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# Injuries in Female Dancers Aged 8 to 16 Years

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***Context:*** Most studies of injured dancers have been carried out on professional adult dancers; data on young, nonprofessional injured dancers are sparse.

***Objective:*** To identify the types of injuries sustained by recreational dancers and to examine their association with age, joint range of motion, body structure, age at menarche, presence of anatomic anomalies, and physical burden (ie, practice hours *en pointe*).

***Design:*** Descriptive epidemiology study.

***Setting:*** The Israel Performing Arts Medicine Center, Tel Aviv.

***Patients or Other Participants:*** A total of 569 injured female dancers, aged 8 to 16 years.

***Main Outcome Measure(s):*** Dependent variables were 61 types of current injuries that were later classified into 4 major categories: knee injuries, foot and ankle tendinopathy, back injuries, and other injuries. Independent variables were age, joint range of motion, body size and shape, age at menarche, anatomic anomalies, and dance discipline (eg, hours of practice per week *en pointe*).

***Results:*** At least 1 previous injury had been sustained by 42.4% of the dancers. The most common injuries involved the knee (40.4%), followed by other injuries (23.4%). The relative frequency of back injuries and tendinopathy decreased with age, whereas knee injuries increased. Types of injuries were significantly associated with ankle plantar flexion, hip external rotation, hip abduction, and knee flexion. Multinomial regression analysis revealed only 3 predictive variables (with *other* as baseline), all for back injury: scoliosis, age, and hip external rotation.

***Conclusions:*** Joint range of motion and scoliosis may signal the potential for future injury. Young dancers (less than 10 years of age) should not be exposed to overload (especially of the back) or extensive stretching exercises.

***Key Words:*** athletes, children, practice time, scoliosis, body mass index, range of motion

**Key Points**

- In this group of young, injured dancers, nearly half had experienced at least 1 previous injury.
- The most common injuries affected the knee, and knee injuries increased with age, whereas ankle and foot tendinopathy and back injuries decreased with age.
- Scoliosis, age, and hip external rotation were predictive of back injury.

In the pursuit of excellence and self-accomplishment through the physical practice of dance, dancers continually face the danger and challenge of dealing with injuries.[1] The rigors of dance training lead to many overuse injuries common to dancers, such as chondromalacia patella and Achilles tendinopathy.[1,2] Causative factors include anatomic structure, heredity, training regime, improper technique, floor surfaces, age, body mass index (BMI), muscle imbalance, nutrition, menstrual function, and dance discipline (eg, hours of practice).[3]

A number of aspects distinguish young dancers from other athletes. First, dancers work *en pointe* (plantar flexion of the ankle and foot joints that puts the dorsum of the forefoot in a direct line with the anterior edge of the tibia[4]) and *demi-pointe* (standing halfway to full point, rising high onto the balls of the feet[5]), which places an extreme load on the joints of the foot. Second, the 5 classical positions require marked turnout of the lower limbs (external rotation at the hip and knee, tibial torsion, and forefoot abduction at the midtarsal joint[5]). Third, the excessive repetitive movements in nonphysiologic positions result in very high loads and strain the muscles and ligaments.[5] Consequently, knee and lower back injuries are more common in dancers compared with athletes active in other sport fields: 36% among dancers versus 13% in gymnasts and 22% in volleyball players.[6–8] Other types of injuries and injury sites, however, are very similar for athletes in dancing and most traditional sports.[5]

As many as 60% to 90% of dancers are injured during their careers, and most of their injuries affect the lower extremities and back.[9,10] This extremely high percentage attests to the compelling need for preventive action. Such prevention is possible only if the relationships among body features (eg, joint range of motion [ROM], anatomical anomalies), dance discipline, and injuries are clarified. Most of our knowledge about dance injuries pertains mainly to mature (older than 18 years of age) professional dancers (mostly ballet dancers).[11] Occurrence, type, and distribution of injuries by body structure and practice time in young, nonprofessional dancers (ie, recreational dancers) has been studied to a much lesser extent.[12] This lack of information concerning young dancers prevents the adoption of any preventive strategy and exposes these dancers to injury. In the long run, it may negatively affect their future careers as dancers.

