# ANKLE ANGLE CONTRIBUTE TO SLIP DURING FOOD PRODUCTION ACTIVITY

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***ABSTRACT***: *Working at the food production environment poses a potential hazard for a slip accident. Prolonged standing working posture reflects human balance issues. Therefore, this study investigated the ankle angle during food production activity to justify the potential of slip during the activity and correlate between the walking steps and slip incident. Vicon motion capture was used to record movements and Vicon Nexus software was used to analyze data. Six male and six female healthy adults aged between 20 years old to 60 years old with a minimum of 3 years on food production activity experience participated in this study. Participants were to walk with four different steps and carry the load upper limb part on flooring with water and oil as a contaminant. The results yielded slip occurred more often when oil acted as a contaminant especially for overweight and obese participants. There was no correlation between carrying load and Body Mass Index (BMI). The longer walking step also created the occurrence of slip. Therefore, walking with longer step in limited time produce slip to participant especially to overweight and obesity.*

**Index Terms:** About four key words or phrases in alphabetical order, separated by commas.

## I. INTRODUCTION

The food production sector is an important industry contributor in Malaysia in providing a variety of special needs for food preparation. Normally, workers work 8 hours per day to complete a food production task in a standing position which might contribute to pain in the knee, lower leg and ankle and finally lead to fatigue [1]. This scenario indicates that workers are exposed to various hazards [2]–[4], static and dynamics posture [5]. Dealing with slippery floors, dirt, working stances at food production workstation [6] potentially results in injury to employees [7]–[9]. A study [10] stressed that the food production environment contributes mostly to slip and fall incidents. Accordingly, slipping is categorized as an accident that occurs when one is losing one's body control on the lower part of the body resulting from the lost interaction between floor and foot [11]–[13]. Fig. 1 shows the slip appearance. Walking style is a relevant study of biomechanical analysis. Some studies [14], [15] found that parameters such as heel strike, ankle angle and heel velocity need to be given priority.

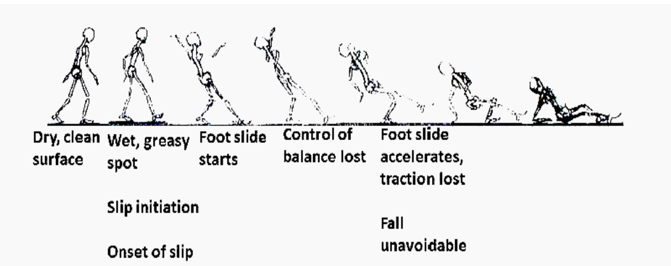


**Figure 1: Slip Appearance [16]**

Fig. 2 depicted that slipping is in all probability either at starting ground contact when just the back of the shoe, (for example, the heel) is included or near toe-off when just the sole has contact [17]. There are three different phases of the walking movement such as:

- **Heel strike:** when heel contacts the ground,
- **Mid-stance:** when the bodyweight is centered over the foot,
- **Toe off:** when up on the ball of your foot ready to push off with your toes before taking the next step,
- **Swing through:** which is just like it sounds, when your weight is on the other foot, and the foot that just pushes off the toe as the foot is swinging through to start again with heel strike.


**Figure 2: Three phases of normal gait (http://drwolgin.com/hallus-rigidus/)**

The aim of this study was to investigate the ankle angle during food production activity to justify the potential of slip during the activity and correlate walking step with slip incident.

## II. METHOD

Twelve healthy (6 male, 6 female) adults with a minimum of 3 years of food production activity experience (age 32 ± 11 years, BMI: 27.82 ± 4.01 kg/m$^2$, mean ± SD) participated in this study. The subjects were fully informed of the procedures to be utilized as well as the purpose of this study. Written informed consent was obtained from all subjects. Upon agreement, markers were placed on the lower limb at 5 specific locations as shown in Fig. 3. Vicon motion capture was used to record participants' movement and ankle angle data were analyzed. By using Vicon Nexus software, 3D coordinate could be detected and calculated through a built-in linkage system [18], [19]. Thus, the researcher can see the graph movement of the subject during the entire experiment. All active physical participants were to walk on the floor surfaces with water and oil as contaminants. Participants walked in four different speeds [20], [21] and carry loads. Table 1 shows the 24 requirements for run experiment testing.

