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Women athletes with menstrual irregularity have increased musculoskeletal injuries

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ABSTRACT

LLOYD, T., S. J. TRIANTAFYLLOU, E. R. BAKER, P. S. HOUTS, J. A. WHITESIDE, A. KALENAK, and P. G. STUMPF. Women athletes with menstrual irregularity have increased musculoskeletal injuries. *Med. Sci. Sports Exerc.*, Vol. 18, No. 4, pp. 374–379, 1986. We have performed a retrospective three-phase study to evaluate the effect of menstrual status upon musculoskeletal injuries in women athletes. Initially, we collected the menstrual and running histories of women participants in a regional 10-km footrace. In this study, 61% of the respondents to our questionnaire reported a continuous running program, and 39% reported an interruption of at least 3 months of their running program. The most common cause for interruption was injury. Those who had interrupted their running were more likely to have had irregular or absent menses and less likely to have been using oral contraceptives than the group of continuous runners.

Secondly, we obtained information on the relationship between bone injury and menstrual status by reviewing the sports medicine records of 207 collegiate women athletes. We found that X-ray-documented fractures occurred in 9% of women athletes with regular menses and in 24% of women athletes with irregular or absent menses. Subsequently, we collected data from a larger population of more serious, but still recreational runners, participating in a national 10-km race. Each portion of this study has yielded similar results: those women who had been injured during their running program were more likely to have had absent or irregular menses, were less likely to have used oral contraceptives, and had been running for more years. We conclude that premenopausal women who have absent or irregular menses, while engaged in vigorous exercise programs, are at increased risk for musculoskeletal injury.

MENSTRUAL ATHLETES, MUSCULOSKELETAL INJURIES, WOMEN ATHLETES

The number of women in the United States who participate in regular vigorous exercise such as running has increased dramatically over the past decade and is estimated to be over 7 million (31). About 80% of these women are premenopausal (31). Previous studies confirm a positive correlation between intensive exercise programs and menstrual dysfunction (2–4, 7, 8, 10, 28, 30). Specifically, exercise increases the rates of oligo- and amenorrhea from about 5% of the sedentary population to approximately 20% of women who exercise regularly and vigorously (31). Several studies have shown that regular vigorous exercise is associated with decreased serum levels of estrogen (3, 4, 9, 28). An increased risk of osteoporosis and subsequent fractures in older women after natural menopause (16, 19, 24, 25), and in younger women with hyperprolactinemia (15, 29), premature ovarian failure, or castration (1, 14), is well documented.

In a recent study, Boyden and co-workers (4) measured the hormonal changes in 19 healthy women during formal training over 14 months for a 26.2 mile marathon. Eighteen of the 19 noted menstrual changes, but none became amenorrheic. However, during the training time, their circulating levels of estradiol (E_2) dropped over 50%. From a baseline of 70 $pg \cdot ml^{-1}$, E_2 fell to 54 $pg \cdot ml^{-1}$ when they were running 30 miles/wk, and then to 34 pg·ml at 50 miles/wk. Other studies have also shown that regular vigorous exercise programs are associated with decreased serum estrogen levels and menstrual irregularity (7, 28).

Circulating estrogens have an effect on the maintenance of bone composition because of their effects on calcium metabolism. Hypoestrogenism among post-

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menopausal women leads to a dramatic increase in osteoporosis in older women (6, 13). Cann and coworkers (5) subsequently determined that premenopausal amenorrheic women who engaged in vigorous exercise programs also had a decrease of 20–30% of spinal trabecular bone mass. Very recently, these workers reported that running-related fractures were more frequent in amenorrheic elite women runners (23). It is noteworthy that all of the athletic subjects for their recent study were truly elite, being selected in part for their ability to complete a marathon race within 3 hr.

In order to test the hypothesis that exercise-induced hypoestrogenism, as manifest by irregular or absent menses, may be accompanied by increased rates of musculoskeletal injuries among recreational and less highly trained athletes, we have performed a three-part retrospective study employing both survey techniques of recreational athletes and a review of the medical records of 207 collegiate women athletes.