Our aim, therefore, was to identify the injuries sustained by recreational dancers and to examine the distribution of these injuries in these dancers by age, ROM, body structure, age at menarche, presence of anatomic anomalies, and physical burden.

## METHODS

A group of 569 injured nonprofessional female dancers, aged 8 to 16 years, were included in the current study. All the girls were referred to the Israel Performing Arts Medicine Center, Tel Aviv, for physical examination and diagnosis, with complaints of pain, discomfort, and inability to practice dance exercises. The girls were active in a variety of dance disciplines, including classical ballet, modern dance, and jazz. The inclusion criterion was that the injury was verified during physical examination by an orthopaedic surgeon specializing in dance medicine (I.S.). If pain could not be reproduced during the clinical examination or signs of injury (such as swelling) were absent, the dancer was excluded from the study.

The study was approved by the Helsinki Committee of Tel Aviv, Human Subjects Review Board, in accordance with the Helsinki Declaration. Each dancer provided assent and one of her parents provided written informed consent for participation.

### Interview: Biological Profile and Dance History

Each participant was interviewed by N.S. and I.S. Based on the data obtained, we created a demographic profile for each dancer that included the biological profile (ie, age, age of onset of menarche) and dance history (years and hours of practice per week, in general and *en pointe*).

### Injury Characteristics

All dancers were asked to report any pain or dysfunction relating to a dance situation. They were also asked to describe the movements or exercises that provoked the pain, the extent of the pain, and in what way the pain disturbed dance practice and daily life activities.[13] Each participant was then physically examined by I.S. Additional clinical information was retrieved from radiographs, computed tomography scans, and magnetic resonance imaging. Past injuries were recorded only if the diagnosis was carried out by the same orthopaedic surgeon (I.S.) with the same protocol and at the same clinic.

The injuries were later classified into 4 major categories: knee injuries (eg, anterior knee pain), foot or ankle tendinopathy (eg, Achilles tendinopathy), back injuries (eg, low back pain), and other injuries (eg, stress fractures).

### Anthropometric Measurements

Weight and height were taken by N.S. and I.S. with standard anthropometric instruments (weight scale, altimeter), following the methods described by Lohman et al,[14] and BMI was calculated.

### Anatomical Anomalies

Eight anomalies (scoliosis, lordosis, knee valgus, knee varum, hindfoot varum, hindfoot valgus, longitudinal arch cavus, and longitudinal arch planus) were defined as either present or absent by I.S. for all dancers, according to the definitions of Magee.[15] Observations were made when the dancers were in an anatomical position.

### Range of Motion

Each dancer was dressed only in a body stocking so that the body contours would be exposed as clearly as possible. For 7 movements of the foot, ankle, knee, hip, and lower back joints, N.S. and I.S. measured ROM (for more details, see Steinberg et al[16]). Each measurement was taken 3 times, and the average was used for analysis. For each movement, joint ROM was classified into 3 categories based upon the data obtained by Steinberg et al[16]: hypomobile ROM ($> -1$ SD of the mean), average ROM ($\pm 1$ SD of the mean), and hypermobile ROM ($> +1$ SD of the mean; Table 1).

### Data Analysis

Chi-square tests were carried out to check for significant associations between type of injury (4 categories: knee, foot and ankle tendinopathy, back, other) and the following variables: age (3 groups: 8–10, 11–13, and 14–16 years old), years of practice (4 categories: $<3$, 4–6, 7–9, and $>10$ years), hours of practice (for ages 14–16 years only: $<8$, 8–11, and $>11$ hours), ROM for 7 movements (3 categories: hypomobile, average, hypermobile), and anatomical anomalies. To determine the relationship between type of injury and body structure, we subdivided the girls (ages 14–16 years only) into 3 groups based on BMI ($<18$, 18–20, $>20$) and carried out a $\chi^2$ analysis. All predictor variables that yielded a significant association with injury type were then included in a multinomial logistic regression analysis, where the outcome variable was type of injury (knee, tendinopathy, back, other) and the possible predictor variables were age, BMI, years of practice, hours of practice, 7 types of joint ROM, and scoliosis. We set the $P$ values at .05 before data analysis, and we report both $\chi^2$ and Cramér V values when the probability of type I error was only slightly greater (eg, .06) than the a priori standard. Although we acknowledge the increased risk of type I error, we believe it is important to report these findings because they likely do represent important relationships that would be revealed in studying a larger sample.

