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The Evaluation Of Vibrating Insole Prototype On Female School Teachers' Comfort

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ABSTRACT– Ergonomic interventions have become more popular and are among the preferred research methods and treatment of work-related musculoskeletal disorders (WMSDs). School teachers are the vulnerable group to WMSDs due to prolonged exposure of posture discomfort during school hours. Objective: To evaluate vibrating insole prototype on female school teachers' comfort. Methods: Respondents were 124 primary school teachers who have met the study's inclusive and exclusive requirements. The respondents were then divided into an experimental group (with a vibrating insole prototype) and a control group (without vibrating insole prototype) by randomisation. The respondents were asked to complete Borg's Scale every 15 minutes until the 1-hour session ended. Experimental groups reported a decrease in discomfort rating for 10 body parts (neck or head, shoulder, upper back, arm and hand, low back, buttock, thigh, knee, calf and ankle, and feet) during 1-hour experimental session. The ankle and feet showed the highest reduction, of discomfort rating (67%) among experimental group compare to control group. Overall, there were 12 to 67% reductions in discomfort rating for all body parts among experimental group compare to control group during 1-hour experimental session in the classroom. Conclusion: The significant reduction of discomfort rating have provided a new insight into the evaluation of vibrating insole prototype on comfort among female school teachers, particularly during teaching sessions in the classroom. The potential use of vibrating insole prototype has provided a beneficial ergonomic aid that reduces body discomfort and enhances school teachers' posture, positively affecting lower leg comfort.

Keywords: Intervention, Prototype, Vibrating Insole, School Teachers, Comfort

1. Introduction

Musculoskeletal disorders (MSDs) typically refer to the condition triggered by a combination of risk factors that function synergistically in the joint or body region over a certain period. In the Karsh model, for example, the integrated concept of the formation of MSDs considers various hazardous factors and considers the various possible mechanisms involved in thedevelopment of work-related musculoskeletal disorders (WMSDs). The model also includes physiological responses such as muscle stress, muscle soreness, and tiredness. The Karsh model has also shown that the accumulated effects of physical job requirements on the body's areas led to physical discomfort (Karsh, 2006). In adjusting to the nature of work conditions, the mechanism by which arises and eventually leads to the output of WMSDs may be characterised by excessive physical ability, accumulated load, fatigue, or adaptation to workplace practices. Recent study showed that teachers from schools teachers are highly affected by WMSDs and constitute a high occupational category of prevalence. Nearly all teachers reported having MSDs during their employment. Due to their work nature, school teachers are vulnerable to MSDs, particularly primary school teachers (Alias et al., 2020).

MSDs are among the main work-related health concerns in the education sector, which has gained attention in recent years, despite being long neglected (Erick and Smith, 2014; Yue et al., 2014). Among these occupations, school teachers stand out the most. For teachers, the prevalence of MSDs had been reported by researchers ranging from 39% to 95% (Erick and Smith, 2011). They found more intense pain in the back, neck, and upper limbs in most cases, although the teachers' postures and the parts of the body that affected them were classified (Solis-Soto et al., 2017). Several studies have shown that physical variables such as prolonged standing, sitting, and awkward postures during teaching sessions are considered to be highly correlated to the prevalence of MSDs (Mohan et al., 2015). This profession requires daily activities to be conducted for extended hours with consistent stress on the musculoskeletal system. This stress, along with additional poor body mechanics, positioning, and postures, could lead to MSDs (Damayanti, Zorem and Pankaj, 2017). MSDs occurred among school teachers due to lifting heavy loads, prolonged sitting and standing, having inappropriate posture, going up and down the stairs, writing on the board, and prolonged computer usage (Samad et al., 2010; Durmus and Ilhanli, 2012; Yue, Liu and Li, 2012). Besides, MSDs have been documented among retired school teachers as one of the primary causes of poor health (Korkmaz, Cavlak and Telci, 2011).

Prolonged standing at work has been correlated in epidemiological research with lower extremity discomfort and pain, including legs and feet. Workplace ergonomics studies associated prolonged standing with foot discomfort, with decreased pain-pressure threshold during the workday and increased blood pressure regulation (Messing and Kilbom, 2001; Laperriere et al., 2005). Laboratory findings have revealed that prolonged standing has resulted in lower extremity swelling and discomfort (Chester, Rys and Konz, 2002). Prolonged sitting was also associated with lower extremity discomfort and cardiovascular effects. Prolonged standing, sitting, and having awkward postures are known to be significantly related to a growing number of MSDs cases among teachers (Abdulmonem et al., 2014).

The feet contribute to the balance and maintenance of standing postures, which also act as a touchpoint between the body and the ground. Studies performed by Hijmans et al., (2007), Hijmans et al., (2008) and Priplata et al., (2006) utilised vibrating insoles in older adults and patients with diabetes and found positive progress in the anteroposterior direction of balance and oscillation strength. There is a mechanical noise in these vibrating insoles that induces auditory stimulation, with a positive effect on posture control. Ohio State University Medical Center(2007) suggests using vibration massage as a pain relief process by causing numbness in affected region. Vibration may also help to relax the muscles around the sore region, further reducing any discomfort. In the past, massage was used to relieve muscle discomfort and aches. Massage products are typically hand-held and can be placed on the body to counter sore points. There are massage systems for foot discomfort on which you can rest your feet. Research into pain relief using vibration is a recent trend. The transcutaneous electrical nerve stimulation (TENS) has also been compared with the vibration, but, in some cases, vibration is much more effective (Radl and Kropp, 2011).