**Table 1: Experiment run testing**

| Age | Gender | Step | Load (kg) | Contaminant | Testing |
|---|---|---|---|---|---|
| 20 - 30 years and 31 – 60 years | Male and Female | Step 1: 84 step/minute | 1, 3, 5 | Water | T1, T2, T3 |
| | | | | Oil | T4, T5, T6 |
| | | Step 2: 100 step/minute | | Water | T7, T8, T9 |
| | | | | Oil | T10, T11, T12 |
| | | Step 3: 116 step/minute | | Water | T13, T14, T15 |
| | | | | Oil | T16, T17, T18 |
| | | Step 4: 132 step/minute | | Water | T19, T20, T21 |
| | | | | Oil | T22, T23, T24 |

N = Normal, OV = Overweight, OB = Obesity, A = 20 - 30 years old, B = 31 – 60 years old

**Figure 3: Ankle angle marker position**

## RESULT AND DISCUSSION

Table 2 (a) and Table 2 (b) summarizes the appearance of slip according to the selected parameter. The higher slip incidents occurred for those with high BMI in the range of overweight and obese, especially when using oil as a contaminant for both groups aged 20 – 30 years old and 31 - 60 years old. However, less slip occurred when water was used as contaminant. Step of walking was also observed as a risky parameter in contributing a slip. The higher walking step resulted in more occurrence of slip especially among the aged participants [21].

**Table 2(a): Slip appearance according to parameter for Male**

| Male | | WATER | | | OIL | | |
|---|---|---|---|---|---|---|---|
| | | 1KG | 3KG | 5KG | 1KG | 3KG | 5KG |
| **84** | **A** | | | | | | OV |
| | **B** | | | | OV,OB | OB | OB |
| **100** | **A** | | | | OB | OV | |
| | **B** | OB | | | | | |
| **116** | **A** | | | | OV,OB | | |
| | **B** | | | | | | |
| **132** | **A** | | | | OB | OV,OB | OV |
| | **B** | | N | | OV,OB | OB | OB |

N = Normal, OV = Overweight, OB = Obesity,
A = 20 - 30 years old, B = 31 – 60 years old

**Table 2(b): Slip appearance according to parameter for Female**

| Female | | WATER | | | OIL | | |
|---|---|---|---|---|---|---|---|
| | | 1KG | 3KG | 5KG | 1KG | 3KG | 5KG |
| **84** | **A** | | | | OB | OB | OV,OB |
| | **B** | | | | OB | OB | OV,OB |
| **100** | **A** | | | | OB | OB | OB |
| | **B** | | | | OV,OB | OV,OB | OB |
| **116** | **A** | | | | OB | OB | OB |
| | **B** | | | | OB | OB | OB |
| **132** | **A** | | | | OV,OB | OB | OB |
| | **B** | | | | OB | OB | OV,OB |

Table 3 illustrates the findings for the ankle angle of plantar flexion and dorsiflexion for Male using oil as a contaminant. It was found that the ankle angle (º) for male participants aged 20 - 30 years old were between 26.2º to 39.9º dorsiflexion (DF) and between 57.9º to 63.5º plantar flexion (PF) and male participants aged between 31 - 60 years old were between 33.2º to 43.7º dorsiflexion (DF) and between 55.5º to 62.4º plantar flexion (PF). Fig. 4 represents the slip accident for male using oil as a contaminant. There were no significant differences among both age groups. Nevertheless, both two age categories are found to be slipping for participants who have BMI category values overweight and obesity. This slipping incident is especially pronounced when running with steps 110, 116 and 132 steps and the highest the step of walking, was the riskiest steps compare to others' step level. According to [22], states that the current speed is causing high heel contact speed and this condition makes slips danger to human. Meanwhile [23] concurred that expansion the higher walking speed runs it increment slipping hazard due to rush.

