimensions 115 × 72 × 22 mm, weighing 160 g, also contained an event marker button. The software run on the PSION pocket computer was developed at our institute (to be reported later). After switching on, eight questions about subjective well-being were to be answered by adjusting a pointer on a 20-step scale. The questions, in English translation, were "How awake, nervous, drowsy, stressed, sluggish, do you feel at the moment?" and "Do you have nausea, headache, muscle/joint ache?," with the markings *not at all* and *very strongly* at the left and right ends of the scale, respectively. Subsequently, the program asked for the readings of three resting blood pressure and heart rate self-measurements conducted by the subjects at the left index finger using the OMRON blood pressure monitor. Finally, information about food and beverage consumption since the last operation of the PSION was requested. A two-level list of food items, consisting of 15 collective terms like *vegetables* or *meat* and up to 18 detail items like *carrots* or *beef,* was presented on the screen. The subjects selected the items consumed and entered estimates of quantity by adjusting the number of units. The list of food items was adapted to local conditions, and the units of quantity were chosen so as to be as simple and clear as possible (e.g., "How many cups (200 ml)?" or "How many pieces?") Subjects were also provided with little booklets containing detailed instructions on the use of all the devices and a list of the food items. These booklets also served as notebooks for noting any technical problems.

Respiratory carbon monoxide (CO) levels were measured in the laboratory using an EC50 Micro Smokerlyzer (Bedford Instruments, UK), and saliva cotinine concentrations were determined at an independent laboratory (Institute for Clinical Chemistry, University Hospital, Zurich, Switzerland) using an immunofluorescence polarisation assay kit (Abbott, UK) with a detection limit of 50 ng/ml. Saliva was obtained using cotton dental rolls which were stored in polypropylene vials and kept frozen until determination. Due to insufficient saliva volume, results for three subjects were not available. The test-retest correlation of 12 blind double samples was .966.

Procedure

Subjects had to complete four (2 × 2) measurement days, which had to be ordinary work days, and come to the laboratory three times (i.e., on the day before the first measurement day and on the days after the second and fourth measurement days). The measurement days were randomized across the weekdays Monday to Friday. During two days, subjects smoked their habitual brand cigarette, and during the other two one brand of a selection of six commercially available ultralight cigarettes. Brands A (nicotine 0.1 mg/tar 1 mg) and B (0.2/1 mg) contained Maryland tobacco, brands C (0.1/1 mg) and D (0.2/2 mg) American Blend tobacco, and brands E (0.2/2mg) and F (0.2/2 mg) German Blend tobacco. The order of habitual versus ultralight cigarettes was balanced. For the ultralight cigarette condition, a free supply of the chosen brand was provided and subjects were told they would not be paid if the data proved that they had smoked their habitual cigarettes. The ultralight cigarettes were to be smoked during the two measurement days and on the following day until the laboratory appointment. At the first appointment, personal data were obtained and subjects agreed by signing a contract not to take illicit drugs or any medicines except contraceptives and to be willing to smoke ultralight cigarettes for two days. The handling of the devices was explained, trained, and tested by some final questions. The actometer/heart rate monitor had to be worn at the hip continuously during 48 h except for showers, starting on the morning of measurement day 1 after getting up. The marker button was to be pressed whenever a cigarette was lit. The PSION pocket computer and the OMRON blood pressure monitor were to be operated six times per day: 1) after getting up, 2) after breakfast or before starting work, 3) before lunch, 4) after lunch, 5) when finishing work or before dinner, and 6) when going to bed. Answering the questions on the PSION took approximately 1 min, and subjects were instructed to sit down before doing this and the blood pressure measurements. At the second and third laboratory appointments, respiratory CO was measured and a saliva sample for cotinine determination was taken. Laboratory appointments were not scheduled before 1000 to make sure that some cigarettes had been smoked before the session. The measuring devices were distributed among the groups in a counterbalanced order.

