Original Article

Determination of the Foot Deformities that May Occur during the Coronavirus Disease 2019 Lockdown Process in Ballet Students

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Abstract

Aim: This study aimed to compare foot injury prevalence, causes, and risk factors before and after the coronavirus disease 2019 (COVID-19) lockdown in ballet dancers. In this study, it is also aimed to determine the foot deformities that may occur during the pandemic process and to obtain results that will enable the necessary measures to be taken. **Subjects and Methods:** Our study includes students between the ages of 13 and 21 years who study full time at the Dokuz Eylül University State Conservatory Ballet Department, which provides professional ballet education. This study used a cross-sectional measurements design to evaluate foot morphometry during two distinct periods of time: the first was before to COVID-19 lockdown, and the second was after end of the lockdown. Measurements were made on the photographs taken for the right and left sides. Our study includes anatomical and morphometric measurements of foot digit length, foot length, foot width, and foot angles (intermetatarsal angle, hindfoot varus angle, and hallux valgus angle). **Results:** Forty-one ballet students with a mean age of 15.81 ± 2.28 years and who had been taking ballet training for an average of 6.93 ± 2.32 years were included in our study. When the foot angles (intermetatarsal angle, hindfoot varus angle, and hallux valgus angle) were examined, a significant difference was found except for the hallux valgus angles before and after lockdown. There was no significant relationship between the lengths of digits, foot length, foot width, age and body mass index parameters, and foot angles (intermetatarsal angle, hindfoot varus angle, and hallux valgus angle). However, a relationship was found between the foot angles before and after the lockdown. **Conclusion:** We can say that this result shows us that the COVID-19 lockdown process increases the tend to foot injury in ballet students. We think that this is due to continuing their ballet training on their own or online without ballet instructors in ballet studios.

Keywords: *Ballet, foot injury, hallux valgus angle, morphometry*

Introduction

The coronavirus disease 2019 (COVID-19) lockdown has led to a large reduction in physical activity for many children and young people across the country and has increased mental health and general well-being issues. Recent studies that have incorporated the lockdown period have focused on how dance can help the general population stay fit and healthy or how lockdown has changed preprofessional dancers' training and life.[1,2] Lockdown itself has meant that preprofessional training institutions alter their face-to-face dance classes to online delivery, which has been an exceptional challenge for both students and teachers as neither had any experience of such conditions. Although these online activities could never replace traditional dance classes, which did provide a stimulus to innovate the dance curriculum and education. Accompanied with unstable internet connections, which led to low image quality, their usual detailed movement feedback was made particularly challenging. Normally, face-to-face ballet education can cause many deformities by exposing the lower extremity to heavy stresses. Anatomical suitability and training technique are very important to minimize these deformities. There is a strong relationship between the development of deformities and disabilities and anatomical features and training technique. In this study, it was conducted to examine the effect of the pandemic process during COVID-19 on foot morphometry, which is important for ballet dancers. Currently, there are no published data on how the lockdown due to the pandemic has affected the foot morphometry in ballet students. This study aimed to compare foot injury

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prevalence, causes, and risk factors before and after the COVID-19 lockdown in ballet dancers. This study also aimed to determine the foot deformities that may occur during the pandemic process and to obtain results that will enable the necessary measures to be taken.

Subjects and Methods

To explore how the COVID-19 pandemic might impact ballet education, we present our own measurements that we wrote in the 1st weeks following university campus shutdowns, city lockdowns, and border closures. Our study includes students between the ages of 13 and 21 years who study full time at the Dokuz Eylül University State Conservatory Ballet Department, which provides professional ballet education. This study used a cross-sectional measurements design to evaluate foot morphometry during two distinct periods: the first was before the COVID-19 lockdown, and the second was after the end of the lockdown. The experimental procedures were conducted in conformity with the Declaration of Helsinki. The relevant guidelines and regulations were strictly followed when conducting the study. The study protocol was approved by the Ethics Committee of Cukurova University. Ethical approval was granted by the University of Cukurova (200/15). Each participant and their parents signed an informed consent form before participation and using their photo in our study. Inclusion criteria include the ballet students who are receiving full-time dance training at least 2 years at Dokuz Eylül University. The ballet students who have graduated or are at the master's or a higher level were omitted.