Table 4 depicts the ankle angle of plantar flexion and dorsiflexion for female using oil as contaminant. The values of the dorsiflexion angle were between 33.5º to 42.8º and for plantar flexion angle was 57.9º to 63.5º for participants aged 20 - 30 years old. On the other hand, ankle angle for participants aged 31 - 60 years old were between 46.4º to 56º dorsiflexion (DF) and between 69º to 76.1º plantar flexion (PF). Fig. 5 shows the slip accident for female participants when using oil as contaminant. It is found that the frequency of slipping accidents among female participants with BMI obesity compares to BMI overweight. There was no significant slips identification among the aged group 20 - 30 years old and aged 31 - 60 years old. For walking steps, there was detected slips accidents for each step of the walking level and the frequency was more for participants in BMI obesity.

**able 3: Ankle angle of plantar flexion (PF) and dorsiflexion (DF) for Male- Oil**

| Male - Oil | | | 1 kg | | 3 kg | | 5 kg | |
|---|---|---|---|---|---|---|---|---|
| Age | BMI | Step/min | DF | PF | DF | PF | DF | PF |
| A | OV | 84 | | | | | 34.1 | 59.3 |
| | | 100 | | | 33.7 | 59.3 | | |
| | | 116 | 35.9 | 57.9 | | | | |
| | | 132 | | | 37.9 | 58.8 | 34.4 | 59.1 |
| | OB | 100 | 39.9 | 61.6 | | | | |
| | | 116 | 26.2 | 63.5 | | | | |
| | | 132 | 26.4 | 61.6 | 27.8 | 61.2 | | |
| B | OV | 84 | 39.4 | 58.2 | | | | |
| | | 132 | 38.6 | 55.5 | | | | |
| | OB | 84 | 33.2 | 59.8 | 36.1 | 61.1 | 39.9 | 63 |
| | | 132 | 41.2 | 62.4 | 35.4 | 62.3 | 43.7 | 63.1 |

N = Normal, OV = Overweight, OB = Obesity,
A = 20 - 30 years old, B = 31 – 60 years old

**Table 4: Ankle angle of plantar flexion (PF) and dorsiflexion (DF) for Female- Oil**

| Female - Oil | | | 1 kg | | 3 kg | | 5 kg | |
|---|---|---|---|---|---|---|---|---|
| Age | BMI | Step/ min | DF | PF | DF | PF | DF | PF |
| A | OV | 84 | | | | | 32.1 | 53.8 |
| | | 100 | | | | | | |
| | | 116 | | | | | | |
| | | 132 | 33.8 | 58.9 | | | | |
| | OB | 84 | 37.3 | 65.6 | 41.6 | 65.4 | 41.9 | 64 |
| | | 100 | 41.4 | 61.7 | 39.5 | 64.7 | 37.9 | 61.6 |
| | | 116 | 39 | 64.6 | 38.8 | 60.3 | 33.5 | 62.1 |
| | | 132 | 34.1 | 60.5 | 40.8 | 60.2 | 42.8 | 65.2 |
| B | OV | 84 | | | | | 53.8 | 75.6 |
| | | 100 | 53.2 | 76.1 | 52.4 | 74.8 | | |
| | | 116 | | | | | | |
| | | 132 | | | | | 56 | 74.2 |
| | OB | 84 | 46.4 | 69 | 50.9 | 75.5 | 48.3 | 73.2 |
| | | 100 | 49.5 | 72.8 | 49 | 73.5 | 48.8 | 72.4 |
| | | 116 | 49 | 71.4 | 49.9 | 73.3 | 49.3 | 72.6 |
| | | 132 | 48.5 | 71 | 47.9 | 73.5 | 47.6 | 72.3 |

N = Normal, OV = Overweight, OB = Obesity,
A = 20 - 30 years old, B = 31 – 60 years old