The data were processed with SPSS (version 18.0; SPSS Inc, Chicago, IL). The level of significance for all statistical tests was $\alpha = .05$.

### Test-Retest Reliability

Kappa and intraclass correlations (ICCs) were calculated to determine the intratester and intertester reliabilities of observations and measurements. Tests were carried out on

Table 1. Range of Motion in Injured, Young, Recreational Dancers, 8–16 Years

| | | Range of Motion, ° | | |
|---|---|---|---|---|
| Joint | Motion | Hypomobile (> −1 SD From Mean) | Average (±1 SD From Mean) | Hypermobile (> +1 SD From Mean) |
| Ankle and foot | *Pointe* | ≤75 | 76–90 | ≥91 |
| Ankle | Plantar flexion | ≤45 | 46–64 | ≥65 |
| | Dorsiflexion | ≤5 | 6–15 | ≥16 |
| Hip | External rotation | ≤50 | 51–60 | ≥61 |
| | Internal rotation | ≤45 | 46–65 | ≥66 |
| | Abduction | ≤45 | 46–59 | ≥60 |
| | Flexion | ≤135 | 136–150 | ≥151 |

20 dancers using the following procedure. Intratester reliability was assessed by N.S., who examined the dancers twice at 3- to 5-day intervals. Intertester reliability involved 2 testers (N.S. and I.S.) who used the same method within an hour of each other. Each tester was blinded to the results of the other's measurements.

## RESULTS

### Test-Retest Reliability

Both ICC and κ tests produced good reliability results for intratester agreement. The ICC for joint ROM ranged between 0.896 and 0.964, and for body measurements between 0.946 and 0.968. The ICC values for intertester tests were 0.741 to 0.951 for joint ROM measures and 0.902 to 0.951 for body structure measures. Kappa values for anatomical anomalies ranged between 0.81 and 0.86.

### Demographic Characteristics of the Study Population

A total of 569 injured female dancers, ages 8 to 16 years (mean = 13.3 years), were included in the study. Almost two-thirds were between 14 and 16 years of age (Table 2). The mean age of onset of menarche was 13 years.

### Injury Characteristics

The most common injuries among our injured dancers were knee injuries (230 of 569, 40.4%), followed by other injuries (133 of 569, 23.4%), back injuries (109 of 569, 19.2%), and ankle and foot tendinopathy (97 of 569, 17.0%). The relative frequency of types of injury by age groups (8–10, 11–13, and 14–16 years) appears in Table 3. Distribution of injury types differed by age ($\chi^2_6 = 24.20$, $P < .001$, V = 0.29). Young dancers manifested injuries related mainly to the back (19 of 59, 32.2%) and tendons of the ankle and foot (18 of 59, 30.5%), whereas among pubertal and adolescent dancers, the most common injury involved the knee (age 14–16 years: 152 of 357, 42.6%). Back injuries (67 of 357, 18.8%) and ankle and foot tendinopathy (55 of 357, 15.4%) occurred much less frequently among pubertal and adolescent girls.

A review of the dancers' medical histories revealed 511 past injuries (injuries that were not documented by the same physician and at the same clinic were not included in the present study). Almost every second dancer (241 of 569, 42.4%) had a record of at least 1 previous injury. Repeated injuries were already noted in the very young dancers: at age 9 years, 5 of the 18 dancers (27.7%) already had a record of a previous injury. At age 16 years, 46.2% (42 of 91) of the dancers had had a previous injury ($\chi^2_8 = 7.27$, $P = .016$).

