ORIGINAL PAPER

International Journal of Occupational Medicine and Environmental Health 2017;30(1):151–159
https://doi.org/10.13075/ijomeh.1896.00818

THE ASSOCIATION BETWEEN BODY-BUILT AND INJURY OCCURRENCE IN PRE-PROFESSIONAL BALLET DANCERS – SEPARATED ANALYSIS FOR THE INJURED BODY-LOCATIONS

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Abstract
Objectives: This study has aimed at identifying prevalence of injury-occurrence in 24 pre-professional-ballet-dancers (females, 16–18 years of age), and identifying the associations between the body-built and prevalence of injuries. **Material and Methods:** The sample of variables included: body mass, body height, and 3 somatotype characteristics (mesomorph, ectomorph and endomorph) and data on injuries over the preceding year. **Results:** Dancers were mostly ectomorphic-mesomorph (endomorphy: 2.6±0.54, mesomorphy: 3.99±0.77, ectomorphy: 3.23±0.54). The most commonly injured locations were the foot (17% of all injuries) and ankle (17%). Majority of the injuries occurred while practising but 37% of hip-injuries occurred while performing. Ankle-injuries resulted in longest absence from ballet. Endomorphy was related to ankle-injury (odds ratio (OR) = 1.9, 95% confidence interval (CI): 1.4–2.3), ectomorphy to foot injury (OR = 1.7, 95% CI: 1.1–2.9), and body-mass to injury to the toes (OR = 1.7, 95% CI: 1.4–3.1). **Conclusions:** The results of this study allow for recognizing those dancers who are particularly vulnerable to injuries of certain body location. A more profound analysis of the possible mechanisms that lead to hip-injury during performance is needed. Int J Occup Med Environ Health 2017;30(1):151–159

Key words:
Training, Performance, Etiology, Predictors, Health-status, Injuries

Received: October 11, 2015. Accepted: January 25, 2016.
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INTRODUCTION

Ballet dancing is a specific occupation and professional activity that is often an exclusive source of financial income for the practitioner. On the other hand, ballet is a sport that involves practice and/or competition throughout the year with little time off. Thus, dancing through pain, performing in challenging environments and risking career-threatening injuries are common. Consequently, ballet dancers are known to be at a high risk of several health-related-problems such as musculoskeletal disorders, injuries, eating disorders, and substance abuse [1–5].

The risk of injury is one of the most common health-hazards in ballet. In general, the lower extremities appear to be the most common injured locations, followed by soft tissue disorders within the lumbosacral region [6–8]. The recent study has explored pre-professional ballet dancers and found an incidence of 1.42 injuries-per-dancer over a 1-year period, corresponding to the 76% risk of injury, with the ankle being the most injured region, which is consistent with previous reports [9,10]. Others have reported 4.4 injuries per 1000 h of practice and the mean of 6.8 overuse injuries per dancer [11]. Therefore, identifying any factor associated to injury occurrence in ballet is highly important.

While studies repeatedly reported the association between intensity and frequency of training and practice with injury occurrence [8,9], there is a lack of studies that have examined the specific association between the body-built and injury prevalence in ballet dancers. This is especially important for 2 reasons. Firstly, having a specific body-built and body size (i.e., low body weight and overall androgynous appearance) is highly important in ballet as the ballerinas' body is accepted as an aesthetic project [12]. Secondly, injury-occurrence as a specific segment of health-status directly defines a dancer's professional success. In other words, while the body-built is unquestionably a factor that directly influences ballet performance, injury occurrence results in the absence from training and performing as well as possibly ending a career [4].

Consequently, the aim of this study has been to explore the association between certain anthropometric and body-built indices with injury occurrence among pre-professional ballet dancers. Additionally, we have aimed at describing the frequency, etiology and consequences of their injuries. The increased body of knowledge in this area will help to identify those dancers who are particularly vulnerable to certain injuries. Therefore, this research will contribute to the development of an effective injury-prevention program in ballet dance.

MATERIAL AND METHODS

Participants and testing design

The participants in this study were 24 female adolescent ballet dancers (body mass (mean ± standard deviation – M±SD): 55.2±5.4 kg, body height (M±SD): 165.3±5.7 cm). At the time of the investigation the participants were all between the ages of 16–18 years old, and participated in ballet-related-exercising-programs for 20–25 h per week. The participants had been practising ballet from 8 to 10 years. All of them were students of the ballet high-school. The testing was done in their last year of mandatory education, when all participants were of pre-professional status. Prior to this study, the formal permission from the school authorities was obtained. The Institutional Ethical Board reviewed and approved the investigation. The participants were informed that they could refuse participation and withdraw from the study at any time, for any reason, and their informed consent was obtained. Participation was anonymous and no personal data directly connected to an individual was included in the study.

