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An Analysis of Slip Incidence for Ankle Angle and Muscle Fatigue During Walking Activities

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ABSTRACT

Human walking speed exposes the higher potential to slip accident especially walking on the oily surface. Prolong walking during working will develop fatigue to the leg and certain body part. In a certain industry, there was a need that worker had to walk and standing in prolong before reaching their break. The aim of this study was to analyze the ankle angle and the muscle fatigue during walking and influence in slip incident. The study involves twelve health participants aged from 23 to 57 years old with a mean of BMI was 27.82 ±4.01 kg/m^2. The procedure will be explained the detail when the participant agreed. Vicon motion capture was used to record movements and the Electromyography (EMG) was used to record muscle fatigue activity. The finding shows that the slip occurred frequently for overweight and obese participants. The female participant experience slips more than a male participant. The range of ankle angle during slip was from 97.2 ±6.7° for male participants and 112.5 ± 12.7° for female participants. The muscle Soleus and Tibialis were producing high muscles fatigue during slip occurrence. The results of the study show that muscle fatigue was significant with the occurrence of slipping during walking speed. Other findings presented that overweight and obese participants' significant slip occurred when walking on oily surfaces. Both aged groups represent the slip occurrence, there was no significant factor of aged during slip occurrence.

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1. INTRODUCTION

Slip is serious injuries, lead to fatal incident and afflicting to human life. The commercial kitchen workplace has potential and risk for hazards to the employees. The restaurant classifies as the third-largest ranking in occupational injuries and the environment contributes mostly to slip and fall [1]. Workers at the hotel and restaurant were frequently reported faced a symptom of a disease that requires ongoing treatment due to exposed static and dynamics posture [2]. Figure 1 shows the total of 8955 accidents at Malaysia Accommodation and Food Services Activities from year 2013 to 2017 [3]-[7]. Therefore, the commercial kitchen exposed various hazards to workers due to environment and design, equipped different types of material, cooking activity, and serving during working hours.

Standing and walking were the most working posture during performing the task [8] at commercial kitchen. Prolong standing and walking will contribute to pain in the knee, lower leg and ankle and this postures finally lead to fatigue [9]. In a certain industry, there was a need that worker had to walk and stand in prolong before break time. The increasing of walking speed will expose the higher potential to slip accident especially walking on the oily surface.

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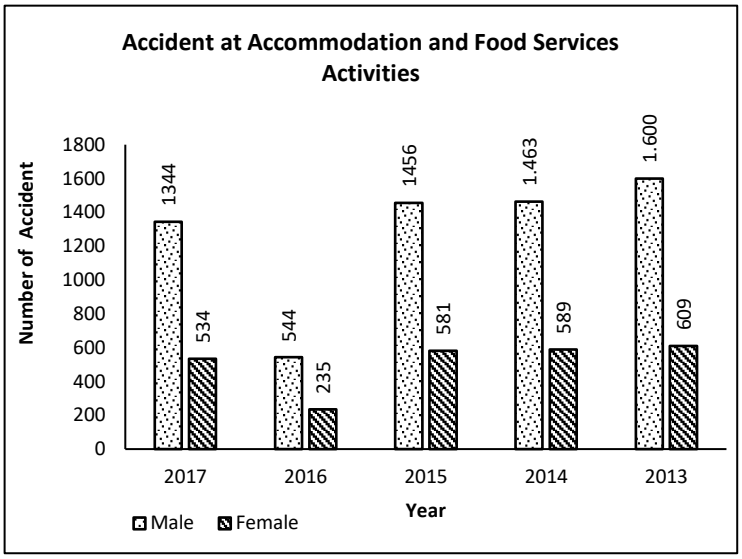

Figure 1: Accident at Accommodation and Food Services Activities [3]-[7]

Figure 2 shows the main part on lower leg and calf body part was identified plays a role in standing, walking and balancing. The muscles soleus (SOL), tibialis anterior (TIB), peroneus longus (PL) were the main muscles for ankle during walking activity [10]. The aim of this study was to analyze the ankle angle and the muscle fatigue during different speed of walking and influence in slip incident.

