# ORIGINAL ARTICLE

# Ankle Angle Contribute to Slip During Commercial Kitchen Activity

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# ABSTRACT

**Introduction:** Working in a Commercial kitchen 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 Commercial kitchen activity to justify the potential of slip during the activity and correlate between the walking step and slip incident. **Method:** Vicon motion capture was used to record movements and Vicon Nexus software was used to analyze data. Six male and six female healthy adults with a minimum of three years of Commercial kitchen activity experience participated in this study. Participants have to walk at four different speeds and carry the load at the upper limb and flooring with water and oil as a contaminant. **Results:** The slip occurred frequently on the oily surfaces compared to water surfaces especially among overweight and obese participants. Ankle angle during slip occurrence was from  $97.2 \pm 6.7^{\circ}$  for male participants and  $112.5 \pm 12.7^{\circ}$  for female participants. **Conclusion:** The results presented that overweight and obese participants' significant slip occurred when walking on oily surfaces. There was no correlation between carrying load and Body Mass Index (BMI). The walking speed also significant with slip occurrence.

Keywords: Ankle angle, Slip, BMI, Commercial kitchen, Contaminant

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#### INTRODUCTION

The commercial kitchen sector is an important industry in Malaysia for providing a variety of special needs for food preparation. Normally, workers work eight hours per day to complete a commercial kitchen 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 Commercial kitchen workstation (6) potentially results in injury to employees (7-9). A study (10) stressed that the Commercial kitchen environment contributes mostly to slip and fall incidents. Accordingly, slipping is categorized as an accident that occurs when one is losing body control on the lower part of the body resulting from the lost interaction between floor and foot (11-13). Figure 1 shows the process of slip appearance. Walking with wet and greasy floor areas creates a hazard to anybody. Walking speed 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)

Figure 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 four different phases of the walking movement (Table I). 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 speed with slip incident.

#### MATERIALS AND METHODS

Twelve healthy (six male, six female) adults with a minimum of three years of food production activity experience (age  $32 \pm 11$  years, BMI:  $27.82 \pm 4.01$  kg/m2, mean  $\pm$  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



Toe needs to clear the floor.

Figure 2: Three phases of normal gait (18)

Table I: Phases of the walking mover	nent
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Heel strike	Mid-stance	Toe off	Swing through
when heel contacts the ground	when the body weight is centered over the foot	when up on the ball of your foot ready to push off with your toes before taking the next step	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.

were placed on the lower limb at five specific locations as shown in Figure 3. Vicon motion capture was used to record participants' movement and ankle angle data were analysed. By using Vicon Nexus software, 3D coordinates could be detected and calculated through a built-in linkage system (19-20). Thus, the researcher can see the graph movement of the subject during the entire experiment. The participant has to wear flat type rubber shoes during testing.

All active physical participants had to walk on the wet and oily flooring surface. Participants walked at four different walking speeds (21-22) from 84 steps/minute, 100 step/minute, 116 step/minute, and 132 steps/minute with carrying loads three different loads whereas 1kg, 3kg, and 5kg during testing. The requirements of the single run experiment testing (Table II).

Figure 3: Ankle angle marker position

Age: 20-30 years or Above 31 years Gender: Male/Female								
Walking speed	Walking speed 84 step/ minute		100 step/ minute		116 step/ minute		132 step/minute	
Load	1kg, 3kg,5kg		1kg, 3kg,5kg		1kg, 3kg,5kg		1kg, 3kg,5kg	
Contaminant	Water	Oil	Water	Oil	Water	Oil	Water	Oil

#### RESULTS

The slip occurrence among Male participants (Table III) aged above 30 years old on wet flooring, for BMI normal with walking speed 132 step/minute and obese participant with 100 steps/minute. The slip most occurred for those participants with BMI overweight and obese especially on the oily floor for both groups aged below than 30 years old and above. The participants faced slip for each walking speed from 84 steps/minute until 132 step/minute, however, walking speed 132 step/minute was the highest slip frequent occurrence. The ankle angle during slip appearance was from 88° to 114.7° with an ankle angle of 97.2  $\pm$  6.7°.

Table	III:	Slip	occurrence	among	Male	partici	pants

Load lifting					3 kg	5 kg
Floor condi- tion	Aged	ВМІ	Walking speed (step/min- ute)	Ankle angle (°)		
	> 30	Obesity	100	101.3		
WATER	years old	Normal	132		114.7	
			84			93.4
OIL	< 30 years old	Overweight	100		93	
			116	93.8		
			132		96.7	93.5
			100	101.5		
		Obesity	116	89.7		
			132	88	89	
		Overweight Obesity	84	97.6		
	> 30		132	94.1		
	years old		84	93	97.2	102.9
			132	103.6	97.7	106.8

The slip occurrence among Female participants (Table IV) in both groups aged below than 30 years old and above especially on oily flooring surface with walking speed from 84 steps/minute until to 132 step/minute. However, the slip most frequently occurred for those participants with BMI obese in both groups aged. The ankle angle during slip occurrence was from 85.9° to 129.4° with an ankle angle of 112.5  $\pm$  12.7°.

#### DISCUSSION

The result clearly shows that the participants with BMI overweight and obese were produced frequent slip occurrence compare to normal participants when walking on the oily surface. Walking with higher walking speed resulted in more occurrence of slip especially among the aged participants (22). Similar

 Table IV: Slip occurrence among Female participants

	Loa	ad lifting	1 kg	3 kg	5 kg		
Floor condi- tion	Aged	ВМІ	Walking speed (step/ minute)	Ankle angle (°)			
			84			85.9	
		Overweight	132	92.7			
OIL	< 30 years old	Obesity	84	102.9	107	105.9	
			100	103.1	104.2	99.5	
			116	103.6	99.1	95.6	
			132	94.6	101	108	
	> 30 years old	Overweight	84			129.4	
			100	129.3	127.2		
			132			130.2	
			84	115.4	126.4	121.5	
			100	122.3	122.5	121.2	
		Obesity	116	120.4	123.2	121.9	
			132	119.5	121.4	119.9	

finding from (23) that increasing the speed of walking will increasing the case of slipping especially walking on the contaminated floor. The relationship between the speed of walking-age will affected health problems especially psychological system (24-25). The pollution of footwear sole will increase three times potential to slip (26) meaning that the presence of oil interaction for the vinyl floor at food production produces lower COF (27). For ankle angle during slip occurrence, both participants produce  $97.2 \pm 6.7^{\circ}$  and  $112.5 \pm 12.7^{\circ}$  for male and female, respectively. The finding was similar to (28), whereby the ankle angle during a different phase of walking was from 80° to 120° for normal and healthy subjects. However, according to (29) finding highlighted that ankle angle dorsiflexion is between 12° and 22° during a normal gait and ankle angle for Plantar flexion between  $0^\circ$  to  $50^\circ$  and Dorsiflexion between  $0^\circ$  to  $20^\circ$ (30).

# CONCLUSION

The results of this study indicate a slip is significant with oily surface especially for those with BMI overweight and obese. There is no specific correlation between carrying load parameter and BMI. In terms of age, it is found that young and old age does not show any difference in the slipping occurrence. Hence, walking speed also significant in slipping incidents, the increasing walking speed will contribute to the frequency of slip occurrence.

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