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QUANTITATIVE ASSESSMENT OF VIBRATING INSOLE PROTOTYPE THAT INDUCED TRANSIENT COMFORT AMONG FEMALE SCHOOL TEACHERS

AYUNI NABILAH BINTI ALIAS

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By

AYUNI NABILAH BINTI ALIAS

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July 2021

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Introduction: Musculoskeletal disorders (MSDs) are amongst the most significant and common occupational health issues in the teaching profession, which although was long neglected, this female-dominated profession has attracted growing attention in recent years. School teachers were found to be at risk of high prevalence of lower extremity MSDs (LEMSDs) compared to other occupational groups. Along with greater responsibilities, teachers are continually exposed to poor posture in unfit working circumstances during school hours, which contributes to a variety of health concerns. Teachers spend much of their time standing and moving about, often contributing to body pain and discomfort, muscle fatigue and even health problems such as musculoskeletal injuries, most of which involved the lower extremity of the body, especially the feet. Due to this, a vibrating insole prototype was assessed in this study to induce transient comfort among female school teachers. **Method:** This research was an experimental pre-posttest study (randomized controlled trial) that involved female primary school teachers in Terengganu. In this study, a total of 124 female school teachers were randomly assigned to experimental and control groups based on inclusion and exclusion criteria. Experimental group consisted of 62 teachers, they were asked to wear a shoe attached with a vibrating insole prototype and another 62 teachers in control group were asked to wear a shoe without a vibrating insole prototype attached. The experimental session took place during teaching session in a classroom (the first period in the morning) and each session lasted for one-hour. Every respondent had to attend an experimental session on two separate days, with a minimum interval of three days between the sessions. During the one-hour session, respondents were attached with wireless electromyography (EMG) on the right and left legs' muscles. The EMG data was collected continuously for one-hour session. They were also needed to evaluate their discomfort level for all body parts in the Borg's scale CR-10 questionnaire for every 15 minutes until the end of one-hour

experimental session. **Results:** Discomfort rating (Borg's scale) revealed that, with the presence of the vibrating insole prototype, the ankles and feet showed highest reduction with 67% of discomfort level for the experimental group compared to the other parts of the body. All in all, there were 12% to 67% reductions of discomfort level for all body parts during one-hour prototype testing among female school teachers. Electromyography (EMG) measurements showed that there were 13% to 16% more reductions of exertion of muscle activity (%) for both right and left legs' muscles for the experimental group compared to the control group during the one-hour prototype testing. The discomfort rating (Borg's scale) for ankles and feet was substantially lower ($p<0.05$) in the experimental group relative to the control group from 15 minutes to the end of the experimental testing in the one-hour duration. Lastly, statistical results reported that there were significant exertion changes of muscle activity (EMG) within the one-hour prototype testing, (X^2 (15) = 289.94, $p<0.001$) for the experimental group compared to the control group. **Conclusion:** Potential use of a vibrating insole prototype has offered valuable ergonomic support that helps to reduce muscle and body discomfort and improve the posture of school teachers with a positive effect on lower leg muscle activity. Therefore, vibrating insole prototype is capable of providing an ideal intervention to the school teachers' feet and potentially reducing the progression of musculoskeletal disorders in a long-term health effect. Further development of the design specifications is required to make vibrating insole more acceptable to school teachers in order to improve the dynamics of body posture without placing excessive stress on the lower leg, especially the feet during school session. A long-term and high-quality study is needed before definitive conclusions can be drawn on the effect of vibrating insole prototype on comfort and muscle activity with a much wider population and more variations in measurements

Keywords: Vibrating insole, prototype, ergonomic intervention, comfort, muscle activity, school teachers.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENILAIAN KUANTITATIF PROTOTAIP TAPAK DALAM KASUT BERGETAR BAGI MENDORONG KESELESAAN SEMENTARA DALAM KALANGAN GURU SEKOLAH PEREMPUAN

Oleh

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Pengenalan: Gangguan muskuloskeletal adalah salah satu masalah kesihatan pekerjaan yang paling lazim dan ketara dalam profesion perguruan dimana, walaupun diabaikan sejak sekian lama, profesion yang dikuasai oleh wanita ini telah menarik minat yang mendalam dalam beberapa tahun sejak kebelakangan ini. Guru sekolah didapati berisiko tinggi bagi mendapatkan gangguan muskuloskeletal bahagian bawah badan berbanding kumpulan pekerjaan yang lain. Seiring dengan tanggungjawab yang lebih besar, para guru terus-menerus terdedah kepada postur tubuh yang tidak bagus dalam keadaan kerja yang tidak sesuai pada waktu sekolah, yang menyumbang kepada pelbagai masalah kesihatan. Guru menghabiskan banyak masa untuk berdiri dan bergerak, sering menyumbang kepada sakit badan dan ketidakselesaan, keletihan otot dan juga masalah kesihatan seperti kecederaan muskuloskeletal, yang kebanyakannya melibatkan bahagian bawah badan, terutamanya kaki. Sehubungan dengan itu, prototaip tapak dalam kasut bergetar telah dinilai dalam kajian ini untuk mendorong keselesaan sementara dalam kalangan guru sekolah perempuan. **Kaedah:** Penyelidikan merupakan kajian eksperimen pra-ujian (percubaan terkawal secara rawak) yang melibatkan guru sekolah rendah perempuan di Terengganu. Dalam kajian ini, seramai 124 guru sekolah perempuan dibahagikan secara rawak kepada kumpulan eksperimen dan kawalan berdasarkan kriteria inklusi dan pengecualian. Kumpulan eksperimen terdiri daripada 62 orang guru, mereka diminta memakai kasut yang dilekatkan dengan prototaip tapak dalam kasut bergetar dan 62 orang guru bagi kumpulan kawalan diminta untuk memakai kasut tanpa prototaip tapak dalam kasut bergetar tersebut. Sesi eksperimen berlangsung semasa sesi pengajaran di dalam kelas (tempoh pertama pada waktu pagi) dan setiap sesi berlangsung selama satu jam. Setiap responden harus menghadiri sesi eksperimen pada dua hari yang berbeza dengan selang tiga hari di antara mereka. Selama sesi satu jam dijalankan, responden dilengkapi dengan

elektromiografi tanpa wayar (EMG) pada otot kaki kanan dan kiri. Data EMG dikumpulkan secara berterusan selama satu jam pada setiap sesi. Mereka juga diperlukan untuk menilai tahap ketidakselesaan mereka bagi semua bahagian badan dalam soal selidik skala Borg (CR-10) untuk setiap 15 minit sehingga akhir sesi eksperimen selama satu jam. **Hasil:** Peringkat ketidakselesaan (skala Borg) mendedahkan bahawa, dengan adanya prototaip tapak dalam kasut bergetar, pergelangan kaki dan kaki menunjukkan penurunan tertinggi dengan 67% tahap ketidakselesaan dalam kalangan kumpulan eksperimen berbanding dengan bahagian badan yang lain. Secara keseluruhan, terdapat penurunan tahap ketidakselesaan 12% hingga 67% untuk semua bahagian badan semasa ujian prototaip selama satu jam dalam kalangan guru sekolah perempuan. Pengukuran elektromiografi (EMG) menunjukkan bahawa terdapat 13% hingga 16% pengurangan aktiviti otot (%) untuk otot kaki kanan dan kiri di dalam kumpulan eksperimen berbanding dengan kumpulan kawalan semasa ujian prototaip satu jam. Peringkat ketidakselesaan (skala Borg) pada pergelangan kaki dan kaki jauh lebih rendah ($p<0.05$) dalam kalangan kumpulan eksperimen berbanding dengan kumpulan kawalan 15 minit sehingga akhir ujian eksperimen dalam jangka masa satu jam. Akhir sekali, hasil statistik melaporkan bahawa terdapat perubahan aktiviti otot (EMG) yang ketara dalam ujian prototaip satu jam (X^2 (15) = 289.94, $p<0.001$) dalam kumpulan eksperimen berbanding dengan kumpulan kawalan. **Kesimpulan:** Potensi penggunaan prototaip tapak dalam kasut bergetar telah memberikan bantuan ergonomik yang bermanfaat yang dapat mengurangkan otot dan ketidakselesaan badan dan memperbaiki postur guru sekolah dengan kesan positif pada aktiviti otot bawah kaki. Oleh itu, prototaip tapak dalam kasut bergetar mampu memberikan intervensi yang ideal pada kaki guru sekolah dan berpotensi mengurangkan perkembangan gangguan muskuloskeletal dalam kesan kesihatan jangka panjang. Pengembangan spesifikasi reka bentuk lebih lanjut diperlukan untuk menjadikan tapak dalam kasut bergetar lebih dapat diterima oleh guru sekolah untuk meningkatkan dinamika postur badan tanpa memberikan tekanan yang berlebihan pada kaki bawah, terutamanya kaki semasa sesi persekolahan. Kajian jangka panjang dan berkualiti tinggi diperlukan sebelum kesimpulan pasti dapat dibuat mengenai kesan prototaip tapak dalam kasut bergetar pada keselesaan dan aktiviti otot dengan populasi yang lebih luas dan lebih banyak variasi pengukuran.

Kata kunci: Getaran tapak dalam kasut, prototaip, intervensi ergonomik, keselesaan, aktiviti otot, guru sekolah.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

WHO	World Health Organization
MSDs	Musculoskeletal disorders
WMSD	Work-related Musculoskeletal Disorder
EMG	Electromyography
sEMG	Surface Electromyography
SOCSO	Social Security Organization
OECD	Economic Cooperation and Development
ILO	International Labor Organisation
AORN	Association for Perioperative Registered Nurses
CCOHS	Canadian Centre for Occupational Health and Safety
LEMSDs	Lower extremity of musculoskeletal disorders
BMI	Body Mass Index
USDHHS	U.S Department of Health and Human Services
MVC	Maximum Voluntary Contraction
CDCP	Centre for Disease Control and Prevention
CIEHF	Chartered Institute of Ergonomics and Human Factors
NIOSH	National Institute for Occupational Safety and Health
PDS	Product design specification
NMDQ	Nordic musculoskeletal disorders questionnaire
WUEMSS	Work-related upper extremity musculoskeletal symptoms

EI	Ergonomic intervention
TENS	Transcutaneous electrical nerve stimulation
LBP	Low back pain
NSP	Neck-shoulder pain
LMD	Localized musculoskeletal discomfort
APDF	Amplitude probability distribution function
RMS	Root Mean Square
MNF	Mean frequency
MDF	Median frequency
PPD	Plantar pressure distribution
HA	Hallux
T2	Second toe
T3-5	Lateral toes
LF	Lateral forefoot
CF	Central forefoot
MH	Medial Midfoot
LM	Lateral midfoot
HF	Hindfoot
LT	Lesser toes
MF	Medial forefoot
MH	Medial heel
LH	Lateral heel

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The World Health Organization (WHO) has described occupational diseases as any diseases that are primarily resulted from exposure to occupational risk factors. WHO also claimed that work related-diseases have several causes, for which work environment and work performance contribute significantly but in varying degrees, along with other risks, to the development of the disease (WHO, 2010). Musculoskeletal disorder (MSD) is one of the main work-related diseases commonly caused by occupational hazards that usually affect the working population (Arvidsson et al., 2016). MSDs are long-term disability in the work area because of pain or dysfunction in the musculoskeletal systems, affecting bones, joints, and soft tissues that protect and support the human body. One of the MSDs classifications is any fingers to shoulders or neck pain or disorder of the upper limb. A lower limb with pain or hip-toe disorders is another type of MSDs (Punnett and Wegman, 2004).

Certain jobs can be very demanding and pose multiple health risks for the involved workers. Due to this, individuals from various occupational groups are likely to be exposed to work-related musculoskeletal discomfort or pain. School teachers are among those involved, a category which stands out the most (Vaghela and Parekh, 2017). School teachers in Malaysia can be regarded as a large-scale occupation with 455,904 teachers and specifically 237,317 from the total are primary school teachers (Figure 1.1), making the educational system with the highest number of general service workers. The Malaysia Government's aim of the teaching profession was to improve education's performance and value as reflected in the policy development and implementation based on the Master Plan for Education Development (2006-2010) and the Malaysia Education Blueprint 2013-2025. Each policy explicitly discusses the teaching profession and strongly concentrates on teachers' important role for Malaysian economic development in building strong professional services for the next generation (Ministry of Education Malaysia, 2019).

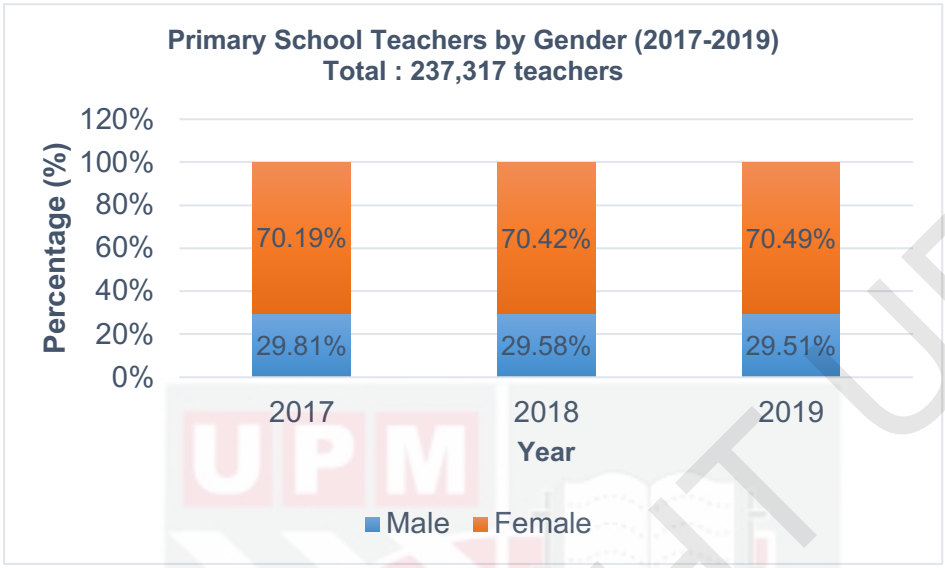

Figure 1.1:Percentage of Teachers at Primary Level by Gender(2017-2019)
(Source: Ministry of Education Malaysia, 2019)

Teachers empower children and offer them endless support, especially in their vulnerable years. Primary school teachers often provide a platform to project positive values to children, prepare them for further education and working life, and therefore, able to make a significant contribution to a great lifelong education for these children. Teachers are a sound and progressive element of society. Apart from their parents, teachers are the primary source of knowledge and values for children's learning (Mesaria and Jaiswal, 2015). In addition to huge work responsibilities during the day, teachers perform various other tasks that could lead to serious issues in their physical wellbeing. The vulnerability of high prevalence MSDs is high for school teachers than other occupational categories (Cardoso et al., 2009). Teachers' job entails educating students and organizing classes, reviewing students' work, and engaging in various school events and activities. This may result in teachers' psychological and physical complications due to having to carry out various tasks during school hours (Chong and Chan, 2010). Despite the connotation that schools are considered one of the best workplaces with the best working conditions, research studies indicate that teachers are still highly likely to suffer from MSDs (Mohseni-Bandpei et al., 2014).