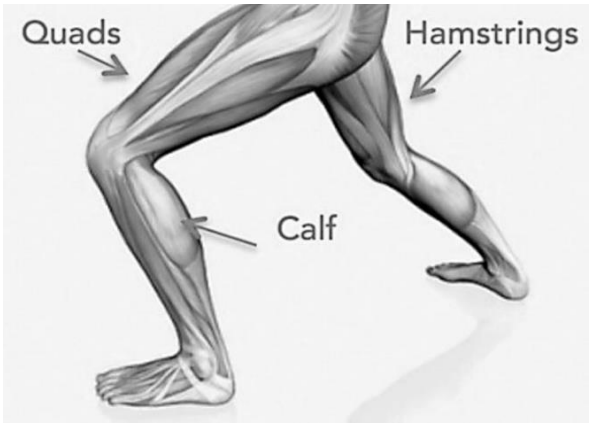

Figure 2: The part of lower leg muscle [11]

2. METHODS

This study involved physically active 12 participants (6 males, 6 females) with a mean of BMI 27.82 ± 4.01 kg/m2 aged between 23 to 57 years in 2 groups which are below 30 years and above 30 years. The classification of BMI based on Asian BMI which are participants in BMI normal, overweight and obesity. When participants agree need to sign a letter of consent to participate. The procedure will be clearly explained and markers will be installed at right foot [12] as shown in Figure 3. Participants have to walk at four different walking speeds [13] from 84 steps/minute, 100 steps/minute, 116 steps/minute, and 132 steps/minute. During walking, participant have to walking through on the 2 types of contaminant of water and cooking oil on the vinyl tile flooring surface.

The Electromyography (EMG) [14] was selected to record and analyzed the value of three muscle fatigue of Tibialis anterior (TIB), Peroneus Longus (PL) and Soleus (SOL). However, for Vicon motion [15] capture

was used to record participants' movement and ankle angle data were analyzed and the slip occurrence will be identified during testing.

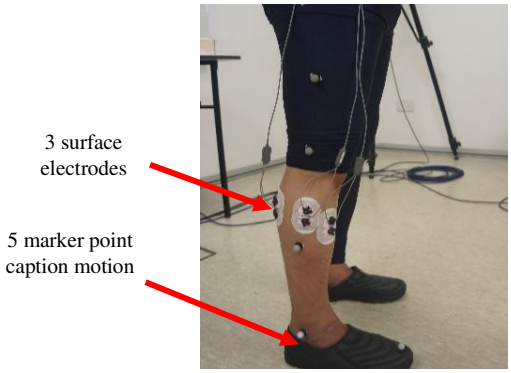

Figure 3: Positions of Ankle angle and Muscle fatigue marker

3. RESULTS AND DISCUSSION

3.1. Male participant

Figure 4 shows the slip occurrence among Male participant aged below 30 years using oil as contaminant. The slip occurs 45% for walking speed 132 steps/minute follow by 22% for 100 and 116 steps/minute respectively and 11% for 84 steps/minute. The slip occurrence 53% among male participant below 30 years, whereas 56% among overweight and 44% among obesity participants. Each muscle produces a different value of muscle activity. The muscle fatigue shows that muscle Soleus produces higher muscle fatigue compared to others. For ankle angle, the lower ankle angle was 88º and the higher ankle angle was 101.5º during slip occurrence.