Variables

Anthropometric variables included body height and mass as well as the following variables that were used for defining each dancer's somatotype: triceps skinfold, subscapular skinfold, suprailiac skinfold, calf skinfold, biepicondylar

breadth, bicondylar breadth, flexed arm circumference, calf circumference [13,14].

Somatotype characteristics were calculated as it follows:

$$\text{endomorphy} = -0.7182 + 0.1451 \times Z - 0.00068 \times Z^2 + 0.0000014 \times Z^3 \quad (1)$$

where:

Z – triceps skinfold + subscapular skinfold + suprailiac skin fold;

$$\text{mesomorphy} = 0.858 \times \text{biepicondylar breadth} + 0.601 \times \text{bicondylar breadth} + 0.188 \times \text{corrected arm circumference} + 0.161 \times \text{corrected calf circumference} - (\text{body height} \times 0.131) + 4.5 \quad (2)$$

where:

corrected arm circumference – flexed arm circumference – triceps skinfold,

corrected calf circumference – calf circumference – medial calf skinfold;

$$\text{ectomorphy} = \text{HMR} \times 0.732 - 28.58 \quad (3)$$

where:

HMR = body height/cube root of body mass.

If HMR ≤ 38.25 than 0.1 is assigned. If HMR > 40.75 than:

$$\text{ectomorphy} = \text{HMR} \times 0.463/17.63 \quad (4)$$

Three consecutive measurements of the anthropometric variables were done by an experienced technician. The reliability analyses showed appropriate reliability for each measurement with the Intra-Class Coefficient (ICC) ranging from 0.81 (for triceps-skinfold) up to 0.99 (for body height).

Data on injuries was collected at the end of the school year by means of a self-administered questionnaire. The participants completed the questionnaire in groups of 10–20 respondents. The examiner was available at all times for questions and answers.

For the purpose of this study an injury has been defined as "any physical complaint sustained as a result of performance or training, irrespective of the need for medical attention or time lost from activity" [15,16]. Students were asked to report the last year's injury occurrence on 11 body locations (wrist/hand, lumbar region, hips, knee, ankle, shoulders, foot, thigh, calf, torso, toes), the circumstance when the injury occurred (training or performance), the absence from ballet practice as a result of injury (responded on a 6-point scale ranging from "no absence" to "more than a month"), and resulting medical treatment (possible responses included: "didn't ask for professional help," "ambulance," "physiotherapy," "orthopedic"). While all students are obligated to keep a diary on their health-status issues, including injuries and consequences, they actually transferred data from their diaries to the questionnaire.

Prior to this study, 10 dancers (not observed herein) were asked to complete the same questionnaire in 2 occasions separated by 2 weeks for test-retest procedures. The reliability of the questionnaire was checked throughout the test-retest correlation (for ordinal variables such as age) and the analysis of equally answered questions (for ordinal and nominal variables; such as injury occurrence) [17]. The test-retest correlation for ordinal variables ranged from 0.84 to 0.99. The consistency of the test-retest answers was 93–100%, evidencing appropriate reliability of the questionnaire.

Statistics

For the somatotype components, the means and standard deviations were reported. For injury occurrence, the circumstance of occurrence, and resulting treatment of the frequencies and proportions were calculated.

The associations between injury occurrence (dependent variable) and anthropometric – somatotype characteristics (independent variables) was established using the forward conditional logistic regression with binomial criterion (injured vs. non-injured). For the purpose of this study we have studied associations between independent variables with injury occurrence for 11 observed body-locations. More precisely we have calculated 11 logistic regressions while observing injury for each body region as a dependent variable. Although descriptive statistics included data on repeated injuries (i.e., if a single dancer injured the same location more than once, the data is reported), for the purpose of logistic regression, only one occurrence of the injury was included in the calculation.

The multiple regression analysis was calculated to establish possible association between anthropometric/body-built and absence (i.e., time-off) as a result of injury.

A value of $p < 0.05$ was considered statistically significant. The statistical analyses were performed using Statsoft's Statistica version 12.

RESULTS

Anthropometric and somatotype data is presented in the Table 1. Most of the ballet dancers observed in this study were characterized as ectomorphic-mesomorph, meaning that mesomorphic component was dominant, while ectomorphy was greater as compared to endomorphy (endomorphy: 2.6±0.54, mesomorphy: 3.99±0.77, ectomorphy: 3.23±0.54).