Data Analysis and Statistics

Data were transferred by appropriate interfaces from the actometer/heart rate monitor and the PSION to a personal computer and analyzed by means of analyses of variance (ANOVAs) with the grouping factors sex and job and the repetition factors measurement day, cigarette type, and intraday measurements. Group differences of 24-h heart rate and physical activity were analyzed by comparing 30-min means between 0800 and 2200, whereas resting blood pressure and heart rate were analyzed by comparing the averages of the three consecutive measurements. If the span between the highest and the lowest reading of such a triplet was higher than 10 mmHg or 10 beats/min, the ratio between the maximal and the minimal difference among the three readings was calculated, and if this ratio exceeded three, only the two readings lying closer together were used. Cigarette consumption was calculated from the marker button presses, and the latter were also used as triggers for the computation of the smoking-related variation of pulse (SRP) and activity (SRA). This method, described in a previous report (2), consisted of averaging individually the 30-s data from 10 min before to 10 min after lighting the cigarettes, accepting only heart rate values between 40 bpm and 180 bpm and the concomitant activity values. The individual linear regressions between 30-min means of heart rate and activity (equation I) of the time intervals between 0800 and 2200 were highly significant, and the average of the individual correlations was .65. This linear dependence of heart rates on activity was written in the form of equation II and used to calculate individual pulse activity index (PAI) curves as a measure of cigarette smoking-induced changes in the ratio of heart rate to activity.

$$\text{pulse} = \text{activity} \times \text{slope} + \text{intercept} \qquad \text{(I)}$$

$$\text{pai}_i = \frac{\text{pulse}_i - \text{intercept}}{\text{activity}_i \times \text{slope}} \qquad \text{(II)}$$

where i = 1–40: 30-s data from 10 min before to 10 min after lighting the cigarette. PAI values different from the value 1 reflect heart rate–activity ratios that differed from the 14-h average. The individual means of SRP, SRA, and PAI were averaged to grand means separately for the different groups (sex, job) and conditions (habitual and ultralight cigarettes).

Total caloric intake and diet composition (carbohydrate, protein, fat) were calculated on the basis of a detailed table of locally available food products (45). Consumed amount in grams of single food items was estimated from the obtained number of units of quantity. Daily total energy intake as kJ and kJ intake as protein, fat, and carbohydrate were computed by summing up the products of amount in grams and the item's protein, fat, and carbohydrate contents.

ANOVAs with the main factors sex, job, smoking condition, and measurement day were carried out for total caloric intake; caloric intake of the main nutritional components protein, fat, and carbohydrates; and the percentage intake of these components. Furthermore, ANOVAs with the same factors as above of the daily frequency of consumption of single food items and groups of food items as assessed by the PSION were carried out. Pearson correlations between measurement day 1 and measurement day 2 were calculated separately for the two smoking conditions for systolic and diastolic blood pressure, resting and 24-h heart rate, physical activity, and caloric intake.

RESULTS

Pearson correlations between the two measurement days were for resting heart rate and systolic and diastolic blood pressure between .75 and .85 for both smoking conditions. For the habitual and the ultralight cigarette condition, the respective day-to-day correlations were .70 and .56 for 24-h heart rate, .83 and .62 for physical activity, and .40 and .67 for caloric intake. All these correlations were highly significant ($p < 0.01$).

Cell means and standard deviations of all significant sex-, job-, cigarette type-, and measurement day-dependent differences and interactions are summarized in Table 1, together with the corresponding ANOVA F values.

Males had significantly higher systolic blood pressure; lower resting heart rates; higher physical activity; higher total caloric intake; and higher carbohydrate, protein, and fat intake. Nonoffice workers smoked significantly more cigarettes irrespective of cigarette type, scored higher on Fagerstrom's nicotine tolerance questionnaire, and had higher respiratory CO concentrations and higher physical activity. On measurement day 1, as compared with measurement day 2, significantly less marker button presses were registered. The smoking of ultralight cigarettes as compared with stronger habitual cigarettes significantly reduced respiratory CO, saliva cotinine, systolic and diastolic blood pressure, and resting heart rates. Smoking intervals (not shown) were also calculated, but revealed no significant differences between groups or cigarette types, or any significant intraday trends. Furthermore, both the absolute and percentage intake of fat increased, whereas the percentage intake of carbohydrate decreased. For subjective muscle/joint ache, office workers scored lower when smoking ultralight cigarettes, while the opposite was true for nonoffice workers, revealing significant Job × Cigarette Type interactions. When smoking ultralight cigarettes, all groups except male nonoffice workers showed decreased 24-h heart rates and all except male office workers showed an increased absolute fat intake, revealing also for these two parameters significant Job × Cigarette Type interactions. Diastolic blood pressure, resting and 24-h heart rate, and physical activity showed significant intraday variance due to considerable variation throughout the day, with a tendency toward lower levels in the mornings and evenings as compared with the rest of the day.