Photography design

All profile photographs were acquired using a Digital SLR Camera with fixed shooting values.(Canon EOS 80D; ISO 100 f/4.5). The students were taken to a meter-high platform, and they were allowed to take positions in the marked area. The photographic setup consisted of a tripod 1 m away from the student. The tripod height was adapted to each subject's knee level. This plane is described as a reference plane. In a standing position, each subject was asked to relax and was anatomic positioned. The photographs of the students were taken from the knee level down to the dorsum of the foot. In addition, foot photographs were taken from the lateral and posterior positions. Acquired images were then transferred to a computer. The measurement scale was divided into degree and was made on the computer screen as digital and estimations were expressed as degree. Measurements were made using Image J 1.52a with 1/100 mm sensitivity. Using the measurement feature of the software (image J 1.52a with 1/100 mm sensitivity), first the distal point of the angle is chosen, and a line is drawn to the mid position of the angle measurement where the mouse button is hold. The second line is drawn by moving the mouse to the third point, and the angle measurement results are recorded. All measurements were made three times by the same person. Measurements were made on the photographs taken for the right and left sides. Our study includes anatomical and morphometric measurements of foot digit length, foot length, foot width, and foot angles (intermetatarsal angle, hindfoot varus angle, and hallux valgus angle).

Statistical analysis

SPSS 21.0 was used for statistical analysis of the measurement results. From these measurements, means, standard deviations, and minimum and maximum values were calculated; $P < 0.001$, $P < 0.01$, and $P < 0.05$ were considered statistically significant. Skewness and kurtosis statistics were used to determine the normality of the data distribution. Values between +1.5 and −1.5 were considered to be in accordance with the normal distribution. Pearson analyses were used for correlation analyses with data showing a normal distribution, and Spearman analyses were used for data that did not fit a normal distribution. In addition, data with a normal distribution were evaluated using ANOVA, and data not without a normal distribution were evaluated using the Mann–Whitney *U*-test.

Results

Forty-one ballet students with a mean age of 15.81 ± 2.28 years and who had been taking ballet training for an average of 6.93 ± 2.32 years were included in our study. The lengths of the foot digits, the foot lengths, and the foot widths were measured on the right and left sides in Table 1. When the foot angles (intermetatarsal angle, hindfoot varus angle, and hallux valgus angle) were examined, a significant difference was found except for the hallux valgus angles before and after lockdown. There was no significant relationship between the lengths of digits, foot length, foot width, age and body mass index (BMI) parameters, and foot angles (intermetatarsal angle, hindfoot varus angle, and hallux valgus angle) in Table 3. However, a relationship was found between the foot angles before and after lockdown in Table 4.

Discussion

Professional ballet dancers are dance artists, and due to the high-intensity training required and the technical discipline and difficulty needed for dance performance, "dance injury" is common in ballet dancers.[3] When the literature is examined, lower extremity injuries are among 65%–80% of all ballet injuries. If the most common damages are examined in detail, since they are located in the lower extremities; 7%–14% hip, 14%–20% knee, 5%–8% leg, 15%–22% wrist, and 13%–15% foot injuries are due to injuries. Studies have shown that 50% of injuries are due to overuse. The overuse percentages are: it was found to be 20% lower extremity, 15% wrist, and 15% foot.[4] Studies are lacking on the intense physical demands of dancing that exposes dancers' feet to a high risk of injuries such as hallux valgus, metatarsal injury, and subsequent ankle pain. We examined foot morphometry and foot

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Table 1: Length measurements of ballet students

Parameters	Mean±SD (minimum–maximum)	
	Right	Left
First digit length (cm)	5.06±0.53 (3.99–6.38)	5.04±0.48 (4.10–6.38)
Second digit length (cm)	4.35±0.58 (3.03–5.50)	4.26±0.81 (3.90–5.31)
Third digit length (cm)	3.73±0.48 (2.63–4.68)	3.85±0.50 (2.68–4.95)
Fourth digit length (cm)	3.46±0.51 (2.34–4.63)	3.55±0.45 (2.40–4.63)
Fifth digit length (cm)	2.92±0.48 (2.14–3.99)	3.01±0.44 (2.17–3.88)
Foot length (cm)	22.90±1.90 (19.36–26.85)	22.79±1.83 (19.63–26.85)
Foot width (cm)	9.10±0.69 (7.39–10.34)	9.13±0.69 (7.41–10.91)