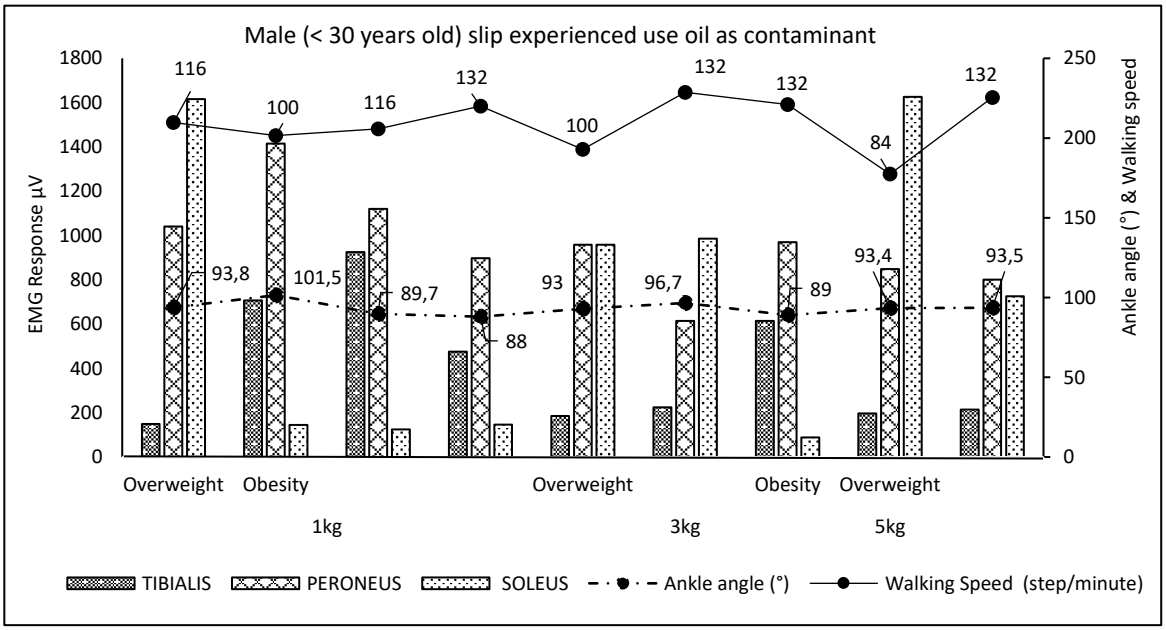

Figure 4: Slip occurrence among Male aged below 30 years

Figure 5 shows the slip occurrence among Male participant aged above 30 years using oil as contaminant. The slip occurs 50% for walking speed 132 steps/minute and 84 steps/minute respectively. The slip occurrence 47% among male participant above 30 years, whereas 25% among overweight and 75% among obesity participants. Each muscle produces a different value of muscle activity. The muscle fatigue shows that muscle Tibialis produces higher muscle fatigue compared to others [20]. For ankle angle, the lower ankle angle was 93º and the higher ankle angle was 106.8º during slip occurrence.

