This Original Article has been reviewed, accepted for publication, and approved by the author. It has not been copyedited, proofread, or typeset and is not a final version.

ORIGINAL ARTICLE

The Impact of Hallux Valgus on Adolescent Ballet Dancer Balance and Health Related Quality of Life Scores

Ozcan Kaya, MD*
Irem Kurt, PT, MsC, PhD†
Okan Ozkunt, MD‡
Kerim Sariyilmaz, MD§

*Department of Orthopedics and Traumatology, SBU Istanbul Kanuni Sultan Suleyman Training and Research Hospital, Istanbul, Turkey.
†Department of Physiotherapy and Rehabilitation, Istanbul Gelisim University Faculty of Health Science, Istanbul, Turkey.
‡Department of Orthopedics and Traumatology, Medicana Health Group Istanbul Bahcelievler Hospital, Istanbul, Turkey.
§Department of Orthopedics and Traumatology, Acibadem MAA University School of Medicine Istanbul, Turkey.
Background: It's well known fact that Hallux valgus (HV) alternates foot biomechanics. In different populations HV and postural stability has been studied but HV and adolescent ballet dancer has not been studied. Aim of the our study is to explore affect of HV on adolescent ballet dancers’ balance. Also we wanted to explore health related quality of life of adolescent ballet dancers with HV.

Methods: Ballets aged between 8-16 years old has been screened prospectively. The dancers divided into two groups group 1;Ballets with HV and group 2; Ballets without HV. HV diagnosis was made clinically. Two groups were compared according to balance parameters and health related quality of life (HRQOL) questionnaires.

Results: Group 1 was formed with 31 participants and group 2 was formed with 24 participants. All participants in both groups were female. Mean age in group 1 was 11.6 (8-16 years old) and 12.2 (8-16 years old) in group 2. Mean first metatarsophalangeal angle was 13.4° (10°-15°) in group 2 and 19.8° (16°-25°) in HV group respectively. A statistically significant difference was found according to the nonparametric Mann Whitney U test results in the comparison of HVA (Hallux Valgus Angle) between groups. According to Spearman Rho correlation analysis, it was determined that the increase in HVA caused deterioration in the static Flamingo test. (r=0.552 p=0.019). No significant relationship was found between HRQoL questionnaires and the presence of HV. (p>0.05)
Conclusions: Adolescent ballet dancers experience static balance impairment due to HV angle increase. Clinical measurement of HV and application of balance parameters made easy without need of set ups to perform evaluation with high numbers of participants in concordance with literature.

Hallux valgus (HV) is a common forefoot deformity. The diagnosis is made by increased first metatarsophalangeal and intermetatarsal angles. The condition affects approximately 23% of adults aged between 18 to 65 years, and its incidence increases up to 36% in adults older than 65 years.\(^1\) Previous studies reported that in 46-57% of the patients, the onset of HV dates much earlier, including adolescence. Females are affected more, with a female to male ratio between 2.3-15.\(^2,3\)

HV in children is named as juvenile or adolescent bunion and is a rare condition. Although there is no consensus on the definition of pediatric hallux valgus, some authors stated that the presence of an open growth plate at the time of diagnosis indicates to juvenile or adolescent HV. Others have advocated that being younger than 20 years is sufficient for the diagnosis of juvenile HV. Four out of five adolescent HV patients are female, and the initial diagnosis is made at age 10 in 50% of the patients. Also, maternal transmission is common (86-94%)\(^4\).
HV disease is known to impair foot biomechanics. HV was associated with lower performance during balance testing in older adults. The relationship between HVA and balance was investigated in different populations, including asymptomatic adults and young and older adults with severe HV angles. (5) Menz et al. found a relationship between increased HV angle and postural sway in the older adult population. (6) HV-related balance disorder can cause falls, potentially leading to serious complications such as head trauma. (5-7)

The balance function is the ability of the body to control the center of gravity (COG) with minimum sway and highest stability within the base of support. It involves several neuromuscular processes. (5,6) Balance is a crucial element of ballet dancing, and musculoskeletal health, flexibility, and strength are also prerequisites. Ballet dance includes typical specific movements which require balance ability and postural control (8,9).