Table 1. Anthropometric and somatotype data on studied pre-professional ballet dancers

Variable	Respondents (N = 24)			
	M	SD	min.	max
Body height [cm]	165.31	5.71	157.00	178.00
Body mass [kg]	55.21	5.40	45.80	65.50
Skinfold thickness [mm]				
triceps	12.38	2.61	7.30	17.30
subscapular	9.65	2.86	6.00	16.80
calf	10.42	2.65	6.10	16.30
suprailiac	10.01	2.86	5.10	15.10
Circumference [cm]				
calf	35.73	1.88	33.00	40.00
flexed arm	23.74	1.72	20.50	26.50
Breadth [cm]				
biepicondylar	6.52	0.46	5.50	7.20
bicondylar	8.85	0.59	8.00	10.30
Body-built [index]				
endomorphy	2.60	0.54	1.85	3.73
mesomorphy	3.99	0.77	2.17	5.19
ectomorphy	3.23	0.54	2.08	4.29

M – mean; SD – standard deviation; min. – minimal value; max – maximal value.

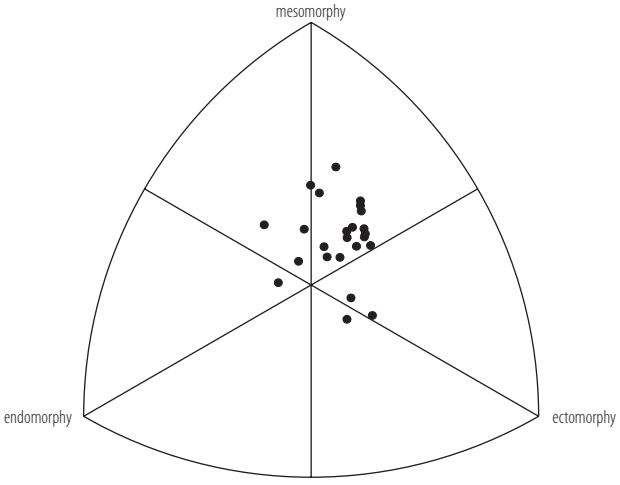


Fig. 1. Somatotype scores for the studied pre-professional ballet dancers

Schematic presentation of the somatotype scores is observable in the Figure 1.

The commonly injured locations were foot and ankle, with each accounting for 16.7% of all injuries. This was followed by hip (13.3%), lumbar region (13.3%), calf (10%) and toes (10%). Injuries mostly occurred during practice or training, though 38% of hip injuries occurred while performing (Table 2).

Table 2. Prevalence of injury by body location and circumstance of injury occurrence in pre-professional ballet dancers

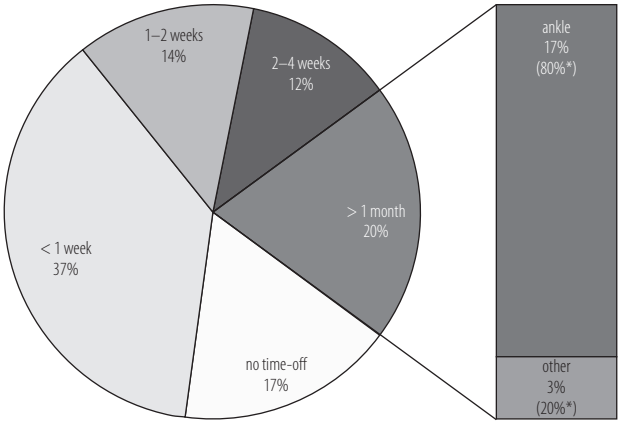
Injured location	Injuries (N = 60) [n (%)]	Circumstance [n (%)]	
		training	performance
Wrist	2 (3.3)	2 (100)	0 (0)
Lumbar region	8 (13.3)	7 (88)	1 (12)
Hip	8 (13.3)	5 (63)	3 (37)
Knee	4 (6.7)	3 (75)	1 (25)
Ankle	10 (16.7)	8 (80)	2 (20)
Foot	10 (16.7)	9 (90)	1 (10)
Shoulder	2 (3.3)	2 (100)	0 (0)
Thigh	2 (3.3)	2 (100)	0 (0)
Calf	6 (10.0)	6 (100)	0 (0)
Torso	2 (3.3)	2 (100)	0 (0)
Toes	6 (10.0)	5 (83)	1 (17)

The dancers were absent from ballet for less than a week for more than 50% of all injuries. However, more than a month recovery was required for nearly 1/4 of injury occurrences. About 80% of the time off that lasted for more than a month was related to an injured ankle (Figure 2).