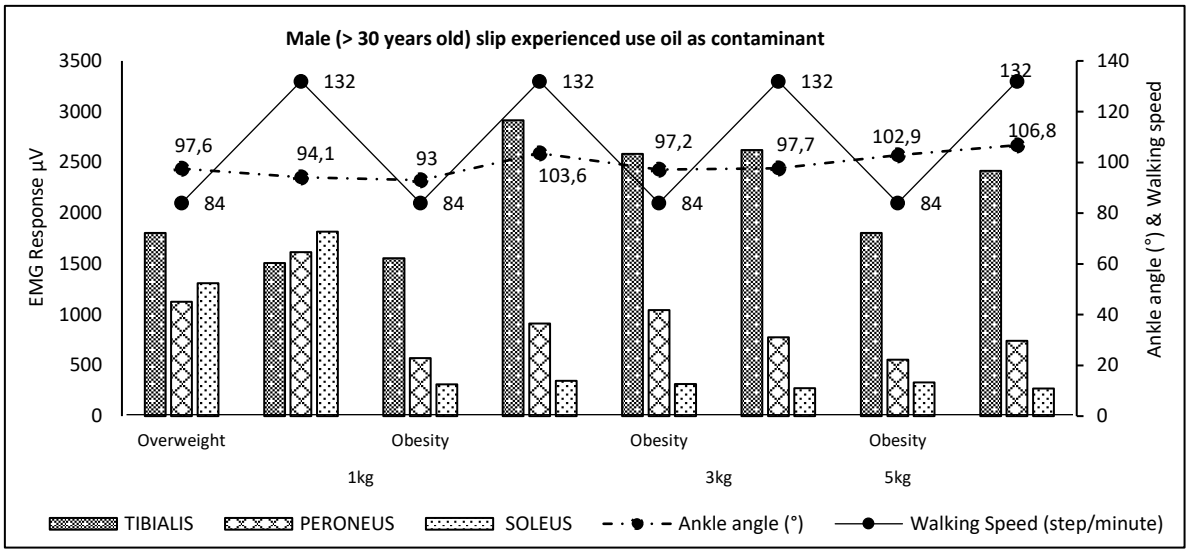

Figure 5: Slip occurrence among Male aged above 30 years' old

3.2. Female participant

Figure 6 shows the slip occurrence among Female participant aged below 30 years using oil as contaminant. The slip occurs 21% for 100 steps/minute and 116 steps/minute walking speed, then increase 29% for walking speed 84 steps/minute and 132 steps/minute respectively. The slip occurrence 47% among female participant below 30 years, whereas 14% among overweight and 86% among obesity participants. Each muscle produces a different value of muscle activity. The muscle fatigue shows that muscle Tibialis produces higher muscle fatigue followed by muscle Soleus. For ankle angle, the lower ankle angle was 92.7º and the higher ankle angle was 108º during slip occurrence.

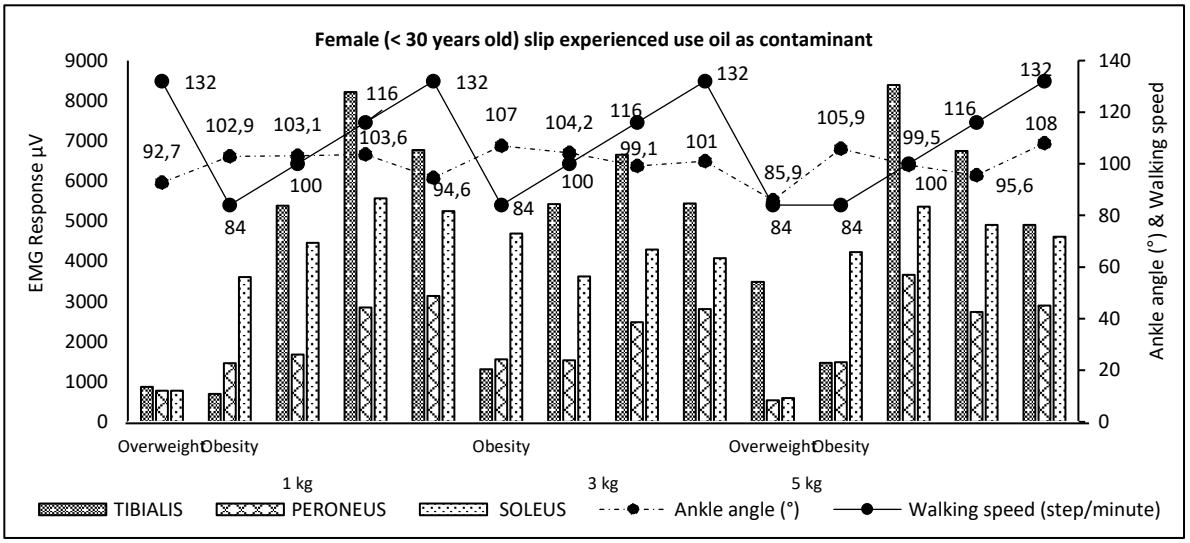

Figure 6: Slip occurrence among Female aged below 30 years

Figure 7 shows the slip occurrence among Female participant aged above 30 years using oil as contaminant. The slip occurs 19% for 116 steps/minute walking speed, then increase 25% for walking speed 84 steps/minute and 132 steps/minute respectively and the highest 31% for 100 steps/minute. The slip occurrence 53% among female participant above 30 years, whereas 25% among overweight and 75% among obesity participants. Each muscle produces a different value of muscle activity. The muscle fatigue shows that

muscle Soleus produces higher muscle fatigue compared to others. For ankle angle, the lower ankle angle was 115.4º and the higher ankle angle was 130.2º during slip occurrence.