Although the effects of foot deformities on functional ambulation or incidence of falls have been previously evaluated by subjective clinical observational tests or outcome measurement scales, to the best of our knowledge there are no reports regarding the impact of hallux valgus on adolescent ballet dancers' balance parameters. Therefore, in this study firstly, we aimed to analyze the effect of HV on the static and dynamic balance parameters in ballet dancers. First part of hypothesis was that, HVA increase would cause impairment in balance parameters. In order to better understand the impact of HV on the daily lives and
ballet activities, effect of HV was studied using HRQoL scales. The second part of our hypothesis is that the increase in HVA has a negative effect on HRQoL scores in adolescent ballet dancers. HV is a challenging issue for ballet dancers. After the surgical treatment of HV, it is almost impossible for ballet dancers to fulfill their profession. For this problem, an investigation of how HV affects performance and daily life in young dancers is important. According to the results of this study, it is expected that it will point to the development of alternative treatment methods in ballet dancers who have HV problem so that they can continue their profession.

**Patients and Methods**

The presence of HV in some ballet dancers attracted the attention of our researchers in a screening study in which we investigated the musculoskeletal well-being, posture and balance parameters of adolescent ballets. The starting point of this study was to reveal the effect of HV in this particular population, which is known to have an effect on balance in different populations.

Since the aim of this study was to investigate the effect of hallux valgus angle (HVA) on balance parameters, ballet dancers with similar demographic characteristics who received the same curriculum as the control group were included in the study in order to compare with the study group. Also, based on the still controversial knowledge that ballet can also cause HV, in order to avoid heterogeneity due to curriculum the ballets included in the study were selected
This Original Article has been reviewed, accepted for publication, and approved by the author. It has not been copyedited, proofread, or typeset and is not a final version.

from those who had been trained in the same dance school with the same curriculum for at least 1 year.

Participants with hallux valgus formed the study group (Group 1; G1). The control group (Group 2; G2) was matched with the study group in terms of sex, age, body mass index (BMI) and education level. The basic criteria for inclusion in the study were diagnosis of adolescent hallux valgus, absence of previous spine or extremity surgery, and absence of a history of systemic or neurological disease or trauma. Attention was paid to the fact that the participants in the control group did not have a history of previous extremity or spine surgery, systemic neurological disease, or recent foot and ankle trauma.

All participants were pain free regarding a musculoskeletal condition. Assessment procedures were performed on the dominant extremity. All participants and parents were informed about the aim of the work, evaluation procedures and use of collected data. The study was approved by the local institutional review board (Acibadem University Istanbul/TURKEY Ethics Committee Approval Number: 202-01/23). The present work was carried out in accordance with the Declaration of Helsinki.

HV angle was defined as the angle between the longitudinal line of hallux and the longitudinal axis of the first metatarsus. An angle greater than 15° was accepted pathologic. Measurement was performed with the participant in the erect position; the fixed arm of the toe goniometer was placed on the longitudinal line of metatarsal bone and the other arm was
placed on the hallux. (Figure 1) All measurements were performed by a senior physiotherapist (10,11). Clinical measurement of HV angle was shown to be in concordance with the radiographic measurement (interclass correlation coefficients:0.81) previously (1,12).

The age, body weight (kg), and height (cm) of each individual included in the study were recorded. An evaluation form was created for all participants, including information such as the duration, frequency and continuity of performing ballet, as well as demographic data and test results.

For the purpose of the study universal dynamic and static balance tests were applied to participants in both groups. In the evaluation of static balance, the Flamingo static balance test, which can be easily applied to large participant groups, was applied. In this test the participant stands on his/her preferred foot, bends the free leg backwards and grips the back of the foot with hand on the same side standing like a flamingo (Figure 2) The measurement time was kept for one minute. As the participant lost balance, the timer was stopped and restarted once balance was regained. The number of restarts was recorded. (13) The Star Excursion Balance Test (SEBT) is a screening tool commonly used to evaluate lower extremity dynamic stability, neuromuscular control, and injury risk in athletes. It is also used to monitor rehabilitation progress after injury. The SEBT is performed by having the participant stand on one leg and extend the other leg away from the body in eight different directions (14). Both Flamingo test and SEBT do not require any set up and tools.
In order to reveal the extent to which HV affected the daily life and ballet activities of dancers, HRQoL scales were used. American Foot and Ankle Society (AOFAS) forefoot scores and Short Form (SF) 36 tools were used as assessment tools of HRQOL (15-17).

