Infectious episodes in runners before and after the Los Angeles Marathon

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An epidemiologic study of Los Angeles Marathon (LAM) applicants was conducted to investigate the relationship between self-reported infectious episodes (IE), training data, and LAM participation. Eight days before the LAM, 4926 of 12,200 applicants were randomly selected, and sent a pilot-tested four page questionnaire, which was received 7 days after the LAM. The 2311 respondents were found to be 2.0 yr older and 7.6 min faster than other LAM finishers ($p<.01$). Univariate and multivariate analyses (logistic regression) were conducted to test the relationship between IE and km/wk of running (6 total categories). The final model tested controlled for age, marital status, reported sickness in other members of the runner's home, perceived feelings of stress in response to personal training regimens, and the suppressive effect of sickness on regular training. In runners training ≥97 *vs* <32 km/wk, the odds ratio (OR) for IE during the 2 month period prior to the LAM was 2.0 (95% confidence interval (CI) 1.2-3.4). A test for trend showed an increase in OR with increase in km/wk category ($p=.04$) which was largely explained by the increased odds of reported sickness in the ≥97 km/wk category. Of the 1828 LAM participants without IE before the LAM, 236 (12.9%) reported IE during the week following the LAM *vs* 3 of 134 (2.2%) similarly experienced runners who did not participate, OR=5.9 (95% CI 1.9-18.8). These data suggest that runners may experience increased odds for IE during heavy training or following a marathon race.
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Much attention has recently been focused on stress, both physical and psychological, as a potent suppressor of the immune system.[1-4] Athletes training for long endurance events such as the marathon experience repeated cycles of physical stress which can be accompanied by mental stress. Anecdotal information from coaches has reflected a concern for increased infectious episodes in their competitive endurance athletes.[5-8]

Results from both animal and human studies suggest that intense exertion, whether short-term and maximal, [4-19] or long-term and submaximal,[5 20-29] may be associated with some potentially negative immune system changes. Various reserchers have implied that such changes may render individuals in hard training more susceptible to infectious episodes.[1 5 14 19 20] On the other hand, some researchers have suggested that moderate submaximal exercise bouts [30-34] and long-term training [14 35 36] may enhance immunosurveillance, potentially decreasing the risk for infection.

To our knowledge, no epidemiological

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studies have previously been conducted to investigate the effects of exercise and perceived stress on infectious episodes in endurance athletes. The Los Angeles Marathon (LAM), conducted on March 1 of 1987, provided us with such an opportunity to study a large population of runners training intensively during the winter months. The purpose of this study was to examine the relationship of reported incidence of infectious episodes in these runners during the two winter months prior to the race with levels of training and perceived stress. In addition, the effect of the race experience on infectious episodes was studied during the week following the LAM.

We theorized based on the studies reviewed above that high- *versus* low-to-moderate distance runners would experience increased odds for infectious episodes, and that low levels of perceived stress in response to the training program would be protective. In addition, we hypothesized that the marathon race experience would increase the odds for infectious episodes during the week following the race in the participants *versus* applicants who chose not to participate.

Methods

Development of the questionnaire

A questionnaire including questions on demographic data, training habits, race results, and the incidence of infectious episodes in both the runners and other people living in their homes was developed and pilot-tested on a group of 300 runners in Southern California.[37] The questionnaire was then developed futher and administered to applicants of the 1987 Los Angeles Marathon (LAM).

With the cooperation of LAM administrators, and Tandem Computers Incorporated who were responsible for processing applicant information and race results, 4926 of 12,200 applicants were randomly selected eight days before the event. The detailed four-page questionnaire, cover letter including the signature of the race director, and return envelope were sent to each of the randomly selected applicants and received approximately one week following the LAM.

Questions on training habits covered average 1986 habits and the two month period prior to the March 1, 1987 LAM. Runners were asked to self-report average weekly running distance, and from this information,six kilometer per week (km/wk) categories were formulated. In addition, runners rated the intensity of their exercise on both "easy" and "hard" days of training using a 10-point rating of perceived exertion scale.[38] Runners also reported their average longest weekly run, frequency of training, and number of weekly "hard runs" for each time period. A "hard" training session was defined as "higher than normal intensity, faster than normal pace".

