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Pilot Study: Different Leg Muscle Activation When Walking on Stable, Unstable & Slippery Floors (Parameters Using Surface Electromyograph)

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ABSTRACT

Introduction: Muscle activation is the interaction of intracellular cell fluid and extracellular cell fluid that occurs in the cell membrane channel and can also be defined as the movement of muscle contraction and relaxation accompanied by changes in muscle fibre length. To determine differences in muscle activation in the legs (m. gastrocnemius, m. tibialis anterior, m. rectus femoris, m. biceps femoris longum, m. gluteus maximus) when walking in various floor/base conditions (stable, unstable, and slippery) using a Surface Electromyograph (sEMG). **Methods**: The research method used is Experimental Single Group Design where the researcher involves only 1 group consisting of 5 subjects. **Results**: The results of this study first used the repeat ANOVA test with scores obtained on stable floor conditions (0.000), unstable floor conditions (0.000), and slippery floor conditions (0.000). **Conclusion**: From the results of research that has been carried out, it can be concluded that there are differences in leg muscle activation as measured using Surface Electromyograph (sEMG) when walking on a stable, unstable, and slippery floor.

***Keywords**: muscle activity, floor, electromyograph, sEMG*

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INTRODUCTION

Walking activities have minimal risks and are relatively easy for everyone to do (Robertson *et al.*, 2012). According to Junaidi (2011), moving movements such as walking are activities that must involve a network in the body and muscle strength in cooling which can allow the muscles to have good resistance to support walking movements and support the entire body weight.

The prevalence of falling according to data from RISKESDAS (2018), states that in Indonesia cases of injury to children in the age range 1-4 years are as much as 8.2%, in adults in the age range 25-34 years there are 7.9% and at the age of 65 years and above reached 8.1%. According to data on the proportion of injuries to the affected body parts, as much as 67.9% occurred in the lower extremities, such as bruises, lacerations, broken bones, and falls.

Fall incidents are included in the category of non-traffic injury incidents. Falls can happen anytime and to anyone without exception, but it is important to know that falls are influenced by two factors, external and internal. External factors include the use of drugs, the footwear worn, and the condition of the floor/base for walking. Meanwhile, internal factors include age, gait, cognitive impairment, and climate muscle strength (Callis, 2016).

The involvement of shivering muscle strength and shivering muscle activation is a major component of human walking (Krogt *et al.*, 2012). Walking activities can be hampered due to weakened cooling muscle activation and loss of muscle strength which can allow falls (Fatmarizka *et al.*, 2023).

Measurement of muscle activation can be measured using the Surface Electromyograph (sEMG). This measurement is used to accurately detect muscle activation in an activity (Muyor *et al.*, 2020). This measurement provides important information in determining which muscles are active and can analyze how much muscle intensity is activated in the leg during walking. The muscles studied in this study include the five leg muscles namely m.gastrocnemius, m.tibialis anterior, m.rectus femoris, m.biceps femoris longum, and m.gluteus maximus.

METHODS

The research method used is an experimental single-group design, where the researcher involves only 1 group consisting of 5 subjects who meet the inclusion and exclusion criteria. The screening results were carried out before data collection using sEMG, this aimed to fulfil the research inclusion and exclusion criteria. The test on individuals consists of Functional Movement Screening (FMS) which is a measuring tool consisting of 7 movements which aims to assess how much risk an individual has in their functional movements so that the risk of injury to the lower limbs can be anticipated during sports activities (Pristianto *et al.*, 2018). The next measurement is the Berg balance test which is a screening tool to predict the risk of falling at a moderate level of accuracy (Park & Lee, 2017), another advanced test is the Functional Reach Test which is an instrument to assess a person's physical weakness and stability (Mason *et al.*, 2019), and the last is the measurement of the lower limb which includes bone length, true length, and appearance length. Data collection using a questionnaire via Google Form to collect Body Mass Index (BMI) data.

This research was conducted based on EC number: 3885/B.2/KEPK-FKUMS/XI/2021, issued by the Health Research Ethics Commission, Faculty of Medicine, UMS. Research location at the Gymnasium Laboratory in the Faculty of Health Sciences UMS. Each respondent received three treatments namely on stable, unstable, and slippery floors/bases randomly by lottery using surface electromyography (sEMG) measurements. The data analysis technique for this research uses the Shapiro Wilk for normality test and the repeated ANOVA effectiveness test to determine whether there are differences in leg muscle activation when walking in three-floor conditions.

Table 1. Respondent Characteristics

Respondent Characteristics		
Characteristics	**Frequency**	**Percentage (%)**
Age (Years)		
18-19	1	20%
20-21	4	80%
Gender		
Male	5	100%
Female	0	0%
BMI		
19-25 (Normal)	5	100%

RESULT

Respondent Characteristics

The criteria for the respondents in this study were based on the inclusion and exclusion criteria of the study which are described in Table 1.