MATERIALS AND METHODS

All studies performed for this report were reviewed and approved by the Institutional Review Board of the Hershey Medical Center. A 56-item questionnaire was used for the first study to collect health and running histories. The questionnaire was enclosed in the registration packet for each woman runner in the 1983 "Chocolate Chase," an annual 10-km foot race held in Hershey, PA. We received responses from 100 of the 238 women entrants (42% response rate). A similar questionnaire was distributed to all women registering for the "Diet Pepsi 10-km National Championship Footrace" held July 1, 1984, in New York City. Of the approximately 700 women entrants, we received completed questionnaires from 267 women (38% response rate). Completion of the questionnaires was entirely voluntary and anonymous.

All responses were analyzed with the Statistical Program for Social Sciences Data Analysis Program. The results in this report are presented as the mean response for a given question or as a percentage of the respondents. Some individuals did not complete all questions. Student's two-tailed *t*-test and chi-square analysis have been used to measure statistical significance. Logistic regression analysis, a multivariate technique which tests the association between several independent variables and a dichotomous dependent variable, was also employed. No individual respondent has been identified.

In addition to standard information on physical characteristics, health history, menstrual history, and running history, we collected information concerning any prior injuries. "Injury" is used as previously defined (17) and refers to any musculoskeletal ailment attributed to running that caused the runner to interrupt her running program and/or to seek medical help. Regular menstrual cycles are defined in this study as every 25–35 days or 10–13 menses/yr. Respondents who reported irregular or absent menses for a minimum of 12 months are considered as one group.

All of the university women athletes studied were on one or more of the Pennsylvania State University collegiate sports teams during the 1983–1984 seasons and had participated in collegiate sports for 1–4 yr. Their complete collegiate medical records were reviewed by two independent research teams on two separate occasions. Anonymity and confidentiality of all patient information was preserved by a coding system. During the review of these medical records only documented injuries involving boney structures were included. Specifically, soft tissue injuries were excluded.

All fractures were confirmed by X-rays taken at this university or by the student's attenting physician. None of the injured collegiate athletes reported using oral contraceptives. However, incomplete documentation or oral contraceptive use precluded the analysis of this variable. The two collegiate groups described had consistent menstrual histories (either regular or oligoamenorrhea) for a minimum of the preceding 12 months.

RESULTS

Respondents to our surveys were not different from the entire population of women runners with respect to mean age and mean speed and are considered to be representative of all women runners in these races. The physical, marital, menstrual, and running histories of the two groups of respondents from our first survey are presented in Table 1. These two groups are very similar

TABLE 1. Physical, marital, menstrual, and running histories of respondents.

Parameter	Running Program: Continuous (N = 61)	Running Program: Interrupted (N = 39)	*P* Value
Age (yr)	30	28	NS*
Height (inches)	65	65	NS
Weight (lbs)	124	124	NS
Age at menarche	12.5	12.9	NS
Marital status			
Married	57	42	NS
Single	29	42	NS
Separated, divorced, widowed	17	16	NS
No. of pregnancies	0.4	0.4	NS
No. of children	0.6	0.9	NS
Used oral contraceptives during running program (%)	30	33	NS
Days run/wk	5.0	5.2	NS
Miles run/session	4.6	4.3	NS
Speed: minutes/mile	8.5	7.8	NS
Weight change (lbs)	−4.3	−3.5	NS
Regular menses before running program (%)	93	53	<0.001
Age started running program	26	22	<0.02
No. of years running	3.7	5.2	<0.02

* NS = not statistically significant.

in all aspects except that the individuals who had an interrupted running program, more frequently had a history of irregular menses before beginning their running program, had started running at an earlier age, and had been running longer than those individuals who had a history of a continuous running program.

Injury was the most frequently cited reason for interrupting a running program (14 of 39 cases or 37%). We did not collect information in this survey on the specific nature of these injuries. Other reasons for stopping an individual's running program included: other health problems, 19% (4/39); pregnancy, 8% (3/39); loss of interest, 13% (5/39); time restrictions, 28% (11/39); and unspecified, 33% (13/39). The data presented in Table 2 show that those women who stopped their running program because of an injury were more likely to have irregular or absent menses while running, and less likely to have used exogenous estrogen in the form of oral contraceptives during their running programs. Since conscientious use of oral contraceptives will produce regular menstrual bleeding, it is likely that some of the respondents reported regular menses which were, in fact, expression of regular use of oral contraceptives. In either case, regular spontaneous menses or oral contraceptive use were both indicative of adequate estrogen stimulation of the endometrium. All individuals who interrupted their running program for any reason other than injury, were indistinguishable from individuals with a continuous running program both in regard to regularity of menses and the use of oral contraceptives.