Among the various populations surveyed, it was apparent that school teachers are at greater risk of suffering musculoskeletal disorders with a prevalence range of 23.7% and 95.1%, although prevalence among the studies is not uniform. Over the years, most of those associated with MSDs are either due to the demanding nature of teaching jobs, or workplace conditions. (Mohd Noor et al., 2013). Musculoskeletal discomfort is the key reason for sick leave, days of absenteeism, and early retirement among school teachers (Kohlmann, 2003;

Cardoso et al., 2009; Korkmaz, Cavlak and Telci, 2011; Samad et al., 2010; Atlas et al., 2007; Jin, Sorock and Courtney, 2004; Kovess-Masfety et al., 2006). MSDs are often discovered particularly in the area of the lower back, neck, and shoulder region caused by prolonged clerical work, prolonged standing during teaching and repeated overhead writing on the board during lessons, prolonged sitting resulting from regular reading, preparing of lessons, grading on examination papers and even working from a screen (Erick and Smith, 2011; Cardoso et al., 2011; Korkmaz, Cavlak, and Telci, 2011; Yue, Liu, and Li, 2012; Durmus and Ilhanli, 2012).

In Malaysia, the number of occupational musculoskeletal disorders (WMDs) increases annually as the overall pay out for WMSD has been significantly higher than the other occupational diseases. In 2018, 1,354 of 2,197 occupational-related diseases were WMDs cases, according to figures from the Social Security Organization, Malaysia (SOCSO, 2018). Ergonomics and WMSDs are intertwined disciplines. Ergonomics is a multi-discipline with an open, safe, and comfortable workplace for the employee and their jobs. Therefore, it is called ergonomics when it comes to the interaction between humans and machines (Norman and Wells, 1998). As shown in the context of school teachers, ergonomics is intended to improve the interaction between teachers (comfort, posture, and body parts) and machines (support features or prototype) in the school environment, especially during the teaching process in the classroom (Figure 1.2). Ergonomics aims to alleviate discomfort symptoms that cause poor work performance due to the limited number of tasks that can be carried out and long-term impairment (Perreault et al., 2008).

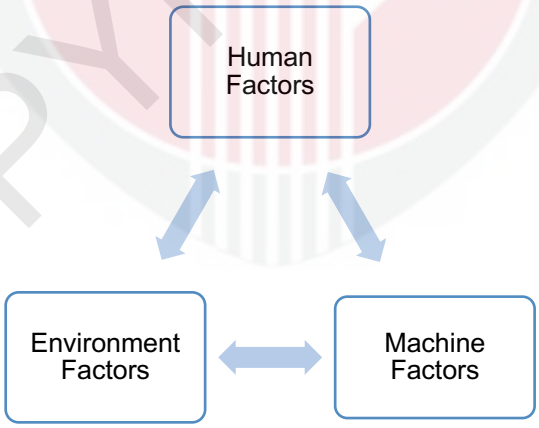

Figure 1.2: Ergonomic Intervention Factors

Ergonomic focuses on ensuring that individual needs for safe and productive jobs are addressed within the work processes' design (Schlick and Vanwonterghem, 2009). Ergonomic is the main intervention in terms of workplace's risk factors. Ergonomic strategies minimize the exposure of a

worker, both physical and emotional, throughout a significant time to occupational risk factors, resulting in pain, muscle tiredness, and tension. Earlier studies have shown the need for ergonomics to address WMSDs (Boschman, Frings-Dresen, and Molen, 2015). Ergonomic risk is a new framework that explains risk factors that may lead to WMSDs developed during working hours (Veselinovic, Hedge, and Veselinovic, 2016). The human body's comfort or satisfaction is a must and an important factor in the current research and development of the industrial and non-industrial fields such as the academic line (Wahab et al., 2008). The words comfort and discomfort, in the working environment context, are likely hard to be described since they include objective and subjective feelings that are difficult to quantify, interpret, and linked to human physiological homeostasis and physical wellbeing (Karmegam et al., 2013).

The Cambridge Advanced Learner's Dictionary describes comfort as a good feeling of relaxation and pain-freeness, while discomfort is described as feeling with slight pain and slight unease. Prevention of discomfort on the body parts is one of the key objectives of ergonomics. Numerous approaches and strategies have been suggested for defining and assessing risk factors for WMDs. Ergonomic methods and approaches are built by adapting the ergonomic expertise to enhance the working system and operation. Ergonomic approaches have become more popular and among the recommended methods for treatment and prevention of WMSD conditions. For school teachers who have been subjected to prolonged standing during school hours, established types of ergonomic assessments such as electromyography (EMG), Borg's scale, and Nordic Musculoskeletal Disorders Questionnaire may be implemented. EMG may provide a real-time examination of muscle weakness or discomfort to enhance the body part's individual perception using Borg's scale and Nordic Musculoskeletal Disorders Questionnaire. In a very convenient process, these ergonomic assessments and experimental techniques can be viewed as one of the methods to assess school teachers' health (Alias et al., 2020).

Footwear interventions, such as shoe insoles, therefore draw interest in to be used within healthy populations. Various shoe insoles promote simple, inexpensive, and non-invasive interventions that could reduce lower limb pain (Collins et al., 2007). A wide selection of shoe insoles is offered and designated with innovative design features such as vibrating components (Novak and Novak, 2006; Priplata et al., 2003). Glycerine-filled shoe insole has been recently designed and developed to provide a foot massaging effect to the foot that may function like other interventions to enhance sensory information of skin contact. Parallel with the rapid growth of the current footwear industry, interventions on shoe insole is becoming an increasingly important area (Hatton et al., 2015) for research, especially for occupational groups that require prolonged standing, sitting, and performing repetitive physical movements when they are working. Compared to other occupational groups, minimal studies provide footwear intervention for school teachers, especially when it comes to using vibrating insoles. It is therefore interesting to conduct this similar type of study among female school teachers.

1.2 Problem Statement

MSDs are one of the most prominent and critical concerns in the education sector, which was ignored for such a long time but has been seriously paid attention to in recent years. MSDs involve a vast range of inflammatory conditions that affect muscles, joints, tendons, ligaments, nerves, bones, and the mechanism of circulation triggered or worsened by working activities and the consequences of working in the surrounding environment. School teachers generally have demonstrated high rates of MSDs, approximately 40% and 95% in contrast with other different occupations (Eric and Smith, 2015). MSDs are one of the leading health complications in the world. Throughout the working population, MSDs have contributed to increased health issues, as mentioned by the International Labour Organisation (ILO, 2009). MSD is caused by repetitive motion, stressful working conditions, unfavourable and static posture. Various researchers had explored the nature of MSDs and alternative methods of treatment. MSDs seem to be the world's leading and severe disease cause for teachers, as several studies have recorded a high rate of MSDs among teachers. Studies have strongly indicated that teachers are at greater risk of developing MSDs. It is also stated that MSDs are most probably an under-researched issue among primary school teachers (Ebied, 2015).

In Malaysia, a total number of 553 claims were recorded related to MSD between years 2009 until 2014 which corresponds to 25.22% of the overall occupational diseases that lead to temporary and permanent disability (Jafri et al., 2016). MSD problems are generally caused by the work-related physical risk factors such as repetitiveness, work environment, and psychosocial factors. This MSD will give employee experience of pain or discomfort in the muscles, nerves and tendons regions including other soft tissue (Nur, Dawal and Dahari, 2014; Asih et al., 2017). The percentage of claimants will be vary depending on the scale of sectors. There is a study shows that MSD commonly occurred at lower back (48%), shoulder (13%), upper extremities (5%), knee (5%), ankle or foot (2%) and multiple sites (5%) (Davis et al., 2014). In Malaysia, MSD (25.2%) has the highest cases claimed among the other diseases. For the year 2014, the total cost was costlier compare for the year 2012, with almost RM3 million. This led to the total cost of 537 MSD claims to be almost RM13 million. Occupational morbidity imposes major health and economic burden on individual workers, employers, and society. Based on SOCSO database provided, MSD total direct cost was reported to be amount RM11 billion for the five-year period, from 2009 till 2014, including private and government sectors. This cost incurred shows that there is a need to concern on MSDs disease from the bottom line to the top level (Zainal Abidin et al., 2018).

In Malaysia, a high prevalence of MSDs was reported by Ng et al., (2019), with a six-month prevalence of 80.1% of primary school teachers. Specifically, the only baseline data for MSDs prevalence in Terengganu was discovered recently by Alias et al., (2020) with a 40.1% MSDs prevalence of primary school teachers. In recent studies, the prevalence of MSDs among primary schools in Malaysia

has also been found to range between 40.4% and 74.5% (Zamri, Moe and Hoe, 2017; Nur Farahwahida et al., 2016; Samad et al., 2010). As a highlight, Alias et al., (2020) recorded a high prevalence of feet MSD, 32.5% for the past 12 months, and 36.8% for the past seven days among female primary school teachers in Terengganu. Ng et al., (2019) also found a high prevalence of feet, with 87.7% among primary school teachers in Kuala Lumpur. Globally, there was a high prevalence of feet documented in Botswana with 37.8% (Eric and Smith, 2014), Iran's high school teachers with 46.8% (Mohammadi, 2013), and physical education subject teachers in Slovenia with 60% (Kovac et al., 2013). These prevalence rates are comparatively greater than that of teachers in primary schools and secondary schools in Turkey with 21.8% and 7.3% (Korkmaz, Cavlak and Telci, 2011; Baskurt, Baskurt, and Gelecek, 2011), music teachers in Sweden, with 9.0% and 5.5% (Fjellman-Wiklund and Sundelin, 1998; Fjellman-Wiklund, Brulin, and Sundeline, 2003) and school teachers in Bolivia (30.4%) respectively (Solis-Soto et al., 2017).

According to Ozturk (2011), teachers' roles have changed due to the advancement of technology, globalisation, and the transformation of educational prerequisites. With the rapid technological growth, the tasks and duties of teachers are becoming more challenging and demanding. Skilled teachers can creatively integrate the knowledge with learning and teaching methodologies to help students' understanding during the learning process (Taharim et al., 2017). Studies stated that MSDs are most likely affected by school teachers' psychosocial factors such as hectic schedules or responsibilities, high levels of stress due to work demand, and lack of job quality and satisfaction (Erick and Smith, 2011; Erick and Smith, 2014). A teacher spends most of the school hours standing in the classroom, working between desks in small spaces, educating students, writing on the board, planning lessons, grading assignments, and doing extra school administrative work, which can develop mental and physical health issues over time (Chong and Chan, 2010).

As per the Organisation for Economic Cooperation and Development (OECD) (2014), statistics showed that school teachers in Malaysia mostly spend 70% of their working hours per week in actual teaching and learning sessions, 18% for keeping order in the classroom, and the rest of their time, and 12% in administrative tasks (Figure 1.3). As indicated earlier, the demands of this profession normally happen for long hours daily in one year or more with excessive pressure on the body’s musculoskeletal system, which may result in WMSDs with added poor body motions (Damayanti, Zorem and Pankaj, 2017). Extended static pose, body posture, and continuous work nature without adequate rest periods expose high-risk teachers to establish WMSDs (Liping, Pengying and Fengying, 2012). School teachers are susceptible to WMSDs with a large prevalence of back, shoulder, neck, and wrist/hand and leg pain. School teachers devote most of their working days for activities involving movements and postures that stress their bodies (Cheng, Cheng, and Ju, 2013).

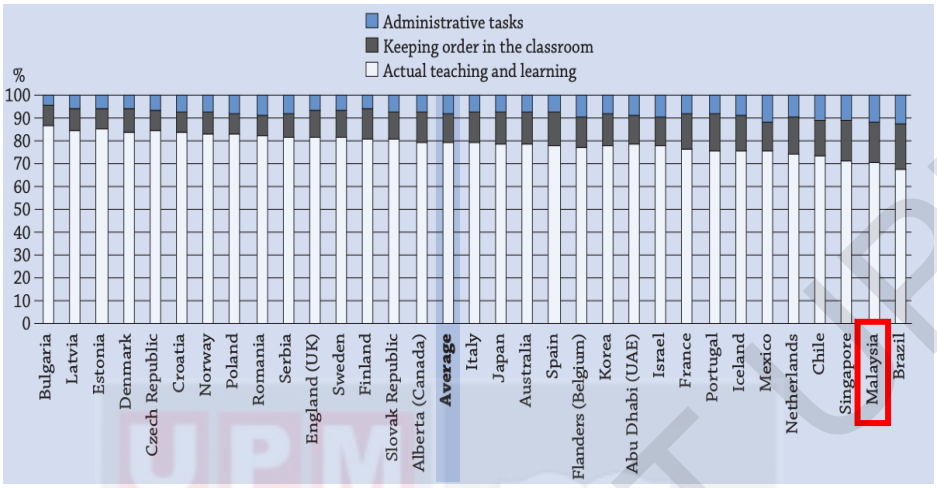

Figure 1.3: Distribution of teachers' task per week 2014
(Source: OECD, 2014)

MSDs are the product of contact between an individual with a host of risk factors, including personal, physical, and psychosocial nature. The most significant risk factors among teachers include gender, age, smoking habits, weekly working hours, length of employment, and postures. One of the risk factors highlighted is long working hours which subsequently forced teachers to undergo prolonged sitting, prolonged standing, or working in an awkward posture. This risk factor has been confirmed by results that were documented regarding teachers with neck pain, shoulder pain, upper limb pain, back pain and lower limb pain (Erick and Smith, 2013). Analysis of logistic regression done by Alias et al., (2020) showed that long working hours in teaching is indiscriminately and substantially associated with MSDs ($p=0.04$) with a probability of 2.39 times among female school teachers. Ultimately, if working hours were increased, the recovery time from musculoskeletal stress among school teachers would be decreased. This can accumulate and expedite disorders due to the disproportionate impact of MSDs caused by long working hours (Ono et al., 2002).

School teachers suffer from MSDs on the lower extremities due to long working hours, especially during teaching sessions, posture discomfort in the classroom, an uncomfortable sitting posture of the lower back, repetitive and uncomfortable bend (Yue, Liu, and Li, 2012). Even so, school teachers are still faced with social and psychological difficulties both within and after school hours every day and have reported less time to relax after teaching because of extra work. This could lead to chronic musculoskeletal problems (Shimizu et al., 2011; Vignoli et al., 2015). A teacher is considered to be subject to prolonged standing if they spend more than half of the school hours every day in a standing position (Darwish and Al-Zuhair, 2013). When teachers spend a long time standing throughout the school hours, they may experience pain and muscle exhaustion at the end of the working day. They may have suffered musculoskeletal injuries over a long period. Slow posture deterioration may be caused by standing for long periods.

Normally, while standing in the classroom, teachers would sluggishly shift weights of the body from one foot to the next to ease the pressure. Slouching encourages a standing posture that makes teachers to be less alert and inactive. When this uncomfortable pose is maintained for long, it may lead to circulation problems such as swollen legs and feet. Standing for a long time also renders the joints in the back, knee, and feet partially immobilised or stiff (Vaghela and Parekh, 2017).

Teachers' work task involve a wide range of tasks and responsibilities that may be handled under unfavourable working conditions, particularly in developing countries. These may include or lead to prolonged standing and awkward posture while writing on the table, helping students with their research or helping students during extracurricular activities, especially during physical education period. Therefore, these factors have been strongly associated with the teaching profession's development of WMSDs (Cardoso et al., 2009; Chong and Chan, 2010). Based on systematically reviewed studies by researchers, the self-reported prevalence among school teachers related to WMSDs varies from 39% to 95%, with upper limbs and lower limbs being the affected symptom areas. The role of school teachers involves teaching students, planning classes, marking homework, and administrative school work that may trigger discomfort on upper limb and lower limb body parts (Chong and Chan, 2010; Yue, Liu and Li, 2012). School teachers are very vulnerable to MSDs due to their nature of work, particularly primary school teachers. They spend most of their time standing and moving around to monitor progress in teaching and to ensure comprehensibility of lessons for their students. A similar study was carried out by Mariammal et al., (2012) who found the teaching culture was greatly affected by physical illness induced by the profession. This form of physical impairment found among teachers may be due to their prolonged standing and frequent walking inside the classroom, as well as repeated hand-raising while writing in the board (Ebied, 2015). It was clear that awkward posture among teachers was significantly associated with MSDs. This includes twisting, such as turning from the board to the class and back again (Delcor et al., 2009) during standing.

