

# Thigh Peak Torques and Lower-Body Injuries in Dancers

Y. Koutedakis, Ph.D., M. Khaloula, M.Sc., P. J. Pacy, M.D., M. Murphy, M.Sc. and G. M. J. Dunbar, M.Sc.

## Abstract

The purpose of this study was to identify possible relationships between the sum of knee flexion and extension peak torques and the severity of lower-body injuries in professional dancers. Twenty male [age 26.6 ( $\pm$  6.0) years] and 22 female [age 27.1 ( $\pm$  5.4) years] ballet and contemporary dancers reported one or more low-back, pelvis, leg, knee and foot injuries. The severity of injuries was established by recording the days off dance activities. Subjects were then monitored on a Cybex II or a KIN-CON isokinetic dynamometer. Knee flexion and extension peak torques were obtained bilaterally during three maximal contractions at the velocities of 1.04 and 4.19 rad/sec. No musculoskeletal injuries were reported at the time of data collection. At 1.04 rad/sec, results revealed significant correlation coefficients between relative thigh peak torques — expressed in Nm/kg fat free mass (FFM) — and prevalence of low extremity injuries. These findings suggest that the lower the thigh-power output, the greater the degree of injury. Female dancers demonstrated higher correlation coefficients ( $r = -0.70$ ;  $p <$

0.005) than their male counterparts ( $r = -0.61$ ;  $p < 0.01$ ). However, no such correlations were found at the angular velocity of 4.19 rad/sec ( $p > 0.05$ ), nor when low-back injuries and thigh-power outputs were considered at both velocities ( $p > 0.05$ ). The main conclusions are: a) low thigh power outputs are likely to be associated with the severity of low extremity injuries, but not with low-back injuries, and b) such relationships are better identified at lower compared to higher isokinetic velocities.

**P**rofessional dancers are normally involved in daily technique classes followed by several hours of rehearsal and/or stage performances. Such demanding timetables render them more liable to suffer from injuries and even permanent disabilities than most sport competitors. In a period of two years, for example, 335 injuries were documented in 159 dancers.<sup>1</sup> The lower back seems to be the most fre-

quently injured anatomical site, which together with pelvis, legs, knees, and feet account for more than 90% of injuries.<sup>2,3</sup> Overwork, unsuitable floors, difficult choreography,<sup>4</sup> inadequate flexibility,<sup>5</sup> and aspects related to muscle imbalances<sup>6</sup> and body composition<sup>7</sup> are thought to contribute to such injuries. However, there is little published information on whether muscle strength levels have a bearing on severity of injury.

Muscle strength may be defined as “the maximal force that can be exerted in a single voluntary contraction,”<sup>8</sup> and it is one of the fitness components that contributes to success in dance.<sup>9,10</sup> Research has revealed lower strength levels in dancers than other sports-people.<sup>11,12</sup> The purpose of this study therefore, was to investigate whether dancers with lower muscle strength demonstrate more severe injuries compared to their stronger counterparts.

## Methods

### Subjects

Twenty male [age 26.6 ( $\pm$  6.0) years] and 22 female [age 27.1 ( $\pm$  5.4) years] professional dancers volunteered as subjects. The males were ballet dancers, whereas most of the females were involved in contemporary dance. All subjects were selected from a larger pool of dancers who participated in a comprehensive as-

Dr. Yiannis Koutedakis is from the School of Health Sciences, Wolverhampton University, Wolverhampton, United Kingdom.

Ms. M. Khaloula and Dr. P. J. Pacy are from the Unit of Metabolic Medicine, St. Mary's Hospital Medical School, London, United Kingdom.

Ms. M. Murphy is from the Division of Sport Sciences, University of Ulster, Northern Ireland.

Mr. G. M. J. Dunbar is from the Human Performance Laboratory, St. Mary's University College, London, United Kingdom.

