

# Factors Associated with Japanese College Students' Foot Condition by Carried Objects: The Second Report

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## Abstract

**Background:** The sole is the foundation not only for body support and the center of gravity transfer but also for sensing stimuli from the floor surface and controlling posture.

Therefore, the purpose of this study was to develop a posture control system using items to be carried in order to investigate the effects of items to be carried on the standing balance and the condition of the plantar surface of college students.

**Method:** The methodology was as follows: undergraduate medical students from University A were included in the study. The survey was administered as a self-administered questionnaire using Google Forms, and foot measurements were taken by FootLook, Inc. The survey items included age, BMI, nail and foot symptoms, type of personal effects, weight of personal effects, shoes usually worn. The angles of the big and small toes were measured from the sole of the foot, the hallux valgus, bunionette and ground contact area was evaluated. The condition of the sole with and without carrying objects were compared.

**Results:** There were a total of 123 participants. The average weight of their personal belongings was 5 kg, and 60% of them carried a backpack. Sneakers were the most common footwear (80%). The incidence of floating toes and hallux valgus decreased when the participants stopped carrying luggage, and there was no change in the incidence of bunionette in 70% of the participants.

**Conclusion:** There were changes in the number of floating toes and the incidence of hallux valgus among college students due to their belongings.

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## Background

The foot (sole) is the only part of the body that is in contact with the ground and is deeply involved in weight bearing, balance maintenance, and mobility. The toes play a particularly important role in maintaining a standing position at rest, in times of disturbance, and in kicking during movement [1]. The sole is the foundation not only for body support and movement of the center of gravity but also for sensing stimuli from the floor surface and controlling posture. The foot is generally considered a single functional unit that includes the foot (forefoot, midfoot, and hindfoot) and ankle joints; the function of the forefoot, in particular, is extremely important [2]. One of the problems with the forefoot is "floating toes," in which the toes do not touch the floor and weight is not transferred to the toes when walking [3]. It has been reported that the ground contact area of the plantar foot is affected by the presence or absence of a floating toe and that the presence of a floating toe tends to cause instability in the standing posture [4]. In a previous study on the foot, it was reported that nearly 70% of women in their 20s had foot problems [5]. The angle of the hallux valgus, which is associated with the risk of falling, was measured in university students and was found to be related to shoe type; however, no significant relationship was found [6]. In a survey on nail problems and foot care among college students, 80% of the women and 50% of the men had foot symptoms such as coldness or foot lesions; those with foot lesions were more likely to practice foot care [7]. College students are likely to develop certain foot problems; however, it is unclear how these problems affect their daily activities. To date, few studies have examined the relationship between foot conditions and daily backpacking in youth. Therefore, in this study, we examined the relationship between the actual condition of college students' feet and the objects they carry in their backpacks daily.

## Materials and Methods

### Research period

This survey was conducted in two phases due to COVID-19.

Phase 1: October 14-29, 2021

Phase 2: April 11- 28, 2023

### Participants

A total of 648 students (248 in the first phase and 400 in the second phase) in the first through fourth years of medical nursing school at University A, in Japan, participated in this study. Students who were willing to cooperate in the survey were selected via a campus-only simultaneous e-mail, and students who overlapped between first- and second-term students were excluded.

### Participants

This is a cross-sectional observational study.

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## Survey procedure

The survey schedule was announced via internal mail and interested participants were recruited. On the day of the survey, the participants were asked to respond to questions about their attributes, footwear, and subjective symptoms of foot conditions, using Google Forms. The sole was measured using a FootLook® footwear device. The measurement method consisted of standing barefoot in line with the display on the FootLook®, looking straight ahead, stepping forward several times, and measuring the plantar area after confirming the stability of the posture. The measurement required approximately 20 seconds of standing still on the FootLook®. The plantar conditions were measured twice: once without the backpack and once with the backpack.

## Survey items

Participants were asked about their age, gender, height, weight, commuting time to school, whether they had a part-time job, presence and duration of the part-time job, prevalence of foot conditions, usual footwear, and weight of their personal belongings. The items checked after measuring the plantar surface of the foot using FootLook® were: the number of floating toes, hallux valgus angle, bunionette angle, foot pressure status, and ground contact area (%). The hallux valgus angle is used to determine hallux valgus; in this study, a hallux valgus angle of 20° or more was defined as hallux valgus with reference to the criteria of the Japanese Orthopaedic Association Guidelines [8] and a fifth toe of 10.1 or more was considered a bunionette [9].

## Analysis method

Body mass index (BMI) was calculated based on age, height, weight, and height and weight attributes, whereas type of shoes, time to commute to and from school, part-time work, presence and nature of foot symptoms, and weight of personal belongings were simply tabulated. For the sole condition, the number of floating toes, angles of the hallux valgus and bunionette, and percentage of foot pressure distribution were calculated. After checking the normality of the number of floating toes, angles of the hallux valgus and bunionette, and ground contact area with and without luggage, the foot pressure distribution was compared in percentages using a corresponding t-test.