Therefore, the formation of vibrating insoles can provide a subsensory mechanical noise signal to the plantar side of the feet and stimulate for balance in healthy young and older adults. The vibrating insole application can intensify the subsensory noise signal's tactile feedback as a shiftin the sole's pressure distribution. It has also been shown that the sway amplitude can be reduced while vibrating insoles are applied to healthy adolescents and older adult (Hijmans et al., 2008).To date, no studies have offered any findings on the impacts of a vibrational massage to the foot during the teaching session to alleviate the foot and leg discomfort among school teachers. This vibration insole prototype will fill the gap in the research field related to fatigue or discomfort, especially at the lower extremity of the body, and therefore, reduce the risks of MSDs among school teachers in Malaysia.

2. Methodology

2.1 Participants Selection

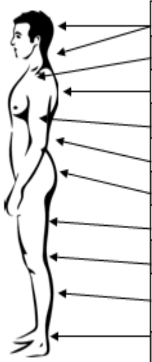
This study aimed to evaluate the vibrating insole prototype on female school teachers' comfort. 124 school teachers at 6 primary schools in Terengganu, Malaysia were subjects of this study with the following criteria: female teachers, aged between 20 and 35 years old with a normal Body Mass Index (between 18.5 and 24.9), with a minimum of 1 year of teaching experience, and with no history of foot injury over the last year. In addition to the exclusion criteria, teachers who are pregnant and had undergone surgery or operations on some parts of the body.

The participants who agreed and fulfilled the inclusion criteria were chosen to be the respondents (n=124) in this study. The respondents were divided into 2 comparison groups, which were the control group (Group A) and experimental group (Group B) using randomisation (simple random sampling). All the respondents' names were labelled with numbers and put into a container. The respondents were then divided randomly into control (Group A) or experimental (Group B) groups using the Fishbowl Technique. 62 respondents were allocated to the control group, and the other 62 respondents were allocated to the experimental group.

The study was endorsed by Ethical Committee Members ofUniversiti Putra Malaysia ((JKEUPM-2019-078) and Ministry of Education Malaysia (KPM.600-3/2/3-eras-4403)

2.2 Preliminary Questionnaire and Borg's (CR-10) Scale

Questionnaires were distributed to the respondents before the experimental session started. Respondents were briefed regarding the questionnaire before the first session was conducted. There were 3 parts (Section A, B and C) in the questionnaire. Section A and B were to determine respondents' personal information (age, height, weight, household income, sleeping hour, shoe type) and work-related characteristics (teaching experience, teaching hours, sitting hours, standing hours and sport activity). The last part (Section C), Borg's Scale Discomfort Rating (Figure 1), the respondents were asked to complete Borg's Scale every 15 minutes until the 1-hour session endedin order to evaluate the discomfort for every part of the body (Borg, 1982).



	Nothing at all		Extremely weak		Very weak		Weak		Moderate		Strong		Very strong			Extremely strong
	0	0.3	0.5	0.7	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10
Neck or head																
Shoulder																
Upper back																
Arms & hands																
Low back																
Buttocks																
Thigh																
Knees																
Calf (les below knee)																
Ankle & feet																

Figure 1: The Body Chart Discomfort using Borg's (CR-10) Scale (Borg, 1982)

2.3 Procedure for Experimental Session

School teachers from the experimental group being asked to wear a pair of shoes attached to a vibrating insole prototype (Figure 2) and for the control group school teachers were asked to wear shoes without a vibration insole prototype. The experimental session took place during a teaching session in a classroom (the first period in the morning), and each session lasted for 1 hour. Every respondent had to attend an experimental session on 2 separate days, with 3 days between them in order to make sure respondents committed to complete the experimental session (Umi Kalsom et al., 2015; Karmegam et al., 2012). Before starting the experimental session, respondents were allowed to choose the size of the insole that fit their feet. Respondents were able to change them before the experimental session began. They were able to move their feet comfortably so that the teaching lesson would not be disrupted. Researcher would remind the respondent that they were not allowed to change the size of the insole in the middle of the experimental session.

The subsensory vibration was set for each respondent by a potentiometer on a control box before each experimental session. The amplification of the insole's noise has been modified for each respondent until the vibration produced by the tactors can be felt underneath each foot. In accordance with the tactile sensitivity threshold variations, the vibration's amplitude was set at 90% of the sensory threshold. During the 1-hour session, respondents were needed to evaluate their discomfort rating for all body parts of the Borg's Scale CR-10 questionnaire every 15 minutes until the end of the 1-hour experimental session for pre- and post-intervention session. During the experimental session, respondents were allowed to carry out their task naturally in the classroom (sitting, standing, and walking). The time spent sitting, standing, and walking during the teaching session was recorded manually by the researcher to identify any movement that may lead to discomfort during the experimental session.