SD: Standard deviation

Table 2: Angle measurements of ballet students before and after lockdown

Parameters	Mean±SD (minimum–maximum)		*P*
	Before lockdown	After lockdown	
Body mass index	19.56±0.77 (18.50–21.80)	20.80±1.39 (19.30–24.00)	0.000
Intermetatarsal angle (right)	18.18±0.21 (15.19–22.00)	19.77±0.23 (16.19–24.94)	0.002
Intermetatarsal angle (left)	17.60±0.19 (14.19–2.25)	19.12±0.22 (15.23–23.51)	0.001
Hindfoot varus angle (right)	8.18±0.23 (4.38–12.21)	9.89–0.25 (4.98–0.1421)	0.002
Hindfoot varus angle (left)	8.32±0.20 (4.13–12.58)	9.05±0.23 (5.13–13.58)	0.001
Hallux valgus angle (right)	24.21±0.71 (12.34–42.39)	26.23±0.75 (13.34–44.39)	0.213
Hallux valgus angle (left)	23.73±0.59 (12.38–35.57)	25.58±0.61 (13.38–38.57)	0.166

P significance value (ANOVA). SD: Standard deviation

angles (intermetatarsal angle, hindfoot angle, and hallux valgus angle) in our study. The weight should be in the center of the foot. Otherwise, since only one side of the leg muscles are used, imbalance will occur. Wrist sprains are facilitated as weight is placed on the lateral ligaments in inward sickling and medial ligaments in outward sickling. Hallux valgus deformity may occur as the thumb will be pushed to the valgus position in outward sickling. Another factor of injury is making wrong practices without the supervision of the instructor. The arrival of the COVID-19 forced nearly all preprofessional dancers to train and study from home due to the lockdown. Before this, the reported injury prevalence for dancers was between 3% and 95%.[5] Injuries were mainly in the muscles of the lower limb and chronic in nature. Perceived causes of these injuries were overwork, fatigue, and the recurrence of an old injury.[6] Furthermore, the anatomical, biomechanical, and hormonal gender differences might have contributed to these results.

Globally, the outbreak of COVID-19 has forced different countries to implement strict social distancing measures and sanitary regimens. People were under the lockdown, working remotely, homeschooling children, and facing quarantine challenges related to eating habits, sleeping time, physical inactivity, and stress. A small-scale study in Italy during lockdown hypothesized based on previous evidence, that children and young people typically gain weight during Summer holidays, that the same would happen during the lockdown. This study concluded that activity decreased while sleep increased.[7] In our study, the mean BMI values of ballet students were 19.56 ± 0.77 before lockdown and 20.80 ± 1.39 after lockdown. We determined that there was a significant increase in BMI values after the lockdown period. Outcomes were stratified by three BMI levels: healthy weight (BMI: 18.5–24.9 kg/m^2), overweight (BMI: 25.0–29.9 kg/m^2), and obesity (BMI: 30.0 kg/m^2 or above).[8] Even though there was an increase in BMI during the lockdown period, ballet students' BMI values remained within a healthy weight.

Hallux valgus was first proposed by Carl Hueter in 1871 and is one of the common diseases in the forefoot characterized by the outward deviation of the hallux beyond the normal physiological angle and first metatarsal adduction. It is a common deformity of the forefoot that usually exists on both feet.[1] It is generally believed that when the outward deviation of the hallux is more than 15°.[9] The normal value of the angle between the longitudinal axis of the first toe and the extended line of the longitudinal axis of the second toe is 8°–12°. For patients with metatarsal adduction, the normal value is 8°–10°. The hallux valgus can be classified according to the hallux valgus angle and the first/second intermetatarsal angle. Moderate intensity: the medial part of the first metatarsal head protrudes with pain, hallux valgus angle <30°, and intermetatarsal angle <13°. Moderate: the thumb has lateral deviation to compress the second toe, the sesamoid bone is dislocated, the hallux valgus angle is 30°–40°, and the intermetatarsal angle is 13°–16°. High intensity: the thumb has lateral deviation to ride across the second toe, the hallux has pronation, the dislocation of the sesamoid bone is located at the fibular margin of the metatarsal head (7°), hallux valgus angle >40°, and intermetatarsal angle >14°.[10] In our study, the hallux valgus angle on the right side was found to be 24.21 ± 0.71 before the lockdown and 26.23 ± 0.75