Medical assistance (i.e., physiotherapy and/or clinical examination) was sought for 65% of the injuries.

Out of each logistic regression equation that was calculated for 11 injured body locations, 3 equations reached statistical significance (i.e., ankle, foot and toes). The increased likelihood of the ankle-injuries was evidenced for those participants with higher endomorphic component (odds ratio (OR) = 1.887, 95% confidence interval (CI): 1.433–2.312). Dancers with higher ectomorphic component were more likely to have an injury of the foot (OR = 1.719, 95% CI: 1.081–2.899). The injury of toes was more prevalent in dancers with a higher body mass (OR = 1.688, 95% CI: 1.41–3.121) (Table 3).

When examined in absolute units (i.e., not dividing by the injured body region), time-off (i.e., absence from ballet) as a result of injury was not associated with observed anthropometric/body-built characteristics ($r = 0.31$, $p = 0.85$).



* Percentage of all injuries that occurred for more than once a month.

Fig. 2. Time-off as a result of injury in pre-professional ballet dancers

Table 3. Forward conditional logistic regression results for the criterion – injury occurrence on different body location in pre-professional ballet dancers

Injured location	Predictor	OR (95% CI)	p
Ankle	endomorphy	1.887 (1.433–2.312)	0.03
Foot	ectomorphy	1.719 (1.081–2.899)	0.05
Toes	body mass	1.688 (1.410–3.121)	0.03

OR – odds ratio; CI – confidence interval.

DISCUSSION

There were several most important findings of this study. Firstly, ankle, foot, lumbar region and hips were the most commonly injured locations among pre-professional ballet dancers. The longest absence from training and performance was connected to an injured foot. Finally, and with regard to the main study aims, the results showed that endomorphic body-built component was associated with injured ankle, ectomorph component was found to be associated to foot injury, while body mass was significantly associated to injured toes.

Our results showed that foot and ankle were the most injured locations, which is consistent with the previous research [10,18]. However, the current study has found a high prevalence of injuries of the lumbosacral region and hips. Previous studies had reported lumbosacral disorders to have been prevalent among male dancers [2]. This is directly related to their work content. The additional load from lifting their female partners logically places additional stress on lumbar region in male dancers [19,20]. However, the current results have shown a relatively high incidence of such disorder among female dancers, as well. Of particular importance was the sample comprising pre-professional adolescent dancers (16–18 years old) who were at school. Therefore, it is possible that prolonged sitting at school, not reaching peak growth and having sub-optimal levels of physical fitness may contribute to the prevalence of injury to the lumbar region [21].

Out of all observed body regions, the hip-region was the only one reported to be injured during performance, with 63% and 37% of occurrences during practice and performance, respectively. This finding may be related to the common etiology of the hip-joint disorder in dancing. Fatigue and/or injury of the muscles that move the hip joint (*musculus rectus femoris*, *musculus sartorius*, and *musculus iliopsoas*) may be the primary issues. Muscular spasm to these areas may result in irritation and decreased flexibility of the hip, consequent abnormal biomechanics of the hip joint, and eventually spasm of the *m. piriformis* (i.e., "turn-out muscle;" also known as "piriformis syndrome") [22]. Dancing over a long-running performance with very little rest even under initial pain occurrence may continue to exacerbate technical error. Meanwhile, it is also possible that limited range of motion in the hip joint (as a primary issue) consequentially resulted in resentment and spasm, which should be examined in greater detail in future investigations.

The fact that 20% of reported injuries resulted in an absence of longer than one month needs a more precise analysis, with the longest absences following injures to the ankle. Although ankle injuries were most prevalent (i.e., accounted for 17% of all the reported injuries) yet explained 80% of the reported absences that lasted longer than 1-month. Therefore, ankle injuries should be observed as the most traumatic musculoskeletal disorder in pre-professional ballet dancers. For that reason, it is important to find any possible factors related to the occurrence of such disorder. Therefore, the results of the analyses where we have defined associations between the body-built indices and injury-prevalence on different locations are particularly interesting.

Most of the studies done so far examined the general prevalence of injury in relation to anthropometric and body-built indices [6,23]. The strength of the current study is that, to our knowledge, it is the first to examine how the body-built is potentially related to an isolated injury of

a specific region. The relatively low occurrence of injuries on some body-locations (i.e., wrist, torso) did not allow for calculation of a significant regression. However, the injuries at 3 locations (ankle, foot and toes) were specifically related to the body-built.