The AOFAS scale is one of the important scales with proven validity and reliability, and often used to evaluate foot problems. The AOFAS scale, which consists of 3 categories: pain, function and smoothness, was applied to all cases. Maximum score is 100, and higher scores indicate better function on the scale (15-17).

SF-36, which is used to evaluate health-related quality of life, is the most frequently used quality of life scale in the health field and consists of 8 subheadings with a total of 36 items that evaluate physical and mental health. These subheadings are physical function, physical role limitation, pain, general health, vitality, social function, emotional role limitation and mental health. Scores range from 0-100, with 100 points indicating the best health condition and 0 points the worst health condition. In order to facilitate the association of the scale with a large number of findings, the scores of the first four subheadings were combined with the Physical Component Score (PCS) and Mental Component score (MCS) and calculated with the scores of the last four subheadings. In this way, physical and mental quality of life scores were calculated (18).
This Original Article has been reviewed, accepted for publication, and approved by the author. It has not been copyedited, proofread, or typeset and is not a final version.

Statistical Analysis

IBM SPSS Statistics 26.0 (released 2019, version 26.0; IBM SPSS Statistics for Mac, Armonk, NY, USA) program was used in the analysis of the findings in the study. In the analysis of the data obtained, non-parametric statistical methods were used because the variables were ordered or categorical and the continuous variables did not show a normal distribution. In this context, the Mann-Whitney U Test was used to compare the groups with HV and without HV. Spearman’s Rho correlation was used to examine the relationship between variables (HVA, Balance test results, HRQoL results). Significance level was evaluated as p<0.05 in all analyses.

Results

Group 1 consisted of 31 participants and group 2 consisted of 24. All participants were female. Mean age was 11.6 (8-16) years in group 1 and 12.2 (8-16 years old) in group 2. Mean first metatarsophalangeal angle was 13.4° (10°-15°) in group 2, and 19.8° (16°-25°) in HV group (p<0.05). Demographic data are summarized in Table 1. There were no significant differences between the groups in terms of age, weight, height, ballet training times per week, daily ballet training times, and attendance to curriculum (p >0.05).

The goal of our work was to find out the effect of HV angle on balance parameters of adolescent ballet dancers. According to the non-parametric Mann Whitney U test analysis, which was used to analyze the difference between groups with and without HV diagnosis, a
statistically significant difference was found between the groups in terms of mean HV angle (p<0.05). The relationship between the hallux valgus angle and the static balance test and HRQOL independent variables was investigated with the Spearman Rho correlation test. According to Spearman Rho correlation analysis there was a significant, positive and intermediate relation between HV angle and Flamingo static balance test (correlation coefficient (r) =0.552 and p=0.019). HV angle and other balance tests did not show a statistically significant relationship. Further analysis showed that Flamingo static balance test improved with older age in both groups (p =0.001).

We used the Short form 36 (SF 36) subdomains (general health, physical function and pain) and AOFAS forefoot score for evaluating the association of HV angle and health related quality of life. Mean SF 36 physical function score was 92.5 (between 75 and 100) in G1 and 91.04 (between 75 and 100) in G2 ; mean SF36 general health score was 78.5 (between 45 and 100) in G1 and 77.5 in G2 (between 45-100); SF36 pain subdomain score was 87.58 (between 57.5 and 100) in G1 and 87.18 (57.5-100) in G2. Mean AOFAS score was 86.74 (between 72 and 93) in G1 and 89.9 (between 73 and 100) in G2 (Figure 3).