Table 2, shows the average value of muscle activation in each respondent with two repeated trials using sEMG. There is a value indicating an increased level of activation which is indicated by a thick colored shading in the table for each floor. In respondents A, B, and D, the muscles that had an increased activation value were m.gastrocnemius on all three-floor conditions. In Respondent C, the value of increased muscle activation is m.rectus femoris on a stable and unstable floor, while on a slippery floor, activation increases in m.gastrocnemius. Respondent E, increased muscle activation values in m.biceps femoris and m.tibialis anterior.

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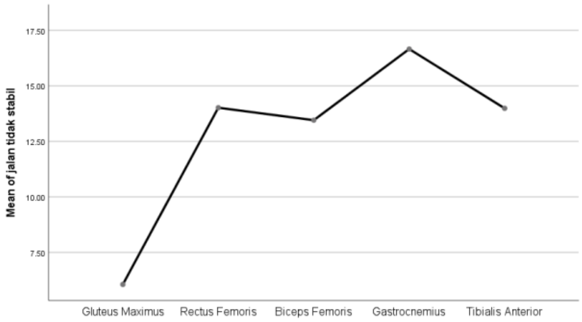

Figure 1. SPSS results of muscle activation on a stable floor/base

Based on calculations and results from SPSS from the characteristic tests above (figure 1), it is known that the muscle that has the highest percentage value in slippery floor conditions is the m.gastrocnemius.

Table 2. Respondent's muscle activation in 2 repeated trials

No	Respondent	Stable base					Unstable base					Slippery base				
		Muscle 1	**Muscle 2**	**Muscle 3**	**Muscle 4**	**Muscle 5**	**Muscle 1**	**Muscle 2**	**Muscle 3**	**Muscle 4**	**Muscle 5**	**Muscle 1**	**Muscle 2**	**Muscle 3**	**Muscle 4**	**Muscle 5**
1.	A	2.3	3.26	8.8	13.2	10.55	9.22	3.18	10.6	16.35	11.05	6.55	3.79	10.8	16	11.6
2.	B	1.49	4.08	12.35	19.95	13.75	1.58	5.24	13.25	18.3	16.25	1.78	4.48	12.6	22.55	16.55
3.	C	5.66	36.8	13.1	19.6	11.59	6.91	52.55	12.3	26.3	12.85	4.64	10.66	10.6	26.85	9.13
4.	D	4.91	6.86	5.10	18.65	10.14	2.63	5.71	4.7	22	10.69	1.64	3.4	4.54	23.4	8.5
5.	E	7.09	2.32	20.95	7.34	14.8	8.81	3.09	16.1	8.97	16.75	5.96	1.80	17.2	10.01	11.85

Muscle 1 = Gluteus Maximus, Muscle 2 = Rectus Femoris, Muscle 3 = Biceps Femoris, Muscle 4 = Gastrocnemius, Muscle 5 = Tibialis Anterior

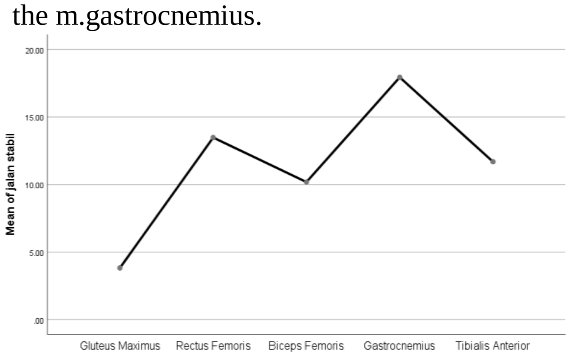

Figure 2. SPSS results of muscle activation on an unstable floor/base

Based on calculations and results from SPSS from the characteristic tests above (figure 2), it is known that the muscle that has the highest percentage value in unstable floor conditions is m.gastrocnemius.

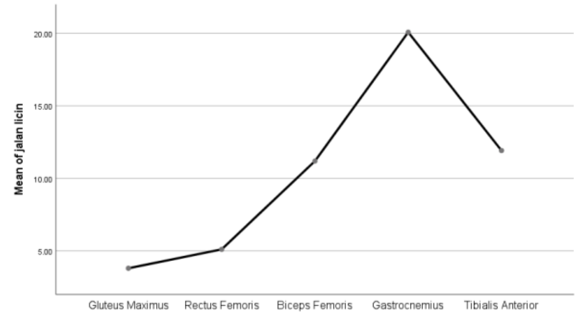

Figure 3. SPSS results of muscle activation on a slippery floor/base

Based on calculations and results from SPSS from the characteristic tests above (figure 3), it is known that the muscle that has the highest percentage value in slippery floor conditions is m. gastrocnemius.