Figure 2: Vibrating Insole Prototype Attached to Shoe

3. Results

3.1 Background Information

The data collections were conducted from the beginning of September 2019 to the end of January 2020.Referring to Table 1 below, the average age of female teachers for both the experimental and control group was 31 years old. There was no significant difference in age between 2 groups. The teachers involved in this study, 20 to 35 years old and identified as young adults. It is necessary to select between 20 and 35 years of age for both groups to ensure that this individual factor may not influence the body parts' strength and comfort (Shephard, 1998) and did not confound the outcomes of the study.

Apart from that, teachers mostly had a monthly income of RM2,000 to RM4,000 for the experimental group and the control group. Most of the teachers had enough sleep, ranging between 7 to 9 hours a day, which optimum hour for adult to sleep (National Sleep Foundation, 2015) for the experimental group and the control group. In terms of shoe preference during school hours, teachers from both groups who chose heels were marginally higher than those favoured flats.

Table 1 Background Information

Variables	**Experimental Group (n=62)**		**Control Group (n=62)**		**z-Value**	**p-value**
	Mean ±SD	**Frequency (%)**	**Mean ±SD**	**Frequency (%)**		
Age (years)	31±3.14		31±2.62		-0.295	0.768
Household Income						
<RM 2,000		1(1.6)		0(0)		
RM 2,000 – RM 4,000		38(61.3)		36(58.1)		
>RM 4,000		21(37.1)		26(41.9)		
Sleeping hour (daily)						
<7 hours		2 (3.2)		1(1.6)		
7-9 hours		55(88.7)		58(93.5)		
>9 hours		5(8.1)		2(4.9)		
Shoe type						
Flat		27(43.5)		30(48.4)		
With heel		35(56.5)		32(51.6)		

Wilcoxon signed-rank test

Significant at $p<0.05$

Table 2 depicted teachers' anthropometric information with average height and weight were 156.7cm and 57.7kg, respectively, for the experimental group and 155.9cm and 56.3kg, respectively, for the control group. Statistical analysis using Paired T-test also revealed that anthropometric parameters in height and weight were not significantly different between the groups. Additionally, BMI data showed that both groups were in the normal range with 22.7kg/m^2 and 22.9kg/m^{2,} respectively. As teachers' health is a priority for this study, the BMI in the normal range was included in the inclusion criterion. Thus, anthropometric differences for both studied groups were also negligible, and it was not confounded for the comparison purpose for the findings of this study.

Table 2 Anthropometric Background

Variables	**Experimental Group (n=62)**	**Control Group (n=62)**	**t-value**	**p-value**
	Mean +SD	**Mean +SD**		
Height (cm)	156.7+5.10	155.9+6.13	0.182	0.627
Weight (kg)	57.7+8.08	56.3+7.95	0.132	0.912
BMI (kg/m^2)	22.7+1.61	22.9+2.19	-	-

Paired T-test

Significant at $p<0.05$

Table 3 presented that most teachers' teaching experience are between 2 and 10 years (88.7% vs. 91.9%) compared to 11 to 20 years (11.3% vs. 8.1%) for both studied groups. Significant number of teachers for both studied groups spent 1 to 4 hours teaching (74.2% vs. 80.6%), sitting (95.2% vs. 96.8%), and standing (85.5% vs. 82.3%) a day during school hours. Also, 87.1% of teachers in the experimental group and 83.9% in the control group involved with sport activity.

Table 3 Work-Related Characteristics

Variables	**Experimental Group (n=62)**	**Control Group (n=62)**
	Frequency (%)	**Frequency (%)**
Teaching experience (years)	55(88.7)	57(91.9)

2 – 10 years	7(11.3)	5(8.1)
11 – 20 years		
Teaching hours (daily)		
1 – 4 hours	46(74.2)	50(80.6)
5 – 8 hours	16(25.8)	12(19.4)
Sitting hours (daily)		
1 – 4 hours	59(95.2)	60(96.8)
5 – 8 hours	3(4.8)	2(3.2)
Standing hours (daily)		
1 – 4 hours	53(85.5)	51(82.3)
5 – 8 hours	9(14.5)	11(17.7)
Sport activity (daily)		
Yes	54(87.1)	52(83.9)
No	8(12.9)	10(16.1)

3.2 Data Distribution of Discomfort Rating (Borg's Scale) among Female School Teachers

Borg's Scale had been used to evaluate discomfort rating for both experimental and control groups. The results of Borg's Scale on discomfort rating between groups were presented in a graph form. The mean discomfort rating for every 15 minutes was illustrated in the Figure 3 until Figure 12 below. As a whole, experimental groups shown reductions in discomfort rating of 10 parts of the body that were neck or head, shoulder, upper back, arm and hand, low back, buttock, thigh, knee, calf and ankle and feet in the 1-hour of experimental session. In the presence of a vibrating insole prototype, the ankle and feet showed the highest reduction, with 67% of the experimental group's discomfort rating than other parts of the body. Overall, there were 12% to 67% reductions in discomfort rating for all body parts during the 1-hour experimental session.