Discussion
The aim of this study was to investigate the relationship between hallux valgus angle and clinical balance tests in adolescent ballet dancers, and analyze the effects of hallux valgus angle
on health related quality of life (HRQOL) questionnaires. We hypothesized that as the hallux valgus angle increases, it negatively affects balance parameters in both static and dynamic balance tests and causes impairment in HRQOL scores in adolescent ballet dancers. According to our correlation analysis, it was found that Flamingo Static test results were negatively affected by the increase in HV angle. Health related quality of life questionnaires were not affected by increased HV angle.

Studies conducted to date have revealed a negative relationship between an increase in the hallux valgus angle and balance, especially in elderly people and patients with rheumatoid arthritis. The negative effect of hallux valgus on balance has been found to be associated with a high risk of falls and serious complications such as head trauma. (5,6) Recently Medeni et al. reported that mild hallux valgus angle resulted in postural stability impairment in asymptomatic adult subjects. (1) Ballet dance is a high-level art sport that needs good musculoskeletal organization with components of balance, high performance and good joint compatibility. Various conditions causing altered anatomy and biomechanics affect the balance and performance of dancers, respectively. (19) According to the results of our study, the increase in HV angle leads to deterioration of static balance in adolescent ballet dancers. In ballet, where balance function must be provided very well, balance dysfunction may lead to postural sway and various injuries.
In previous reports, hallux valgus angle (HVA) degree has been shown to be related to impaired postural stability. Menz et al. found that moderate or severe HVA affected the maximum balance range and walking speed. (6) Nix and colleagues found that moderate HVA (mean ±SD=29.1±7.8) affected coronal plane dynamics at standup position (20). This study is the first to show that mild HVA (15° - 25°) is related to static balance impairment in adolescent ballet dancers (Spearman Rho correlation analysis with a correlation coefficient r=0.552 and p=0.019). We could not find a relationship between dynamic balance parameters and mild HVA (p>0.05). Higher degrees of HVA may be related to impaired dynamic balance parameters (21).

In previous studies, hallux valgus has been shown to have a negative effect on HRQoL scales. (17) The reason for investigating HRQoL scales in our special patient group is the fact that it affects the future plans of ballet dancers according to HV treatment. Ballet dancers who have undergone surgical treatment cannot return to ballet. We tried to investigate the daily lives of dancers and effect on dance performances, using HRQoL. The results of our study showed that there was no significant correlation between the sub-headings of the AOFAS and SF36 scales used to determine the functional status of the cases, and the HV angle obtained by using the clinical measurement method.

Recent studies have focused on various methods such as 3D computerized and stabilometric analysis while investigating the relationship between balance and different ballet dance movements. (22-26). In our study we used the flamingo test and the star excursion
balance test (SEBT) for our participants. Reliability of the tests were confirmed with the literature (9,13,14). Similar to other studies, we found that balance measurements could be performed without need for any additional infrastructure and cost, and they were useful in groups with high participant numbers.

The question whether ballet dancers are more prone to the development of hallux valgus than the normal population remains unanswered. Some dance techniques may promote the development of HV. Einarsdottir et al. retrospectively compared the radiographs of 63 active and 38 retired ballet dancers of both sexes with non-dancers, and found no significant difference between the groups in terms of hallux valgus angle.(27) On the other hand, a higher prevalence of hallux valgus was found in retired ballet dancers compared to non-dancer controls aged 50 to 70 (23-25). Adolescent hallux valgus is mostly a maternally transmitted condition (86-94%). (2) Based on above mentioned points ( age, sex and ballet activity ) ballet dance and hallux valgus relationship during adolescence becomes more complicated. The relationship between hallux valgus and gender, and maternal transition could not be evaluated in our study since the students studying in ballet school were female and their mothers were not evaluated.

In our study, we tried to reveal the effects of a specific disease group in a specific population, but there are numerous limitations. First, the study and control groups are small. It is difficult to find enough subjects in countries where ballet education is not very popular. The
second limitation in our study is that the diagnosis of HV in patients was made clinically, not radiologically. We benefited from the method proven to be effective in the literature, without exposing the patients to radiation for a prospective screening study. Finally, the effect of the training method on the results can be eliminated and more generalized conclusions can be drawn on adolescent ballet dancers by performing studies which involve a greater number of participants from different dance schools that provide training with different curricula.