*Correspondence and reprint requests:* Dr. Yiannis Koutedakis, School of Health Sciences, Wolverhampton University, Wolverhampton, WV1 1DJ, United Kingdom.

assessment and welfare program commissioned by Dance UK. The selection criteria were: a) an affirmative response to the question "have you had any low-back, pelvis, leg, knee, and/or foot injuries during the last 12 months?" and b) the absence of any musculoskeletal symptom at the time of data collection.

### **Fat Free Mass**

Fat free mass (FFM) was calculated from body fat and body weight measurements. Biceps, triceps, subscapular, and suprailiac skinfold thicknesses were assessed using Harpenden calipers. For each subject, body fat was then estimated from the mean of three readings per site according to the formula of Durnin and Rahaman.<sup>13</sup>

### **Questionnaire**

A 34-item, self-administered questionnaire was given to all subjects. The specific questions regarding injuries were: "have you ever had any low-back, pelvis, leg, knee, and/or foot injuries?" and, if yes, "how many days off physical activity (i.e., dancing) have you had in the last 12 months due to these injuries?"

### **Isokinetic Dynamometry**

A KIN-COM or a Cybex 11 isokinetic dynamometers were used to assess knee extensor and flexor muscle peak torques obtained from both dominant and non-dominant legs. Prior to testing, a warm-up period was given during which each dancer used his/her

familiar preparation routines. Subjects were then asked to sit on the isokinetic apparatus, without shoes, and with hip and knees flexed at 110° and 90° respectively. They were coupled to the dynamometer by aligning the lateral femoral condyle with the axis of rotation of the dynamometer, and attaching the ankle cuff proximal to the lateral malleolus. Each subject's functional range of motion was set at 90° to prevent hyperextension and hyperflexion. Gravitational corrections were made for the effect of limb weight on torque generation. Calibration of the angular velocity speed control of the dynamometer was checked by counting the number of revolutions per minute at 1.04 rad/sec.

Once properly positioned, the subjects underwent a further warm-up and familiarization period. The warm-up routine consisted of 10-15 submaximal repetitions of knee extension and flexion at the angular velocities of 1.04 and 4.19 rad/sec, which were also the velocities used to collect the subsequent data. The isokinetic measurements were made over 90° in serial, reciprocal concentric contractions. The sequence of the two velocities was randomized to eliminate any dependent ordering effect. By using their legs alternatively, the subjects were asked to perform three maximal contractions for each muscle group at each velocity. Rest periods of approximately 10 minutes

were allowed between tests. Means ( $\pm$  SD) were calculated for knee flexors and extensors, using the average peak torques obtained from both dominant and non-dominant legs.

### **Treatment of Data**

For the purposes of the present study the reported injuries were grouped into: low-back injuries and injuries of pelvis, legs, knees and feet. The two-tailed unpaired t-test was employed to test for differences between male and female dancers. The Pearson's correlation coefficients test was utilized to assess the relationships between: a) thigh-power outputs and severity of low-back injuries expressed in terms of days off, and b) thigh-power outputs and severity of injuries associated with pelvis, legs, knees, and feet. The criterion for significance was set at  $p < 0.05$ .

### **Results**

Table 1 shows body weight, percentages body fat, and FFM in the male and female dancers. As expected, males demonstrated significantly higher ( $p < 0.005$ ) body weight, whereas females had higher ( $p < 0.05$ ) estimated body fat. Table 1 also illustrates that, although not significant ( $p > 0.05$ ), the number of days off dance due to low-back problems was higher in both male and female dancers, than the days off dance due to lower-body (i.e., pelvis, leg, knee, and/or foot) injuries. Females demonstrated a trend for higher number of days off dance due to low-back and lower-body injuries than their male counterparts but, again, this was not significant.