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Table 3: Correlation analysis between anatomical parameters

	r (*P*)											
	IA1R	**IA1L**	**HA1R**	**HA1L**	**HVA1R**	**HVA1L**	**IA2R**	**IA2L**	**HA2R**	**HA2L**	**HVA2R**	**HVA2L**
Age	0.05 (0.73)	−0.15 (0.92)	0.05 (0.75)	0.02 (0.90)	0.14 (0.37)	0.03 (0.84)	0.03 (0.84)	−0.07 (0.68)	0.04 (0.80)	0.08 (0.61)	0.13 (0.44)	0.01 (0.93)
BMİ1	−0.05 (0.76)	0.05 (0.78)	−0.01 (0.97)	0.08 (0.64)	−0.07 (0.65)	−0.15 (0.36)	−0.05 (0.78)	−0.03 (0.84)	−0.08 (0.63)	0.06 (0.70)	−0.05 (0.76)	−0.13 (0.42)
BMİ2	0.01 (0.95)	0.14 (0.39)	−0.01 (0.99)	0.08 (0.63)	−0.01 (0.93)	−0.09 (0.59)	0.02 (0.99)	0.03 (0.88)	−0.03 (0.83)	0.10 (0.52)	−0.01 (0.96)	−0.08 (0.60)
Year	0.19 (0.23)	0.08 (0.64)	0.15 (0.36)	0.09 (0.56)	0.19 (0.23)	0.14 (0.40)	0.18 (0.27)	0.04 (0.82)	0.14 (0.39)	0.15 (0.36)	0.18 (0.26)	0.11 (0.50)
DL1R	0.09 (0.57)	0.06 (0.71)	0.02 (0.90)	0.12 (0.47)	−0.08 (0.60)	0.03 (0.85)	0.02 (0.91)	0.04 (0.80)	0.11 (0.51)	0.22 (0.17)	−0.11 (0.49)	0.02 (0.92)
DL2R	0.11 (0.49)	0.22 (0.16)	−0.01 (0.93)	0.13 (0.42)	0.07 (0.68)	0.11 (0.51)	0.03 (0.87)	0.14 (0.37)	0.09 (0.57)	0.23 (0.15)	0.02 (0.88)	0.08 (0.62)
DL3R	0.04 (0.81)	0.15 (0.36)	0.01 (0.94)	0.02 (0.90)	0.03 (0.84)	0.07 (0.68)	−0.03 (0.84)	0.07 (0.65)	0.09 (0.60)	0.09 (0.58)	−0.02 (0.93)	0.03 (0.84)
DL4R	0.16 (0.32)	0.21 (0.18)	0.18 (0.25)	0.31 (0.05)	−0.04 (0.81)	−0.02 (0.90)	0.07 (0.66)	0.17 (0.30)	0.25 (0.11)	0.33 (0.04)	−0.06 (0.71)	−0.02 (0.93)
DL5R	0.08 (0.60)	0.22 (0.17)	−0.10 (0.55)	0.11 (0.50)	0.08 (0.60)	0.10 (0.54)	0.01 (0.94)	0.11 (0.51)	−0.01 (0.94)	0.19 (0.24)	0.05 (0.75)	0.10 (0.55)
FLR	0.01 (0.95)	0.01 (0.99)	−0.16 (0.32)	−0.03 (0.87)	−0.03 (0.84)	−0.03 (0.87)	−0.03 (0.87)	−0.03 (0.85)	0.08 (0.63)	−0.08 (0.63)	−0.08 (0.63)	−0.09 (0.59)
FWR	0.27 (0.09)	0.11 (0.49)	0.08 (0.62)	0.15 (0.36)	0.13 (0.41)	0.01 (0.95)	0.16 (0.31)	−0.03 (0.88)	0.24 (0.13)	0.32 (0.04)	0.11 (0.48)	0.03 (0.87)
DL1L	0.09 (0.57)	0.05 (0.78)	−0.02 (0.88)	0.04 (0.82)	0.10 (0.52)	0.04 (0.82)	0.02 (0.93)	0.07 (0.67)	0.07 (0.59)	0.09 (0.59)	0.01 (0.99)	0.08 (0.63)
DL2L	0.09 (0.56)	0.08 (0.63)	−0.15 (0.34)	−0.02 (0.91)	0.02 (0.92)	0.20 (0.22)	0.02 (0.93)	−0.02 (0.94)	0.03 (0.86)	0.13 (0.42)	0.01 (0.95)	0.13 (0.42)
DL3L	−0.08 (0.61)	0.18 (0.27)	−0.19 (0.23)	−0.06 (0.69)	0.05 (0.75)	0.16 (0.33)	−0.20 (0.21)	0.04 (0.80)	−0.14 (0.40)	0.01 (0.99)	0.01 (0.97)	0.13 (0.44)
DL4L	0.03 (0.86)	0.12 (0.47)	0.01 (0.96)	0.09 (0.57)	−0.01 (0.98)	0.04 (0.81)	−0.11 (0.49)	0.03 (0.88)	0.08 (0.63)	0.14 (0.38)	0.04 (0.80)	0.03 (0.85)
DL5L	−0.03 (0.84)	0.20 (0.20)	−0.16 (0.33)	0.08 (0.64)	0.03 (0.84)	0.03 (0.84)	−0.10 (0.52)	0.08 (0.62)	−0.13 (0.44)	0.12 (0.46)	−0.01 (0.94)	0.04 (0.79)
FLL	0.02 (0.90)	0.03 (0.84)	−0.16 (0.33)	−0.07 (0.65)	−0.03 (0.83)	−0.01 (0.99)	−0.03 (0.87)	−0.07 (0.65)	−0.03 (0.85)	0.04 (0.82)	−0.07 (0.65)	−0.06 (0.71)
FWL	0.17 (0.29)	0.13 (0.44)	−0.06 (0.69)	0.17 (0.30)	0.03 (0.87)	−0.06 (0.69)	0.06 (0.71)	−0.08 (0.63)	0.11 (0.48)	0.33 (0.03)	0.01 (0.94)	−0.04 (0.79)