Conclusion

Hallux valgus is a condition that occurs in adolescence and is often thought to be associated with maternal transmission. It can cause adverse effects on balance during ballet dance, and lead to complications during ballet movements. Conservative treatment methods should be preferred, as it will not be possible to perform active ballet after surgical treatment. This work shows the first evidence that the degree of hallux valgus affects static balance in adolescent ballet dancers. According to our results, ballet dancers and their trainers should be careful for injuries that may be caused by the negative effect of hallux valgus on static balance in ballet dancers.
Acknowledgement: We want to thank to teachers and Professional ballet candidates of TC MEB Beyaz Kugu Ballet Dancer and Music School for voluntary participation and completing tests in a very short time for this work.

Financial Disclosure: None reported.

Conflict of Interest: None reported.

References

https://doi.org/10.3233/BMR-150606


4-Chell J, Dhar S. Pediatric Hallux Valgus. Foot Ankle Clin N Am 19 (2014) 235-243
https://doi.org/ 10.1016/j.fcl.2014.02.007


23-Hopper LS, Sato N, Weidemann AL. Single-leg squats can predict leg alignment in dancers

https://doi.org/10.2147/OAJSM.S119388 PMID: 2789551R


https://doi.org/10.12678/1089-313X.18.2.86.


https://doi.org/10.1177/036354659502300307.
Table 1: Descriptive analysis of participants (N: number of participants; X: arithmetic mean; S refers to the standard deviation of a sample; S^2 refers to the variance of a sample)

<table>
<thead>
<tr>
<th></th>
<th>Age (Years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>HV (°)</th>
<th>AOFAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>X</td>
<td>11.8909</td>
<td>149.9636</td>
<td>55.6727</td>
<td>246.9636</td>
<td>17.0545</td>
<td>88.1455</td>
</tr>
<tr>
<td>Median</td>
<td>12.0000</td>
<td>154.0000</td>
<td>42.0000</td>
<td>181.0000</td>
<td>17.0000</td>
<td>90.0000</td>
</tr>
<tr>
<td>Mod</td>
<td>11.00</td>
<td>160.00</td>
<td>42.00</td>
<td>184.00</td>
<td>20.00</td>
<td>93.00</td>
</tr>
<tr>
<td>S</td>
<td>2.70577</td>
<td>15.18401</td>
<td>75.25612</td>
<td>378.76881</td>
<td>3.89405</td>
<td>7.45708</td>
</tr>
<tr>
<td>S^2</td>
<td>7.321</td>
<td>230.554</td>
<td>5663.484</td>
<td>143465.813</td>
<td>15.164</td>
<td>55.608</td>
</tr>
<tr>
<td>Min</td>
<td>8.00</td>
<td>121.00</td>
<td>22.00</td>
<td>15.00</td>
<td>10.00</td>
<td>72.00</td>
</tr>
<tr>
<td>Max</td>
<td>16.00</td>
<td>172.00</td>
<td>515.00</td>
<td>1950.00</td>
<td>25.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Figure 1: Clinical measurement of hallux valgus angle. Measurement was performed with the participant in the erect position; the fixed arm of the toe goniometer was placed on the longitudinal line of metatarsal bone and other arm placed on the hallux.
This Original Article has been reviewed, accepted for publication, and approved by the author. It has not been copyedited, proofread, or typeset and is not a final version.

Figure 2: Flamingo static balance test on wooden block. In this test the participant is standing on his/her preferred foot, bends his/her leg backwards and grips the back of the foot with hand on the same side, standing like a flamingo.
Figure 3: Diagram is showing health related quality of life and hallux valgus in adolescent ballet dancers. p > 0.05 was in overall subdomains of SF36 and AOFAS. (Group 1: Hallux valgus angle >15°; Group 2: Hallux Valgus angle ≤15° SF36: Short Form 36; PF: Physical Function; P: Pain; GH: General Health; AOFAS: American Foot & Ankle Association Forefoot Score)