On the other hand, teachers must wear appropriate attire during school hours including the selection of style of shoes, often teachers will wear two type of shoes during school hours which were shoe with heels and flat shoe. According to study done by Alias et al., (2020), teacher wearing shoes with heels have a substantial correlation of calf MSD ($p=0.02$) relative with teachers wearing flat shoes. This significant value is parallel to the study in Saudi, showing that teachers wearing high-heel shoes had a strong positive relationship with musculoskeletal pain disorders ($p<0.01$). This can be attributed to the disturbance of gait and posture for the whole body causing severe muscles and ligament strain. Chaiklieng and Suggaravetsiri (2012) have found significant correlation in teachers (OR=1.60) between high heels use and repetitive strain injury. Gastwirth et al., (1991) observed that proximal symptomatology associated with wearing high heels, such as the knee, hip and back problems, may be linked to the limitation of the subtalar joint. The subtalar joint pronation in shock absorption that occurs typically at heel strike aids. If this pronation is

limited, the joints proximal to the foot need to absorb an increased shock wave. Because of the use of heels, misalignment of the spine and lower limbs may predispose to musculoskeletal disorders in adolescents, and low back pain is one of the main issues described in the literature in high-heels users. Nevertheless, the increased activity of the spinal error muscles and abdominal distension during heel use may be associated with the user-reported pain and discomfort. A high-heeled shoe causes damage to the musculoskeletal system when the height of the sole promoted an inclination that is characterized by an elevation of the heel region of support over the forefoot (Santos et al., 2008).

To overcome these health problems among school teachers, several researchers proposed that insole interventions could be adopted due to their practicality when applied to different types of footwear (Nagano and Begg, 2018). Other than that, research in pain reduction through the application of vibration had been extensively used and, in some cases, were shown to be even more effective (Radl and Kroop, 2011). It is also supported by a statement from Ohio State University Medical Centre (2017) that says vibration massage was known as a method of pain relief by inducing numbness in the affected area. Vibration can also help to relax the muscles around the sore site, further minimising muscle aches and discomfort (Hijmans et al., 2007). However, there has been no studies conducted using this type of intervention among school teachers, especially in Malaysia. In this regard, the vibrating insole prototype was assessed in this study to indicate the levels of discomfort rating (Borg's scale) and electromyography (EMG) data distribution among female school teachers.

1.3 Study Justification

In Malaysia, the educational system needs to be very progressive to achieve better outcomes in for future generations. Traditionally, teachers are primarily responsible to teach according to the guidelines and designated syllabus provided by the Ministry of Education. However, nowadays, teachers' roles and responsibilities have evolved and become more challenging with higher demands and requirements to prepare the future generations for the 21st century. According to Ozturk (2011), teachers' roles have changed due to the advancement of technology, globalisation, and changes in educational needs and demands. Studies stated that MSDs among school teachers are most likely influenced by psychosocial factors such as high workload or demands, high perceived stress levels, low job satisfaction, and poor work quality (Erick and Smith, 2011; Erick and Smith, 2014).

MSDs constitute common occupational health problems (Guo et al., 2004; Halim et al., 2014) and one of the most prevalent health disorders that cause occupational disability (Karimi et al., 2016). Essentially, MSDs are a state wherein the muscles are under tension. It is attributed to muscle sensitivity to static and repeated movements for a prolonged period, resulting in damage to ligaments, tendons, and joints (Sholihah et al., 2015). There are numerous

musculoskeletal health problems, both for men and women, which presumably reflect their division into different opportunities. Teaching is a professional field, and in most countries, the proportion of female teachers is significantly higher than their male counterparts. Numerous research has shown that women have become less qualified for a job with a low wage and have had less time to handle a considerable workload and greater demand than men, which have shown disparities in the employment of males and females (Arauja et al., 2006). The prevalence of musculoskeletal problems is positively linked to female teachers (Chiu and Lam, 2007; Chong and Chan, 2010; Korkmaz et al., 2011). MSDs for the first episode of 2-4 weeks can be treated (McKeon et al., 2006). In contrast, teachers who have long-term musculoskeletal disorders may experience various physical, psychological, and emotional consequences detrimental to their teaching jobs (Tavafian et al., 2007).

The main workspace for school teachers is their classrooms. Teachers typically try to modify their existing work environment to cater for the diverse needs of students. A classroom with an improper design can directly impact the effectiveness of teachers' performance, leading to poor health, and resulted in low quality teaching. Teachers have to perform various tasks in a single day, such as teaching multiple subjects to students, checking students' notebooks, maintaining class discipline, writing on the blackboard, dictating notes to students, and taking students' attendance. Szeto (2003) found that many schools have non-adjustable furniture, which made it harder to match teachers' different physical needs, which could result in poor posture and long-term negative impact on the musculoskeletal health. It was reported that teachers sometimes feel pain in different parts of the body while doing school tasks. Musculoskeletal disorders, such as low back pain, neck/shoulder pain, arm pain, joint pain, bones, and muscles, are common and often occurring diseases that arise from abnormal posture over time. Teachers are often pressured to take an uncomfortable posture due to a poor classroom design. Teachers can also experience many kinds of physical discomfort during teaching, which can lead to MSDs. If this conflict persists for a lengthy period, it could significantly impact teachers in conducting their daily teaching tasks (Mesaria and Jaiswal, 2015).

Nonetheless, the epidemiology of lower extremity of musculoskeletal disorders (LEMSDs) had been given much less consideration compared to work-related MSDs in the upper extremity. LEMSDs is different from MSDs, for which it impacts the back, neck, and upper limbs since they often contribute to higher levels of immobility and thus would considerably deteriorate the quality of health and wellbeing (Lohmander et al., 2004). In recent research in Terengganu showed that female teachers from primary schools have reported feet was the highest prevalent with 32.5% and followed with other LEMSDs which were knee (28.8%), lower back (25.0%), and calf (24.1%) (Alias et al., 2020). In Bentong, Pahang, many secondary school teachers had severe low back pain compared to minor back pain (50.6% vs. 40.5%) (Balakrishnan, Chellapan, and Thenmozhi, 2016). Cardoso et al., (2009) examined the frequency and association of MSDs with their work-related variables among school teachers in Brazil with a high prevalence of lower limb (41.1%). A previous study among school teachers in

India documented a significant prevalence of knee (33.7%), ankle, and foot (25.4%), and hip and thigh discomfort (7.1%) as results of long-standing at school, especially in the classroom for several hours and repetitive staircase climbing during school periods. In Kenya, teachers that taught between one to two hours recorded a higher prevalence of MSDs affecting knee part (Ndawa, Nyamari, and Ireri, 2019).

In several studies, musculoskeletal pain or painful feeling has been checked in teachers as a major health issue. These pain and feelings are mainly because of the musculoskeletal systems disorders are the main causes of absenteeism and professional diseases in this category. MSD decreases the productivity at work due to sick leave, absenteeism, and early retirement (Cardoso et al., 2009; Vaghela and Parekh, 2017). Everyone, excluding individuals with congenital insensitivity, has already felt discomfort and pain sometimes in their lives. However, when symptoms continue, they become a problem, a reason for reducing work activity, work leave and absence, in addition to the possibility of developing depression. Several sociodemographic, psychosocial, physical and organizational factors are related to triggering, developing and maintaining the musculoskeletal pain (Vaghela and Parekh, 2017). Darwish and Zuhair (2013) reported the findings in their study that secondary school female teachers showed high prevalence of MSDs (79.17%) and more than half (53.3%) of those suffering pain were considered significant/disabling and were associated with more days of absenteeism. The days of absenteeism among these female school teachers have been positively associated with higher Orebro musculoskeletal pain score ($p=0.015$). Similar finding done in Natal, Brazil, the musculoskeletal pain was the main cause of absenteeism in school teachers of Natal (Porto et al., 2004). Musculoskeletal pain is the main cause of absenteeism from work, decreased quality of life and early retirement of school teachers, limiting physical and professional functions and, finally, causing a huge economic loss for the state (Althomali et al., 2021).

Various motor task including daily, and sport activities induce fatigue. Fatigue can induce postural instability and even lead to falls. Multiple studies have quantified the effect of fatigue on postural stability and found that fatigue diminishes postural control ability and causes higher variability of joint movement and unintentional body tremor (Gribble and Hertel, 2004; Cortes, Onate and Marrison, 2014). However most current methods to delay or reduce fatigue require long prepatory time or large and expensive equipment. Collins, Imhoff and Grigg (1996) have shown that noise can increase somatosensory perception when stochastic resonance (SR) amplifies the necessary signal to exceed the detection threshold. More specifically, application of sub-threshold mechanical vibration enhances the sensitivity of degraded somatosensory systems in the elderly and patients with peripheral neuropathy, resulting in an increase in postural stability (Dettmer et al., 2016; Dettmer et al., 2015). In the case of young healthy adults, application of SR can improve postural control and reduce fatigue as well as discomfort on body parts especially feet. The sub-threshold mechanical vibration generated by an active insole can counteract the degradation of postural stability after fatigue (Allen, Lamb and Westerblad,

2008). Moon et al., (2020) stated that this effective sub-sensory vibration can be implemented compactly. In their study, the vibration was applied by embedding the active insole units in shoes. The rechargeable battery and the actuator were all inside the shoes as well as wireless vibrating insole. The efficacy in improving balance and the simple implementation of the active insole vibration unit suggests the use of the devised system as a convenient intervention to compensate for deterioration in balance due to fatigue.

Considering the higher prevalence of MSDs among school teachers, the ergonomics approach as one of the preventive measures that can mitigate the incidence of these disorders, particularly in those at higher risk, should be practiced by the teachers. Since teachers are the leading resource for unleashing the next generations' potential and making them progressive citizens of the country, priority should be given to their health. Therefore, preventing teachers' MSDs at the workplace should be an essential aim of rehabilitation (Damayanti, Zorem, and Pankaj, 2017). More intervention approaches should be implemented among school teachers to reduce the prevalence of MSDs. Alias et al., (2020) suggested that teachers should be supported with ergonomic design shoes or insoles to wear, especially during classroom activities which require prolonged standing and repetitive leg movements. Teachers should be supplied with this ergonomic footwear to reduce discomfort or pain in lower limbs during school hours, especially in the middle of the teaching session. Only a few studies focused on the prevalence of lower limbs among school teachers, specifically footwear ergonomic interventions, which play a significant role in maintaining a healthy posture during the teaching process. Past researchers have reported that ergonomic interventions, such as shoe insoles, can minimize pain and discomfort, particularly in the lower legs (King, 2002; Sousa et al., 2016). A study by Sousa et al., (2016) indicated that putting on steady shoes in standing posture can enhance the individual's posture control system's efficacy and effectiveness and provide them with more comfort during the working process. In this regard, a vibrating insole prototype was assessed in this study to improve comfort level among female school teachers.

Lastly, this study expected to fill the gap as there has been no reliable ergonomic intervention for school teachers in the school setting and with this vibrating insole, school teachers may adapt well without disrupting their daily routine and activities, particularly during teaching process in the classroom. In fact, with this dynamic and built-in intervention, vibrating insole is an appropriate option for footwear intervention as school teachers are involved with various movements and postures. To be highlighted in this study, it is beneficial to occupational groups especially school teachers as vibrating insoles have previously only been applied as treatment and rehabilitation for individuals with health issue. The main purpose of this vibrating insole is to induce comfort among healthy individuals as previously, research on vibration and massage effect only focused to improve fall and balance control among elderly and Parkinson patients, postural stability among diabetic patients and plantar sensation for those who have nerve injury. Most importantly, this intervention of vibrating insole will provide health-care professionals and practitioners with some new insight on the potential application

of vibrating insole on comfort and muscle activity and at the same time optimize the current insole' design and development for daily use and working activity.

1.4 Conceptual Framework

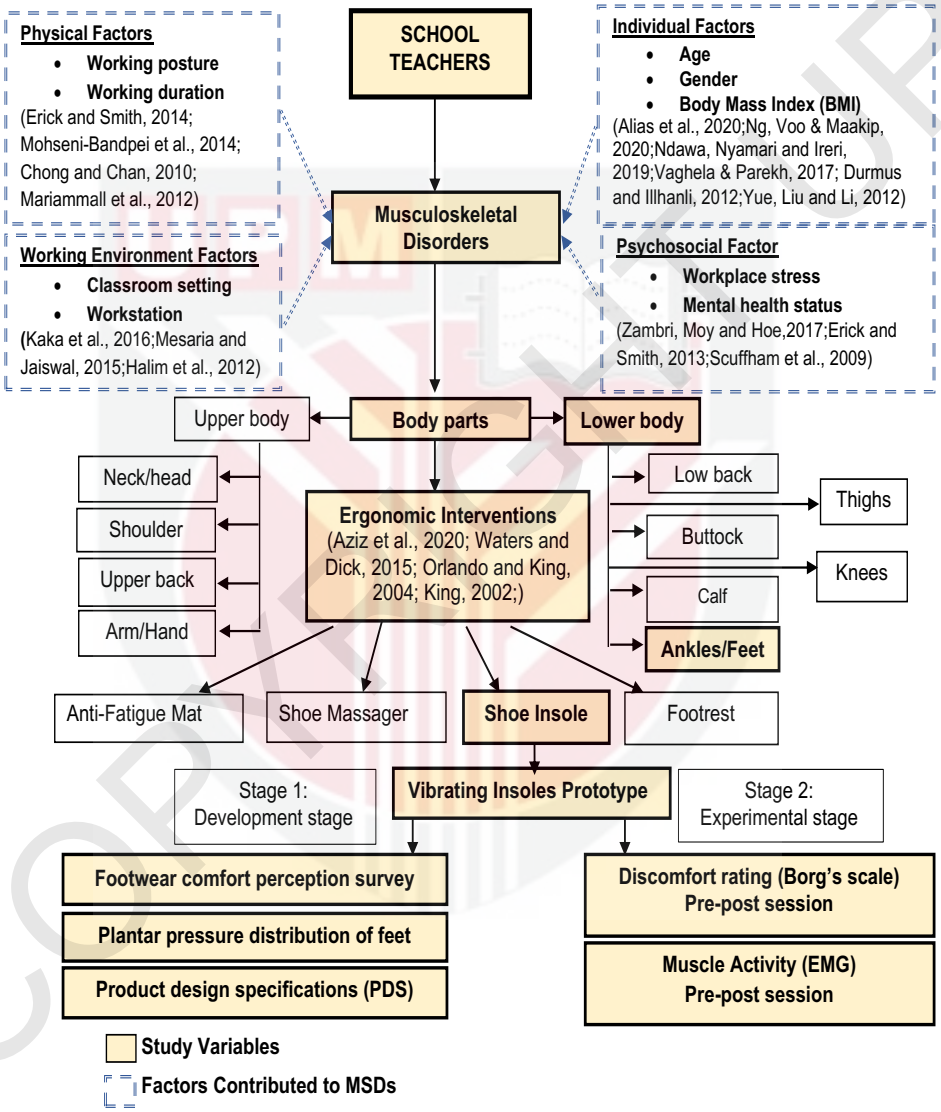

Figure 1.4: Conceptual Framework of Quantitative Assessment of Vibrating Insole Prototype That Induced Transient Comfort Among Female School Teachers

1.5 Study Objectives

1.5.1 General Objectives

To assess the prototype of vibrating insole by quantitative assessment of discomfort rating (Borg's Scale) and muscle activity (Electromyography) to induce transient comfort among female school teachers.