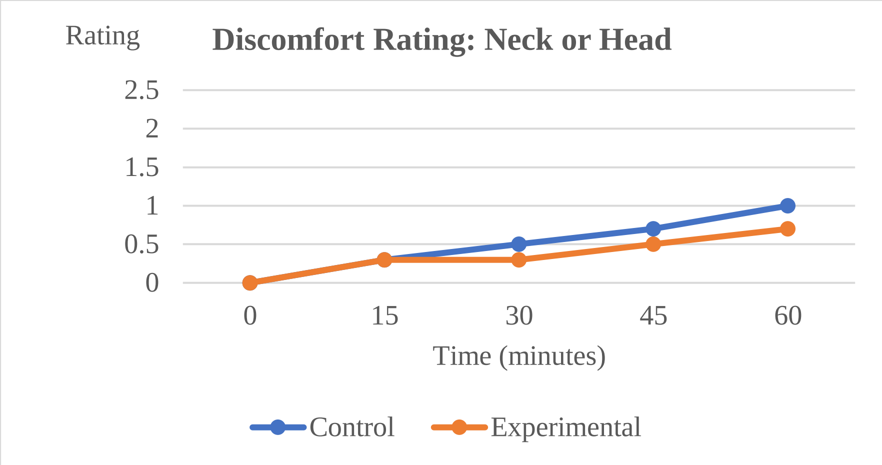


Figure 3: Changes of Discomfort Rating (Neck or Head) during 1-Hour Teaching Duration between Experimental and Control Groups

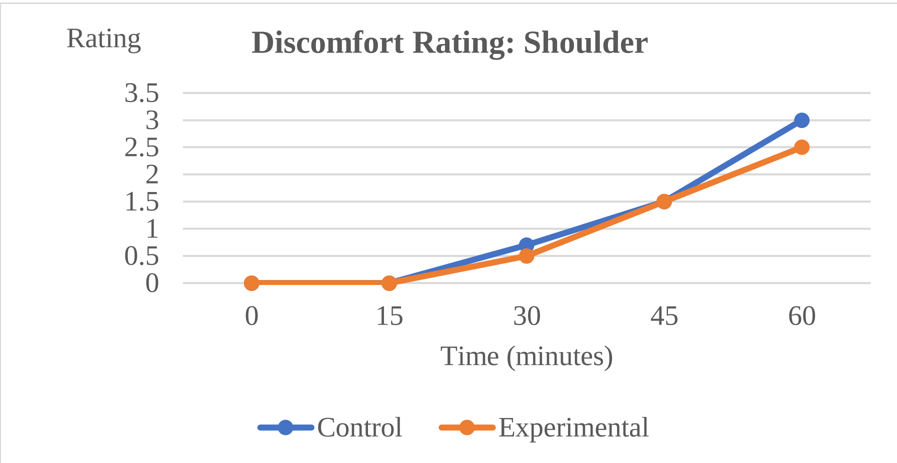


Figure 4: Changes of Discomfort Rating (Shoulder) during 1-Hour Teaching Duration between Experimental and Control Groups

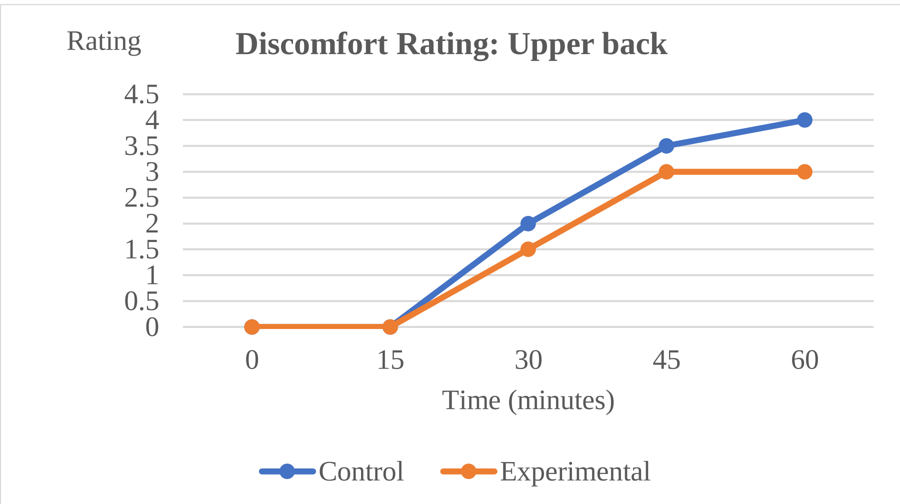


Figure 5: Changes of Discomfort Rating (Upper back) during 1-Hour Teaching Duration between Experimental and Control groups

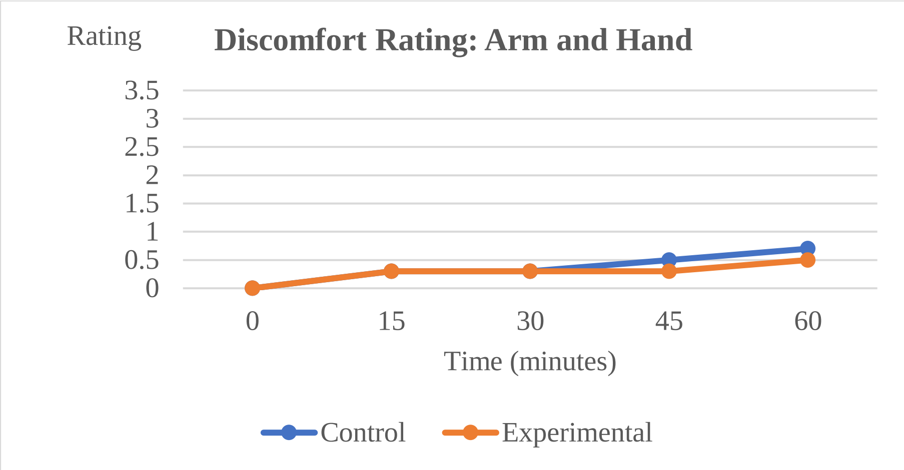


Figure 6: Changes of Discomfort Rating (Arm and Hand) during 1-Hour Teaching Duration between Experimental and Control Groups