Highly significant correlations were obtained between saliva cotinine and respiratory CO (habitual cigarettes: r = .522, $p < 0.001$; ultralight cigarettes: r = .639, $p < 0.001$) and between cigarette consumption and respiratory CO (habitual cigarettes: r = .399, $p < 0.01$; ultralight cigarettes: r = .382, $p < 0.01$), whereas between cigarette consumption and saliva cotinine significance was reached only for the habitual cigarettes (habitual cigarettes: r = .351, $p < 0.01$; ultra-light cigarettes: r = .160).

TABLE 1

SIGNIFICANT SEX, JOB, CIGARETTE TYPE, AND MEASUREMENT DAY DIFFERENCES FOR SMOKING, PHYSIOLOGICAL, DIETARY, AND SUBJECTIVE PARAMETERS (means ± standard deviations, and F values)

	Female Nonoffice Workers	Female Office Workers	Male Nonoffice Workers	Male Office Workers	Significant F Values (df = 1, 44)			Other Significant Factors and Interactions
					Sex	Job	Cigarettes	
Smoking Parameters								
Cigarette Consumption								
Habitual Cig. Day 1	28.3 ± 7.1	22.8 ± 9.2	30.1 ± 8.5	23.7 ± 7.3				
Habitual Cig. Day 2	24.0 ± 8.6	22.2 ± 6.2	34.8 ± 11.4	29.9 ± 8.0		4.56*		Day†
Ultralight Cig. Day 1	25.7 ± 9.2	23.6 ± 7.7	31.6 ± 12.3	26.5 ± 7.9				$F(1, 44) = 7.91$
Ultralight Cig. Day 2	34.1 ± 10.8	26.4 ± 9.4	31.5 ± 10.9	28.3 ± 9.4				
Carbon Monoxide (ppm)								
Habitual Cigarette Type	31.9 ± 14.0	24.5 ± 7.2	34.1 ± 11.8	21.1 ± 8.7		10.59†	7.88†	
Ultralight Cigarette Type	29.5 ± 15.4	18.5 ± 5.6	26.0 ± 8.1	18.8 ± 10.3				
Saliva Continine (ng/ml)								
Habitual Cigarette Type	369 ± 158	313 ± 138	387 ± 188	345 ± 184			25.80‡	
Ultralight Cigarette Type	248 ± 115	238 ± 155	252 ± 122	248 ± 135				
Physiological Parameters								
Systolic Blood Pressure (mm Hg)								
Habitual Cigarette Type	120.5 ± 15.1	116.2 ± 15.6	130.8 ± 17.9	127.1 ± 14.7	20.66‡		7.43†	
Ultralight Cigarette Type	116.2 ± 15.5	111.9 ± 16.3	126.6 ± 17.6	126.0 ± 12.5				
Diastolic Blood Pressure (mm Hg)								
Habitual Cigarette Type	79.7 ± 11.5	76.4 ± 12.7	81.7 ± 12.9	76.4 ± 11.9			8.75†	Intraday†
Ultralight Cigarette Type	76.8 ± 12.6	71.6 ± 13.3	77.8 ± 11.5	76.3 ± 10.6				$F(5, 220) = 3.40$
Resting Heart Rate (bpm)								
Habitual Cigarette Type	80.8 ± 11.0	85.0 ± 16.9	76.6 ± 11.5	79.4 ± 10.8	5.30*		7.64†	Intraday‡
Ultralight Cigarette Type	79.5 ± 9.7	82.1 ± 13.4	74.8 ± 11.4	75.3 ± 11.0				$F(5, 220) = 5.91$
Allday Heart Rate (bpm)								Cigarette Type × Job*
Habitual Cigarette Tvpe	92.3 ± 15.5	94.3 ± 14.7	93.4 ± 14.5	91.2 ± 13.0				$F(1, 44) = 4.18$