1.5.2 Specific Objectives

1. To identify the perception of footwear comfort among female school teachers.
2. To identify the plantar pressure distribution of feet among female school teachers.
3. To determine the product design specifications (PDS) of vibrating insole prototype conceptual design for female school teachers.
4. To determine data distribution of discomfort rating (Borg's scale) and exertion of muscle activity (electromyography) of tibialis anterior and peroneus longus muscles among female school teachers.
5. To compare the differences of discomfort rating (Borg's scale) for ankle and feet between experimental and control groups among female school teachers.
6. To compare the differences in the exertion of muscle activity (electromyography) of tibialis anterior and peroneus longus muscles between experimental and control groups among female school teachers.

1.5.3 Study Hypothesis

1. The vibrating insole prototype induce transient comfort within one-hour with the reductions of discomfort rating (Borg's scale) and exertion of muscle activity (electromyography) of tibialis anterior and peroneus longus muscles among female school teachers.
2. There are significant differences in discomfort rating (Borg's scale) for ankle and feet between experimental and control groups among female school teachers.
3. There are significant differences in muscle activity exertion (electromyography) for tibialis anterior and peroneus longus muscles between experimental and control groups among female school teachers.

1.6 Definition

1.6.1 Body Mass Index

Conceptual Definition

The Body Mass Index (BMI) is a weight-for-height measurement that is widely used to identify underweight, overweight, and obese in adults (WHO, 2020).

Operational Definition

Body weight and the height of a person are calculated using this formula: Body mass index = weight (kg) / Height^2 (m^2).

Table 1.0: The Classification of BMI by WHO(2020)

Classification	BMI (kg/m^2)
Underweight	<18.50
Normal	18.50-24.99
Overweight	25.00-29.99
Obese	≥30.00

1.6.2 Plantar Pressure Distribution

Conceptual Definition

Plantar pressure analysis is one of the most prevalent methods used to study the relationship of foot posture with the lower limb's biomechanical interposition. It refers to the calculation of the magnitude and intensity distribution exerted to the plantar surface of the foot during the period of standing posture and walking processes (Buldt et al., 2018; Landorf and Keenan, 2000).

Operational Definition

Insole pressure sensor technology enables the recording of data from multiple steps in a single dataset. When the foot posture is positioned on the relative sensor, data from multiple steps can be measured seamlessly, thereby lessening measurement errors than platform devices that can be generated at a time. Insole technique also allows a more natural movement of the gait between study subjects (Chun et al., 2018).

1.6.3 Discomfort

Conceptual Definition

Discomfort is a "phenomenon of perception" related to pain, fatigue, and perceived exertion and arises when physical activities have excessive bodily energy beyond the human body's potential (Korhan, 2012). Discomfort occurs when there is a limitation of blood supply in the lower legs and individuals may experience pain in the lower limb muscles (lower back, thighs, knees, and feet) (Halim et al., 2012).

Operational Definition

Discomfort is assessed by subjective rating assessment, which allow individuals to assess their discomfort or fatigue using a diagram of their body position (Waters and Dick, 2015). The Borg's scale (CR-10) body discomfort chart (a figure accompanied by the written assessment) are used to determine the level of perceived discomfort on the part of the body (Karmegam et al., 2012).

1.6.4 Electromyography (EMG)

Conceptual Definition

Electromyography is the calculation of electrical potential on the skin due to the contraction of neuromuscular activities. Non-invasive techniques like EMG are suitable for ergonomics applications to assess muscle fatigue characteristics and measurements (Merlo and Campanini, 2010).

Operational Definition

A measuring, recording, and evaluation process of right and left leg muscles (tibialis anterior and peroneus longus muscles) with the surface electrode is attached to the leg region. The biopotential electrodes and lead wires were attached at the left and right leg for both muscles and measured using electromyographic measurement.

1.6.5 Muscle Activity

Conceptual Definition

Muscle activity is any muscle recruitment that takes place and is a good measure to use in ergonomic design cases to determine a tool or a posture that minimises the effort of a given work task. Muscle activity can be measured as the number

of stimulated motor units varies according to the force requirement. More action potentials are produced in a muscle per unit time. The amplitude of the EMG thus increases with an increase in force (USDHHS, 1992).

Operational definition

Time series recordings of muscle activities during the teaching process for one-hour were obtained with wireless electromyography (EMG) and analysed with standard root-mean-square (RMS) amplitude measurements and converted from the time domain to frequency domain. The mean power frequencies of the RMS-processed with the Maximum Voluntary Contraction (MVC) signals of 10 seconds were then calculated to estimate exertion frequency known as the percentage of exertion (%). Thus, the increasing value of exertion percentage indicated increasing muscle activity on leg muscles.

1.6.6 Vibrating Insole Prototype

Conceptual Definition

Vibrating insole prototype is a feature that has been ergonomically designed. The prototype will be attached to the shoes in order for them to have a vibration effect on their feet without interrupting their teaching routines in the classroom.

Operational definition

Experimental testing in the classroom involved two different sessions, one with a vibrating insole prototype attached to the shoes for the experimental group, and one without a vibrating insole prototype attached to the shoes for the control group.

REFERENCES

Abdulmonem, A., Algethami, H., Ahmed, E., Tokhtah, H., & Aldouhan, J. (2014). The prevalence of musculoskeletal pain and its associated factor among female Saudi school teachers. *Pakistan Journal of Medical Sciences*, 30(6):1191-1196.

Abdul Razak, A. H., Zayegh, A., Begg, R. K., & Wahab, Y. (2012). Foot plantar pressure measurement system. A review. *Sensors*, 12:9884-9912.

Aboutorabi, A., Arazpour, M., Farahmand, F., Bahramizadeh, M., Fadayevatan, R., & Abdollahi, E. (2018). Design and evaluation of vibratory shoe on balance control for elderly subjects: Technical note. *Disability and Rehabilitation: Assistive Technology*, 13(2).

Alemany, S., Gonzalez, J. C., Garcia, A. C., Olaso, J., Montero, J., Chirivella, C., Prat, J., & Sanchez, J. (2005). A novel approach to define customized functional design solution from user information for Hong Kong: 3rd Interdisciplinary World Congress on Mass Customization and Personalization.

Almeida, J. S., Vanderlei, F. M., Pastre, E. C., Martins, R. A. D. M., Padovani, C. R., & Filho, G. C. (2016). Comparison of two types of insoles on musculoskeletal symptoms and plantar pressure distribution in a work environment: A trial randomize clinical trial. *Clinical Medicine & Research*, 14(2): 57-74.

Alias, A. N., Karuppiah, K., Vivien, H., & Perumal, V. (2020). Prevalence of musculoskeletal disorders (MSDs) among primary school female teachers in Terengganu, Malaysia. *International Journal of Industrial Ergonomics*, 77:102957.

Alias, A. N., Karuppiah, K., Vivien, H., & Perumal, V. (2020). Does prolonged standing at work among teachers associated with musculoskeletal disorders (MSDs)?. *Malaysian Journal of Medicine and Health Sciences*, 16(2):281-289.

Alias, A. N., Karuppiah, K., Vivien, H., Perumal, V., Sambasivam, S., & Tamrin, S. B. M. (2019). Are teachers standing too much at Work?. *Ergonomic International Journal*, 3(5). DOI:10.23880/EOIJ-16000216.

Alias, A. N., Karuppiah, K., Vivien, H., Perumal, V., Sambasivam, S., Tamrin, S. B. M., & Naeini, H. S. (2020). The perception on school footwear comfort among primary school female teachers in Terengganu. *International Journal of Pharmaceutical Research*, 12(3). DOI:https://doi.org/10.31838/ijpr/2020.12.03.288.

Allen, D. G., Lamb, G. D., & Westerblad, H. (2008). Skeletal muscle fatigue: Cellular mechanisms. *Physio. Rev.,* 88:287-332.

Almeida, J. S., Vanderlei, F. M., Pastre, E. C., Martins, R.A.D.M., Padovani, C. R., & Filho, G. C. (2016). Comparison of two types of insoles on musculoskeletal symptoms and plantar pressure distribution in a work environment: A Randomized Clinical Trial. *Clin Med Res*., 14(2):67-74.

Althomali, O. W., Amin, J., Alghamdi, W., Shaik, D. H. (2021). Prevalence and factors associated with musculoskeletal disorders among secondary schoolteachers in Hail, Saudi Arabia: A cross-sectional survey. *International Journal of Environmental Research and Public Health*, 18:6632.

Amell, T. & Kumar, S. (2001). Work-related musculoskeletal disorders: Design as a prevention strategy. A review. *Journal of Occupational Rehabilitation*, 11(4):255-65.

Anderson, J., Williams, A. E., & Nester, C. (2017). An explorative qualitative study to determine the footwear needs of workers in standing environments. *Journal of Foot and Ankle Research*, 10:41.

Anderson, S. P., & Oakman, J. (2016). Allied health professionals and work-related musculoskeletal disorders: A systematic review. *Safety and Health at Work*., DOI:10.1016/j.shaw.2016.04.001

Ankrum, D. R. (2000). On the confusion between static load level and static task. *Applied Ergonomics*, 31:545-546.

Armstrong, D. G., Peters, E. J. G., Athanasiou, K. A., & Lavery, L. A. (1998). Is there a critical level of plantar foot pressure to identify patients at risk for neuropathic foot ulceration?. *J. Foot Ankle Surg*., 37:303-307.

Arauja, T. M., Godinho, T. M., Reis, E. J. F. B., & Almeida, M. M. G. (2006). Gender differentials and health impacts in the teaching profession. *Ciencia & Saude Coletiva*, 11(4):1117-1129.

Ariens, G.AA., Bongers, P. M., Hoogerndoorn, W. E., Houtman, I. L., & Van Der Wal, G. et al., (2001). High quantitative job demands and low coworker support as risk factors for neck pain: Results of a prospective cohort study. *Spine*, 26:1896-1901. PMID:11568702.

Arvidsson, I., Simonsen, J. G., Dahlqvist, C., Axmon, A., Karlson, B., Bjork, J., & Nordander, C. (2016). Cross-sectional associations between occupational factors and musculoskeletal pain in women teachers, nurses and sonographers. *BMC Musculoskeletal Disorders*, 17:35.

Asih, S., Neblett, R., Mayer, T. G., & Gatchel, R. J. (2017). Does the length of disability between injury and functional restoration program entry affect treatment outcomes for patients with chronic disabling occupational musculoskeletal disorders?. *Journal of Occupational Rehabilitation,* 1-11.

Atlas, A., Bondoc, R. G., Garrovillas, R. A., & Lo, R. D. (2007). Prevalence of low back pain among public high school teachers in the city of Manila. *Philippine Journal of Allied Health Sciences*, 2(1):34-40.

Ayoub, M. A. (1990). Ergonomic deficiencies: II. Probable causes. *J. of Occupational Medicine*, 32(2):131-136.

Ayuni, N. A., Karmegam, K., Vivien, H., & Velu, P. (2020). A Systematic Review for Musculoskeletal Disorders (MSDs) among School Teachers in Malaysia. *Research Journal of Recent Sciences*, 9(3):1-8.

Aziz, A. A., Karuppiah, K., Suhaimi, N. A., Perumal, V., Perimal, E. K., & Tamrin, S. B. M. (2020). Footrest Intervention: Association between Prolonged Standing and Perceived Exertion in the Body Parts among Industrial Workers using Borg's Scale Questionnaire. *International Journal of Industrial Ergonomics*, 76:102898. DOI:10.1016/ j.ergon. 2019.102898.

Balakrishnan, R., Chellapan, M. E., & Thenmozhi (2016). Prevalence of low back pain and its risk factors among secondary school teachers at Bentong, Pahang. *International Journal of Physical Education, Sports and Health*, 3(2):35-40.

Balasubramanian, V., Adalarasu, K., & Regulapati, R. (2009). Comparing dynamic and stationary standing postures in an assembly task. *International Journal of Industrial Ergonomics*, 39:649-654.

Barnett, S. (1998). International protocol guidelines for plantar pressure measurement. *The Diabetic Foot*, 1(2): 137-40.

Basford, J. R., & Smith, M. A. (1998). Shoe insoles in the workplace. *Orthopedics*, 11(2): 285-288.

Baskurt, F., Baskurt, Z., & Gelecek, N. (2011). Prevalence of self-reported musculoskeletal sympotms in teachers. *SDÜ Saglik Bilimleri Enstitüsü Dergisi Cilt.,* 2:58-64.

Bergin, S. M., Gurr, J. M., Allard, B. P., Holland, E. L., Horsley, M. W., Kamp, M. C., Lazzarini, P. A., Nube, V. L., Sinha, A. K., Warnock, J. T., et al. (2012). Australian diabetes foot network: Management of diabetes-related foot ulceration-A clinical update. *Med. J. Aust.,* 197:226-229.

Beyen, T. K., Mengestu, M. Y., & Zele, Y. T. (2013). Low back pain and associated factors among teachers in Gondar Town, North Gondar, Amhara Region, Ethiopia. *Occup Med Health Aff.*, 1:5.

Borg, G. A. V. (1982). A category scale with ratio properties for intermodal and interindividual comparisons*:* H.G. Geissler and P. Petzold, VEB Deutscher Verlag der Wissenschaften (Ed) in *Psychophysical Judgment and the Process of Perception,* (pp. 25-34). Berlin.

Boschman, J. S., Frings-Dresen, M. H., & Molen, H. F. (2015). Use of ergonomic measures related to musculoskeletal complaints among construction workers: A 2-year follow-up study. *Safety and Health at Work*, 6(2):90-96. DOI:10.1016/j.shaw.2014.12.003.

Bradley, S. N., Ian B. G., Geoffrey, J. D., George, S. M., Shannon, E. M., Melinda, M. F. S. (2014). Foot posture as a risk factor for lower limb overuse injury: A systematic review and meta-analysis. *J Foot Ankle Res.,* 7(55):1-13.

Bridger, R. S. (1995). *Introduction to ergonomics*. New York: McGraw-Hill.

Bridger, R. S., & Whistance, R. S. (2006). Postural adaption. *International Encyclopedia Ergonomics Human Factors,* 2:467-468.

Broega, A.C., Righetto, M., & Ribeiro, R. (2017). Female high heel shoes: A study of comfort. *IOP Conference Series: Materials Science and Engineering*, 254(23). DOI:10.1088/1757-899X/254/23/232001.

Bruchal, L. C. H. (1995). *Occupational Knee Disorders: An Overview*. London: Taylor & Francis.

Bryant, A. R., Tinley, P., & Cole, J. H. (2005). Plantar pressure and radiographic changes to the forefoot after the Austin bunionectomy. *J Am Podiatr Med Assoc*, 95(4):357-365.

Buldt, A. R., Tinley, P. & Singer, K. P. (2018). The relationship between foot posture and plantar pressure during walking in adults: A systematic review. *Gait & Posture*, 62:56-67.DOI: https://doi.org/10.1016/j.gaitpost.2018.02.026

Burnfield, J. M. Few, C. D., Mohamed, O. S., & Perry, J. (2004). The influence of walking speed and footwear on plantar pressures in older adults. *Clin. Biomech*., 19:78-84.