Questions on incidence of infectious episodes in both the runners and residents in their homes covered the two month period prior to the LAM, and the 7-day period immediately before and after the LAM. Runners were asked to self-report whether or not they or individuals in their residence had been sick with a cold, flu, or sore throat during the time periods indicated. Because of the exploratory nature of this study, runners reporting at least one infectious episode during the two month period prior to the race or during the seven day period following the race were contrasted with runners reporting no infectious episodes during these time periods. In other words, a binary variable (yes or no) for self-reported infectious episodes during these time periods was created. In addition, the number of symptom days for infectious episodes during each month prior to the LAM was recorded.

Runners used a four-point Likert scale in evaluating their energy and stress levels, and in reporting their quality of sleep and overall feelings since they had started running (compared to pre-running years). From this self-reported information a "perceived low stress" group was formulated. Runners were categorized as being in the "perceived low stress" group if they reported "definitely better" responses for each factor (sleep, energy and stress levels, and overall feelings since starting running).

Nonresponders were compared with responders by using data supplied by Tandem Computers Incorporated. The age, percentage of male *vs* female finishers, and race times of the LAM finishers in the sample were compared with all other LAM finishers.

Statistical analyses

To test the relationship between self-reported infectious episodes and training, demographic, perceived level of stress, and race data, univariate and bivariate analyses were first conducted. Multivariate analyses using a logistic regression model were then conducted in order to assure that the observed results were not caused by confounding or interaction. The logistic regression model was developed by first entering important variables from the univariate testing, and then checking whether or not elimination effected the odds ratio of the relationship between sickness and the six km/wk categories. Tests for multicolinearity and significant interaction terms were conducted on variables used in the final model. A test for exponential trend was conducted on the odds ratios for the six km/wk categories using the logistic regression model with the six km/wk categories expressed as a single variable representing the trend.

The Statistical Package for the Social Sciences (SPSS/PC+) software program [39] was used for all univariate and bivariate testing. Training and demographic differences between runners reporting infectious episodes and those not by km/wk categories were analyzed using MANOVA (2 by 6) and Chi-square. Trend analysis for training variables across km/wk categories was conducted using oneway analysis of variance with polynomial contrasts. Categorical data across km/wk categories was analyzed for trend using the method described by Cochran.[40] The Logit module (logistic regression), version 1.11 (1986), of SYSTAT, Incorporated [41] was used to determine the odds of runners acquiring an infectious episode during the two month period prior to LAM and the week following and whether variables were significantly related. Results are expressed as means ± SE and statistical significance was tested at the $p<.05$ level. Odds ratios are expressed with 95% confidence intervals (CI).

Results

Study sample vs *other LAM finishers*

Of the 4926 questionnaires mailed to LAM applicants, 2311 were returned (46.9%). There were 10,759 official finishers in the LAM, of which 2016 responded to the questionnaire. Races times, percentage male *vs* female finishers, and ages of the LAM finishers in our sample were compared with the 8,743 other LAM finishers. Results of this comparison show that finishers comprising the study sample were on the average two years older (36.9 ± 0.2 *vs* 34.9 ± 0.1, $p<.01$) and ran an average of 7.6 minutes faster (255.5 ± 1.1 *vs* 263.1 ± 0.6, $p<.01$) than the other LAM finishers. There were no significant differences in the percentages of male *vs* female finishers (85.0% male/15.0% female in the study sample *vs* 86.2% male/13.8% female other LAM finishers). While these differences are statistically significant they are small, and we urge caution in extrapolating results to other LAM finishers. The 295 applicants who did not finish the LAM yet responded to our questionnaire (which we urged in our cover letter) were included in the analysis primarily to compare LAM participants with non-participants during the week following the race.

TABLE I.—*Subject characteristics by kilometer/wk training categories (means ± SE).*

Category (km/wk)	<32	32-47	48-63	64-79	80-96	≥97	Probabilities Km/wk	Trend
N	263	391	559	552	311	231		
Age	35.1 ± 0.7	36.2 ± 0.5	37.7 ± 0.4	37.6 ± 0.5	37.9 ± 0.5	36.9 ± 0.7	.002	.006
Body mass index[1]	23.2 ± 0.2	23.0 ± 0.1	23.0 ± 0.1	22.8 ± 0.1	22.6 ± 0.1	22.1 ± 0.1	.000	.000
Never married[2]	42.2%	29.6%	29.7%	25.1%	27.4%	33.8%	.000	.014
College graduate[3]	58.9	63.9	65.7	67.4	69.8	59.1	.029	.246
# home residents[4]	2.7 ± 0.1	2.8 ± 0.1	2.8 ± 0.1	2.9 ± 0.1	2.9 ± 0.1	2.9 ± 0.1	.520	.051
Perceived low stress[5]	25.2%	24.3%	26.7%	25.8%	30.2%	36.4%	.018	.003
LAM race time[6]	300.7 ± 3.8	274.4 ± 2.6	260.4 ± 1.9	248.0 ± 1.8	236.1 ± 2.6	219.5 ± 2.9	.000	.000