Dietary Parameters							
Caloric Intake (kJ × 10^3)							
Habitual Cigarette Type	7.60 ± 2.50	7.20 ± 1.37	11.48 ± 2.26	11.40 ± 2.82	31.64‡		
Ultralight Cigarette Type	8.18 ± 3.72	6.81 ± 2.01	13.27 ± 4.68	11.18 ± 3.99			
Carbohydrates (kJ × 10^3)							
Habitual Cigarette Type	4.07 ± 1.53	4.03 ± 0.81	6.53 ± 1.89	5.62 ± 1.51	20.53‡		
Ultralight Cigarette Type	4.17 ± 2.32	3.35 ± 1.15	6.76 ± 3.16	5.76 ± 2.61			
Protein (kJ × 10^3)							
Habitual Cigarette Type	1.14 ± 0.45	0.95 ± 0.19	1.65 ± 0.34	1.73 ± 0.61	31.51‡		
Ultralight Cigarette Type	1.19 ± 0.44	0.98 ± 0.24	1.91 ± 0.63	1.69 ± 0.60			
Fat (kJ × 10^3)							
Habitual Cigarette Type	2.38 ± 0.91	2.21 ± 0.86	3.30 ± 0.79	4.05 ± 1.33	24.92‡	5.05*	Cigarette Type × Job*
Ultralight Cigarette Type	2.82 ± 1.41	2.47 ± 0.96	4.60 ± 1.78	3.73 ± 1.17			$F(1, 44) = 5.86$
Carbohydrates (% kJ)							
Habitual Cigarette Type	53.3 ± 8.4	56.4 ± 7.1	55.8 ± 8.7	49.1 ± 6.4		6.66*	
Ultralight Cigarette Type	50.7 ± 11.0	49.1 ± 7.1	50.1 ± 10.0	49.8 ± 9.2			
Protein (% kJ)							
Habitual Cigarette Type	15.2 ± 5.0	13.3 ± 3.5	14.7 ± 3.5	15.7 ± 4.0			
Ultralight Cigarette Type	14.8 ± 3.5	15.2 ± 5.2	15.1 ± 3.8	15.8 ± 6.2			
Fat (% kJ)							
Habitual Cigarette Type	31.4 ± 6.6	30.3 ± 7.0	29.4 ± 7.1	35.1 ± 5.8		5.79*	
Ultralight Cigarette Type	34.4 ± 10.7	35.6 ± 6.7	34.8 ± 8.7	34.3 ± 5.3			
Subjective Parameters							
Muscle/Joint Ache (units)							
Habitual Cigarette Type	2.78 ± 3.29	2.10 ± 2.41	2.45 ± 3.09	2.10 ± 2.40			Cigarette Type × Job*
Ultralight Cigarette Type	3.51 ± 4.03	1.76 ± 1.44	3.42 ± 4.00	1.65 ± 1.48			$F(1, 44) = 4.97$

*$p < 0.05$. †$p < 0.01$. ‡$p < 0.001$.

The daily frequency of consumption of single food items or groups of items revealed no differences after switching to ultralight cigarettes or between measurement days, whereas males consumed more often meat, $F(1, 44) = 9.6, p < 0.01$; sausages, $F(1, 44) = 8.0, p < 0.01$; potatoes, $F(1, 44) = 4.5, p < 0.05$; and sweetened soft drinks, $F(1, 44) = 6.8, p < 0.05$, and nonoffice workers consumed more often meat, $F(1, 44) = 4.9, p < 0.05$, and sausages, $F(1, 44) = 7.9, p < 0.05$.

SRP, SRA, and PAI are shown in Fig. 1 for both sexes and cigarette types. Job-specific plots revealed analogous courses of the three curves and are not shown.