The previous research found a positive association between body-fat measures and injury occurrence in ballet and dancing [23]. While an endomorphic somatotype component explained the fatness and roundness of the body, the results of higher ankle-injury prevalence of those ballet dancers who have higher endomorphic component were therefore expected. Injury occurs when tissues are unable to adapt to meet the demands of a given posture or task [16]. The relative fatness of the body should be observed as a potential burdening factor that increases the load which is applied on a certain structure (i.e., ankle joint) while not being associated with increased adaptation of the structure (as it will be the case with fat-free-mass – mesomorphy).

While body-fatness (i.e., endomorphic component of the body-built) is not likely to be an important factor with regard to injuries of other regions, the standard ballet pointe technique (Photo 1) defines the importance of the endomorphic body-built in ankle injuries. Namely, throughout ballet pointe, the dancer supports all body weight on the tips of fully extended feet. In this position the emphasis is placed on the dancers' alignment, and consequently involves balance (i.e., avoiding "sickling" – waving of the foot). While body fatness, as measured with the skinfold technique, negatively influences balance ability [24], the association between endomorphy and occurrence of ankle injuries is also logical.

Knowing that an ectomorphic type explains the slenderness of the body, the findings of the higher occurrence of foot injury in more ectomorph dancers seems somewhat surprising. In explaining this, it must be stressed that ectomorphy actually explains not only slenderness (i.e., thinness) but also linearity of the body (i.e., the relative length

Photo 1. Ballet pointe technique

of body segments) [25]. In this particular case (i.e., foot injury) it mostly relates to length of the foot.

Throughout ballet dancing the foot is mostly burdened by dynamic forces. A longer foot (i.e., the lever) results in a greater amount of force. Greater force compromises the ability of the foot and its tissues to resist and adapt, resulting in increased risk of injury. To support this postulation, a very recent study that examined potential factors related to injury risk in adolescent ballet dancers reported changes in the foot length as directly associated with overuse injury occurrence [26]. In addition, similar results are presented when Twitchett et al. [14] examined associations between body composition and ballet injuries.

Body mass is the single measure found to be related with injury of the toes. In general, the association is relatively logical but asks for a brief overview of the ballet pointe technique (Photo 1). The ballet pointe technique is classical closed-kinetic chain movement in which the distal segment(s) (i.e., toes) experience considerable resistance and strain. The top of the toes (i.e., final distal segments) are fixed, emphasizing joint compression and stabilization. With the increase of the dancer's body mass, the forces also increase (force (F) = mass (m) × acceleration (a)). Finally, a higher body mass increases the stress applied on the toes, which may predispose higher injury occurrence.

Study limitations

The main limitation of this study comes from the fact that we have examined only somatic factors associated to injury occurrence. Mainly, the causes of the injury in ballet could be also functional (i.e., quality of dancing technique; range of motion; muscular strength; specific training factors such as a number and height of the jumps, etc.). In addition, there is a certain possibility that current anthropometric and the body-built (i.e., somatotype) status will not accurately present dancers' status at the moment an actual injury occurred. However, since all dancers are involved in ballet for a substantial period of time it is reasonable to consider the changes of the body-built to be minimal. At any rate, we believe that our study contributes to the body of knowledge in this field.

CONCLUSIONS

The results of the study have confirmed previous reports that foot and ankle are the most common injured body regions in female ballet dancers. However, a more precise analysis of the etiology of the injury occurrence in lumbosacral region in adolescent ballet-dancers is needed.

While most of the injuries occurred during practice (i.e., training), the hip-region is the only body region reported to be injured during ballet-performance. While such occurrence may have direct implications on performance of the whole ballet ensemble, the specific analysis of the mechanisms that lead to hip-injury during performance is needed.

It is likely that higher level of body fatness alter balance, leading to poorer alignment during pointe technique, and consequently resulting in higher stress that is placed on dancers' ankles. Those dancers with relatively longer body segments are found to be at a higher risk for foot injury. Independently of the dancers' somatotype, the higher body mass is recognized as a risk factor for a toe injury. Therefore, dancers should be introduced to these specific risks.

Future studies should examine other (functional) factors of injury occurrence such as technique, dancers' motor qualities, quality of the execution of the ballet elements, and/or specific ballet performance duties (i.e., brises, arabesques, entrechats, etc.).

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