IA1R: Intermetatarsal angle right before lockdown, IA1L: Intermetatarsal angle left before lockdown, HA1R: Hindfoot varus angle right before lockdown, HA1L: Hindfoot varus angle left before lockdown, HVA1R: Hallux valgus angle right before lockdown, HVA1L: Hallux valgus angle left before lockdown, IA2R: Intermetatarsal angle right after lockdown, IA2L: Intermetatarsal angle left after lockdown, HA2R: Hindfoot varus angle right after lockdown, HA2L: Hindfoot varus angle left after lockdown, HVA2R: Hallux valgus angle right after lockdown, HVA2L: Hallux valgus angle left after lockdown, BMİ1: Body mass index before lockdown, BMİ2: Body mass index after lockdown, Year: The year she studied ballet, DL1R: Digit 1 length right, DL2R: Digit 2 length right, DL3R: Digit 3 length right, DL4R: Digit 4 length right, DL5R: Digit 5 length right, FLR: Foot length right, FWR: Foot width right, DL1L: Digit 1 length left, DL2L: Digit 2 length left, DL3L: Digit 3 length left, DL4L: Digit 4 length left, DL5L: Digit 5 length left, FLL: Foot length left, FWL: Foot width left, *r*: Pearson correlation analysis value, *P*: Degree of significance