All three variables (SRP, SRA, PAI) revealed curves for both sexes analogous to those previously described for female subjects (2). SRP and SRA increased during the last minutes before lighting the cigarettes, reached a maximum with lighting, and dropped instantly after lighting below the prelighting levels. Whereas SRP recovery started immediately after this drop, SRA remained at a low level for about 6 min before slowly recovering; PAIs increased after lighting the cigarettes. An ANOVA of the SRP, SRA, and PAI values without the peak-containing interval from 4 min before to 4 min after lighting the cigarettes, thus comparing pre- to postlighting levels, revealed significantly increased heart rates, $F(1, 44) = 7.19, p < 0.05$; decreased physical activity, $F(1, 44) = 7.11, p < 0.05$; and increased PAIs, $F(1, 44) = 24.91, p < 0.001$, after the lighting of the cigarettes. Furthermore, the SRP curves revealed significantly decreased heart rates, $F(1, 44) = 10.01, p < 0.01$, for the ultralight cigarette condition, and the SRA curves revealed significantly higher physical activity in males, $F(1, 44) = 6.56, p < 0.05$, and in nonoffice workers, $F(1, 44) = 9.01, p < 0.01$.

DISCUSSION

The acceptance of the blood pressure monitor and the electronic diary was generally excellent, and most subjects were interested in obtaining their personal data. The pulse activity monitor was reported to be the least comfortable, since it had to be worn day and night. Nevertheless, the high correlations between measurement days 1 and 2 obtained for all devices including the pulse activity monitor, and the nearly complete absence of significant day differences in the ANOVAs, demonstrated the reliability of the methods. The only significant difference between measurement days 1 and 2 was approximately two more marker button presses on day 2 irrespective of the type of cigarette. However, whether this reflected the actual cigarette consumption or an improving compliance with the instruction to press the button when lighting a cigarette remains open. For future studies, a method for checking the compliance to button pressing when lighting a cigarette would be to ask subjects to save their cigarette butts.

As expected, men revealed higher systolic and diastolic blood pressure and lower heart rates (15), and nonoffice workers revealed higher physical activity. Despite this job-dependent difference in activity, no differences in heart rate were observed, possibly due to a cardiovascular adaptation of the nonoffice workers to their physical work. Males also revealed higher physical activity but not higher heart rates. However, the relation between activity levels and resulting heart rates is different for the two sexes. Although our subjects did not constitute representative samples of different occupational groups, the higher cigarette consumption, Fagerstrom index, respiratory CO, and physical activity in nonoffice workers revealed the internally consistent picture, also described by others (12), that the physical demand of the job is positively correlated with smoking intensity. However, the differences in these smoking habits were not accompanied by concomitant differences in saliva cotinine levels, whereas the reduction in nicotine yield of the cigarettes after switching to ultralight cigarettes did produce a significant reduction in saliva cotinine. This, and the low correlations between cigarette consumption and saliva cotinine, reflected that the nicotine yield of the cigarettes was more decisive for nicotine intake than were other factors. On the other hand, consistent with previous findings (22,38), our subjects generally kept the daily number of cigarettes constant without full compensation for nicotine or CO. This might mean that for habituated smokers the conditioned behaviors are more important than the pharmacological effects.

The observed main effects of switching to ultralight cigarettes were decreases in resting and 24-h heart rate, systolic and diastolic blood pressure, respiratory CO, and saliva cotinine concentrations. Furthermore, fat intake increased, whereas smoking rate, physical activity, and subjective well-being, except muscle/joint ache, were not affected. Rather surprisingly, these cigarette type–dependent differences did not interact with the various group differences, with the exception of the increased fat intake after switching, which was more pronounced in nonoffice workers.

The reduced respiratory CO (49,51) and saliva cotinine concentrations (1,8,27,42) after switching are consistent with previous findings. The latter, as an indirect measure of nicotine intake, may also explain the lower heart rates when smoking ultralight as compared with habitual cigarettes (3,13,30, 31,34,37,48,50). With respect to blood pressure, the available evidence is in part equivocal. On the one hand, acute increases after smoking a single cigarette have been reported (9), and on the other, epidemiologic studies have revealed lower blood pressure in smokers as compared with nonsmokers (6,14,15). One of these studies also revealed a significant negative correlation between serum cotinine concentrations and blood pressure (6), although cotinine has no direct effect on blood pressure (5). Our data suggest decreased systolic and diastolic blood pressure after reducing nicotine intake by switching from stronger to lighter cigarettes. Correlations between saliva cotinine and blood pressure failed to produce any significance, probably due to an insufficient sample size.