[1]Body mass index = weight in kilograms divided by height in meters squared.
[2]Percent of runners reporting never having been married.
[3]Percent of runners with at least a college degree.
[4]Number of residents in the home of the runner (includes runner).
[5]Percent runners in "perceived low stress" category (see text for explanation).
[6]Los Angeles Marathon race time.

Subject characteristics

Males represent 83.75% of respondents. For the entire sample, 30.1% reported they had never been married *versus* 69.9% who reported either being married (56.2%) or separated-divorced-widowed (13.7%). Of the respondents, 16.8% reported they reside alone, 49.4% with one or two others, and 33.7% with three or more other people. The average body mass index (kg/m^2) for men averaged 23.3 ± 0.05 for the males and 20.5 ± 0.10 for the females. Only 16% of the entire sample (in comparison to 52% of all US adults) had a body mass index of 25 or greater which has been used as a measure of being overweight.[42] Yet 49.6% of the runners reported wanting to lose five pounds (2.27 kg) or more. Body weight was reported by 76.9% of the runners to be lower since starting regular running (compared to pre-running years). For the entire sample, 64.7% reported possessing a college (36.6%) or advanced degree (28.1%). Of the respondents, 79.2% reported being White, 11.0% Hispanic, 4.2% Oriental and 3.3% Black. Only 3.0% of the respondents reported they were current smokers, with 37.0% reporting they had smoked formerly, and 60.0% never. Males averaged 6.0 minutes per kilometer during the LAM and female 6.5. This pace was approximately 20-25 seconds per kilometer slower than reported marathon personal records.

Subject characteristics are outlined in table I. Statistics represent males and females combined. When subjects were divided into six categories based on km/wk reported during training, significant trends were found including decreases in body mass index (kg/m^2), percent of runners never married, and LAM race time, and increase in age and percent of runners perceiving their stress levels as low (see following section).

Perceived low stress group

The majority of runners reported that since starting regular running in comparison to pre-running years, energy levels were higher (51.5% "definitely higher", 39.5% "somewhat higher"), stress was being handled better (60.2% "definitely better", 38.7% "somewhat better"), sleep was better (48.2% "definitely better", 47.1% "somewhat better"), and overall feelings were better (79.1% "definitely better", 20.2% "somewhat better"). Table I shows that the percentage of runners included within the "perceived low stress" group increased significantly with increase in km/wk of trining. For the entire sample, 27.5% were included in the "perceived low stress" group.

TABLE II.—*Two month period to Los Angeles Marathon: average training statistics for runners reporting at least one infectious episode vs none by km/wk categories.*