Table 4: Correlation analysis between foot angles

	r (*P*)										
	IA1R	IA1L	HA1R	HA1L	HVA1R	HVA1L	IA2R	IA2L	HA2R	HA2L	HVA2R	HVA2L
IA1R	-	0.58 (0.00)	0.71 (0.00)	0.33 (0.03)	0.43 (0.01)	0.38 (0.02)	0.95 (0.00)	0.64 (0.00)	0.76 (0.00)	0.40 (0.01)	0.45 (0.00)	0.41 (0.01)
IA1L	0.58 (0.00)	-	0.24 (0.13)	0.37 (0.02)	0.38 (0.02)	0.13 (0.41)	0.04 (0.83)	0.61 (0.00)	0.93 (0.00)	0.27 (0.09)	0.39 (0.01)	0.48 (0.00)
HA1R	0.71 (0.00)	0.24 (0.13)	-	0.38 (0.01)	0.13 (0.41)	0.04 (0.83)	0.61 (0.00)	0.35 (0.03)	0.95 (0.00)	0.40 (0.01)	0.15 (0.35)	0.08 (0.60)
HA1L	0.33 (0.03)	0.37 (0.02)	0.38 (0.01)	-	−0.23 (0.15)	−0.29 (0.07)	0.33 (0.03)	0.36 (0.02)	0.38 (0.01)	0.94 (0.00)	−0.22 (0.17)	−0.23 (0.16)
HVA1R	0.43 (0.01)	0.38 (0.01)	0.13 (0.41)	−0.23 (0.15)	-	0.83 (0.00)	0.42 (0.01)	0.39 (0.01)	0.16 (0.31)	−0.13 (0.43)	0.99 (0.00)	0.85 (0.00)
HVA1L	0.38 (0.01)	0.46 (0.00)	0.04 (0.83)	−0.29 (0.07)	0.83 (0.00)	-	0.40 (0.01)	0.51 (0.01)	0.06 (0.69)	−0.19 (0.25)	0.83 (0.00)	0.99 (0.00)
IA2R	0.95 (0.00)	0.62 (0.00)	0.61 (0.00)	0.33 (0.03)	0.42 (0.01)	0.39 (0.01)	-	0.72 (0.00)	0.65 (0.00)	0.38 (0.02)	0.45 (0.00)	0.43 (0.01)
IA2L	0.64 (0.00)	0.93 (0.00)	0.36 (0.02)	0.35 (0.03)	0.39 (0.01)	0.51 (0.00)	0.72 (0.00)	-	0.32 (0.04)	0.32 (0.04)	0.41 (0.01)	0.53 (0.00)
HA2R	0.76 (0.00)	0.27 (0.09)	0.95 (0.00)	0.38 (0.01)	0.16 (0.31)	0.06 (0.69)	0.65 (0.00)	0.32 (0.04)	-	0.46 (0.00)	0.17 (0.28)	0.10 (0.55)
HA2L	0.40 (0.01)	0.38 (0.02)	0.40 (0.01)	0.94 (0.00)	−0.13 (0.43)	−0.19 (0.25)	0.38 (0.02)	0.32 (0.04)	0.46 (0.00)	-	−0.12 (0.45)	−0.14 (0.39)
HVA2R	0.45 (0.00)	0.39 (0.01)	0.15 (0.35)	−0.22 (0.17)	0.99 (0.00)	0.83 (0.00)	0.45 (0.00)	0.41 (0.01)	0.17 (0.28)	−0.12 (0.45)	-	0.86 (0.00)
HVA2L	0.41 (0.01)	0.48 (0.00)	0.08 (0.60)	−0.22 (0.16)	0.85 (0.00)	0.99 (0.00)	0.43 (0.01)	0.53 (0.00)	0.10 (0.55)	−0.14 (0.39)	0.86 (0.00)	-

IA1R: Intermetatarsal angle right before lockdown, IA1L: Intermetatarsal angle left before lockdown, HA1R: Hindfoot varus angle right before lockdown, HA1L: Hindfoot varus angle left before lockdown, HVA1R: Hallux valgus angle right before lockdown, HVA1L: Hallux valgus angle left before lockdown, IA2R: Intermetatarsal angle right after lockdown, IA2L: Intermetatarsal angle left after lockdown, HA2R: Hindfoot varus angle right after lockdown, HA2L: Hindfoot varus angle left after lockdown, HVA2R: Hallux valgus angle right after lockdown, HVA2L: Hallux valgus angle left after lockdown, *r*: Pearson correlation analysis value, *P*: Degree of significance