## Ethical approval and informed consent

The purpose and contents of the study were explained orally and in writing to the participants by the researcher. It was clarified that they would not be disadvantaged if they did not respond, they could discontinue the study at any point, their results would not be reflected in the study results, individuals would not be identified, and the content and results of the study would be publicized. The researcher explained that the results would not reflect, that their participation is voluntary and not mandatory, and that consent would be deemed to have been obtained upon receipt of the Google Forms. This study was conducted after obtaining approval from the Nagasaki Prefectural University Research Ethics Review Committee to which the researcher belongs (approval number: 486).

## Results

### Phase 1

Of the 248 eligible respondents, 87 responded (response rate: 35.1%). Of these, 85 were excluded because two were absent on the day of the survey (valid response rate: 98.0%).

### Phase 2

Of the 400 participants, 51 responded (response rate: 12.7%). Of these, 38 were included in the sample (valid response rate: 74.5%), excluding 13 students who were duplicates in the first phase.

In the sample design, we aimed for 199 students by obtaining an effect size of 0.20, a significance level of 0.05, and a power of 0.8; however, we targeted a total of 123 students [10].

## Participant characteristics

The mean age of participants was 19.7 years (SD=1.4), with a mean BMI of 20.3. Of these, 116 (94.3%) were female and 7 (5.7%) were male, with a mean BMI of 20.3 (SD=2.6). The average time spent commuting to and from college was 37.7 min (SD=32.9 min), 91 (74.0%) had part-time jobs, and the average time spent on weekdays was 5.3 hours (SD=24.0 hours) and on weekends was 4.4 hours (SD=3.3 hours). The average weight of personal belongings was 5310.6 g (SD=1995.5 g). Sneakers were the most common type of daily footwear regardless of the presence or absence of foot symptoms (Table 1). In all, 58 (47.2%) of the 123 patients had foot symptoms: 43 (21.3% of 47.2%) had foot symptoms such as cold feet and pain, 8 (13.8% of 47.2%) had ingrown nails, and 7 (12.1% of 47.2%) had both ingrown toenails and tired foot problems (Table 2).

|   |                              | Mean   | SD     |
|---|------------------------------|--------|--------|
| Age (years)   |                              | 19.7   | 1.4    |
| Height (cm)   |                              | 159.3  | 5.5    |
| Bodyweight (kg)                                     |                              | 51.6   | 8.2    |
| BMI   |                              | 20.3   | 2.6    |
| Weight of objects (g)                               |                              | 5310.6 | 1995.5 |
| One-way commuting time to college (minutes)         |                              | 37.7   | 32.9   |
| Average hours of part-time work on weekdays (hours) |                              | 5.3    | 24.0   |
| Average hours worked part-time on holidays (hours)  |                              | 4.4    | 3.3    |
|   |                              | n      | %      |
| Gender  | Female                       | 116    | 94.3   |
|   | Male                         | 7      | 5.7    |
| Commuting   | Bus/train                    | 62     | 50.4   |
|   | Private car/motorbike        | 21     | 17.1   |
|   | Walking                      | 40     | 32.5   |
| Part-time job                                       | Yes                          | 91     | 74.0   |
|   | No                           | 32     | 26.0   |
| Daily footwear                                      | Sneakers                     | 104    | 84.6   |
|   | Ballet shoes/flat shoes      | 11     | 8.9    |
|   | Sandals (without heel strap) | 5      | 4.1    |
|   | Sandals with heels           | 3      | 2.4    |
| Carried objects                                     | Backpack                     | 89     | 63.1   |
|   | Tote-bag                     | 49     | 34.8   |
|   | Hand-held bag                | 3      | 2.1    |
| Difference which one when carried tote-bag          | Right shoulder               | 28     | 57.1   |
|   | Left shoulder                | 21     | 42.9   |

Table 1: Characteristics of the participants.

|                       | Part        | Symptoms                     | n   | %     |
|-----------------------|-------------|------------------------------|-----|-------|
| Symptoms in the foets | Nails       | Ingrown nails                | 6   |       |
|                       |             | Pncer nails                  | 1   | 13.8  |
|                       |             | Pncer nails, Ingrown nails   | 1   |       |
|                       | Foets       | Cold feet                    | 22  |       |
|                       |             | Tired feet                   | 12  |       |
|                       |             | Cold feet/Tired feet         | 5   | 21.3  |
|                       |             | Feet pain/Foot tiredness     | 2   |       |
|                       |             | Swollen feet                 | 2   |       |
|                       | Nails Foets | Ingrown toenails, tired foot | 7   | 12.1  |
|                       | subtotal    |                              | 58  | 47.2  |
| No foot symptoms      |             |                              | 65  | 52.8  |
| total                 |             |                              | 123 | 100.0 |

Table 2: Symptoms of nails and foets.