Category (km/wk)	<32	32-47	48-63	64-79	80-96	≥97	Probabilities		
							km/wk	Sickness	Interaction
N									
S[1]	80	157	222	209	128	97			
NS	112	201	298	286	172	123			
Age									
S	33.9±1.0	34.3±0.7	36.0±0.7	36.8±0.7	37.3±0.9	36.0±1.0	.010	.000	.578
NS	36.6±1.1	37.6±0.7	39.1±0.6	38.3±0.6	38.5±0.7	37.4±0.9			
Body mass index									
S	23.4±0.3	22.6±0.2	22.8±0.2	22.8±0.2	22.5±0.2	22.1±0.2	.000	.267	.046
NS	23.0±0.2	23.4±0.2	23.2±0.1	22.8±0.1	22.6±0.2	22.0±0.2			
Km/wk 1987 2 mo									
S	20.7±0.8	38.7±0.4	54.1±0.3	69.4±0.3	84.7±0.4	109.8±1.9	.000	.089	.670
NS	20.7±0.7	39.1±0.3	54.6±0.3	69.5±0.3	85.4±0.2	112.1±2.0			
Km/wk 1986[2]									
S	23.5±2.0	33.6±1.3	37.5±1.1	48.1±1.4	61.3±1.9	78.1±3.2	.000	.700	.515
NS	23.3±2.1	30.3±1.0	39.2±1.0	49.3±1.2	61.2±2.3	81.2±2.5			
Days/wk									
S	3.0±0.2	4.2±0.1	4.9±0.1	5.5±0.1	5.8±0.1	5.9±0.1	.000	.017	.168
NS	3.3±0.2	4.2±0.1	4.9±0.1	5.5±0.1	5.9±0.1	6.3±0.1			
Longest run/wk									
S	12.4±0.7	16.6±0.5	20.6±0.4	23.8±0.4	25.1±0.5	26.6±0.6	.000	.001	.058
NS	12.7±0.6	18.6±0.5	20.7±0.4	23.6±0.4	26.5±0.5	28.6±0.6			
# hard days/wk									
S	0.9±0.1	1.4±0.1	1.8±0.1	2.1±0.1	2.1±0.1	2.4±0.1	.000	.535	.341
NS	1.0±0.1	1.4±0.1	1.7±0.1	1.9±0.1	2.2±0.1	2.4±0.1			
RPE easy days[3]									
S	3.3±0.2	4.0±0.1	4.0±0.1	4.0±0.1	4.0±0.1	4.1±0.2	.000	.485	.880
NS	3.4±0.1	3.9±0.1	3.9±0.1	4.0±0.1	4.0±0.1	4.3±0.2			
RPE hard days									
S	5.9±0.3	6.6±0.2	6.8±0.1	6.7±0.1	6.9±0.2	6.9±0.2	.000	.270	,456
NS	5.9±0.2	6.4±0.1	6.3±0.1	6.6±0.1	7.0±0.1	7.0±0.2			
Years running									
S	5.6±0.6	6.0±0.4	6.9±0.4	7.4±0.4	8.3±0.5	7.1±0.5	.000	.038	.004
NS	5.1±0.5	7.6±0.5	7.5±0.4	7.6±0.3	7.2±0.4	9.5±0.6			

[1]S=at least one self-reported infectious episode during the two month period prior to the LAM; NS=no self-reported infectious episodes during the two month period prior to the LAM.
[2]Average kilometers per week during all of 1986.
[3]RPE=rating of perceived exertion using a 10 point scale (3=moderate; 4=somewhat hard; 5=hard; 7=very hard; 10=very, very hard or maximal).

Average training statistics

Table II outlines average training statistics for the two month period (January/February 1987) prior to the race for both the runners reporting at least one infectious episode and for those reporting none by km/wk categories. Because females did not differ significantly from males in most of the training variables, statistics are presented for males and females combined. For both groups, the higher distance runners were significantly more experienced and older, trained more frequently and intensely, ran further during their longest run of the week, and had a lower body mass index ($p<.01$). Trend analysis revealed significant increases for age, and significant decreases for body mass index, across km/wk categories ($p<.000$). trend analysis for all training variables revealed significant increases across km/wk categories ($p<.000$).

For the entire sample, the average runner had 7.2±0.1 years of experience, and during January/February 1987 ran 61.0 ± 0.6 km/wk, trained 4.9 ± 0.03 days/wk, ran 16.0 ± 0.2 km during the weekly longest run, reported a rating of perceived exertion (RPE) using a 10-point scale [38] of 3.9 ± 0.03 on easy days and 6.6 ± 0.04 on hard days, and participated in heavier than normal training 1.8 ± 0.03 days/wk. Only 23.7% of the runners averaged more than 80.5 km/wk during January/February 1987 (11.1% in 1986). The average runner increased training by 15.6 ± 0.5 km/wk in January/February 1987 *vs* all of 1986. This varied widely based on the km/wk category (-5.9 ± 1.4 km/wk for the <32 km/wk group *vs* 31.0 ± 2.1 km/wk for the ≥ 97 km/wk group).

Infectious episodes in runners before the LAM

Table II also shows the relationship of self-reported infectious episodes and km/wk categories with training variables. An overall MANOVA test of these relationships showed that the km/wk categories were significantly related to the training variables (Pillais Trace=1,02, $F(45,10345) = 58.90$, $p < .0005$), that the infectious episode category (at least one during the two month period prior to the LAM) was significantly related to some of the training variables (Pillais Trace=0.018, $F(9,2065) = 4.15$, $p < .0005$), and that these variables interact in some ways in predicting the training variables (Pillais Trace=0.030, $F(45,10345) = 1.40$, $p = .039$).