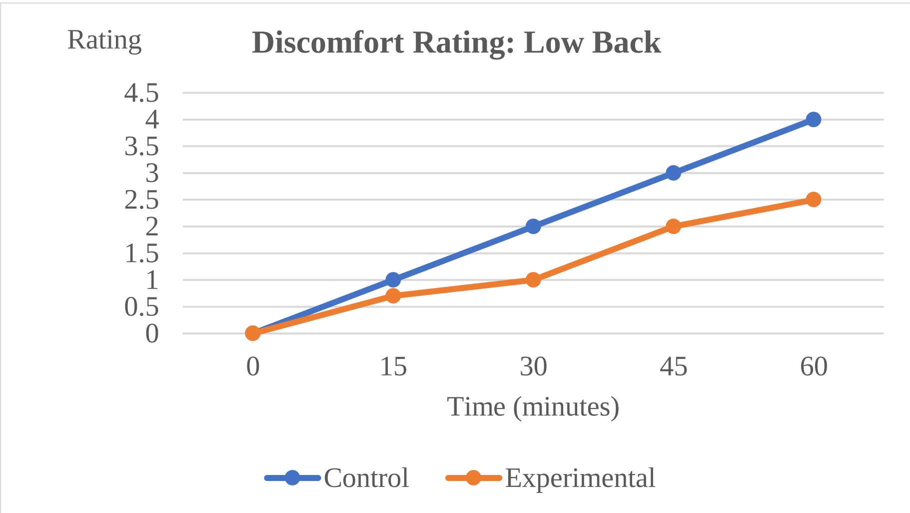


Figure 7: Changes of Discomfort Rating (Low Back) during 1-Hour Teaching Duration between Experimental and Control Groups

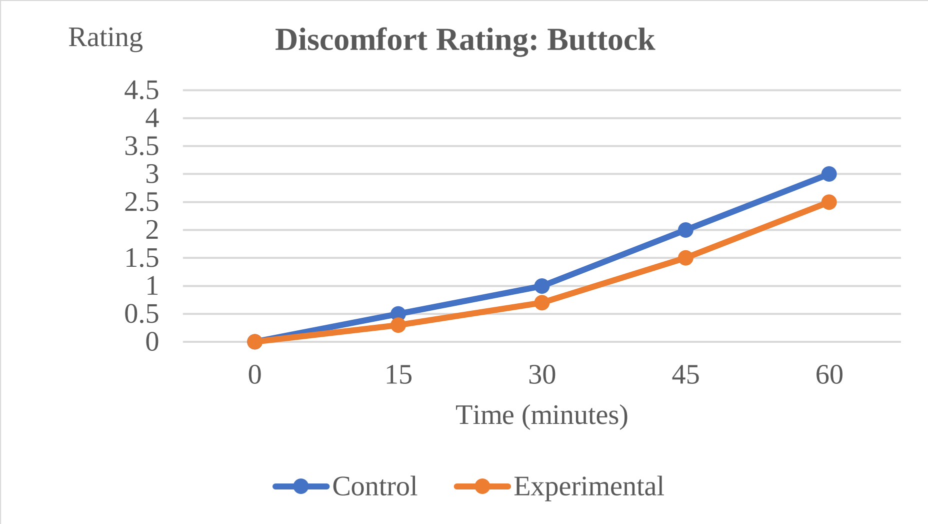


Figure 8: Changes of Discomfort Rating (Buttock) during 1-Hour Teaching Duration between Experimental and Control Groups

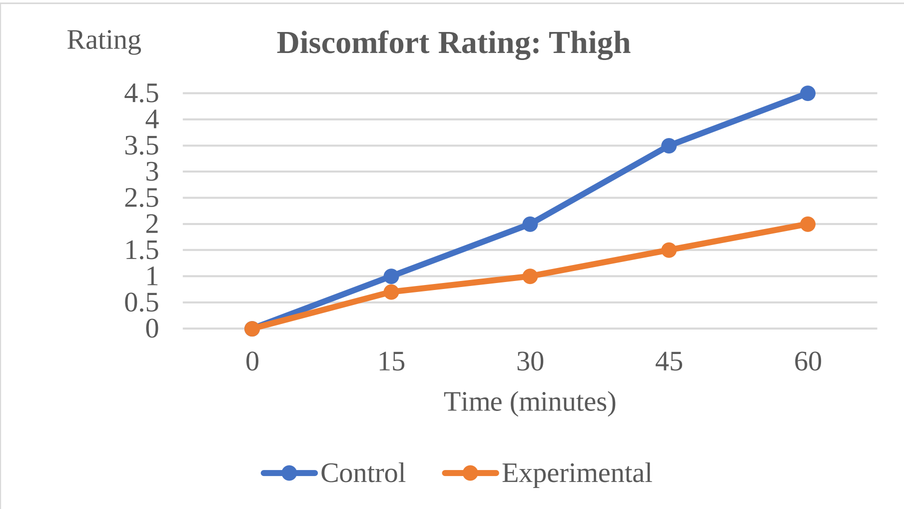


Figure 9: Changes of Discomfort Rating (Thigh) during 1-Hour Teaching Duration between Experimental and Control Groups