### Comparison of the number of floating toes, hallux valgus angle, bunionette angle, and ground contact area by carried objects

The left-right difference in the number of floating toes due to the transported objects was higher only in the right foot when there was no transported object in the right foot ( $p < 0.05$ ). There were no significant differences in the hallux valgus angle, bunionette angle, or ground contact area between the right and left feet. Regarding the angle of the hallux valgus of the right foot due to a carried object, 8.1% of those who held their toes without a carrying object and 5.7% of those who held their toes while holding a carrying object had a hallux valgus. Regarding the angle of the hallux valgus of the left foot due to a carried object, 4.1% of those who held their toes without a carrying object and 2.4% of those who held their toes while holding a carrying object had a hallux valgus. Both feet taken together, with and without carried objects, such as luggage, had a low percentage of hallux valgus (less than 8%) (Table 3).

|                                   |                                     | Mean | SD   | "95 % Interval" Confidence |               | t-value | p - value |
|-----------------------------------|-------------------------------------|------|------|----------------------------|---------------|---------|-----------|
|                                   |                                     |      |      | "Lower bound"              | "Upper bound" |         |           |
| floating toes (right)             | "( n = 123 ) non - carried objects" | 2.6  | 1.9  | 0.103                      | 0.504         | 2.991   | 0.003     |
|                                   | "carried objects ( n = 123 )"       | 2.3  | 1.8  |                            |               |         |           |
| floating toes (left)              | "( n = 123 ) non - carried objects" | 2.5  | 1.8  | -0.243                     | 0.194         | -0.221  | 0.826     |
|                                   | "carried objects ( n = 123 )"       | 2.6  | 1.8  |                            |               |         |           |
| "hallux valgus angle (°)" (right) | "non - carried objects ( n = 123 )" | 10.4 | 5.2  | -0.8405                    | 0.6356        | -0.275  | 0.784     |
|                                   | "carried objects ( n = 123 )"       | 10.5 | 4.8  |                            |               |         |           |
| hallux valgus angle (°) (left)    | "non - carried objects ( n = 123 )" | 9.2  | 4.6  | -0.6309                    | 0.3838        | -0.482  | 0.631     |
|                                   | "carried objects ( n = 123 )"       | 9.3  | 4.4  |                            |               |         |           |
| buninette angle(°) (right)        | "non - carried objects ( n = 123 )" | 12.8 | 4.8  | -0.1949                    | 0.9558        | 1.309   | 0.193     |
|                                   | "carried objects ( n = 123 )"       | 12.4 | 4.9  |                            |               |         |           |
| buninette angle(°) (left)         | "( n = 123 ) non - carried objects" | 12.8 | 4.7  | -0.6846                    | 0.4212        | -0.472  | 0.638     |
|                                   | "carried objects ( n = 123 )"       | 12.9 | 4.8  |                            |               |         |           |
| "ground contact area (%)" (right) | "non - carried objects ( n = 123 )" | 59.5 | 9.4  | -0.9976                    | 0.6220        | -0.459  | 0.647     |
|                                   | "carried objects ( n = 123 )"       | 59.7 | 9.4  |                            |               |         |           |
| "ground contact area (%)" (left)  | "non - carried objects ( n = 123 )" | 59.5 | 9.5  | -0.8454                    | 1.1218        | 0.278   | 0.781     |
|                                   | "carried objects ( n = 123 )"       | 59.4 | 10.0 |                            |               |         |           |

Table 3: Comparison of the number of floting toes, hallux valgus angle, buninette angle, and ground contact area by carried objects. unpaired t-test

### Comparison of hallux valgus and bunionette by carried objects

In cases of right hallux valgus, 8.1% of the participants did not carry objects and 5.7% carried objects. For the left hallux valgus, 4.1% of participants did not carry objects and 2.4% carried objects. Both left and right hallux valgus decreased when the objects were carried. In cases of right bunionette, 73.2% of the participants did not carry objects, and 69.1% carried objects. In cases of left bunionette, 75.6% of the participants did not carry objects and 75.6% carried objects (Table 4).

|                                 |                     | n   | %    |
|---------------------------------|---------------------|-----|------|
| non - carried objects ( right ) | non - hallux valgus | 113 | 91.9 |
|                                 | hallux valgus       | 10  | 8.1  |
| non - carried objects ( left )  | non - hallux valgus | 118 | 95.9 |
|                                 | hallux valgus       | 5   | 4.1  |
| carried objects ( right )       | non - hallux valgus | 116 | 94.3 |
|                                 | hallux valgus       | 7   | 5.7  |
| carried objects ( left )        | non - hallux valgus | 120 | 97.6 |
|                                 | hallux valgus       | 3   | 2.4  |
| non - carried objects ( right ) | non - buninette     | 33  | 26.8 |
|                                 | buninette           | 90  | 73.2 |
| non - carried objects ( left )  | non - buninette     | 30  | 24.4 |
|                                 | buninette           | 93  | 75.6 |
| carried objects ( right )       | non - buninette     | 38  | 30.9 |
|                                 | buninette           | 85  | 69.1 |
| carried objects ( left )        | non - buninette     | 29  | 23.6 |
|                                 | buninette           | 93  | 75.6 |