Table II shows that runners reporting at least one infectious episode during the two month period prior to the LAM were significantly younger than those not reporting an infectious episode. In addition, runners reporting at least one infectious episode also reported lower distances during the average longest weekly run, a slightly lower frequency of training, and slightly fewer years of running experience ($p < .05$). Runners reporting at least one infectious episode also tended to report lower training distances. Significant two-way interactions (km/wk categories and reported sickness) occurred for only two variables, body mass index and number of years of running.

A separate analysis was conducted using repeated measures ANOVA to evaluate the effect of sickness on training. Runners reporting an infectious episode in January but not February, February but not January, January and February, or neither January or February were contrasted.

Sickness in February but not January, or sickness in both months was found to be associated with a decreased running distance during the average longest weekly run ($p = .026$), with a trend also towards fewer kilometers of running ($p = .067$) per week during the month of reported sickness.

Frequency of training was also reduced in those reporting sickness in February or both months, but this was not significant ($p = .14$). LAM race times were nearly exactly the same in runners sick during January/February 1987 *vs* runners not-sick (255.46 ± 1.7 *vs* 255.49 ± 1.4 respectively, $p = .989$) implying that the two groups were of equal running ability. So runners reporting infectious episodes did appear to reduce the magnitude of their training, especially when the episode occurred during the month preceding the LAM.

During the two month period (January/February 1987) prior to the March 1, 1987 LAM, 43.2% of all runners reported at least one infectious episode. Fifty percent of the runners reported at least one person sick at home during this period. Table III shows that the percentage of runners reporting at least one infectious episode during January/February 1987 was not significantly different by km/wk categories. The percentage of runners reporting at least one infectious episode in at least one resident of their home was significantly different by km/wk category. However, trend analysis revealed that the increase was not significant over all

TABLE III.—*Demographic variables by km/wk categories: percent runners reporting at least one infectious episode during the two month period prior to the LAM.*

Category (km/wk)	No.	<32	32-47	48-63	64-79	80-96	≥97	Probabilities Km/wk	Group
% of all runners reporting at least one infectious episode	980	42.7	44.2	42.5	42.3	43.4	44.2	.991	
% of all runners reporting home sickness[1]	1136	42.4	49.7	52.4	51.0	55.5	44.2	.013	
Sex									
Males	1906	40.8	43.5	42.1	43.3	44.2	44.3	.969	.820
Females	366	51.0	47.1	46.5	37.8	39.2	43.2	.653	
Marital status[2]									
Never married	686	43.2	53.9	48.8	51.1	48.2	44.9	.646	.001
Married	1584	42.4	40.5	39.9	39.2	41.3	43.8	.937	
Education									
<College grad	797	40.7	41.1	45.8	42.9	50.0	48.9	.630	.390
≥College grad	1474	44.2	46.0	41.1	42.0	40.6	41.2	.824	
Race									
White	1801	41.8	43.8	42.6	43.5	42.2	41.7	.995	.772
Non-white	465	44.2	45.2	43.1	37.1	47.2	51.8	.618	
Home sickness									
Yes	1136	58.6	53.1	57.0	54.1	54.1	57.8	.886	.000
No	1132	31.1	35.2	26.7	30.1	29.7	33.3	.500	
Perceived low stress[3]									
Yes	606	39.1	33.3	41.7	34.1	29.7	39.0	.463	.000
No	1608	43.9	48.4	42.5	44.9	47.1	46.2	.708	

[1]Home sikness: report by runner of at least one infectious episode in at least one member residing in home of runners during the month period prior to LAM.
[2]Married category include runners both currently or formerly married.
[3]Perceived low stress: see text for explanation.

categories (p=.26). Nearly twice as many runners reporting at least one infectious episode in residents of their home also reported an infectious episode in themselves. For runners reporting infectious episodes, most (75-78%) reported symptom days of 7 days or less per month.

Analyses for trend of all variables in table III revealed no significant changes over km/wk categories. A significantly higher percentage of never married runners reported at least one infectious episode during the two month period prior to the LAM *versus* married or formerly married runners. Because married runners did not differ significantly in reported infectious episodes from divorced/separated runners (41.3% *vs* 38.7% respectively, p=.43), these two groups were contrasted together with never married runners in all analyses. A significantly lower percentage of runners in the "perceived low stress" group reported at least one infectious episode during this time period. Males and females, college graduates and non-college graduates, and whites and non-whites did not differ significantly in reports of infectious episodes.