We performed a review of the medical histories of collegiate women athletes to examine the hypothesis that premenopausal women with exercise-associated menstrual irregularities may be at increased risk for both traumatic and stress fractures. The results are summarized in Table 3. The two groups of injured women athletes did not differ from one another or from the population of uninjured women athletes with respect to height, weight, age, or number of years in competitive sports, regardless of their menstrual patterns. The frequency of stress fractures in women with irregular menses was nearly four times that of the group with regular menses (15 vs 4%, $P < 0.025$). When all fractures are compared, the fracture rate for the irregular group was nearly three times the rate for the regular group (25 vs 9%, $P < 0.025$).

TABLE 2. Patterns of menses and oral contraceptive (OC) use.

Runner Category	Menses*		Used OCs†	
	Regular	Irregular	Yes	No
A. Interrupted due to injury	2	7	1	9
B. Other runners	69	11	30	59

Chi-square P values: menses, $P = <0.001$; oral contraceptives, $P = <0.24$.
* Eleven respondents did not answer the question regarding menses.
† One respondent did not answer the question regarding oral contraceptives.

TABLE 3. Comparison of all 1983-1984 Pennsylvania State University female athletes who sustained a bone fracture.*

	Menstrual History		
	Regular	Irregular or Absent	P Value
Characteristics of study subjects†			
Height (cm)	165.5 ± 1.8	164.8 ± 1.8	NS‡
Weight (kg)	60.0 ± 1.4	58.0 ± 1.7	NS
Age (yr)	20.1 ± 0.2	19.4 ± 0.3	NS
Menarche (yr)	13.0 ± 0.2	13.7 ± 0.5	NS
Fracture frequency			
Stress fractures	4% (7/158)	15% (6/41)	<0.025
All fractures	9% (15/158)	24% (10/41)	<0.025
Sport			
Basketball	3	1	
Cross country	2	3	
Fencing	1	0	
Field hockey	5	1	
Gymnastics	1	2	
Lacrosse	2	1	
Softball	0	1	
Swimming	2	0	
Track	4	3	
Volleyball	3	1	

* There was a total of 22 reported bone injuries among 165 regularly menstruating individuals, of which 15 were confirmed by X-ray. Similarly, of the 11 reported bone injuries in the irregular/absent menses group, 10 were confirmed by X-ray. Accordingly, the number of non-injured women in the first group was 148 and in the second 31. The denominators shown in the above figures of 158 and 41 reflect the summation of confirmed fractures and uninjured individuals, as is required for chi-square analysis. The unconfirmed bone injuries do not enter into these calculations. Several individuals in each group participated in more than one sport.
† The physical data presented are for the injured athletes. However, their profiles are statistically indistinguishable from the uninjured group.
‡ NS = not statistically significant.

The distribution of injuries by sport was similar within the two groups of subjects. The contact and running sports accounted for 80% of the injuries in both groups. Fencing, gymnastics, softball, and swimming accounted for only 20% in both groups. Fractures of the lower extremities accounted for 70% of all fractures found in the irregular group and for 93% of all fractures found in the regular group. The frequency of soft tissue injuries was the same for both groups.

Finally, we have studied a large group of recreational women runners who had either remained uninjured or who had had an injury causing them to interrupt their running program. Characteristics of the injured and noninjured groups of women runners are compared in Table 4. The two groups are indistinguishable with respect to age, height, weight, menarche, parity, age started running, number of days/wk, and speed of running. The two groups differ with respect to years of running, number of miles/run, oral contraceptive use, and menstrual history. The injured group had been running longer, ran more miles/run, was more likely to have irregular or absent menses, and to not have been using oral contraceptives.

We were especially interested in learning whether the risk factors of oral contraceptive use, menstrual irregularity, and years of running acted in concert or independently as risk factors leading to injury. Accordingly,

TABLE 4. Characteristics of uninjured and injured women runners.