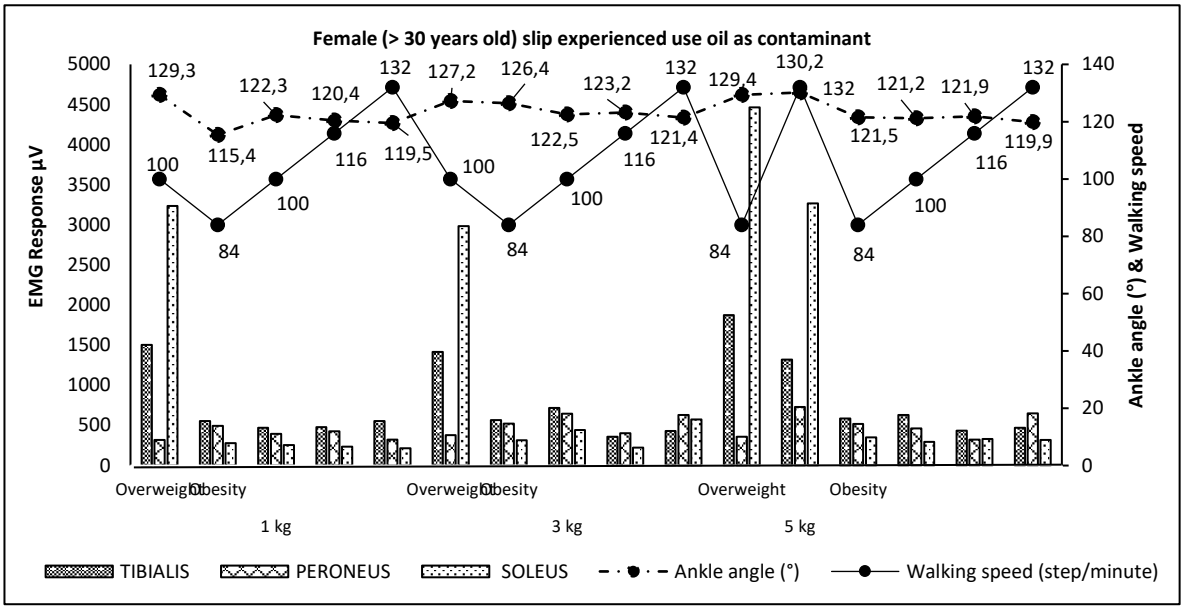

Figure 7: Slip occurrence among Female aged above 30 years' old

The result show that walking speed, oily surface, BMI, ankle angle, and muscle fatigue was significant to slip occurrence. This finding was similar to previous researcher. The oily floor surface on vinyl will result in a low coefficient of friction [16]. However, the walking speed is significant with slip incident whereas the occurrence of a slip in every walking speed especially on the contaminate floor [17]. The factor of BMI reveals significant with slip occurrence whereas the overweight and obese participants experienced more and this BMI group has reported faced higher risk at workplace related to slip, trip and fall [18]. For ankle angle during slip occurrence, the finding similar to [19] during walking different phase of walking was from 80° to 120° for normal and healthy subjects. For muscle fatigue is significant to slip occurrence especially the muscle Soleus and muscle Tibialis produce higher muscle activity during slip occurrence [21].

4. CONCLUSION

The finding of the study indicates that the increasing walking speed especially walking on the oily surface significant with slip incident. For BMI, Overweight and obese participant were significant with slip occurrence to compare to the normal participant. The ankle angle during slip was from 97.2 ± 6.7° for male participants and 112.5 ± 12.7° for female participants. For muscle fatigue, the findings show that muscle of Soleus and muscle Tibialis significant with slip incident when producing higher muscle fatigue during slip. The ankle angle significant with slip occurrence. Among of aged group, the participant represents no significant factor with slip incident. However, the slip incident will be affected by the health condition among elder participant due to the recovery treatment process.

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