Table 2 shows means ( $\pm$  SD) for knee flexion and extension peak torques and their sums — expressed in Nm/kg FFM — obtained at 1.04 and 4.19 rad/sec. At the lower velocity, male dancers showed significantly higher knee flexion ( $p < 0.01$ ), knee extension ( $p < 0.005$ ), and the sum of these two parameters ( $p < 0.01$ ) compared to female dancers. At the relatively higher velocity of 4.19 rad/sec, only knee flexion and extension

**Table 1** Physical Characteristics and Days Off Dance Due to Low-Back and Lower-Body Injuries in All Dancers

	Male Dancers	Female Dancers
Body Weight (kg)	73.7 $\pm$ 6.5 (n = 20)	56.4 $\pm$ 4.3** (n = 22)
Body Fat (%)	14.1 $\pm$ 2.4 (n = 20)	19.2 $\pm$ 5.8* (n = 22)
FFM (kg)	63.0 $\pm$ 5.1 (n = 20)	45.3 $\pm$ 4.1** (n = 22)
Days Off (low-back)	4.0 $\pm$ 2.4 (n = 20)	4.6 $\pm$ 2.2 (n = 22)
Days Off (lower-body)	2.6 $\pm$ 1.5 (n = 16)	3.7 $\pm$ 2.3 (n = 19)

Numbers are mean  $\pm$  6 SD; n = number of subjects.

Differences between male and female dancers (\*  $p < 0.05$ ; \*\*  $p < 0.005$ ).

**Table 2** Knee Flexion (Nm) and Extension (Nm) Peak Torques and Their Sums (Nm/kg FFM) — Obtained at 1.04 and 4.19 rad/sec — in Male and Female Dancers

Angular Velocity (rad/sec)		Male Dancers (n = 20)	Female Dancers (n = 22)
1.04	Knee Flexion (Nm)	121 (± 15)	63 (± 11)*
	Knee Extension (Nm)	248 (± 24)	151 (± 26)**
	Sum (Nm/kg FFM)	5.8 (± 0.5)	4.6 (± 0.4)*
4.19	Knee Flexion (Nm)	81 (± 10)	60 (± 8.4)*
	Knee Extension (Nm)	131 (± 12)	83 (± 11)*
	Sum (Nm/kg FFM)	3.3 (± 0.3)	3.1 (± 0.2)

Numbers are mean 6SD.

Differences between male and female dancers (\*  $p < 0.01$ ; \*\*  $p < 0.005$ )

were significantly different ( $p < 0.01$ ) between the two groups.

Figure 1 shows relationships between days off dance due to lower-body injuries, and the sum of knee flexion and extension peak torques — expressed in Nm/kg FFM — at 1.04 rad/sec. The general trend would appear to be that the lower the thigh-power output, the greater the degree of injury. However, although the calculated coefficients were significant in both male and female dancers, the latter group revealed a higher coefficient ( $p < 0.005$ ) than their male colleagues ( $p < 0.01$ ). No such correlations were

found at the angular velocity of 4.19 rad/sec ( $p > 0.05$ ). The same was also true when low-back injuries and thigh torques at both velocities were considered ( $p > 0.05$ ).

### Discussion

Hitherto dancers have tended not to be given the same medical attention as sport competitors. This appears to have been based on the assumption that the dancers' movements are not capable of generating sufficient power to cause the muscular injuries that are seen in sports. However, dancers do get injured and the effects of these in-