### Type of Injury and Dance History

Most girls (347 of 569, 61%) had been dancing between 6 and 11 years before the first injury occurred. Relative frequency of types of injury by years of dance practice appears in Table 3. Although the relative frequency of knee problems showed a tendency to increase with years of practice, this finding was not significant ($\chi^2_1 = 1.53$, $P = .22$). In contrast, relative frequency of back injuries decreased with years of practice ($\chi^2_1 = 3.44$, $P < .05$, V = 0.13). The relative frequency of the other types of injury (ankle or foot tendinopathy, other) did not vary with years of practice. Although the association between types of injury and hours of practice per week was not significant ($\chi^2_6 = 12.11$, $P = .06$), the analysis suggests a strong relationship (V = 0.22) between the factors. Of note, none of the 12 dancers aged 14 to 16 years who practiced *en pointe* for less than 60 minutes per week had back injuries, whereas 18 of 69 dancers (26.1%) who practiced this position for more than 60 minutes per week had back injuries. The percentage of dancers with ankle or foot tendinopathy who practiced *en pointe* for more than 60 minutes per week (16 of 69, 23.2%) was higher than those who practiced less than 60 minutes per week (1 of 12,



Table 2. Anthropometric Measures and Hours of Dance Practice per Week for Injured Recreational Dancers by Age

| | | Anthropometric Measure | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Weight, kg | | Height, cm | | Body Mass Index | | Practice per Week, h | |
| Age, y | No. | Mean ± SD | Median | Mean ± SD | Median | Mean ± SD | Median | Mean ± SD | Median |
| 8 | 5 | 4.4 ± 6.7 | 26.0 | 7.2 ± 129.6 | 127 | 1.3 ± 15.8 | 16.4 | 0.6 ± 2.7 | 3.0 |
| 9 | 18 | 9.6 ± 24.5 | 27.0 | 5.6 ± 134.1 | 135 | 1.8 ± 15.4 | 15.0 | 0.3 ± 3.1 | 3.0 |
| 10 | 36 | 6.3 ± 28.7 | 28.3 | 23.6 ± 33.6 | 136 | 1.6 ± 15.6 | 15.6 | 5.4 ± 5.5 | 3.0 |
| 11 | 36 | 7.9 ± 30.9 | 30.5 | 7.9 ± 142.4 | 142 | 2.2 ± 15.6 | 15.1 | 3.7 ± 6.1 | 5.0 |
| 12 | 59 | 8.0 ± 36.1 | 35.0 | 10.0 ± 46.7 | 146 | 3.2 ± 17.1 | 16.6 | 3.1 ± 6.3 | 5.3 |
| 13 | 58 | 9.6 ± 38.9 | 40.0 | 9.7 ± 151.2 | 153 | 3.2 ± 17.8 | 17.2 | 3.7 ± 9.7 | 9.0 |
| 14 | 119 | 8.3 ± 46.7 | 47.5 | 15.8 ± 57.7 | 159 | 2.2 ± 18.6 | 18.6 | 4.6 ± 13.4 | 9.8 |
| 15 | 147 | 8.1 ± 49.7 | 50.0 | 14.5 ± 158.9 | 160 | 2.2 ± 19.5 | 19.2 | 4.6 ± 11.6 | 11.5 |
| 16 | 91 | 9.7 ± 50.5 | 52.0 | 17.6 ± 159.4 | 161 | 2.0 ± 19.8 | 19.7 | 4.6 ± 12.0 | 11.3 |