Bus, S. A. (2012). Priorities in offloading the diabetic foot. *Diabetes/Metab. Res. Rev*., 28:54-59.

Bus, S. A., Haspels, R., & Busch-Westbroek, T. E. (2011). Evaluation and optimization of therapeutic footwear for neuropathic diabetic foot patients using in-shoe plantar pressure analysis. *Diabetes Care*, 34:1595-1600.

Bus, S. A., Ulbrecht, J. S., & Cavanagh, P. R. (2004). Pressure relief and load redistribution by custom-made insoles in diabetic patients with neuropathy and foot deformity. *Clin., Biomech.,* 19:629-638.

Canadian Centre for Occupational Health and Safety (CCOHS). (2014) Basic information on standing at work. Retrieved from http://www.ccohs.ca/oshanswers/ergonomics/ standing/standing_basic/html. [Accessed on 10th September 2020].

Cardoso, J. P., Ribeiro, I. D. Q. B., Araujo, T. M., & Carvalho, F. (2009). Prevalence of musculoskeletal pain among teachers. *Rev Bras Epidemiol.,* 12(4):1-10.

Cardoso, J. P., Araujo, T. M., Carvalho, F. M., Oliveira, N. F., & Reis, E. J. (2011). Psychosocial work-related factors and musculoskeletal pain among schoolteachers. *Cad Saude Publica*., 27(8):1498-506.

Carfagni, M., Governi, L., & Volpe, Y. (2007). Comfort assessment of motorcycle saddles: A methodology based on virtual prototypes. *Int J Interact Des Manuf.*, 1: 155-167.

Cavanagh, P. R., & Bus, S. A. (2010). Off-loading the diabetic foot for ulcer prevention and healing. *J. Vasc. Surg*., 52:37S-43S.

Cavanagh, P. R., & Rodgers, M. M. (1987). The arch index: A useful measure from footprints. *Journal of Biomechanics*, 20(5):547-551.

Cavanagh, P. R., & Ulbrecht, J. S. (1994). Clinical plantar pressure measurement in diabetes: rationale and methodology. *The Foot*, 4:123-135.

Centers for Disease Control and Prevention, (CDCP) (2014). Workplace safety and health topics: Ergonomics and musculoskeletal disorders. Retrieved from http://www.cdc.gov/niosh/topics/ergonomics/. [Accessed on 19th September 2018].

Ceyte, H., Cian, C., Zory, R., et al. (2007). Effects of Achilles tendon vibration on postural orientation. *Neurosci Lett*., 416:71-75.

Chaiklieng, S. & Suggaravetsiri, P. (2012). Risk factors for repetitive strain injuries among school teachers in Thailand. *Work*, 41:2510-15.

Chartered Institute of Ergonomics and Human Factor, (CIEHF) (2015). Ergonomics and human factors. Retrieved from http://www.ergonomics.org.uk/learning/what-ergonomics/. [Accessed on 19th September 2018].

Chen, H., Nigg, B. M., & De Koning, J. (1994). Relationship between plantar pressure distribution under the foot and the insole comfort. *Clinical Biomechanics*, 9:335-341.

Cheng, H. Y. K., Cheng, C. Y., & Ju, Y. Y. (2013). Work-related musculoskeletal disorders and ergonomics risk factors in early intervention educators. *Appl Ergon*., 44(1):134-41.

Chester, M., Rys, M. J., & Konz, S. A. (2002). Leg swelling comfort and fatigue when sitting, standing and sit/standing. *International Journal of Industrial Ergonomics*, 29:289-296.

Chiu, T. T., & Lam, P. K. (2007). The prevalence of and risk factors for neck and upper limb pain among secondary school teachers in Hong Kong. *J Occup Rehabil.,* 17:19-32.

Chiu, T. W., Lau, K. T., Ho, C. W., Ma, M. C. & Yeung, F. T. et al. (2006). A study on the prevalence of and risk factors for neck pain in secondary school teachers. *Public Health*, 120:563-565. PMID:16684548.

Childs, R. A., Olsen, B. A., McPoil, T. G., Cornwall, M. W. (1996). The effect of three treatment techniques in reducing metatarsal head pressure during walking. *Lower Extremity*, 3:25-29.

Choi, S. D., & Woletz, T. (2010). *Do stretching programs prevent work-related musculoskeletal disorders?.* Department of Occupational & Environmental Safety & Health, USA.

Choi, Y. R., Lee, H. S., Kim, D. E., Lee, D. H., Kim, J. M., & Ahn, J. Y. (2014). The diagnostic value of pedobarography. *Orthopaedics*, 37(12):1063-1067.

Chong, E. Y., & Chan, A. H. (2010). Subjective health complaints of teachers from primary and secondary schools in Hong Kong. *Int J Occup Saf Ergon.,* 16:23-29.

Chun, C. K., Solihin, M. I., Chan, W. J., & Ong, Y. Y. (2018). Study of plantar pressure distribution. *MATEC Web of Conference*, 237:01016. DOI:http://doi.org/10.1051/matecconf/201823701016.

Clairborne, N., Vandenburgh, H., Krause, T. M., & Leung, P. (2002). Measuring quality of life changes in individuals with chronic low back pain conditions: A back education programme evaluation. *Evaluat. Programme Plann*., 25:61-70. DOI:10.1016/S0149-7189(01)00049-0.

Collins, J. J., Imhoff, T. T., & Grigg, P. (1996). Noise-enhanced tactile sensation. *Nature,* 383:770.

Collins, K. A., Turner, M. J., Hubbard-Turner, T., & Thomas, A. C. (2020). Gait and plantar sensation changes following massage and textured insole application in patients after anterior cruciate ligament reconstruction. *Gait and Posture*, 81:254-260.

Collins, N., Bisset, L., McPoil, T., & Vicenzino, B. (2007). Foot orthoses in lower limb overuse conditions: A systematic review and meta-analysis. *Foot Ankle Int.*, 28:396-412.

Cooper, H. (2011). *Reporting research in psychology: How to meet journal article reporting standards*. Washington, DC: APA.

Corbin, D. M., Hart, J. M., Mckeon, P. O., Ingersoll, C. D., & Hertel, J. (2007). The effect of textured insoles on postural control in double and single limb stance. *Journal of Sport Rehabilitation*, 16:363-372.

Corlett, E. N., & Bishop, R. P. (1976). A technique for assessing postural discomfort. *ergonomics,* 19 (2):175-182.

Cornwall, M. W., & McPoil, T. G. (1996). The use of an external metatarsal bar in the treatment of hallux limitus: A case report. *Lower Extremity*, 3:203-206.

Cortes, N., Onate, J., & Morrison, S. (2014). Differential effects of fatigue on movement variability*. Gait Posture,* 39:888-893.

Costa, M., Priplata, A., Lipsitz, L., et al. (2007). Noise and poise: Enhancement of postural complexity in the elderly with a stochastic-resonance-based therapy. *EPL (Europhy Lett),* 77-68008.

Craft, R. M., Mogil, J. S., & Aloisi, A. M. (2004). Sex differences in pain and analgesia: The role of gonadal hormones. *Europe Journal of Pain*, 8:397-411.

D'Souza, J. C., Franzblau, A., & Werner, R. A. (2005). Review of epidemiologic studies on occupational factors and lower extremity musculoskeletal and vascular disorders and symptoms. *J.Occup.Rehab*., 15:129-165.

Dalal, S., Widgerow, A. D., & Evans, G. R. D. (2015). The plantar fat pad and the diabetic foot-A review. *International Wound Journal,* 12(6):636-640.

Damayanti, S., Zorem, M., & Pankaj, B. (2017). Occurrence of work-related musculoskeletal disorders among school teachers in Eastern and Northeastern part of India. *International Journal of Musculoskeletal Pain Prevention,* 2:1.

Dariusz, C., Lukasz, S., Marcin, T., Mateusz, K., & Tomasz, K. (2018). Non-structural misalignments of body posture in the sagittal plan*. Scoliosis Spinal Disorder*, 13(6).

Darwish, M. A., & Al-Zuhair, S. Z. (2013). Musculoskeletal pain disorders among secondary school Saudi female teachers. *Pain Research and Treatment*, 1-7.

Das, B. (1987). An ergonomic approach to designing a manufacturing work system. *Int. J. of Industrial Ergonomics*, 1(3):231-240.

Das, B., & Shikdar, A. (1999). Participate versus assigned production standard setting in a repetitive industrial task: A strategy for improving worker productivity. *Int. J. of Occupational Safety and Ergonomics*, 5(3):417-430.

Davidson, K. W., Goldstein, M., Kaplan, R. M., Kaufmann, P. G., Knatterud, G. L., Orleans, C. T., Spring, B., Trudeau, K. J., & Whitlock, E. P. (2003). Evidence-based behavioural medicine: What is it and how do we achieve it?. *Ann Behav Med*., 26(3):161-71.

Davis, K., Dunning, K., Jewell, G., & Lockey, J. (2014). Cost and disability trends of work-related musculoskeletal disorders in Ohio. *Occup Med,* 64(8):608-15.

Dawson, J., Thorogood, M., Marks, S., Juszczak, E., Dodd, C., Lavis, G., & Fitzpatrick, R. (2002). The prevalence of foot problems in older women: A cause for concern. *Journal of Public Health Medicine*, 24:77-84.

Delcor, N. S., Araujo, T. M., Reis, E. J. F. B., Porto, L. A., Carvalho, F. M., Silva, M. O. (2009). Prevalence of musculoskeletal pain among teachers. Rev. Bras. Epidemiol, 12(4): 1-10.

De Luca, C. J. (1997). The use of surface electromyography in Biomechanics. *Journal of Applied Biomechanics*, 13:135-163.

Department of Occupational Safety and Health (DOSH) (2002). Guidelines on occupational safety and health for standing at work. ISBN 983-2014-21-2. Retrieved from: www.dosh.gov.my. [Accessed on 6th August 2021]

Department of Occupational Safety and Health (DOSH) (2018). Guidelines for manual handling at workplace. ISBN 978-983-2014-92-8. Retrieved from: www.dosh.gov.my. [Accessed on 6th August 2021]

Deros, B. M., Darius, D. D., & Basir, I. M. (2015). A study on ergonomic awareness among workers performing manual material handling activities. *Procedia Social and Behavioral Sciences*, 195:1666-1673. DOI:10.1016/j.sbspro.2015.06.238.

Deschamps, K., Birch, I., McInnes, J., Desloovere, K., & Matricalli, G. A. (2009). Inter and intra-observer reliability of masking in plantar pressure analysis. *Gait Posture*, 30:379-382.

Dettmer, M., Pourmoghaddam, A., Lee, B., & Layne, C. (2016). Do aging and tactile noise stimulation affect responses to support surface translations in healthy adults? *Curr. Gerontol. Geriatr. Res.* 2941964.

Dettmer, M., Pourmoghaddam, A., Lee, B., & Layne, C. (2015). Effects of aging and tactile stochastic resonance on postural performance and postural control in a sensory conflict task. *Somatosens. Mot. Res.* 32:128-135.

Dowling, G. J., Murley, G. S., Munteanu, S. E., Franettovich, S. M. M., Neal, B. S., Griffiths, I. B. et al. (2015). Dynamic foot function as a risk factor for lower limb overuse injury: A systematic review. *J Foot Ankle Res.*, 7(1).

Dul, J. (1994). Ergonomic guidelines for the prevention of discomfort of static postures can be based on endurance data. *Ergonomics*, 37:807-815.

Durmus, D., & Ilhanli, I. (2012). Are there work-related musculoskeletal problems among teachers in Samsun, Turkey?. *J Back Musculoskeletal Rehabil*., 25(1):5-12.

Ebied, E. M. E. S. (2015). Work-related musculoskeletal pain among primary school teachers: A recommended health promotion intervention for prevention and management. *World J. Nurs. Sci.*, 1(3):54-61.

Edling, C. W., & Fjellman-Wiklund, A. (2009). Musculoskeletal disorders and asymmetric playing postures of the upper extremity and back in music teachers: A pilot study. *Med Probl Perform Art,* 24(3): 113-118.

Elftman, H. (1969). Dynamic Structure of the Human Foot. *Artif Limbs*, 13(1):49-58.

Erick, P. N., & Smith, D. R. (2011). A systematic review of musculoskeletal disorders among school teachers. *BMC Musculoskelet Disord*., 12:260.

Erick, P. N., & Smith, D. R. (2013). Musculoskeletal disorder risk factors in the teaching profession: A critical review. *OA Musculoskelet Med*., 1(3):29.

Erick, P. N., & Smith, D. R. (2014). The prevalence and risk factors for musculoskeletal disorders among school teachers in Botswana. *Occup Med Health Aff*., 2:4.

Erick, P. N., & Smith, D. R. (2015). Musculoskeletal disorders in the teaching profession: An emerging workplace hazard with significant repercussions for developing countries. *Industrial Health*, 53:385-386.

European Agency for Safety and Health at Work (2010). Work-related musculoskeletal disorders in the EU - Facts and figures, European risk observatory Report. Retrieved from: http://www.themusculoskeletalelf.net/are-school-teachers-at-a-high-risk-of-developing-musculoskeletal- disorders/#sthash.Qd9hTAvW.dpuf. [Accessed on 23rd March 2020].

Fabre, J. M., Ellis, R., Kosma, M., & Wood, R. H. (2010). Falls risk factors and a compendium of falls risk screening instruments. *The Journal of Geriatric Physical Theraphy*, 33:184-197.

Fernando, M. E., Crowther, R. G., & Wearing, S. (2018). *The importance of foot pressure in diabetes*. Handbook of Human Motion, Muller, B. and Wolf, S.

I., Eds., pp. 759-787, Springer International Publishing AG, part of Springer Nature.

Fjellman-Wiklund, A., & Sundelin, G. (1998). Musculoskeletal discomfort of music teachers: An eight-year perspective and psychosocial work factors. *International Journal Occupational & Environmental Health*, 4:89-98.

Fjellman-Wiklund, A., Brulin, C., & Sundelin, G. (2003). Physical and psychosocial work-related risk factors associated with neck-shoulder discomfort in male and female music teachers. *Medical Problems of Performing Artists*, 18:33-41.

Finestone, A., Novack, V., Farfel, A., Berg, A., Amir, H., & Milgrom, C. (2004). A prospective study of the effect of foot orthoses composition and fabrication on comfort and the incidence of overuse injuries. *Foot Ankle Int.,* 25(7):462-6.

Franciosa, P., Gerbino, S., Lanzotti, A., & Silvestri, L. (2013). Improving comfort of shoe sole through experiments based on CAD-FEM modelling. *Medical Engineering & Physics*, 35:36-46.

Gabell, A., Simons, M.A., & Nayak, U.S.L. (1985). Falls in the healthy elderly: predisposing causes. *Ergonomics*, 28:965-75.

Gagey, P. M., & Webwe, B. (2000). *Posturology: Regulation and Disorders of Orthostic Position*. Sao Paulo: Manole.

Galen, S. S., Guffey, D. R., Coburn, J. W., & Malek, M. H. (2015). Determining the electromyography fatigue threshold following a single visit exercise test. *J Vis Exp*., 101:52729. DOI:10.3791/52729.

Galica, A. M., Kang, H. G., Priplata, A. A., et al. (2009). Subsensory vibrations to the feet reduce gait variability in elderly fallens. *Gait Posture*, 30: 383-387.

Gangopadhyay, S., & Dev, S. (2014). Design and evaluation of ergonomic interventions for the prevention of musculoskeletal disorders in India. *Annals of Occupational and Environmental Medicinie*, 26:18.