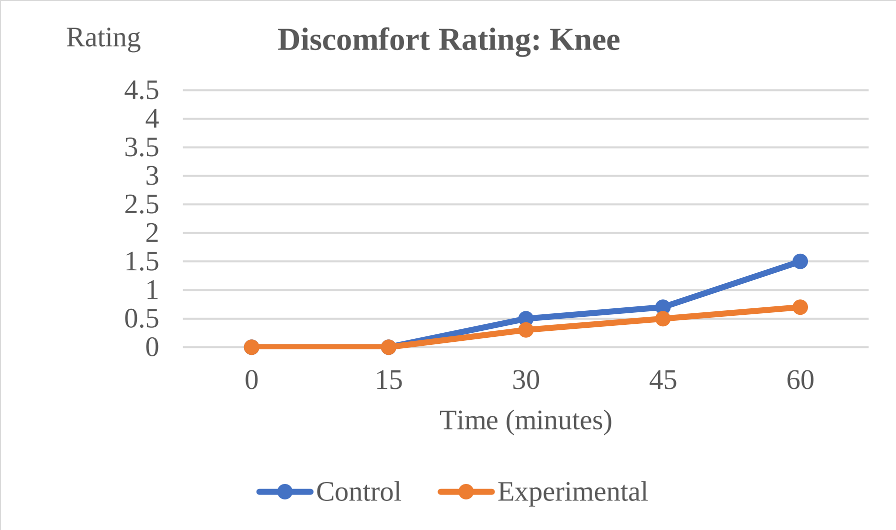


Figure 10: Changes of Discomfort Rating (Knee) during 1-Hour Teaching Duration between Experimental and Control Groups

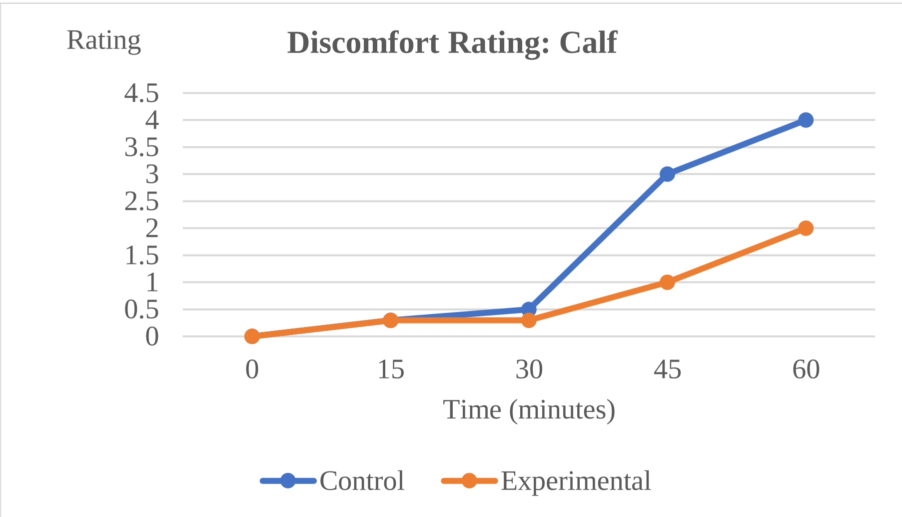
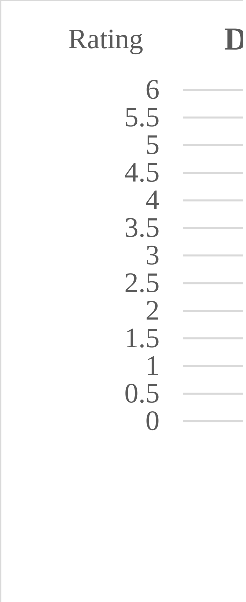


Figure 11: Changes of Discomfort Rating (Calf) during 1-Hour Teaching Duration between Experimental and Control Groups



Time (minutes)	Median (IQR)		z-value	p-value
	Experimental Group (n=62)	Control Group (n=62)		
15	0.5 (0.2,1.0)	1.5 (1.0,2.0)	-1.67	0.004*
30	0.7 (0.3,1.5)	2.5 (1.5,4.0)	-2.06	0.003*

Figure 12: Changes of Discomfort Rating (Ankle and Feet) during 1-Hour Teaching Duration between Experimental and Control Groups

3.3 Discomfort Rating (Borg's Scale) for Ankle and Feet between Experimental and Control

Table 4 showed a comparison of discomfort rating for the ankle and feet between the experimental and control group. A normality test (Kolmogorov-Smirnov) was carried out beforehand to assess discomfort rating distribution (ankle and feet). The outcome of the normality test on the distribution of discomfort rating (ankle and feet) was not normally distributed ($p<0.05$). Wilcoxon signed-rank test was performed to compare discomfort rating (ankle and feet) between the experimental and control groups. The discomfort rating was significantly lower ($p<0.05$) for the experimental group compared to the control group from 15 minutes to the end of the 1-hour experiment. The results highlighted that female school teachers' discomfort rating for ankle and feet had reduced when tested with a vibrating insole prototype.