Characteristics	Noninjured (N = 180)	Injured (N = 80)	P Value (t-test or chi-square)
Age (yr)	31.58 ± 0.62	33.65 ± 0.85	NS*
Height (inches)	64.66 ± 0.24	64.45 ± 0.34	NS
Weight (lbs)	124.44 ± 1.10	123.30 ± 1.63	NS
Menarche (yr)	12.90 ± 0.12	12.86 ± 0.17	NS
No. of children	0.49 ± 0.08	0.40 ± 0.10	NS
Age started running	27.61 ± 0.63	27.82 ± 0.90	NS
No. of days/wk running	4.80 ± 0.11	5.05 ± 0.13	NS
No. of min/mile	9.11 ± 0.11	8.82 ± 0.12	NS
No. of miles/run	5.43 ± 0.15	6.31 ± 0.20	0.001
Duration of running (yr)	4.03 ± 0.21	5.65 ± 0.57	0.009
Oral contraceptive use			
Yes	64	2	<0.001
No	116	78	
Menstrual history			
Regular	103	33	<0.025
Irregular	66	41	

All values are expressed as mean ± SE.
* NS = not statistically significant.

TABLE 5. Logistic regression analysis: injury = dependent variable.

Variable	Chi-Square	P Value
Age	0.96	NS*
Height	0.46	NS
Weight	0.13	NS
No oral contraceptive use	15.84	0.0001
Absent or irregular menses	4.76	0.0291
No. of years running	10.28	0.0013

N = 243: 168 uninjured, 75 injured; 24 respondents had missing values for one or more variables.
* NS = not statistically significant.

we performed logistic regression analysis of the data using injury as the dependent variable. The results are shown in Table 5. The risk of injury is independent of age, height, and weight (as well as menarche, number of children, age started running, days/wk running, min/mile, and miles/run), but is dependent on oral contraceptive use, menstrual history, and years of running. That is, runners who did not use oral contraceptives, had irregular menses, or who had been running for longer periods of time have a higher risk of injury than those who used oral contraceptives, had regular menses, or had run for fewer years, respectively. Each of these associations is independent of the others.

Analysis of fracture rates as a function of menstrual status from the New York City 10-km race respondents is presented in Table 6. Fractures were reported to occur twice as frequently among the group with irregular or absent menses. The anatomical distribution of fractures was similar between the two groups and included, in order of prevalence: foot, 55%; leg, 18%; knee, 12%; ankle, 5%, hip, 5%; and back, 5%.

DISCUSSION

The survey that focused on recreational women runners participating in a well-attended, annual, local, 10-km footrace was designed to identify women runners who had a significant interruption in their running program, to determine the reason for that interruption, and to evaluate its impact upon subsequent menstrual patterns. Injury was found to be the most frequent cause for women to interrupt their running programs. These injured women were more likely to be runners who were clinically likely to be hypoestrogenic, as manifested by irregular or absent menses during their running program. Furthermore, the injured group was less likely to have been using oral contraceptives than the noninjured women runners.

TABLE 6. Reported fractures by recreational women runners.*

	No. of Reporting Fracture/ Group Total	%
Regular menses	10/169	5.9
Irregular/absent menses	9/74	12.1

* $P < 0.10$. Of the total of 19 individuals who reported a fracture during their running program, 18 had not been using oral contraceptives either before or at the time of the fracture. The single user of oral contraceptives classified herself as having regular menses.

To test the hypothesis that exercise-induced hypoestrogenism can lead to an increased risk of injury, and more specifically bone injury, we reviewed the medical records of all 207 women athletes on the various collegiate teams at Pennsylvania State University in the 1983–1984 season. We found that those athletes with exercise-associated menstrual irregularity are at increased risk for bone fractures. Specifically, radiologically documented bone fractures occurred in only 9% of women athletes with regular menses, but in 24% of women athletes with irregular or absent menses ($P < 0.025$). In our review of the athletes' medical records, we were able to review basic physical, medical, and sports histories. It is possible that variables other than menstrual status contributed to the differences in fracture frequency, but we did not find any others to account for the observed differences in fracture frequency.