**Table 3. Associations Between Risk Factors and Injury Type**

| Risk Factor | Category | Injury, No. (%) | | | | *P* Value |
|---|---|---|---|---|---|---|
| | | Knee | Ankle or Foot Tendinopathy | Back | Other | |
| Practice, y | ≤3 | 20 (34.5) | 9 (15.5) | 15 (25.9) | 14 (24.1) | .322 |
| | 4–6 | 42 (33.9) | 26 (21.0) | 29 (23.4) | 27 (21.8) | |
| | 7–9 | 92 (44.7) | 30 (14.6) | 40 (19.4) | 44 (21.4) | |
| | ≥10 | 41 (40.6) | 21 (20.8) | 13 (12.9) | 26 (25.7) | |
| Practice per week, h | <8 | 20 (37.7) | 6 (11.3) | 18 (34.0) | 9 (17.0) | .060 |
| | 8–11 | 27 (45.0) | 4 (6.7) | 10 (16.7) | 19 (31.7) | |
| | >11 | 46 (46.0) | 16 (16.0) | 16 (16.0) | 22 (22.0) | |
| Age group, y | 8–10 | 9 (15.3) | 18 (30.5) | 19 (32.2) | 13 (22.0) | <.001[a] |
| | 11–13 | 69 (45.1) | 24 (15.7) | 23 (15.0) | 37 (24.2) | |
| | 14–16 | 152 (42.6) | 55 (15.4) | 67 (18.8) | 83 (23.2) | |
| Body mass index | <18 | 36 (36.4) | 12 (12.1) | 18 (18.2) | 33 (33.3) | .062 |
| | 18–20 | 63 (50.4) | 20 (16.0) | 19 (15.2) | 23 (18.4) | |
| | >20 | 53 (41.7) | 22 (17.3) | 28 (22.0) | 24 (18.9) | |
| Scoliosis? | Yes | 50 (27.3) | 14 (7.7) | 86 (47.0) | 33 (18.0) | <.001 |
| | No | 175 (47.4) | 78 (21.1) | 21 (5.7) | 95 (25.7) | |
| Ankle plantar flexion | Hypomobile | 24 (10.4) | 8 (8.3) | 13 (12.1) | 10 (7.8) | .044[b] |
| | Average | 153 (66.5) | 54 (56.3) | 78 (72.9) | 89 (69.5) | |
| | Hypermobile | 53 (23.0) | 34 (35.4) | 16 (15.0) | 29 (22.7) | |
| Hip abduction | Hypomobile | 22 (9.7) | 5 (5.3) | 13 (12.6) | 10 (7.9) | .030[b] |
| | Average | 143 (63.0) | 48 (50.5) | 65 (63.1) | 71 (56.3) | |
| | Hypermobile | 62 (27.3) | 42 (44.2) | 25 (24.3) | 45 (35.7) | |
| Hip external rotation | Hypomobile | 45 (19.6) | 17 (17.5) | 30 (27.8) | 22 (16.8) | .016[b] |
| | Average | 136 (59.1) | 45 (46.4) | 60 (55.6) | 74 (56.5) | |
| | Hypermobile | 49 (21.3) | 35 (36.1) | 18 (16.7) | 35 (26.7) | |

[a] $P < .05$: Age 8–10 y compared with age 11–13 y and age 8–10 y compared with age 14–16 y.
[b] $P < .05$: Dancers with hypermobile range of motion compared with those with average range of motion.

8.3%; $\chi^2_3 = 8.26$, $P = .028$, V = 0.32). Knee and other injuries were not associated with this demanding dance position.

## Type of Injury and Anthropometric Profile

Major body characteristics of the injured dancers by age appear in Table 2. We found no association between type of injury and body structure as evaluated via BMI ($\chi^2_6 = 11.98$, $P = .062$). Yet the Cramér V (0.112) showed a moderate relationship between the factors (Table 3).

## Type of Injury and Anatomical Anomalies

Of the 8 anatomical anomalies studied, only scoliosis showed an association with type of injury. In the group with scoliosis, injuries were distributed as follows: knee injuries, 27.3% (50 of 183); ankle or foot tendinopathy, 7.7% (14 of 183); back injuries, 47.0% (86 of 183); and other injuries, 18.0% (33 of 183). In the group without scoliosis, the distribution was as follows: knee injuries, 47.4% (175 of 369); ankle or foot tendinopathy, 21.1% (78 of 369); back injuries, 5.7% (21 of 369); and other injuries, 25.7% (95 of 369; $\chi^2_3 = 136.3$, $P < .001$, V = 0.49; Table 3).