Garg, R. (2016). Methodology for research I. *Indian Journal of Anaesthesia*, 60 (90): 640-645.

Gastwirth, B. W., O'Brien, T. O., Nelson, R. M., Manger, D. C., Kindig, S. A. (1991). An electromyographic study of foot function in shoes of varying heel height. *J. Am. Podiatr. Med. Assoc.*, 81:463-472.

Gendy, E. M., & Korish, M. M. (2017). Work-related musculoskeletal disorders among preparatory school teachers in Egypt. *Egyptian Journal of Occupational Medicine*, 41(1):115-126.

Giacomozzi, C. (2010). Appropriateness of plantar pressure measurement devices: A comparative technical assessment. *Gait Posture*, 32:141-144.

Goonetilleke, R. S. (2001). Designing for comfort: A footwear application for Computer-Aided Ergonomics and Safety Conference.

Goonetilleke, R. S., & Feizhou, S. (2001). A methodology to determine the optimum seat depth. *International Journal of Industrial Ergonomics*, 27(4):207-217.

Gregory, D. E., & Callaghan, J. P. (2008). Prolonged standing as a precursor for the development of low back discomfort: An investigation of possible mechanisms. *Gait and Posture*, 28(1):86-92. DOI:10.1016/j.gaitpost.2007.10.005.

Gribble, P. A., & Hertel, J. (2004). Effect of hip and ankle muscle fatigue on unipedal postural control. *J. Electromyogr. Kinesiol*, 14:641-646.

Grieve, D. W., & Rashdi, T. (1984). Pressure under normal feet in standing and walking as measured by foil pedobarography. *Ann Rheum Dis*, 43:816-818.

Gross, M. L., & Napoli, R. C. (1993). Treatment of lower extremity injuries with orthotic shoe inserts an overview. *Sports Medicine*, 15:66-70.

Guo, H., Chang, Y., Yeh, W., Chen, C., & Guo, Y. L. (2004). Prevalence of musculoskeletal disorder among workers in Taiwan: A nationwide study. *Journal of Occupational Health*, 46(1):26-36. DOI:10.1539/joh.46.26.

Gureje, O., Simon, G. E., & Von Korff, M. (2001). A cross-national study of the course of persistent pain in primary care. *Pain*, 92(1-2):195-200.

Gurney, J. K., Kersting, U. G., & Rosenbaum, D. (2008). Between-day reliability of repeated plantar pressure distribution measurements in a normal population. *Gait Posture*, 27:706-709.

Haider, S., Luger, E., Kapan, A., Titza, S., Lackinger, C., Schindler, K. E., & Dorner, T. E. (2016). Associations between daily physical activity, handgrip strength, muscle mass, physical performance and quality of life in prefrail and frail community-dwelling older adults. *Quality of Life Research*, 25:3129-3138.

Halim, I., & Omar, A. R. (2011). A review on health effects association with prolonged standing in the industrial workplace. *International Journal of Recent Research and Applied Studies,* 8(1): 14-21.

Halim, I., & Omar, A. R. (2012). Development of prolonged standing strain index to quantify risk levels of standing jobs. *International Journal of Occupational Safety Ergonomics,* 18:85-96.

Halim, I., Arep, H., Kamat, S. R., Abdullah, R., Omar, A. R., & Ismail, A. R. (2014). Development of a decision support system for analysis and solutions of prolonged standing in the workplace. *Safety and Health at Work*, 5(2):97-105. DOI:10.1016/j.shaw.2014.04.002.

Halim, I., Omar, A. R., Saman, A. M., & Othman, I. (2012). Assessment of muscle fatigue associated with prolonged standing in the workplace. *Safety and Health at Work*, 3(1):31-42. DOI:10.5491/shaw.2012.3.1.31.

Hamzaid, N. A., Smith, R. M., & Davis, G. M. (2013). Isokinetic cycling and elliptical stepping: A kinematic and muscle activation analysis. *Clinical Research on Foot & Ankle,* 1:117. DOI:10.4172/2329-910X.1000117.

Han, J., Anson, J., Waddington, G., Adams, R., & Liu, Y. (2015). The role of ankle proprioception for balance control in relation to sports performance and injury. *Biomed Research International,* 1-8.

Hatton, A. L., Hug, F., Brown, B. C. M., Green, L. P., Hughes, J. R., King, J., Orgar, E. J., Surman, K., & Vicenzino, B. (2015). A study of the immediate effects of glycerine-filled insoles, contoured prefabricated orthoses and flat insoles on single-leg balance, gait patterns and perceived comfort in healthy adults. *Journal of Foot and Ankle Research*, 8:47.

Hatton et al. (2012). Altering gait by way of stimulation of the plantar surface of the foot: The immediate effects of wearing textured insoles in older fallers. *J Foot Ankle Res,* 5.

Haworth, N., & Rowden, P. (2006). *Investigation of fatigued-related motorcycle crashes-Literature review*. Reports to Vicroads. Queensland: The Centre for accident Research & Road Safety.

Hermens, H. J., Freriks, B., Merletti, R., Stegeman, D., Blok, J., Rau, G., Disselhorst-Klug, C., & Hagg, G. (1999). SENIAM 8: European Recommendations for Surface Electromyography. *Roessingh Research and Development*. Retrieved from http://www.seniam.org/. [Accessed on 24th September 2018].

Hermens, H. J., Freriks, B., Disselhorst-Klug, C., & Rau, G. (2000). Development of recommendations for sEMG sensors and sensor placement procedures. *J Electromyogr Kinesiol*, 10(5):361-74.

Hertel, J. (2008). Sensorimotor deficits with ankle sprains and chronic ankle stability. *Clinical Sports Medicine*, 27(3):353-370.

Hessert, M. J. et al., (2005). Foot pressure distribution during walking in young and old adults. *BMC Geriatr*, 5:8.

Hijmans, J. M., Geertzen, J. H., Schokker, B., & Postema, K. (2007). Development of vibrating insoles. *Int J Rehabil. Res*., 30(4):343-5.

Hijmans, J. M., Geertzen, J. H., & Zijlstra, W., Hof, A. L., & Postema, K. (2008). Effects of vibrating insoles on standing balance in diabetic neuropathy. *J Rehabil Res Dev*., 45:1441-1449.

Hodge, M. C., Bach, T. M., & Carter, G. M. (1999). Orthotic management of plantar pressure and pain in rheumatoid arthritis. *Clinical Biomechanics*, 14:567-575.

Hudges, J., Pratt, I., Linge, K., Clark, P., & Kienerman, L. (1991). Reliability of pressure measurements: The EMED-F system. *Clin Biomech.*, 6:14-18.

Hudges, N. J., Nelson, A., Matz, M. W., & Lloyd, J. (2011). AORN Ergonomic Tool 4: Solutions for prolonged standing in perioperative settings. *Association for Perioperative Registered Nurses* (*AORN) Journal*, 93(6):767-774.

International Ergonomic Association (EIA) (2020). Definition and applications of ergonomic. Retrieved from https://iea.cc/what-is-ergonomics/. [Accessed on 24th April 2020].

International Labour Office (ILO) (2009). *Standards on occupational safety and health: Promoting a safe and healthy working environment*. International Labour Office, Geneva.

International Labour Office (ILO) (2011). Your health and safety at work: Ergonomics. Retrieved from https://www.ilo.org/global/topics/safety-and-health-at-work/resources-library/training/WCMS_113080/lang--en/index.htm. [Accessed on 20th December 2020].

Jacob, S. (2008). *Chapter 6 – Lower Limb*. Human Anatomy, (pp. 135-179). Elsevier Ltd.

Jafri, M. R., Affandi, M. Z., Raemy, M. R., Ismail, A. R., & Mohamed (2016). Analysis of compensation cost related to musculoskeletal disorders (MSDs) against younger and older Malaysian manufacturing workers. *In Proceeding of the 2016 International Conference on Industrial Engineering and Operations Management 2016*. Kuala Lumpur, Malaysia.

Jalil, S. W., Achan, P., Mojolou, D. N., & Rozaimie, A. (2015). Individual characteristics and job performance: Generation Y at SMEs in Malaysia. *Procedia Social and Behavioral Science*, 170:137-145. DOI:10.1016/j.sbspro.2015.01.23.

Jin, K., Sorock, G.S., & Courtney, T.K. (2004). Prevalence of low back pain in three occupational groups in Shanghai, people's Republic of China. *Journal of Safety Research*, 35:23-28.

Jinquan, L., Tong, Z., & Shuai, Y. (2019). Design of multi-channel wireless array wearable surface electromyography testing equipment. *IOP Conf. Ser.: Mater. Sci. Eng*., 563:042040.

Jordan, C., & Bartlett, R. (1995). Pressure distribution and perceived comfort in casual footwear. *Gait Posture*, 3:215-220.

Juhanson, K., & Merisalu, E. (2017). Ergonomic intervention programs in different economics sectors: A review article. *Agronomy Research*, 15(1):170-186.

Jung-Keun, P., & Seung-Hee, J. (2010). Association between upper extremity musculoskeletal disorders and psychosocial factors at work: A review on the job DCS model's perspective. *Safe Health Work*, 1(1):37-42.

Juul-Kristensen, B., Fallentin, N., Hansson, G.A., & Madeleine, P. (2002). Physical workload during manual and mechanical deboning of poultry. *International Journal of Industrial Ergonomics*, 29:107-115.

Kaka, B., Idowu, O. A., Fawole, H. O., Adeniyi, A. F., Ogwumike, O. O., & Toryila, M. T. (2016). An analysis of work-related musculoskeletal disorders among butchers in Kano Metropolis, Nigeria. *Safety and Health at Work*, 7(3):218-224. DOI:10.1016/j.shaw.2016.01.001.

Karimi, N., Moghimbeigi, A., Motamedzade, M., & Roshanaei, G. (2016). Evaluation of related risk factors in number of musculoskeletal disorders among carpet weavers in Iran. *Safety and Health at Work*. DOI:10.1016/j.shaw.2016.04.004.

Karmegam, K., Mohd Sapuan, S., Mohd Yusof, I., Napsiah, I., & Shamsul B. M. T. (2011). Conceptual design of motorcycle's lumbar support using motorcyclist's anthropometric characteristics. *Maejo Int. J. Sci. Technol*., 5(01):69-82.

Karmegam, K., Mohd Sapuan, S., Mohd Yusof, I., Napsiah, I., & Shamsul B. M. T. (2012). Evaluation of motorcyclist's discomfort during prolonged riding process with and without lumbar support. *Annals of the Brazilian Academy of Sciences*, 84(4):1169-1188.

Karmegam, K., Mohd Sapuan, S., Mohd Yusof, I., & Napsiah, I. (2013). Motorcyclist's riding discomfort in Malaysia: Comparison of BMI, riding experience, riding duration and riding posture. *Human Factors and Ergonomics in Manufacturing & Service Industries,* 23(4):267-278.

Karsh, B. T. (2006). Theories of work-related musculoskeletal disorders: Implications for ergonomic interventions. Theor. Issues Ergon. Sci. 7(1):71-88.

Karwowski, W. (2005). *The Discipline of Ergonomics and Human Factors*. Handbook of Human Factors and Ergonomics, (pp. 3-32). Wiley, New York.

Kawnine, T. (2008). *A radial-ulnar deviation and wrist-finger analysis based on electromyography*. (Unpublished degree thesis). Malardalen University, Sweden.

Kennedy, P. M., & Inglis, J. T. (2002). Distribution and behaviour of glabrous cutaneous receptors in the human foot sole. *J Physiol.*, 538: 995-1002.

Ketola, R., Toivonen, R., Hakkanen, M., Luukkonen, R., Takala, E. P., & Viikari-Juntura, E. (2002). Effects group in ergonomic intervention in work with video display units. *Scandinavian Journal of Work, Environment & Health*, 28(1):18-24.

Kim, J. Y. (2018). The effect of insole on muscle activity and muscle fatigue at sit to standing of tibialis anterior and gastrocnemius in adult male. *The Journal of Physical Therapy Sciences*, 30:297-299.

Kim, J. Y., Stuar-Buttle, C., & Marras, W. S. (1994). The effects of mats on back and leg fatigue. *Applied Ergonomics*, 25(1):29-34.

Kim, S. E., Chun, J. C., & Hong, J. (2013). Ergonomic intervention as a treatment and prevention tool for work-related musculoskeletal disorders. *International Journal of Caring Sciences*, 6(3):339-347.

Kimmeskamp, S., & Henning, E. M. (2001). Heel to toe motion characteristics in Parkinson patients during free walking. *Clin Biomech*, 16:806-812.

King, P. M. (2002). A comparison of the effects of floor mats and shoe insoles on standing fatigues. *Applied Ergonomics*, 33(5):477-484. DOI:10.1016/s0003-6870(20)00027-3.

Koblauch, H., Samuelsen, J. A. S., & Sporsheim, S. B. (2017). The effect of three different foot interventions on standing balance in healthy adults. *European Journal of Physiotherapy*, 20(1):20-24.

Kohlmann, T. (2003). Musculoskeletal Pain in the Population. *Schmerz*. 17(6):405-11.

Kokubo, T., Hashimoto, T., Nagura, T., Nakamura, T., Suda, Y., Matsumoto, H., et al. (2012). Effect of the posterior tibial and peroneal longus on the mechanical properties of the foot arch. *Foot Ankle Int.*, 33: 320-325.

Kolich, M. (2008). A conceptual framework proposed to formalize the scientific investigation of automobile seat comfort. *Applied Ergonomics*, 39 (1): 15-27.

Korhan, O. (2012). Work-related musculoskeletal discomfort in the shoulder due to computer use. *Ergonomics-A Systems Approach*. DOI:10.5772/34809.

Konrad, P. (2005). The ABC of EMG: A practical introduction to kinesiological electromyography. Retrieved from https://hermanwallace.com/download/ The_ABC_of_EMG_by_Peter_Konrad.pdf. [Accessed on 15th September 2018].

Konz, S. (1995). *Work Design: Industrial Ergonomics.* (2nd ed). Grid Columbus, Ohio.

Korkmaz, N. C., Cavlak, U., & Telci, E. A. (2011). Musculoskeletal pain associated risk factors and coping strategies in school teachers. *Scientific Research and Essays*, 6(3):649-657.

Kovess-Masfety, V., Sevilla-Dedieu, C., Rios-Seidel, E., Nerriere, & Chee, C. C. (2006). Do teachers have more health problems? Results from a French cross-sectional survey. *BMC Public Health*, 6:101.

Kovac, M., Leskosek, B., Hadzic, V., & Jurak, G. (2013). Injuries among Slovenian physical education teachers: A cross-sectional study. *Int. J. Occup. Saf. Ergon.*, 19(1):87–95.

Kroemer, K. H. E. (2006). '*Extra-ordinary" ergonomics: How to accommodate small and big persons, the disabled and elderly, expectant mothers, and children*. CRC Press, Taylor and Francis Group, Boca Raton, (pp.102-103).

Kuijt-Evers, L. F. M. (2009). *Chapter 15: The Design of Artisans' Hand Tools Users' Perceived Comfort and Discomfort.* International Handbook of Occupational Therapy Interventions, Springer Science & Business Media, (pp.167-177).

Kuorinka, I., Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sorensen, F., Andersson, G., & Jorgensen, K. (1987). Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon.*, 18(3):233-7.

Lafond, D., Champagne, A., Descarreaux, M., Dubois, J. D., Prado, J. M., Duarte, M. (2009). Postural control during prolonged standing in persons with chronic low back pain. *Gait & Posture*, 9:421-427.