The development of acute and chronic tolerance to the heart rate–increasing effects of nicotine has been reported from laboratory studies (35,36). Our results, as deduced from the SRP, SRA, and PAI curves, suggest a modest acute but not a complete tolerance. Heart rate baselines were lower with the ultralight cigarettes, but the magnitudes of the postsmoking boosts of heart were nearly identical for the two smoking conditions; also, the PAI curves, as a measure of effects other than those of activity on heart rate, failed to differ between the two types of cigarettes. The PAI curves only revealed a general increase of heart rates above levels to be expected from the concomitant activity readings, irrespective of cigarette type. The parallel prelighting increases of SRP and SRA also did not differ between the two types of cigarettes. As the PAI levels remained constant, the prelighting increases of heart rate are explainable as an effect of the increasing activity. However, it is rather unclear what induced this gradual activity increase starting about 4 min prior to lighting the cigarettes. One aspect is certainly the preparatory handling of the cigarettes before lighting up. But since a habituated smoker hardly needs several minutes to light a cigarette, these prelighting activity increases might also reflect in part a condi-

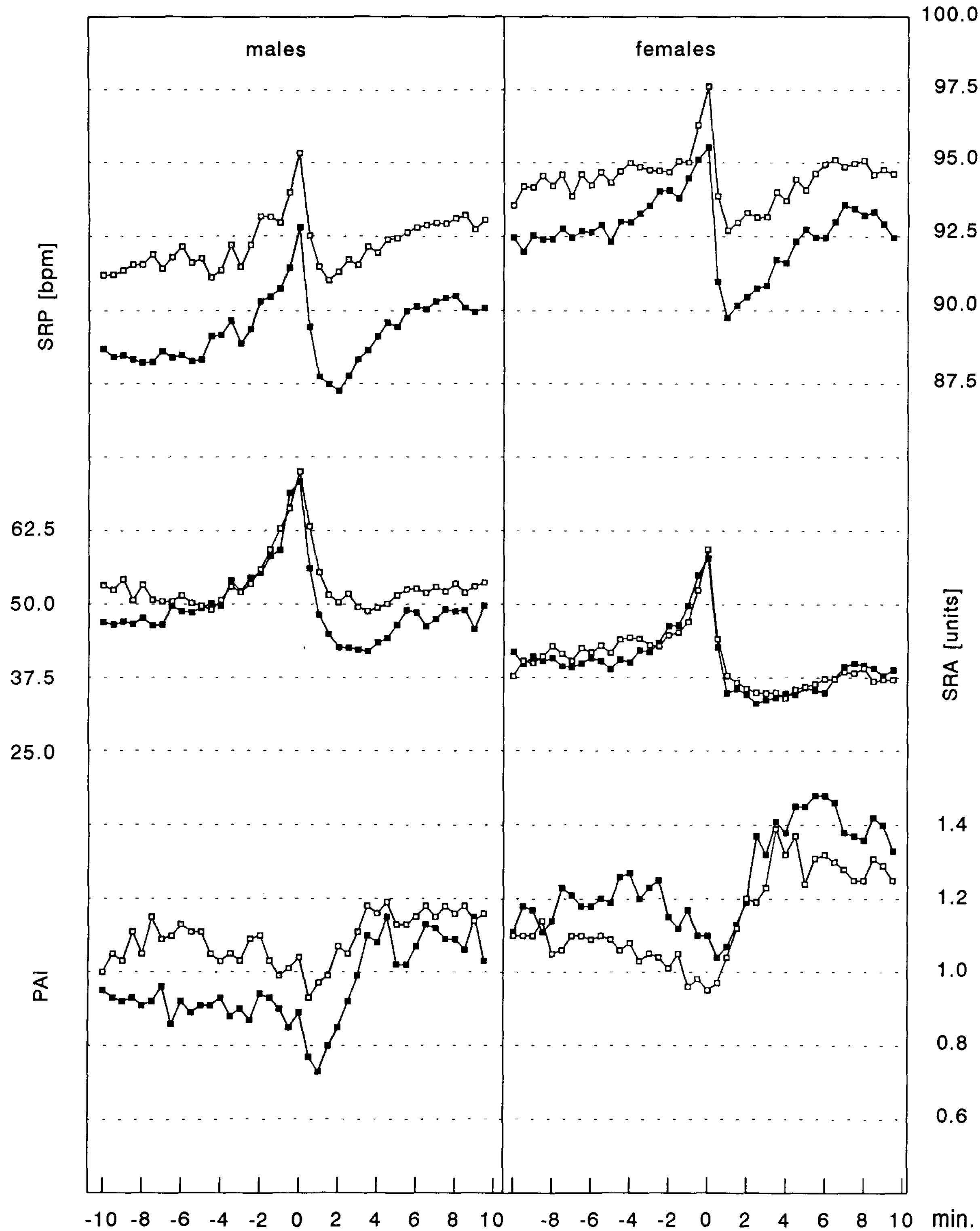

FIG. 1. Smoking-related variation of pulse (SRP) and activity (SRA) and pulse activity index (PAI) when smoking habitual (□) and ultralight (■) cigarettes. Cigarettes were lit at 0.

tioned phenomenon, as suggested in a previous study (2). To dissociate between such unconscious anticipatory unrest or psychomotor activation and the effects of cigarette handling, a control study would be required comparing ad lib smoking with smoking at given irregular intervals, which should produce mere handling responses.

The possibility that these prelighting gradual increases of activity are the result of imprecise button pressing is not likely, since such an artefact would produce symmetric peaks instead of the observed sharp decreases after lighting up.

Mean total caloric intake and the caloric intake of carbohydrates, protein, and fat were for both sexes comparable to data published by other authors (25,32,46). Similarly, the intake of these main components as a percentage of total caloric intake also varied in a range consistent with several other reports (23,26,46,47). Although a higher caloric intake in nonoffice workers was to be expected (12), and the group means of the caloric intake for nonoffice and office workers did tend in this direction, we did not obtain significant differences.