Table IV outlines the final logistic regression model parameters and statistics used in predicting the odds of acquiring at leasr one infectious episode during the two months prior to the LAM. Variables were tested for their effect on the odds ratio statistic representing the relationship between km/wk categories and self-reported infectious episodes. Important variables included the number of resi-

TABLE IV.—*Logistic regression model parameters and statistics used in predicting the odds of acquiring at least one infectious episode during the two month period (January/February) prior to the Los Angeles Marathon.*

Parameter*	Estimate	Standard error	t-statistic	2-tailed p value
Constant	1.03805	0.43166	2.405	.016
#home residents	−0.14058	0.03940	−3.568	.000
Age	−0.01413	0.00556	−2.543	.011
Longest run/wk	−0.02675	0.01163	−2.301	.021
Days/wk	−0.07173	0.04340	−1.653	.098
Contrasts			Odds ratio	95% CI
Sickness in runner's home				
Yes *vs* no	1.25858	0.10123	3.52	(2.89-4.29)
Perceived low stress				
Yes *vs* no	0.34852	0.10470	1.42	(1.15-1.74)
Never married *vs* married	0.30455	0.12351	1.35	(1.06-1.73)
<32 *vs* ≥97 km/wk	0.69773	0.27330		
32-47 *vs* ≥97 km/wk	0.38192	0.21126		
48-63 *vs* ≥97 km/wk	0.42088	0.18651		
64-79 *vs* ≥97 km/wk	0.32364	0.17717		
80-96 *vs* ≥97 km/wk	0.31935	0.19082		

*See legends for tables I, II and III for explanation of parameters. See figure 1 for odds ratios and 95% confidence intervals of km/wk contrasts.

dents in the runner's home, reports of infectious episodes in other members of the runner's home, marital status, "perceived low stress", age, average longest run per week, and average days per week of training. The latter two training variables had the effect of controlling for the decrease in training experienced by runners reporting infectious episodes during the two month period prior to the LAM.

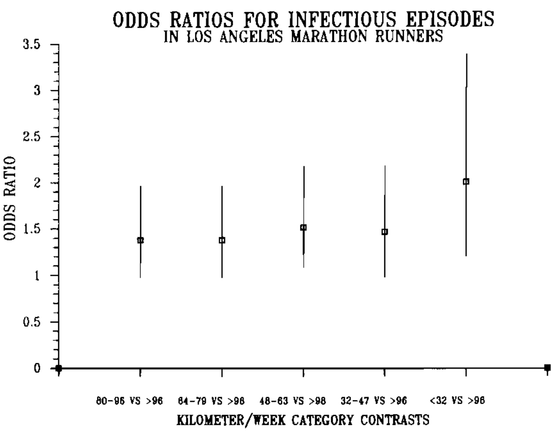

Fig. 1.—Odds ratios and 95% confidence intervals for km/wk contrasts (highest distance group, <96 km/wk *versus* each other km/wk category) in predicting at least one infectious episode (self-reported) in applicants of the Los Angeles Marathon during the two months prior to the event.

Variables in the final model were tested for significant interaction with the km/wk categories, and none of the terms were found to be significant. Tolerance levels as well an multicolinearity diagnostics recommended by Wilkinson [41] showed no evidence of multicolinearity. In addition, the two significant interaction terms from table II were tested with the final model and neither were found to be significant.

Figure 1 portrays the odds ratios for predicting self-reported infectious episodes by km/wk category with other variables controlled. In runners training ≥97 *versus* <32 km/wk, the odds ratio for self-reported infectious training episodes during the two month period prior to the LAM was 2.0 (95% CI 1.2-3.4). A test for trends showed an increase in odds ratio with increase in km/wk category (p=.04). However, further analysis revealed a significant contrast between the ≥97 km/wk group and all other groups (p=.045). A test

TABLE V.—*Logistic regression model parameters and statistics used in predicting the odds of acquiring an infectious episode during the week following the Los Angeles Marathon*.*

Parameter**	Estimate	Standard error	t-statistic	2-tailed p value
Constant	−2.67399	0.65494	−4.083	.000
# home residents	−0.16783	0.05757	−2.915	.004
Age	−0.02148	0.00750	−2.866	.004
Contrasts			Odds ratio	95% confidence intervals
Sickness in runner's home Yes *vs* no	1.14083	0.16946	3.1	(2.2-4.4)
Participation *vs* non-participation in LAM	1.77734	0.58983	5.9	(1.9-18-8)

*Sample includes only those runners (both participants and applicants who choose not to run) who reported not being sick during the week just before the Los Angeles Marathon.
**See explanation for various parameters in text and tables I and III.

for trend with the lower five km/wk groups (with the ≥97 km/wk group left out of the analysis) was not significant (p=.63). Thus the significant trend in odds ratios across km/wk categories is largely explained by the high odds of reported sickness in the ≥97 km/wk category.