Table 4 Discomfort Rating (Borg's Scale) for Ankle and Feet between Experimental and Control Groups among Female School Teachers

45	1.0 (0.5,2.0)	3.0 (2.0,5.0)	-4.13	<0.001**
60	2.0 (0.9,3.0)	5.0 (2.5,6.0)	-3.19	<0.001**

Wilcoxon signed-rank test

*p is significant at p<0.01

**p is significant at p<0.001

4. Discussion

The vibrating insole prototype's main function is to minimise the risk of having leg fatigue or discomfort during teaching sessions that are caused by physical factors such as prolonged standing, sitting, and having awkward postures. Vibration insoles have all of the vibration sensors mounted so that they are situated right below the soles of the feet. So, basically, a human goes through the processes for vibratory massages. Results showed that the vibrating insole prototype, with a reduced discomfort rating and muscle activity on the ankle and feet part, may provide comfort by reducing muscle activity for both legs. Along with that, muscle pain may also be reduced. Minimising the discomfort on teachers' body parts may also improve posture balance, especially during standing and sitting. The vibrating insole prototype is equipped with vibration tactors that have a wide range of frequency with adjustable intensity. The intensity rating can be adjusted according to individuals' variations in a tactile perception threshold to induce comfort during demanding physical activities. The vibrating insole prototype is wireless, and real-time data analysis is controlled by software to detect any movements during sitting, standing, walking, and other physical activities that take place throughout teaching sessions. With the user-friendly element that had been implemented during the design process, this prototype is strongly believed to be uncomplicated and non-interruptive. The materials and components of the vibrating insole prototype will not harm school teachers, especially during a prolonged wear. However, undoubtedly, further improvement needs to be done to maximise the safety features of this prototype. From the discomfort monitoring and recording using Borg's Scale (CR-10), teachers reported any discomfort of their body parts once every 15 minutes throughout the 1-hour experimental session. The reason this reporting strategy was used was to provide sufficient data points and to minimise the potentially adverse effects of recording discomfort experiences while maintaining a constant internal focus of attention on teaching activities in the classroom (Villemure and Bushnell, 2002). According to Kolich(2008), it is better to measure discomfort in the present situation than to assess it. Using Borg's Scale, respondents were asked to rate the body areas experiencing discomfort. Borg's Scale evaluation can be measured in a very convenient manner, and the outcome can be viewed as a wellbeing assessment for school teachers(Alias et al., 2020).

With the vibrating insole prototype, the ankle and feet showed the highest reduction with 67% of the experimental group's discomfort rating than other parts of the body. All in all, there were 12% to 67% reductions of discomfort rating for all body parts during 1-hour experimental session. When compared to the control group, the experimental group had shown more reductions in discomfort rating of other 9 body parts: neck or head, shoulder, upper back, arm and hand, low back, buttock, thigh, knee, and calf. With the highest reductions (67%) on ankle and feet compared to other parts of the body, the vibrating insole prototype directly contributed to a substantial comfort to the ankle and feet. The other parts of the body might have reductions too due to the effect systems of our body. When other body parts are relaxed, the other parts of the body involved might experience the same. Hence, it can be projected that mechanical stimulation produced by vibrating the insole would enhance ankle proprioception, balance, and comfort on the body parts (Hijmans et al., 2007). Balance is an essential feature of the body since it is an intrinsic aspect of human mobility. Damaged equilibrium would lead to a higher risk of falling (Fabre et al., 2010; Maki, Holliday and Topper, 1994). When an individual's standing balance is threatened, it can lead to discomfort of the body parts, reduce the quality of life, and significantly affect their daily routine (Haider et al., 2016). An improved posture might enhance workers' performance and minimise injury risks for the lower limbs (Han et al., 2015). Therefore, it is critical for the body's stability and comfort to be restored immediately by a simple ergonomic intervention such as a footwear insole (Alias et al., 2020).