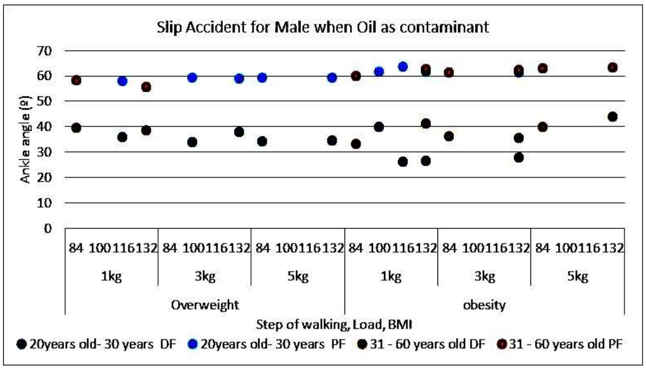


**Figure 4: Slip accident for male using oil as contaminant**

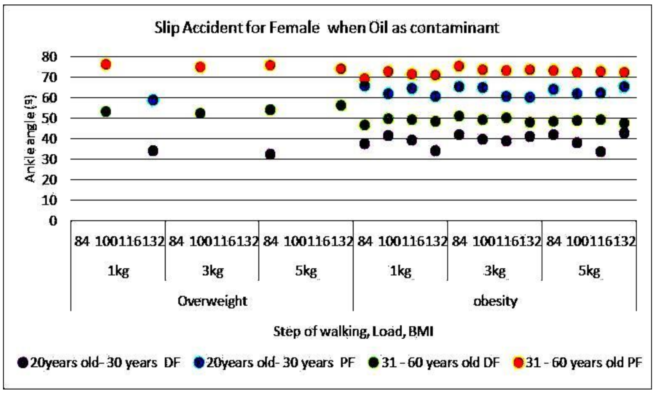


**Figure 5: Slip accident for female using oil as contaminant**

Fig. 6, below, represents two different positions of ankle angle during a motion known as plantar flexion (PF) and dorsiflexion (DF). Table 5 lists the normal Ankle Values for Range of Motion of Joints. According to the findings represent the higher range from the requirement for plantar flexion and dorsiflexion.

This finding is equivalent to the finding [24] ankle angle during walking gait phases from 80º to 120º, but contrary to standard value Range of Motion of Joints as represented in Table 2.6 that normal ankle angle for Plantar flexion was 0º-50º and Dorsiflexion was 0º -20º. However, according to [25] walking postures with a larger ankle plantar flexion at heel contact causes fatigue and this was seen as a dangerous slip signal. Hence, when workers work with unhealthy posture, an awkward ankle position [26] will be produced easily to create fatigue to the lower leg muscle [27].

The food production workplace was classified as hazard workplace [28] as most areas reported the presence of oil spills, especially when transfer cooking oil from the frying pan and oily floor surfaces resulting from the use of shoes moving around the workplace.

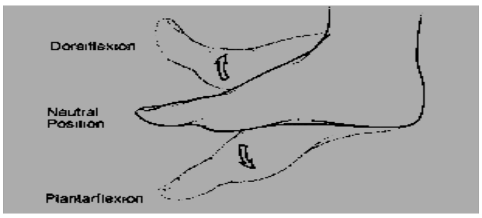


**Figure 6: Position of dorsiflexion and plantar flexion ankle (Source: https://realmovementpt.com/tt-improving-ankle-mobility/)**

**Table 5: Normal Ankle Values for Range of Motion of Joints**

| Motion | Range (°) |
|---|---|
| Plantar flexion | 0–50 |
| Dorsiflexion | 0–20 |

(Source: https://www.msdmanuals.com/professional/special-subjects/ rehabilitation/physical-therapy-pt)

## III. CONCLUSION

The findings of this research show that a slip occurs commonly when oil is used in testing as a contaminant, particularly for those with elevated BMI in the range of overweight and obese. There is no specific correlation between the parameter of the carrying load and the BMI. In terms of age, it is discovered that there is no distinction in the slipping case among younger and elder. Nevertheless, if slips happen among elders people will take time to recover compared to a younger age in terms of cell growth, internal strength, and spontaneous reactions in the event of an accident. Therefore, one's weight influences the incidence of slipping as it contributes to overweight or obesity. Furthermore, the walking step also affects the slipping event, so the quicker pace adds to the slipping event.

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