The non-significant univariate relationship between self-reported infectious episodes and km/wk category became significant under multivariate analysis. This is perhaps best explained in that higher distance runners were also older, ran more days per week and kilometers during their average longest weekly run, reported more sickness at home, and were more likely to report never having been married. When these variables were controlled, the relationship between self-reported infectious episodes and km/wk category became important, especially when the lowest and highest km/wk categories were contrasted.

Other univariate results held up under multivariate analysis except for the number of residents in the runner's home, and number of years of running experience. The number of residents in the runner's home was found to be positively associated with reported sickness at home ($\chi^2(4,N=2298)=315.1$, p=.000). In addition, as expected, fewer residents were reported in the homes of "never married" runners ($\chi^2(4,N=2303)=290.43$, p=.0000). Under multivariate analysis, these relationhips became important.

Odds of acquiring an infectious episode during the week following the LAM

Table V outlines the logistic regression model parameters and statistics used in predicting the odds of acquiring an infectious episode during the week following the LAM.

In this analysis, only race participants free of sickness the week before the race were used. During the week before the race, 342 runners reported an infectious episode. Of these, 132 (38.6%) participated in the race and were still sick the week after (176 participated and were not sick the week after, 34 chose not to run). So only sick-free runners were included in the logistic regression analysis to predict what runners would become sick with an infectious episode following the race.

Of the 1828 LAM participants sick-free before the race, 236 (12.9%) became sick during the week following the race. A total of 134 runners (not sick the week before LAM) choose not to run the race

(DNR). Of the DNR only 3 (2.2%) became sick during the week following the race. In the logistic regression analysis, this factor (race participation) was highly significant in predicting sickness following the LAM, odds ratio=5.9 (95% CI 1.9-18.8). Univariate analysis showed that the 134 DNR runners were similar in age (37.6±0.9 *vs* 37.3±0.2, p=.74), running experience (7.6±0.5 *vs* 7.2±0.1 years, p=.46), body mass index (22.86±0.2 *vs* 22.87±0.1, p=.97), reported sickness in January/February 1987 (38% *vs* 33%, p=.27), and 1986 kilometers of running (42.5±1.9 *vs* 45.4±0.6 km/wk, p=.13) to the 1828 LAM participants. However, training by the 134 DNR runners in 1987 did not increase as it did in the 1828 LAM participants (44.0±2.4 *vs* 62.5±0.6 km/wk, January/February 1987). Thus the increase in odds of becoming sick in the race participants *vs* those runners who choose not to run might be slightly affected by the decreased training experienced during the two month period prior to the LAM. However, entering km/wk 1987 into the logistic regression model did not effect the outcome, and was found to be non-significant. Other parameters that were non-significant included other training variables, marital status, and the percent of runners in the "perceived low stress" group.

LAM participants who reported someone sick at home *versus* LAM participants reporting no one sick at home during the week following the race experienced an increase in odds of acquiring an infectious episode, odds ratio=3.1 (2.2-4.4).

Comment and conclusions

The results of this study of 2311 applicants of the Los Angeles Marathon support the hypothesis that runners experience increased odds for infectious episodes during heavy training or following a marathon race. During the two month period (January/February 1987) prior to the March 1, 1987 LAM, 43.2% of the runners reported at least one infectious episode. With important variables controlled for, runners training 97 or more km/wk in contrast to less than 32 km/wk during these two winter months doubled their odds for self-reported infectious episodes. In addition, of the LAM participants who did not report an infectious episode during the week prior to the LAM, 12.9% became sick during the week following the race, *versus* only 2.2% of similarly experienced, sick-free runners who chose not to run, odds ratio=5.9 (95% CI 1.9-18.8).