## Type of Injury and ROM

The relative distribution of types of injury in dancers with hypomobile, average, and hypermobile ROM showed differences in ankle plantar flexion, hip external rotation, and hip abduction (Table 3).

## Multinomial Logistic Regression Analysis

Results for this analysis (with *other* as the baseline category) appear in Table 4. Significant predicted variables were demonstrated only for back injury: presence of scoliosis (odds ratio [OR] =17.32, 95% confidence interval [CI] = 8.19, 36.59); young age (8–10 years compared with 14–16 years old; OR = 3.07, 95% CI = 1.06, 8.94); and hypermobile external-rotation ROM (compared with average ROM; OR = 3.79, 95% CI = 1.34, 10.75). The correct classification for back injury (versus other injury) was 83.7%.

## DISCUSSION

Young nonprofessional dancers, similar to professional dancers, have a high potential for suffering an injury during their training.[13] As the dancers aged, not only did the

**Table 4. Multinomial Logistic Regression Analyses: Baseline Group = Other Injury**

| Model Component | Variables | Coefficient | Standard Error | *P* Value | Odds Ratio | 95% Confidence Interval |
|---|---|---|---|---|---|---|
| Back injuries | Scoliosis | 2.852 | 0.382 | .000 | 17.3 | 8.2, 36.6 |
| | Age[a] | 1.122 | 0.545 | .039 | 3.1 | 1.1, 8.9 |
| | Hip external rotation[b] | 1.334 | 0.531 | .012 | 3.8 | 1.3, 10.8 |

[a] Age 8–10 y compared with age 14–16 y.
[b] Hip external rotation = hypermobile compared with average range of motion.

relative number of injured girls increase, but the relative proportions of injury types also changed.

Older dancers (>11 years) tended to have knee injuries, a phenomenon observed in another study.[17] The fact that the increase in the relative proportion of knee injury corresponded with the start of the dancers' pubertal spurt suggests 2 possible explanations. First, the girls who do not yet have adequate experience in attaining proper balance and landing techniques are now much heavier[18] and are exposed to more repetitive jumping and landing exercises than are young dancers.[19] Furthermore, adolescent dancers are required to perform strenuous exercises that may place exaggerated forces on the medial aspect of the knee.[3] Second, incorrect technique may be a causative factor. Orishimo et al[18] explained that in most nonprofessional dancers, the knees tend to assume a valgus position during landing (accompanied by hip adduction). Conversely, mature professional dancers use their strong hip and knee joint muscles to produce an external moment toward the opposite direction in an attempt to reach a neutral or varus position during landing. This enables them to avoid a marked deviation from the normal alignment of the leg, reduce stress on the joints, and protect their knees from injuries due to incorrect technique.

Tendinopathy of the foot and ankle among young dancers comprised about 20% of all injuries. Tendinopathy is a common traumatic injury in dancers.[20] The joint hypermobility required by many dance styles may increase the risk of tendinopathy.[19] During the growth spurt, as bones grow faster than ligaments and tendons (which become shorter relative to bone length), the soft tissues are exposed to a greater risk of injury.[21] Hamilton et al[3] claimed that dancers in the growth spurt who force their soft tissues into greater ROMs are more vulnerable to injury. A high proportion of tendinopathy is also related to insufficient warm-up[21] and the effects of fatigue.[22]

The considerable numbers of young female dancers with back injuries in our study population is not surprising; this has already been reported for both young[5,23] and adult dancers[24,25] as well as for young female athletes involved in gymnastics.[8] Nilsson et al[5] and Koutedakis and Jamurtas[23] noted that low back pain is the most common diagnosis among dancers and is found in all age groups and with all dance styles. Back injury is linked in the literature to high preseason training intensity, a history of low back pain, low body weight, and stress fracture in the pars interarticularis.[26–28]