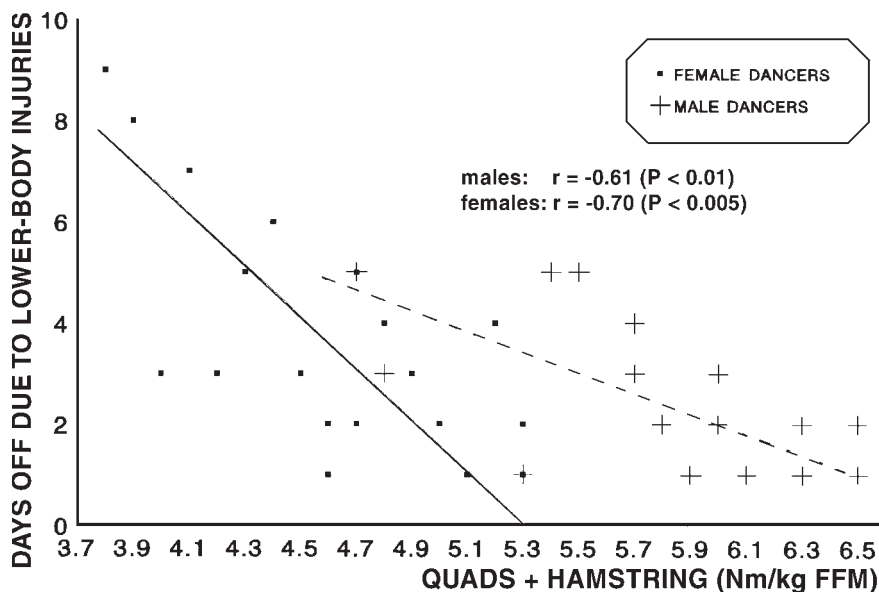
juries on their health and career may be detrimental.<sup>1-3</sup>

There is an increasing pool of anecdotal evidence suggesting that most of the dance related injuries occur toward the end of rehearsals and/or stage performances, and more specifically toward the end of the season when they are physically tired. This trend, if valid, might reflect the fact that fatigue normally causes a breakdown in movement mechanics that, in turn, places dancers closer to potential injury. Thus, it would be anticipated that the weaker the dancer, the greater the injury risk since there is tendency to work close to his/her individual fatigue threshold.

Indeed, this seems to be the principal finding of the present study; there is an association between muscle weakness and injury. Male and female dancers with lower thigh-power outputs demonstrated higher degree of pelvis, leg and foot injuries, an association which is in line with previously published data on athletes.<sup>14</sup> This relationship is further supported by the fact that, compared with male dancers, females demonstrated significantly lower relative thigh peak torques (Table 2), and also a higher correlation coefficient between severity of injuries and thigh-power outputs (Fig. 1). We suggest that the introduction of supplementary strength training may circumvent such problems and provide a relatively cost effective way of reducing injuries in dancers. Indeed, it has been found that such training is more beneficial to weaker male<sup>15</sup> and female<sup>16</sup> dancers than their stronger counterparts.

The relationships found in this study may also stimulate a debate as to whether conventional dance exercises are of sufficiently high intensity to promote enhancement of muscle strength and power in trained individuals. It has been observed, for instance, that bar and center floor exercises alone do not produce adequate physiological responses to bring about measurable aerobic<sup>17</sup> and anaerobic<sup>18</sup> training effects.

The present experimental design does not permit a clear understand-



**Figure 1** Correlation coefficient between days off dance due to lower-body injuries and the sum of knee flexors and extensors peak torques — expressed in Nm/kg FFM — at 1.04 rad/sec.

ing of the factors involved in the apparent lack of significant correlations between the severity of low-back injuries and thigh strength levels in both male and female subjects. The available data imply that muscle imbalances<sup>6</sup> rather than muscle strength and power levels are more related to the severity of low-back injuries in dancers.

We also noted that most of the significant relationships between incidence of injuries and levels of thigh torques were established at the relatively low angular velocity of 1.04 rad/sec rather than the higher equivalent of 4.19 rad/sec. This finding is comparable to published reports on elite athletes where leg strength changes reached significant levels at lower compared to higher angular velocities.<sup>19</sup> As discussed elsewhere,<sup>20,21</sup> motor unit recruitment may account for these observations.

We conclude that: a) low combined knee flexors and extensors power outputs (i.e., thigh strength) are likely to be associated with the severity of pelvis, leg, knee, and foot injuries, but not with incidence of low-back injuries, b) female dancers are more likely to develop a lower-body injury than males, probably due to the relatively low muscular strength they demonstrate, and c) the relationships described above are better identified at lower compared to higher isokinetic velocities.

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