The hallux valgus angle was 20 degrees or more, and the non-hallux valgus angle was less than 20 degrees. The buninette angle was 10.1 degrees or more, and the non - buninette angle was less than 10 degrees.

Table 4: Comparison of hallux valgus and bunionettes by carried objects.

### Discussion

This study aimed to examine the relationship between the actual condition of college students' feet and the objects they carry daily. The participants were mostly female university students with an average age of approximately 20 years and an average BMI of 20.1, that is, normal weight and standard. The average time students spent commuting to and from the university was approximately 40 minutes and the average time spent working part-time was 5.3 hours on weekdays, suggesting that there were individual differences. No differences were found according to nail or foot symptoms. Most students wore sneakers as daily footwear, and more than 60% carried backpacks. Studies have reported that female university students are aware that sneakers are the most comfortable and preferred footwear when they need to be worn for a long period than other footwear types [11]. Since the average weight of the items carried by student participants daily in this study was more than 5 kg, it was inferred that students might have preferred sneakers as comfortable footwear for walking while carrying heavy loads.

Regarding the effect of carried objects on the plantar surface, the number of right toes that floated was higher when the students were not carrying objects, and no change was observed in the hallux valgus angle, bunionette angle, or ground contact area. The percentage of the big toe was more on the right foot when there was no carrier and also more on the right foot when there were carried objects. This result is higher than the 3.5% reported in a previous study [12]; however,

the comparison is limited because the standard for determining hallux valgus was not based on the hallux valgus angle. In a survey of nursing students, 6.1% of the participants had hallux valgus of 20° or more [13], while in the present study, it was about 2-8%, despite the differences in left-right feet and luggage holding. The average angle of hallux valgus was 14.0°, which was larger than the average of 12.4-12.8° in the present study. Therefore, it is difficult to conclude that the participants in this study had a higher hallux valgus.

In this study, approximately 30% of the participants carried a tote bag, and approximately 60% lowered the bag to the right shoulder. A previous study [5] reported that when a bag other than a backpack was worn on one shoulder, the shoulder of the person wearing the bag was raised; when the bag was worn on one arm, the shoulder of the person wearing the bag was lowered; the longer the bag is carried, the greater the difference in shoulder inclination. When the backpack was carried on both shoulders, the trunk was straight from the head, indicating the usual method of carrying the bag and others. The authors reported that the weight of the bag influences the posture. Furthermore, it is not clear whether the sloping of the shoulders affects the soles of the feet, but it is possible that a breakdown in the basic posture may affect the soles of the feet. In the present study, because approximately 60% of the participants carried backpacks, it was assumed that they maintained their basic posture and did not change their plantar positions. A report [14] that examined the center of gravity of female university students in two categories, one in front of the feet and the other at the back of the feet (21.3% and 58.2 %, respectively), pointed out that many of them had their center of gravity at the back of their feet. In this study, there was no difference in the ground contact area where foot pressure was applied while holding an object, but the hindfoot and midfoot (lateral) areas had the most foot pressure, suggesting that the center of gravity may be in the hindfoot or midfoot (lateral) area.

### Conclusion

The effects of holding different kinds of personal belongings on the plantar feet of college students were observed in terms of the number of floating toes and incidence of hallux valgus. In light of the fact that the weight of the luggage carried by college students affects their plantar feet to some extent, we believe that this will lead to awareness regarding self-care of one's feet and how to appropriately carry luggage.

We reported these results at the 68th and 69th Annual Meetings of the Japanese Association of School Health as part of this study.

### Competing Interests

The authors declare that they have no competing interests.

### Author Contributions

Study conceptualization and design: Narumi Ooshige, Sachiko Nitta, Hitomi Sakamoto, Tae Yamaguchi, and Takuro Tobina.

Data collection: Narumi Ooshige, Sachiko Nitta, Hitomi Sakamoto, Tae Yamaguchi, and Takuro Tobina.

Supervision: Narumi Ooshige.

Original draft: Narumi Ooshige, Sachiko Nitta, Hitomi Sakamoto, Tae Yamaguchi, and Takuro Tobina.

Critical revisions & editing: Narumi Ooshige, Sachiko Nitta, Hitomi Sakamoto, Tae Yamaguchi, and Takuro Tobina.

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