We modified our questionnaire to collect specific information from a larger population of recreational women athletes concerning: (a) extent of athletic involvement (i.e., number of years, days/wk, miles/run, and min/mile); (b) nature of any prior injury (type, site, frequency, seriousness, and documentation); (c) menstrual history prior to, during, and at interruption of the running program; and (d) use of oral contraceptives. This questionnaire was distributed to all women participants in a championship 10-km footrace in New York City, in order to survey a large, diverse group of noncollegiate women runners who exercise regularly and vigorously.

The injured and noninjured groups of runners were indistinguishable with respect to physical characteristics (age, height, and weight), menarche, and most running characteristics. The injured group had been running for a longer period of time, ran more miles/run, and were

less likely to have been using oral contraceptives. Furthermore, women runners with irregular menstrual histories were much more likely to have sustained an injury (Table 4). Specifically, women runners who did not use oral contraceptives, who had irregular menses, or who had been in running programs for longer periods of time have a higher risk of injury than those who used oral contraceptives, had regular menses, and had been running for fewer years, respectively (Table 5). Logistic analysis was used because the dependent variable, injury, is dichotomous. Injury was used as the dependent variable based upon the findings in our two previous studies.

Despite the diversity of the three populations surveyed (the first, participants in a local race; the second, collegiate women athletes; and the third, contestants in a national race), we have observed in each case that the likelihood of injury has been positively correlated with irregular or absent menses and negatively correlated with oral contraceptive use.

The results of our study are consistent with recent information concerning the impact of exercise on the menstrual cycle (7, 10, 28, 31, 33) and the sensitivity of bone composition to relatively small changes in circulating estrogens (11, 12, 18, 34). Menstrual irregularity among women who exercise vigorously ranges from 10 to 50%, with 20 to 25% being most commonly reported (2). Complete amenorrhea reflects a marked reduction in circulating levels of E_2, but E_2 may be reduced by 50% in the course of a vigorous training program without amenorrhea (4). Normal mid-follicular phase levels of E_2 range from 70 to 100 $pg \cdot ml^{-1}$. After the menopause, circulating levels of E_2 fall below 50 $pg \cdot ml^{-1}$. Accordingly, it is not surprising that Cann and co-workers (5) observed significant loss in bone density in their premenopausal amenorrheic group (average age about 30 yr) whose mean circulating E_2 levels were about 42 $pg \cdot ml^{-1}$. Other workers have suggested that exercise-induced hypoestrogenism might lead to premenopausal osteoporosis and increased fracture risk (32).

The risk of osteoporosis and subsequent fractures in older women after menopause and in younger women with hyperprolactinemia, ovarian failure, or castration is well known (1, 14–16, 19–21, 24–26, 27, 29). Two recent reports show that premenopausal women with exercise-induced amenorrhea have decreased bone density (5, 9). Cann and co-workers (5) found that premenopausal women with exercise-induced amenorrhea have a 20–30% decrease in their vertebral trabecular bone mass and appeared, therefore, more susceptible to fractures. This group's subsequent study of elite women runners showed a significantly larger number of running-related fractures in the amenorrheic group than had occurred in the regularly cycling group (23). Drinkwater and associates (9) reported that vertebral bone density and mean E_2 concentration were significantly lower in the amenorrheic group than in the eumenorrheic group. Our findings concur with these studies. Linnell and associates (22), however, have found no difference in the mean bone mineral content in runners (with or without menstrual irregularity) and nonathletic women. In the latter study, peripheral cortical bone mass rather than central (vertebra) tubecular bone density was measured. From this information, it appears that premenopausal women with irregular or absent menses are likely to be at an increased risk for osseous fractures. Our studies with Penn State collegiate athletes and recreational runners support this hypothesis.

Finally, it must be noted that these results have been obtained from a retrospective study and depend upon subject recall. We recognize that recall menstrual histories cannot be as accurate as those obtained by prospective record keeping. However, it should be noted that our study populations had mean ages of 20–33 yr, and we believe that these menstrual histories are likely to be accurate because the populations were relatively young and had relatively short histories to recall, and they are athletes who tend to be aware of their overall health. Although irregular or absent menses suggest decreased circulating levels of E_2, measurement of serum E_2 levels would provide additional quantative information. Such measurements were outside of the scope and resources of the present study and must await further long-term prospective investigations in this area.

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