Finally, after switching from habitual to ultralight cigarettes a generally increased fat intake and, as assessed by the percentage intake, a decreased carbohydrate intake were observed. Similar results have been published in studies on the dietary effects of quitting smoking. A transient increase of fat consumption (17) as well as an increased intake of polyunsaturated fatty acids in recent quitters (46) has been reported. This would suggest a nicotine-related regulation of fat intake. Others, however, found increased carbohydrate and decreased protein rather than changed fat consumption in abstinent smokers (42). Current explanations for such postquitting differences in diet are that after quitting smokers develop a sweet taste preference (42) or that smokers may have a genuine sweet taste preference (39) which after quitting leads to increased intakes of high sucrose, high fat snacks. However, these arguments appear less decisive for the situation of switching to lighter cigarettes. We also tried to identify the sources of fat intake for each cigarette type by counting the frequency of daily consumption of single food items and by splitting the fat content of each food item according to its content of saturated and polyunsaturated fatty acids. However, we observed only sex- and job-specific differences in the average frequency of intake of single food items, but no cigarette type–dependent differences in the frequency or in the absolute amount of consumption of single food items, thus suggesting for the ultralight cigarette condition a generally increased intake of a wide range of high fat items rather than an increased intake of a specific kind of fat-containing food such as chocolate. To identify such subtle differences as these, our sample size was probably not sufficiently large and/or the measuring period not sufficiently long.

Taken together, our methods revealed highly reliable data allowing the discrimination of sex- and job-specific differences as well as subtle cigarette type–induced changes in physiological and dietary parameters. These changes were qualitatively similar to those expected when quitting smoking, but quantitatively considerably smaller. The widely held belief that smokers are able to compensate completely or almost completely for reduced nicotine by adequate changes in puffing behavior is only moderately supported by the present study. In fact, saliva cotinine did decrease by 30%. Surprisingly, even under field conditions this decrease in nicotine intake was accompanied by changes in cardiovascular parameters. The increased intake of fat without a change in total caloric intake suggests further that smoking—in a subtle fashion—may go along with changes in food preference, perhaps due to alterations of taste perception.

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