In our sample, trend analysis revealed that increase in km/wk of running was significantly associated with increase in frequency and intensity of training. When weekly training distances exceeded 96 km/wk, the average weekly longest run averaged approximately 27 km. This amount of training, and the marathon race experience itself were associated with increased odds for self-reported infectious episodes. These results are supportive of clinical studies. Six researchers [5 20-24] have reported results on 38 highly trained athletes engaging in 32 to 42 kilometer runs or 20-50 km cross country ski races. Athletes in these studies experienced strong leucocytosis (175-290%) and granulocytosis (~375%), and these changes were correlated with large increases in cortisol. Eskola *et al.*[20] reported depression of lymphocyte function in eight long distance runners for several hours following a 42 km run which returned to normal within 24 hours following the event. They hypothesized that marathon running as a maximal psycho-physical stressor in impairing lymphocyte function may make runners more susceptible for infections. Tomai *et al.*[5] has reported that the mucosal immune system is suppressed by prolonged exercise, and has offered that this also may make athletes more susceptible to upper respiratory infections.

Other factors other than quantity of

training were significantly associated with infectious episodes. Younger runners were more likely to report infectious episodes during the two month period prior to the LAM than older runners. This agrees with other studies that have shown an inverse relationship between incidence of upper respiratory illness and age.[43] In addition, only 40.8% of married or formerly married runners reported infectious episodes during this period in contrast to 48.6% of never married runners, odds ratio = 1.35 (95% CI 1.1-1.7). Runners who reported infectious episodes in members of their home were nearly twice as likely to report personal infectious episodes (55.7% *vs* 30.6%). However, it is not possible from our data to ascertain cause and effect from this relationship. Variables not found to be important in either univariate or multivariate testing included educational status, race, sex, body mass index, number of hard training sessions per week, intensity of training, or number of years of running experience.

Our data support the growing evidence of the negative relationship between stress and infectious episodes.[44 45] Only 36.3% of runners who perceived themselves as responding to their training programs with "definitely better" levels of sleep, energy, overall feelings, and ability to handle stress since starting regular running reported infectious episodes. This compares with 45.2% of runners not included in the "perceived low stress" group, odds ratio = 1.42 (95% CI 1.15-1.74). Interestingly, more of the higher distance runners were categorized into this group. Other researchers [46 47] have reported that regular aerobic training is associated with mood elevation and an improved self-concept, with decreased feelings of depression and anxiety.

This epidemiologic study is the first to explore the relationship between self-reported infectious episodes, and training and demographic variables. It should be considered exploratory, with additional research needed to corroborate significant findings. The data is self-reported, the sample bias is only partly defined, the "perceived low stress" group used simple and self-reported criteria, and the number of applicants used in establishing the increased odds for infectious episodes following the LAM was limited in size. The non-significant univariate relationship between reported infectious episodes and km/wk categories only became important under multivariate analysis when various training and demographic variables were controlled for.

However, because of the high educational level of the study sample, the interest shown by the runners in the study, awareness by runners in general regarding their health and lifestyle habits, and the small differences seen when comparing the race times, ages, and percentages of male *vs* female LAM finishers in responders *vs* nonresponders, some of these potential weaknesses may not have been overly important in their effect on the final outcome.

The present sample represented a wide range of runners of varying talents and training habits (km/wk in January/February 1987 ranged from 0 to 282, with 8.9% running 24 km/wk or less and 5.7% running 105 km/wk or more). We hypothesized that higher- *vs* lower-to-moderate distance runners might experience increased odds of acquiring an infectious episode. Our data suggest that this relationship is most important when the highest km/wk runners ($\geq$97 km/wk) are contrasted either with the $<$32 km/wk group or all other runners combined. Data from table II indicate that the present sample included fewer very-high distance runners than would be expected in a group of runners training for a marathon. It is possible that by including more subjects at both extremes (habitual sedentary and very-high distance runners), a stronger relationship might be seen, perhaps U-curve in effect, with both sedentary and very-high distance runners experiencing the highest odds for infectious episodes.

One of the more important findings from the present study is the increase in odds of acquiring an infectious epusode by LAM participants *versus* similarly experienced runners who did not participate. These data are strengthened by the non-significant differences between LAM participants *vs* non-participants in years of running experience, age, and 1986 training data. Although non-participants did not train as hard during January/February 1987, entering this information into the logistic regression model did not change the outcome and was not significant.

However, sick-free non-participants numbered 134 as compared to 1828 sick-free LAM participants. Further research with larger numbers of non-participants is needed to confirm these findings.

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