Normality test

Table 3. Shapiro Wilk Normality Test Results

Variable	p-value	α = 0,05	Note
Stable	0,000	< 0,05	Abnormal
Unstable	0,000	< 0,05	Abnormal
Slippery	0,003	< 0,05	Abnormal
MVIC	0,000	< 0,05	Abnormal

Based on calculations and results from SPSS from the Shapiro Wilk test (table 3), it is known that the p-value < 0.05, that is, in unstable road conditions, the Shapiro Wilk score is 0.000, so the data results on unstable roads are 0.00 < 0.05 and are not normally distributed. In slippery road conditions, the Shapiro Wilk score is 0.003, so the data results in slippery road conditions are 0.003 < 0.05, so it can be concluded that the data

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obtained is not normally distributed. Stable road conditions have a Shapiro Wilk score of 0.000, so the results of the data on stable roads 0.000 <0.05 are not normally distributed. Meanwhile, MVIC has a Shapiro-Wilk score of 0.000, so the data results for MVIC 0.000 < 0.05 are not normally distributed.

Repeated ANOVA Test

This study, to determine whether there are differences in leg muscle activation when walking on stable, unstable, and slippery floors (Parameters using Surface Electromyograph).

Table 4. Repeated Anova Test

Variable	p-value	α = 0,05	Note
Stable	0,017	< 0,05	Significant effect
Unstable	0,250	> 0,05	No significant effect
Slippery	0,000	< 0,05	Significant effect

Based on the SPSS calculations and results from the repeated Anova test above (table 4), it is known that the p-value < 0.05, that in unstable road conditions, the repeated Anova score is 0.250, so the data results on unstable roads are 0.250 > 0.05 and are not correlated. If slippery road conditions have a Repeated ANOVA score of 0.000, then the data results for slippery road conditions are 0.000 < 0.05 so it can be concluded that the data that has been obtained correlates. Stable road conditions have a repeated ANOVA score of 0.017, so the results of data on stable roads 0.017 < 0.05 correlate.

DISCUSSION

Respondent Characteristics

The m.gastrocnemius involving m.soleus will produce the main plantar flexor movement in the ankle joint area. M. gastrocnemius is also a strong knee flexor (Noor, 2016). On walks, m.gastrocnemius was found to increase more on a stable and slippery floor during the mid-stance phase providing significant propulsive force. A higher activity of m.gastrocnemius is needed to control the body and prevent the body from falling during the push-off phase (Susilo, 2023).

Different leg muscle activation when walking on a stable floor

In the stance phase when walking, activation of the hamstring muscles which include m.semimembranosus and m.biceps femoris twice as high as the unstable base (Pristianto & Perdana, 2023). Research shows that the main effect of the walking surface is significant for m.gastrocnemius activity during the mid-stance phase. Another comparison revealed that the activity of m.gastrocnemius is larger when walking on unstable ground compared to walking on stable ground. Higher activity of m.gastrocnemius is needed in controlling the body and preventing falls during push-offs and plays a high role in generating power during walking (Jafarnezhadgero *et al.*, 2019).

Differences in leg muscle activation when walking on an unstable floor

The activation of m.gastrocnemius on an unstable floor plays a role in preventing the body from falling forward when walking in the terminal stance phase. M.triceps sure which consists of m.gastrocnemius and m.soleus during this position is active to control dorsiflexion of the foot and as a knee flexor to prevent hyperextension which will then initiate knee flexion. M. gastrocnemius activation on an unstable floor/base may indicate that the biological systems in the lower extremities optimize their work optimally to produce stability when walking (Svenningsen *et al.*, 2019).

Different leg muscle activation when walking on a slippery floor

Failure of normal movement and attempts to restore balance after an imbalance leads to problems such as slipping, tripping, and even the risk of falling. Muscle activity for the front and back thighs, especially m.gastrocnemius and m.soleus often occurs on slippery floors. Activity on m.hamstrings has the greatest increase of the lower extremity muscles, while m.gastrocnemius has the earliest muscle activation during alert movements while walking. Activation of the agonist/antagonist pair of m.gastrocnemius anterior, m.medial tibialis, m.vastus lateralis, and m.biceps femoris was found to be larger when on smooth surfaces and individuals had greater

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contractions while walking (Chander *et al.*, 2021).

CONCLUSION

From the results of research that has been carried out for one week, it can be concluded that the difference in leg muscle activation when walking on unstable walking conditions has a Repeated ANOVA score of 0.250, so the data results on unstable walking are 0.250 > 0.05 and are not correlated. If slippery road conditions have a Repeated ANOVA score of 0.000, then the data results for slippery road conditions are 0.000 < 0.05 so it can be concluded that the data that has been obtained correlates. Stable road conditions have a score of 0.017 Repeated ANOVA, so the results of the data on stable roads are 0.017 < 0.05, there is a correlation. Based on this research, the muscles that have the biggest role when walking are the m.gastrocnemius on stable and slippery road/base conditions. This is m.gastrocnemius involves m.soleus will produce the main plantar flexor movement in the ankle joint area and is found to increase on a stable and slippery floor which is needed to control the body and prevent the body from falling during the push-off phase.

It is hoped that the results of the research can be a reference regarding differences in muscle activation in the legs when walking on three floors/bases and can provide training programs to improve muscles that have low activation when walking on stable, unstable, and slippery floors. Advice for future researchers is that before conducting research, it is hoped that they first ensure that respondents have met the inclusion and exclusion criteria, and do not have a history of ankle injuries and pain in the foot like plantar fasciitis or calcaneus spurs.

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