after the lockdown. We evaluated the hallux valgus angle on the left side before and after lockdown as 23.73 ± 0.59 and 25.58 ± 0.61, respectively. We observed an increase in the values on the right and left sides after lockdown. However, it was not statistically significant. We also noticed that the right side has more tendency to be hallux valgus deformity. The results of our study were found to be higher than the normal values in the literature. We think that this result is due to the fact that the individuals in our study have been doing ballet for an average of 6.93 ± 2.32 years. Hallux valgus degrees of ballet students in our study were found to be low. Hallux valgus deformity is usually accompanied by an increase in the intermetatarsal angle. In the ballet students in our study, the intermetatarsal angle values on the right side were found to be 18.18 ± 0.21 before lockdown, 19.77 ± 0.23 after lockdown, 17.60 ± 0.19 before lockdown, and 19.12 ± 0.22 after lockdown on the left side. A significant increase was observed after lockdown on both sides (right $P = 0.002$ and left $P = 0.001$). The increase in the intermetatarsal angle was also seen more on the right side. The increase in intermetatarsal angle values after lockdown in ballet students supports the increase in hallux valgus angle values [Table 2]. In our correlation analysis results, a strong positive correlation was found between the intermetatarsal angle and the hallux valgus angle on both the right and left sides before and after the lockdown. Another angle in our study that is positively correlated with the intermetatarsal angle on both sides and before and after lockdown is the hindfoot varus angle. In the ballet students in our study, the hindfoot varus angle on the right side was 8.18 ± 0.23 before lockdown and 9.89–0.25 after lockdown, 8.32 ± 0.20 before lockdown, and 9.05 ± 0.23 after lockdown on the left side. It was found that there was a significant increase in hindfoot varus angle values on both sides (right $P = 0.002$ and left $P = 0.001$) after lockdown. It occurs as a result of an imbalance in hindfoot varus muscle strength. During the lockdown process, we thought that there might be changes in muscle strength due to the disruption of the ballet training in the ballet studio. Therefore, we included the hindfoot varus angle, which will reflect the change in muscle strength, in our measurements. The back of the foot is in varus, the lateral part of the foot overloading and thus ankle instability, peroneal tendinitis, and stress fracture. Hindfoot movements were examined and showed within normal (5°–10°) inversion values and eversion values (10°–20°) at the subtalar joint.[11] The hindfoot varus degree values in our study showed a significant increase after lockdown on both the right and left sides. The hindfoot varus degrees of ballet students in our study before and after lockdown were within the normal range in both inversion and eversion. Moreover, in our study, we also included ballet students' morphometric measurements such as digit lengths, foot lengths, and foot widths. No relationship was found between the foot angles and these length and width measurements. Hallux valgus angle, intermetatarsal angle, and hindfoot varus angles increased after the lockdown period. We can say that this result shows us that the COVID-19 lockdown process

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increases the tend to foot injury in ballet students. We think that this is due to continuing their ballet training on their own or online without ballet instructors in ballet studios. Most ballets are absolutely and completely committed to ballet, making great sacrifices during their training from a young age onward, with the aim of becoming professional ballet dancers. In the everyday schedule of training and rehearsals, discipline is a fundamental prerequisite for a career as a professional ballet dancer. Ballet students must work with perseverance, purpose, and concentration. They are used to accepting and swiftly reacting to criticism and constructively taking instructions.[12,13] Therefore, during the lockdown due to COVID-19, ballet students stayed away from ballet studios with mirrors, one-on-one guidance from their instructors, and training with their group mates. We think that this situation will increase the susceptibility to injuries. For example, during every relevé, pay attention to the optimal weight distribution in the foot. The main load should lie between the first and second metatarsals. Especially if the mobility of the metatarsophalangeal joint of the big toe is limited, it cannot compensate for this lacking range of motion by "sickling" the foot when rising to relevé. Otherwise, the first and second metatarsals will be overloaded; injuries and deformities may occur with the increase of the hallux valgus angle and the intermetatarsal angle.

Conclusion

With this study, we wanted to emphasize the importance of training with teamwork in ballet studios and training with a ballet trainer during the lockdown process. In addition, we think that we will guide orthopedists and physical therapists with measurement values that will affect foot deformities and tend to injury in ballet students. To prevent such injuries, we recommend performing supportive practices such as mobilizing the tarsus, strengthening the transverse arch respectively and the intrinsic foot muscles, strengthening the long peroneal muscle, contract-relax stretching of the calf muscles.[14] We also think that the following points will prevent injuries in daily life:

- Watch out when walking – and especially when jogging – to put down your feet as parallel as possible and push off from the transverse arch
- Let your feet have a rest sometimes. A footbath in the evening will relax the foot muscles. Massage the painful spots and pay particular attention to the inner side and the sole as well as to the insertion of the Achilles tendon
- Take your time when buying shoes. All of your shoes should fit properly, not only dance ones. Especially after long training days, your walking shoes should not put additional strain on your feet.

Since the COVID-19 is a pandemic process, measurements with instruments could not be made by direct physical contact. Evaluations were made quickly and safely with the photographing method. However, the flexibility factor, which we think will be affected by lockdown, could not be evaluated. This is one of the limitations of the study. We suggest that similar studies in which the flexibility factor is evaluated be produced with more ballet students.

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Conflicts of interest

There are no conflicts of interest.

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