A substantial prevalence of MSDs was reported by female teachers at Terengganu primary school (40.1%), with 32.5% in the last 12 months and 36.8% in the last 7 days. The most affected region was the foot. Similar risk factors were evaluated, such as age, BMI, athletic activities, types of shoes, teaching hours, and standing hours. Because of these major risk factors, they are still more likely to have a higher prevalence of MSDs than current findings if no effort is taken to minimise the prevalence of MSDs among school teachers. The high prevalence of MSDs of the feet has demonstrated that ergonomically designed footwear should be developed for teachers. Teachers can then use these shoes for work, particularly during a teaching session that required continuous standing and repetitive movements. Teachers should be supplied with these shoes to enhance their lower limbs’ comfort. There are only a few recent findings focused on the condition of the lower limbs, most of which play a crucial role for teachers to keep good posture during teaching sessions and school hours as a whole(Alias et al., 2020). Musculoskeletal diseases cause a significant cause of work-related injuries and employees' absence from the workplace. However, compared to work-related MSDs in the upper limb and lower back area, less focus has been given to the epidemiology of lower extremity musculoskeletal disorders (LEMSDs) (Alemany et al., 2005). LEMSDs can also lead to higher immobility rates and thereby dramatically deteriorate the quality of life (Goonetilleke, 2001; Miller et al., 2000) as it involves the disorders and discomfort of the ankle, feet, hip, and thigh. The majority of LEMSDs occur over time and are either due to the nature of the job itself or the work environment (Cordoso et al., 2009). Among varieties of working groups, teachers are the most vulnerable to LEMSDs. Teachers may experience distress and exhaustion, especially in the lower appendage muscles (legs, thighs, lower back), if the standing position is in a continuous manner and inactively cured (Alias et al., 2020). However, school teachers are still expected to maintain a right standing posture while giving lessons. This is done by frequently adjusting desired positions and maintaining their posture in a form that is considered the most pleasant for at least 4 hours a day, despite the fact that they might be wearing uncomfortable footwear (Halim and Omar, 2011).

The findings showed that the discomfort rating was significantly lower ($p<0.05$) among the experimental group compared to the control group from the first 15 minutes until the end of 1-hour experimental testing. This significant reduction showed that the vibrating insole prototype decreases the rating of discomfort among female school teachers during the teaching process. This, therefore, has indirectly shown that the vibrating insole prototype might be suitable for teachers as it does not disrupt their movements or distracts their focus in any way. Finding in this study presented that the ankle and feet showed a significant reduction of discomfort rating towards the end of testing (30 to 60 minutes) than early experimental testing (0 to 30 minutes). Thus, this discomfort rating data among respondents showed that they started to feel more comfortable with the vibrating insole prototype later than at the beginning of the experimental testing. The maintenance of posture control, especially on lower limbs, relies not just on diminishing signals from the central nervous system (CNS) but also on the existence and accumulation of somatosensory inputs (muscle, joint, skin, and pressure receptors) and visual and vestibular inputs (Perry, McIlroy and Maki, 2008). Numerous studies have shown that foot-sole sensation is a relevant source of somatosensory information that is sent through the CNS and using foot and ankle in evaluating adequate postural responses may improve balance through this mechanism (Perry, Santos and Patla, 2001; Meyer, Oddson and De Luca, 2004). It is also possible to enhance body alignment balance by providing additional sensory tactile feedback on the plantar surface of the feet by vibrating the insole. Wells et al., (2005) revealed that random vibration on foot soles improve the recognition of poor contact. Applying a subsensory mechanical noise by vibration to the feet' soles, insoles or footwear may be used. The presence of a subsensory mechanical noise signal under the soles greatly decreases postural distance and enhances the feet' comfort (Priplata et al., 2003).

The insole was designed as the shoe's inner part that acts as an interface between the shoe and the foot. Therefore, the relationship between the shoe and the foot or the lower limb must be recognised when speaking about the role of the insole. Instinctively, the insole's influence is included in the shoe analysis because its role is to enhance the shoe's usability. Good shoes and well-made insoles, therefore, are important. Insoles aim to correct the balance of leg muscles and make it possible to walk and stand safely without any discomfort and to prevent injuries. The duty of maintaining the health and wellbeing of a person’s feet with enhanced comfort should be decidedly considered when making an insole. Shoe insoles are used to reduce work-related symptoms in the workplace as an ergonomic intervention, particularly for workers who remain predominantly in a standing position (Sobel et al., 2001; Basford and Smith, 1998). Blood supply, intervertebral discomfort, and weight are impaired by venous tension while standing for a long time (Messing, Tissot and Stock, 2008; Melzer, 2008). As more studies are done on insole analysis and ergonomic intervention of the vibrating insole prototype, more related data is expected to be revealed (Urabe et al., 2014). Ultimately, this study provides valuable findings on footwear's comfort and may provide other researchers with the opportunity to develop a more advanced design and intervention, especially for shoe insoles among school teachers(Alias et al., 2020).

5. Conclusion

Findings revealed that, in the presence of a vibrating insole prototype, the ankle and feet experienced the highest reduction with 67% of discomfort ratings for the experimental group compared to control group. There were 12% to 67% reductions of discomfort rating for all body parts during the 1-hour experimental session in a classroom setting among female school teachers. This ergonomic prototype has initially been distributed to school teachers to help them be more comfortable and minimise pain on their body parts when adaptingto specific postures and repetitive movements in the classroom. The findings from this study have provided new insights into the effects of vibrating insole prototype on comfort among female school teachers, particularly during teaching sessions. The use of a vibrating insole prototype has provided a valuable ergonomic assist that decreases muscle and body discomfort and improves school teachers' posture, significantly affecting lower leg comfort. Therefore, the use of vibrating insole is necessary to provide ideal support to school teachers’ feet and indirectly minimise musculoskeletal disorders that are contributed by the physical activities and awkward postures during classroom teaching sessions. School teachers are likely to develop musculoskeletal problems in the long term if there is no ergonomic footwear solution available to them.

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