Lalande, X., Vie, B., Weber, J. P., & Jammes, Y. (2016). Normal values of pressure and foot measured in the static condition. *Journal of the American Podiatric Medical Association*, 106(4):265-272.

Landorf, K. B., & Keenan, A. M. (2000). Efficacy of foot orthoses. What does the literature tell us?. *J Am Podiatr Med Assoc.*, 90(3):149-158. DOI:http://doi.org/10.1016/0966-6362(95)99064-R.

Lanfranchi, I. B., & Duveau, A. (2008). Explicative models of musculoskeletal disorders (MSD): From biomechanical and psychosocial factors to clinical analysis of ergonomics. *Rev. Eur. De Psychol. Applied*, 58:201-213. DOI:10.1016/j.erap.2008.09.004.

Laperriere, E., Ngomo, S., Thibault, M. C., & Messing, K. (2005). Indicators for choosing an optimal mix of major working postures. *Applied Ergonomics*, 37:349-357.

LeClaire, W. E. (2012). Massage for postural control in individuals with chronic ankle instability. *Athlete Train Sport Health Care*, 4(5):213-219.

Lee, S. W., Cho, K. H., Lee, W. H. (2013). Effect of a local vibration stimulus training programme on postural sway and gait in chronic stroke patients: A randomized controlled trial. *Clin Rehabil*., 27: 921-931.

Lehmann, J. F., De Lateur, B. J., & Price, R. (1992). Biomechanics of normal gait. *Phys Med Rehabil Clin North Am*, 3:95-109.

Leme, A., & Maia, I. (2015). Evaluation of fatigue at work in teachers using modern resources in the classroom. *Procedia Manufacturing*, 3:4852-4859.

Lementowski, P. W., & Zelicof, S. B., (2008). Obesity and osteoarthritis. *Am. J. Orthoped.,* 37:148-151.

Lemoyne, J. L. (2007). Occupational health problems and injuries among Quebec's physical educators. *Applied Ergon*., 38:625-634.

Li, L., Shen, C., Li, X., & Robins, J. M. (2013). On weighting approaches for missing data. *Statistical Methods in Medical Research*, 22(1):14-30.

Little, R., & Rubin, D. (2002). *Statistical analysis with missing data.* Wiley.

Lin, Y. H. (2014). Effects of different surfaces on biomechanical loading of the upper extremities while handling wheelbarrows. Advances in physical ergonomics and human factors: Part 1 for Applied Human Factors and Ergonomics Conference 2014 (AHFE), (pp. 358-364).

Lin, Y. H., Chen, C. Y., Cho, M. H. (2012). Influence of shoe/floor conditions on lower leg circumferences and subjective discomfort during prolonged standing. *Applied Ergonomics*, 43:965-970.

Liping, L., Pengying, Y., & Fengying, L. (2012). Work-related musculoskeletal disorders among school teachers in China, prevalence and occupational factors. *Inj Prev*., 18(1):A1-A246.

Lipsitz, L., Lough, M., Niemi, J., Travison, T., Howlett, H., & Manor, B. (2015). A shoe insole delivering subsensory vibratory noise improves balance and gait in healthy elderly people. *Arch Phys Med Rehabil*., 96(3):432-439.

Lohmander, L. S., Ostenberg, A., Englund, M., & Roos, H. (2004). High prevalence of knee osteoarthritis, pain and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. *Arthritis Rheum*., 50(10):3145-52.

Ludwig, O., Jens, K., & Michael, F. (2016). The influence of insoles with a peroneal pressure point on the electromyographic activity of tibialis anterior and peroneus longus during gait. *Journal of Foot and Ankle Research*, 9(33).

Luttman, A. J. M. (2003). Preventing musculoskeletal disorder in the workplace (Protecting Workers' Health Series) Gevena. World Health Organization (WHO). Retrieved from: http://apps.who.int/iris/handle/10665/42651. [Accessed on 23rd March 2018].

Maguire, M., & O'Connell, T. (2007). Ill-health retirement of school teachers in the Republic of Ireland. *Occupational Medicine*, 57:191-193.

MacLean, S. M., May, S., Klaber-Moffet, J., Sharp, D. M. & Gardiner, E. (2010). Risk factors for the onset of non-specific neck pain: A systematic review. *Journal of Epidemiology and Community Health*, 64(7): 565-572.

Malchaire, J., Cock, N., & Vergracht, S. (2001). Review of the factors associated with musculoskeletal problems in epidemiological studies. *Int Arch Occup Environ Health*, 74(2):79-90.

Maki, B. E., Holliday, P. J., & Topper, A. K. (1994). A prospective study of postural balance and risk of falling in an ambulatory and independent elderly population. *The Journal of Gerontology*, 49:72-84.

Mariammal, T. A. J. (2012). Occupation influenced physical illness observed among the teachers of Thoothukudi Town. *Int J PharmTech Res*., 4:3.

Matsumoto, T., Nakamura, I., Miura, A., Momoyama, G., & Ito, K. (2014). Radiologic patterning of joint damage to the foot in rheumatoid arthritis. *Arthritis Care Res (Hoboken)*, 66(4):499-507. DOI:10.1002/acr.22174.

McKeon, M., Albert, W. J., & Neary, J. P. (2006). Assessment of neuromuscular and hemodynamic activity in individuals with and without chronic low back pain. *Dynamic Medicine*, 5:6.

McPoil, T. G., Cornwall, M. W., & Yamaha, W. (1995). A comparison of two in-shoe plantar pressure measurement systems. *Lower Extremity*, 2:95-103.

Mehta, C. R., & Tewari, V. K. (2000). Seating discomfort for tractor operators – A critical review. *Int J. Ind Ergonom.*, 25:661-674.

Melzer, A. C. S. (2008). Physical and organizational risk factors associated to work-related musculoskeletal disorders in textile industry. *Fisioterapia e Pesquisa*, 15(1):19-25.

Menz, H., & Morris, M. (2005). Footwear characteristics and foot problems in older people. *Gerontology*, 51:346-351.

Mercer, J., Bezodis, N., DeLion, D., Zachry, T., & Rubley, M. (2006). EMG sensor location: Does it influence the ability to detect differences in muscle contraction conditions?. *J. Electromyogr Kinesiol*, 16:198-204.

Merlo, A., & Campanini, I. (2010). Technical aspects of surface electromyography for clinicans. *The Open Rehabilitation Journal*, 3(1):98-109. DOI:10.2174/1874943701003010098.

Mesaria, S., & Jaiswal, N. (2015). Musculoskeletal disorders among teachers residing in various nations: A Review. *Res. J. Recent Sci.*, 4:23-27.

Messing, K., & Kilbom, A. (2001). Standing and very slow walking: Foot pain-pressure threshold, subjective pain experience and work activity. *Appl Ergon.,* 32:81-90.

Messing, K., Tissot, F., & Stock, S. (2008), Distal lower-extremity pain and work postures in the Quebec population. *American Journal of Public Health*, 98(4):705-713.

Meyer, P. F., Oddson, L. I., & De Luca, C. J. (2004). The role of plantar cutaneous sensation in unperturbed stance. *Exp Brain Res*, 156:505-512.

Miedema, M. C., & Douwes, M. (1995). *Maximum Holding Times of Static Standing Postures*. (Thesis of Extended Essay), TNO Institute of Preventive Health Care, Leiden, The Netherlands.

Miller, J. E., Nigg, B. M., Liu, W., Stefanyshyn, D. J., & Nurse, M. A. (2000). Influence of foot, leg and shoe characteristics on subjective comfort. *Foot Ankle International Journal*, 21:759-767.

Ministry of Education Malaysia: Quick Facts 2019 for Malaysia Educational Statistics. Retrieved from https://www.moe.gov.my/muat-turun/penerbitan-dan-jurnal/terbitan/ buku-informasi/2722-quick-facts-2019/file [Accessed on 4th February 2021].

Mittlemeier, T. W. F., & Morlock, M. (1993). Pressure distribution measurements in gait analysis: Dependency on measurement frequency. Abstract presented at 39th Annual Meeting of the Orthopaedic Research Society, San Francisco, California.

Mofizuddin, M. M. & Sohel R. S. M. (2017). Effects of four factors on the customer satisfaction of footwear products. *IOSR Journal of Business and Management*, 19(3):44-50.

Mohammadi, G. (2013). Musculoskeletal disorders complaints among high school teachers. *J. Muscoskel. Res.*, 16:13500101-13500110.

Mohan, V., Justine, M., Jagannathan, M., Aminudin, S., & Johari, S.H. (2015). Preliminary study of the patterns and physical risk factors of work-related musculoskeletal disorders among academicians in a higher learning institute. *J Ortho Sci*., 20(2):410-7.

Mohd Noor, S. N. A., Ahmad, I. N., Wahab, N. A., & Nor Ma'arof, M. I. (2013). A review of studies concerning prolonged standing working posture. *Advanced Engineering Forum*, 10:131-136.

Mohseni-Bandpei, M. A., Ehsani, F., Behtash, H., & Ghanipour, M. (2014). Occupational low back pain in primary and high school teachers: Prevalence and associated factors. *Journal of Manipulative and Physiological Therapeutics*, 37:9.

Monica, S. J., John, S., & Madhanagopal, R. (2008). Risk of obesity among female school teachers and its associated health problems. *Curr. Res. Nutr. Food Sci.,* 6(2): 404-411.

Moon et al., (2020). Shoes with active insoles mitigate declines in balance after fatigue. *Scientific Reports,* 10:1951.

Moser, P. (2019). *Good research practice in non-clinical pharmacology and biomedicine*. Handbook of Pharmacology 257 (eds.), France.

Mundermann, A., Stefanyshyn, D. J., & Nigg, B. M. (2001). Relationship between footwear comfort of shoe inserts and anthropometric and sensory factors. *Medical Science Sport Exercise*, 33:1939-1945.

Nagano, H., & Begg, R. K. (2018). Shoe-insole technology for injury prevention in walking. *Sensors (Basel),* 18(5):1468.

Nagata, H. (1991). Occupational accidents while walking on stairways. *Saf Sci,* 14:199-211.

National Institute for Occupational Safety and Health (NIOSH) (2007). Ergonomic guidelines for manual material handling. Dhhs publication no. 2007-131. Washington, Dc: Us. Department of Health and Human Services, Centers for Disease Control and Prevention, NIOSH. Retrieved from http://www.cdc.gov/niosh/docs/2007-131/pdfs/2007-131.pdf [Accessed on 13rd October 2018].

National Sleep Foundation (2015). How much sleep do we really need?. Retrieved from https://sleepfoundation.org/how-much-sleep-works/how-much-sleep-do-we-really-need. [Accessed on 10th October 2020]

Ndawa, A. N., Nyamari, J. M., & Ireri, A. M. (2019). Predictors of work-related musculoskeletal disorders among primary school teachers in Machakos County, Kenya. *International Journal of Prevention and Treatment*, 8(2):29-40. DOI:10.5923/j.ijpt.0801.01.

Nelson-Wong, E., Gregory, D. E., Winter, D. A., Callaghan, J. P. (2008). Gluteus medius muscle activation patterns as a predictor of low back pain during standing. *Clinical Biomechanics*, 23:545-553.

Ng, Y. M., Voo, P., & Maakip, I. (2020). Predictors of musculoskeletal disorders among teachers: An exploratory investigation in Malaysia. *Asian Social Science*., 16:7.

Ng, Y. M., Voo, P., & Maakip, I. (2019). Psychosocial factors, depression and musculoskeletal disorders among teachers. *BMC Public Health,* 19:234.

Ng, Y. M., Voo, P., & Maakip, I. (2017). Prevalence and risk factors of musculoskeletal disorders (MSDs) among primary and secondary school teachers: A narrative review. Austin J. Musculoskelet. Disord., 4(2):1046

Nixon, J. D., Dey, P. K., & Davies, P. A. (2013). Design of a novel solar thermal collector using a multi-criteria decision-making methodology. *Journal of Cleaner Production*, 59(0):150-159.

Norman, R., & Wells, R. (1998). Ergonomic interventions for reducing musculoskeletal disorders: An overview, related issues and future directions. http://www.qp.gov.bc.ca/rcwc/research/norman-wells-interventions.pdf. [Accessed on 18th August 2018].

Novak, P., & Novak, V. (2006). Effect of step-synchronized vibration stimulation of soles on gait in Parkinson's disease: A pilot study. *J Neuroeng Rehabil*, 3:9-16.

Nur Farahwahida, M. A., Irniza, R., Suhainizam, M. S., & Emilia, Z. A. (2016). Work task and job satisfaction predicting low back pain among secondary school teachers in Putrajaya. *Iranian Journal of Public Health*, 45:85–92.

Nur, N. M., Dawal, S. Z. M., & Dahari, M. (2014). The prevalence of work related musculoskeletal disorders among workers performing industrial repetitive tasks in the automotive manufacturing companies. *In the Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management*. Bali, Indonesia.

Oakman, J., Rothmore, P., & Tappin, D. (2016). Intervention development to reduce musculoskeletal disorders: Is the process on target?. *Applied Ergonomics*, 56:179-186. DOI:10.1016/j.apergo.2016.03.019.

Occupational Safety and Health Administration (2020). Ergonomics. Retrieved from https://www.osha.gov/ergonomics. [Accessed on 3rd October 2020].

Ohio State University Medical Center (2017). What are the benefits of vibrational massage? Retrieved from https://www.livestrong.com/article/135062-what-are-benefits-vibrational-massage/. [Accessed on 23rd March 2018].

Ono, Y., Imaeda, T., Shimaoka, M., Hiruta, S., Hattori, Y., Ando, S., Hori, F., & Tatsumi, A. (2002). Associations of length of employment and working conditions with neck, shoulder and arm pain among nursery school teachers. *Industrial Health*, 40(2):149-58.

Organization for Economic Cooperation and Development (OECD) (2014). Indicator D4: How Much Time Do Teachers Spend Teaching?, in Education at a Glance 2014: OECD Indicators, OECD Publishing. Retrieved from http://dx.doi.org/10.1787/888933120005. [Accessed on 23rd March 2018].

Orlando, A., & King, P. (2004). Relationship of demographic variables on perception of fatigue and discomfort following prolonged standing under various flooring conditions. *Journal of Occupational Rehabilitation*, 14:63-76.

Orlin, J. M. N., & McPoil, T. G. (2000). Plantar pressure assessment. *Phys Ther*., 80(4):399-409.

Ozturk, G. (2011). Report 121: Public primary school teachers' perceptions of their working conditions and job stress. Retrieved from http://www.edu.su.se/polopoly_fs /1.50914.1320920307!/ Public_ Primary_School_Teachers.pdf. [Accessed on 25th March 2018].

Paksaichol, A., Janwantanakul, P., Purepong, N., Pensri, P., & Van Der Beek, A. (2012). Office workers' risk factors for the development of non-specific neck pain: A systematic review of prospective cohort studies. *Occupational and Environmental Medicine*, 69(9): 610-618.

Parashar, U., Khalid, S., & Kumar, Y. (2020). The influence of foot orthotic interventions on workplace ergonomics. *Int J Health Sci Res*., 10(7):132-138.

Peat, J., & Barton, B. (2005). *Medical Statistics: A guide to data analysis and critical appraisal*. 1st ed. India: Blackwell Publishing Ltd.

Perreault, N., Brisson, C., Dionne, C. E., Montreuil, S., & Punnett, L. (2008). Agreement between a self-administered questionnaire on musculoskeletal disorders of the neck-shoulder region and a physical examination. *BMC Musculoskeletal Disorders*, 9(34): 1-9.