Our multinomial regression analysis revealed significant predicting variables for back injury only: presence of scoliosis, young age, and hypermobile hip external-rotation ROM. Scoliosis is a common phenomenon among female athletes such as gymnasts, figure skaters, and dancers.[24] The high proportion of back injuries among our young scoliotic dancers is probably attributable to the extreme stress generated by many dance exercises that is not evenly distributed along the spine. Stress fracture (of the vertebral body or the neural arch), late fusion of the vertebral parts, or a delay in the formation of the epiphyseal ring[29,30] can result in spine instability. When strenuous training continues into adolescence (>12 years), young dancers may experience late menarche[31] and subsequently develop menstrual dysfunction. Bone mass accumulation, which is most intensive during puberty, may then be affected. As has been shown for young athletes, low levels of bone mass may result in injuries such as stress fractures in the spine.[32] Athletes with delayed menarche have lower bone mineral density than those with normal onset of menarche and are therefore more prone to developing stress fractures and low back pain.[33]

The fact that hypermobile external rotation of the hip is a significant predictive variable for back injury is probably linked to joint hypermobility, which indicates less stability both in landing and in many dance positions. Clinicians often recommend strengthening exercises for joints with hypermobile ROM as a way of managing and preventing athletes' injuries.[34] Additionally, because turnout is a key position in dancing, a considerable number of exercises are designed to increase external rotation at the hip joint, which can eventually lead to adaptive shortening of the soft tissue structures (hip external rotators) and, in turn, to increased chances of local injuries and back pain.[35]

It is noteworthy that the mean age of onset of menarche in our dancers was 13 years, 1 year later than that of nondancers[31] and delayed by 6 months compared with uninjured dancers of the same population.[31] Although Gamboa et al[17] did not find a difference in the age of menarche between injured and uninjured dancers, other researchers[33] demonstrated that dancers with delayed menarche manifested more stress fractures than dancers with average onset of menarche. These authors suggested that the delay in sexual maturity may adversely affect bone quality and functional strength. This delayed reproductive maturity may also attenuate the well-known benefits of weight-bearing exercises on bone mass accretion during adolescence.[33]

Injured dancers with low, average, or high BMI show similar patterns of injury types. This finding is not surprising, because a relationship between BMI and injuries was found only in dancers who had eating disorders.[33] Claessens et al[36] proposed that the low body weight found in young ballet dancers is more likely related to a light skeletal frame and to a below-average amount of muscle tissue.

Finally, our analysis failed to reveal an association between hours of practice and type of injury or between BMI and type of injury at the established $\alpha$ level ($P < .05$). However, those associations warrant attention, as the probability of type I error in concluding that a relationship exists between these variables and type of injury is only 6 of 100 (according to the $\chi^2$ test). The Cramér V correlations calculated to estimate the strength of the association between these variables suggests strong to moderate relationships.

The main limitations of the current study were that all the dancers in our study were injured and that we included no healthy participants. In addition, data on previous injuries was recorded only for dancers who were previously examined by the same orthopaedic surgeon (S.I.), with the same protocol, and at the same clinic. Thus, the number of previous injuries was likely underestimated. The injured dancers took classes at different schools and with different teachers and, therefore, could have been exposed to different physical burdens, although the number of practice hours was similar.

## CONCLUSIONS

Physical examination of dancers for joint ROM and anatomical anomalies by a physician specializing in dance medicine is mandatory. Other factors, such as age and age of onset of menarche, may reveal an existing injury and also serve as warning signs for potential injury. Dancers, dance teachers, and dance experts should be aware of the dancer's physical limitations (such as excessive or limited ROM in specific joints) and anatomical anomalies (such as scoliosis). Young dancers should not be exposed to overload exercises (especially involving the spine) or extensive stretching exercises and should adopt a suitable training program to reduce the chance of injury. In addition, injured dancers should be advised to pursue adequate assessment, appropriate rehabilitation, and suitable prevention programs to try to avoid future injury.

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