Perry, S. D., McIlroy, W.E., & Maki, B. E. (2000). The role of plantar cutaneous mechanoreceptors in the control of compensatory stepping reactions evoked by unpredictable, multi-directional perturbation. *Brain Res*, 877:401-406.

Perry, S. D., Santos, L. C., & Patla, A. E. (2001). Contribution of vision and cutaneous sensation to the control of centre mass (COM) during gait termination. *Brain Res*, 913:27-34.

Palomo-Lopez, P., De-Bengoa-Vallejo, R.B., Losa-Iglesias, M. E., Rodriguez-Sanz, D., Calvo-Lobo, C., & Lopez-Lopez, D. (2018). Impact of plantar fasciitis on the quality of life of male and female patients according to the foot health status questionnaire. *J Pain Res.*, 11:875-880.

Patil, V., Frisch, N. C., & Ebraheim, N. A. (2007). Anatomical variations in the insertion of the peroneus (fibularis) longus tendon. *Foot Ankle Int*., 28: 1179-1182.

Porto, L. A., Reis, I. C., Andrade, J. M., Nascimento, C. R., & Carvalho, F. M. (2004). Occupational benefits to school teachers attended by the Centre for the Study of Occupational Health (CESAT). *Baiana Public Health*, 28(1):33-49.

Priplata, A. A., Niemi, J. B., Harry, J. D., Lipsitz, L. A., & Collins, J. J. (2003). Vibrating insoles and balance control in elderly people. *Lancet,* 362:1123.

Priplata, A. A., Patritti, B. L., Niemi, J. B., Hughes, R., Gravelle, D. C., Lipsitz, L. A., Veves, A., Stein, J., Bonato, P., & Collins, J. J. (2006). Noise-enhanced balance control in patients with diabetes and patients with stroke. *Ann Neurol*., 59:4-12.

Pugh, S. (1991). *Total Design: Integrated Methods for Successful Product Engineering*. Addison-Wesley, Wokingham, (pp. 21-45).

Punnett, L., & Wegman, D.H. (2004). Work-related musculoskeletal disorders: The epidemiologic evidence and the debate. *Journal of Electromyography & Kinesiology*, 13-23.

Qiu et al. (2012). Enhanced somatosensory information decreases postural sway in older people. *Gait Posture*, 35:630.

Radl, L. C., & Kropp, R. (2011). Asynchronously vibrating device for use with footwear and methods of use. Retrieved from https://patents.justia.com/patent/20110232134. [Accessed on 23rd March 2018].

Rai, D. V., & Aggarwal, L. M. (2006). The study of plantar pressure distribution in normal and pathological foot. *Pol J Med Phys Eng*, 12(1):25-34.

Reid, C. M., Bush, P. M., Karwowski, W., Durrani, S. K. (2010). Occupational postural activity and lower extremity discomfort: A review. *International Journal of Industrial Ergonomics*, 40:247-256.

Reis, E. J. F. B., Araujo, T. M., Carvalho, F. M., Barbalho, L., & Silva, M. O. (2006). Teaching and emotional exhaustion. *Educ Soc*., 27(94):229.

Robbins, S., Gouw, G. J., & McClaran, J. (1992). Shoe sole thickness and hardness influence balance in older men. *J Am Geriatr Soc.,* 40:1089-1094.

Robinson, M., Riley, J., & Myers, C. (2000). Psychosocial contributions to sex-related differences in pain responses. In R. Fillingin (Ed.), *Sex, Gender and Pain, Progress in pain research and management* (pp. 41-68). Seattle, WA: IASP Press.

Rosenbaum, D., & Becker, H. P. (1997). Plantar pressure distribution measurements. Technical background and clinical applications. *Foot and Ankle Surgery*., 3(1):1-14.

Sabri, M. I., Miskon, M. F., Yaacob, M. R., Basri, A. S. H., Soo, Y. G., & Bukhari, W. M. (2014). MVC based normalization to improve the consistency of EMG signal. *Journal of Theoretical and Applied Information Technology*, 65(2).

Salles, A. S., & Gyi, D. E. (2013). Delivering personalized insoles to the high street using additive manufacturing. *International Journal of Computer Integrated Manufacturing*, 26:386-400.

Samad, N. I. A., Abdullah, H., Moin, S., Tamrin, S. B. M., & Hashim, Z. (2010). Prevalence of low back pain and its risk factors among school teachers. *American Journal of Applied Sciences,* 7:634-639.

Sammarco, V. J., & Sammarco, G. J. (2008). *Chapter 6 – Injuries to the Tibialis Anterior, Peroneal Tendons and Long Flexors of the Toes*. Baxter's the Foot and Ankle in Sport (2nd Ed), (pp. 121-146). Elsevier Ltd.

Sandmark, H. (2000). Musculoskeletal dysfunction in physical education teachers. *Occup Environ Med.*, 57(10): 373-377.

Sandmark, H., Wiktorin, C., Hogstedt, C., Klenell-Hatschek, E. K., & Vingard, E., (1999). The physical workload in physical education teachers. *Appl. Ergon*., 30(5):435-442.

Santilli, V., Frascarelli, M. A., Paoloni, M., Frascarelli, F., Camerota, F., De Natale L, et al. (2005). Peroneus longus muscle activation pattern during gait cycle in athletes affected by functional ankle instability. *Am J Sports Med*., 33: 1183-1187.

Santos, A., Ramos, H., Ramasamy, G., & Fernandes, C. (2014). Prevalence of musculoskeletal pain in a sample of migrant workers in the manufacturing industry in Malaysia. *Public Health,* 128(8):759-761. DOI:10.1016/j.puhe.2014.04.003.

Santos, C. L., Noronha, D. O., Gomes, C. A., Fernandes, P. R., & Filho, J. F. (2008). Biomechanical repercussions of the use of high heels in the kinematics of the March: A retrospective study from 1990 to 2007. *Rev. Educ. Fisica.,* 143:47-53.

Sapuan, S. M., Maleque, M. A., Hameedullah, M., & Sudin, M. N. (2005). A note on the conceptual design of polymeric composite automotive bumper system. *J. Mater. Process. Technol*., 159:145-151.

Sartika, S. J., & Dawal, S. Z. (2012). Investigation of lower limb fatigue on two standing posture. *Jurnal Optimasi Sistem Industri*, 11:208-213.

Schaff, P. S. (1993). An overview of foot pressure measurement systems. *Clin Podiatr Med Surg.,* 10:403-415.

Schaff, P. S., & Cavanagh, P. R. (1990). Shoes for the insensitive foot: The effect of a “rocker bottom” shoe modification on plantar pressure in older adults. *Clin. Biomech*., 19:78-84.

Schlick, C. M., & Vanwonterghem, K. (2009). *Ergonomics and human factors: Methodological considerations about evidence based design of work Systems*. In Schlick, C. M. (Ed.), Industrial Engineering and Ergonomics (pp. 413-425). Berlin: Springer.

Scuffham, A. M., Legg, S. J., Firth, E. C., & Stevenson, M. A. (2009). Prevalence and risk factors associated with musculoskeletal discomforts in New Zealand veterinarians. *Applied Ergon*., 41:444-453. DOI:10.1016/j.apergo.2009.09.2009.

Shahrukh, M., Chawla, S., & Dubey, P. (2017). A study on customer satisfaction towards footwear in Bilaspur City, India. *Research Journal of Management Sciences*, 6(5):44-49.

Shaikh, A. S., & Shelke, R. D. (2016). Studies assessing the effects of prolonged standing at work: A review. *International Journal of Advanced Engineering Research and Science,* 3:10. DOI:10.22161/ijaers/3.10.15.

Shephard, R. J. (1998). *Aging and exercise*. Encyclopaedia of Sports Medicine and Science.

Shimizu, M., Wada, K., Wang, G., Kawashima, M., Yoshino, Y., Sakaguchi, H., Ohta, H., Miyaoka, H., & Aizawa, Y. (2011). Factors of working conditions and prolonged fatigue among teachers at public elementary and junior high schools. *Ind Health*, 49(4):434–42.

Sholihah, Q., Hanafi, A. S., Bachri, A. A., & Fauzia, R. (2016). Ergonomics awareness as efforts to increase knowledge and prevention of musculoskeletal disorders on fishermen. Aquatic Procedia, 7:187-194. DOI:10.1016/j.aqpro.2016.07.026.

Sizer, P. S., Cook, C., Brismee, J. M., Derick, L., & Phelps, V. (2004). Ergonomic pain part 1: Etiology for subacute and chronic low back pain: An updated Cochrane review. *Spine,* 34(1): 49-59.

Slapsinskaite, A., Razon, S., Serre, N. B., Hristovski, R., Tenenbaum, G. (2015). Local pain dynamics during constant exhaustive exercise. *PLOS One*. DOI:10.1371/journal.pone.0137895.

Snedecor, G. W., & Cochran, W. G. (1989). *Statistical methods*. (8th Ed.). Ames: Iowa State Press.

Soares, J. J. F., & Jablonska, B. (2004). Psychosocial experiences among primary care patients with and without musculoskeletal pain. *Eur J Pain*, 8:79-89.

Sobel, E., Levitz, S. J., Caselli, M. A., Christos, P. J., & Rosenblum, J. (2001). The effect of customized insoles on the reduction of post work discomfort. *Journal of American Podiatric Medical Association*, 91(10):515-520.

Social Security Organization, Malaysia (SOCSO) (2018). Annual report 2018 of SOCSO. Retrieved from https://www.perkeso.gov.my/images/ laporan_tahunan/Laporan_ Tahunan2018.pdf. [Accessed 12th April 2020]

Solis-Soto, M. T., Schon, A., Solis-Soto, A., Parra, M., & Radon, K. (2017). Prevalence of musculoskeletal disorders among school teachers from urban and rural areas in Chuquisaca, Bolivia: A cross-sectional study. *BMC Musculoskeletal Disord*., 18:425.

Sousa, A. S., Macedo, R., Santos, R., Sousa, F., Silva, A., & Tavares, J. M. (2016). Influence of prolonged wearing of unstable shoes on upright standing postural control. *Human Movement Science*, 45:142-153.

Sowell, M. E. (2013). Foot anatomy. Retrieved from https://etfaonline.com/wp-content/uploads/2013/10/footAnatomy-worksheet.2.pdf. [Accessed on 23rd March 2018].

Straker, L. M. (1999). *Body discomfort assessment tools*. In Karwowski, W. and Marras, W.S., (Ed.). The Occupational Ergonomics Handbook, (pp. 1239-1252). CRC Press, Boca Raton, FL.

Stanley, K. (2007). Design of randomized controlled trials*. Circulation*, 115:1164-9.

Stanton, N., Salmon, P., Walker, G., Baber, C., & Jenkins, D. (2005). *Human factors methods*. Aldershot: Ashgate.

Stebbins, J. A., Harrington, M. E., Giacomozzi, C., Thompson, N., Zavatsky, A., & Theologis, T. N. (2005). Assessments of sub-division of plantar pressure measurements in children. *Gait P*osture, 22:372-376.

Stephen et al. (2012). Baseline dependent effect of noise-enhanced insoles on gait variability in healthy elderly walkers*. Gait Posture*, 36:537.

Summers, K., Jinnett, K., & Bevan, S. (2015). Musculoskeletal disorders, workforce health and productivity in the United States. The Centre for Workforced Health and Performance. London: Lancester University. Retrieved from http://www.theworkfoundation.com/wp-content/uploads/2016/11/385_White-paper-Musculoskeletal-disorders-workforce-health-and-productivity-in-the-USA-final.pdf. [Accessed on 23rd March 2018].

Sutkowska, E., Sutkowski, K., Sokolowski, M., Franek, E., & Dragon, S. S. (2019). Distribution of the highest plantar pressure regions in patients with diabetes and its association with peripheral neuropathy, gender, age, and BMI: One centre study. *Journal of Diabetes Research*, 11.

Szeto, G. (2003). Potential health problems faced by an Asian youth population with increasing trend for computer use. *Proceeding of the National Seminar on Ergonomic Research Techniques, Delhi*. Wisdom Publication.

Tamrin, B. M. T., Yokoyama, K., Jalaluddin, J., Aziz, N. A., & Jemoin, N. et al. (2007). The association between risk factors and low back pain among commercial vehicle drivers in peninsular Malaysia: A preliminary result. *Ind. Health*, 45:268-278. DOI:10.2496/indhealth.45.268.

Tan, C. F. et al., (2008). Subjective and objective measurements for comfortable truck driver's seat. *AVEC*, 141.

Taharim, N. F., Jayasuriya, D. P., Xiang, W. L., & Mazhar, S. F. (2017). Clerical work for school teacher: A burden or a responsibility?. *Journal of Humanities, Language, Culture and Business (HLCB)*, 1:26-36.

Tavafian, S. S., Jamshidi, A., Mohammad, K., & Montazeri, A. (2007). Low back pain education and short-term quality of life: a randomized trial. *BMC Musculoskeletal Disorder*, 8:21.

Thompson, C., Belanger, M., Fung, J. (2007). Effects of bilateral Achilles tendon vibration on postural orientation and balance during standing. *Clin Neurophysiol*, 118: 2456-2467.

Timothy, S. J., & Michelle, A. (2015). *A comprehensive guide to Geriatric rehabilitation*. Third ed. Elsevier BV, London.

Treaster, D., & Burr, D. (2004). Gender differences in prevalence of upper extremity musculoskeletal disorders. *Ergonomics*, 47(5):495-526.

Tsuboi, H., Takeuchi, K., Watanabe, M., Hori, R., & Kobayashi, F. (2002). Psychocial factors related to low back pain among school personnel in Nagoya, Japan. *Ind. Health*, 40:266-271. PMID:12141375

Umi Kalsom, M. S., Karmegam, K., Shamsul, B. M. T., & Goh, Y. M. (2015). The effectiveness of new model of motorcycle seat with built-in lumbar support. *Jurnal Teknologi*, 77(27): 97-103.

University of Connecticut Health Centre, (2018). Anatomy of lower legs. Retrieved from https://www.verywellhealth.com/lower-leg-anatomy-3119329. [Accessed on 23rd March 2018].

Urabe, Y., Maeda, N., Kato, S., Shinohara, H., & Sasadai, J. (2014). Effect of shoe insole for prevention and treatment of lower extremity injuries. *J Phys Fitness Sports Med*, 3(4):385-398.

Urry, S., & Wearing, S. (2001). The accuracy of footprint contact area measurements: Relevance to the design and performance of pressure platforms. *Foot,* 11:151-157.

U.S Department of Health and Human Services (USDHHS), (1992). Overview of electromyography in ergonomics: Selected topics in surface electromyography for use in the occupational setting: Expert perspectives: U.S Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute Occupational Safety and Health. DHHS (NIOSH) Publication No. 91-100.

Van der Grinten, M. P., & Smitt, P.K. (1992). *Development of a practical method for measuring body part discomfort.* Advances in Industrial Ergonomics and Safety *IV,* (pp. 311-318).

Van Deursen, R. W., Sanchez, M. M., Derr, J. A., Becker, M. B., Ulbrecht, J. S., & Cavanagh, P. R. (2001). Vibration perception threshold testing in patients with diabetic neuropathy: Ceiling effects and reliability. *Diabet Med.,* 18:469-475.

Van Schie, C. H., Whalley, W., Vileikyte, L., & Boulton, A. J. (2002). Efficacy of injected liquid silicone is related to peak plantar pressures in the neuropathic diabetic foot. *Wounds*, 14:26-30.

Van Schie, C. H., Whalley, W., Vileikyte, L., Wignall, T., Hollis, S., & Boulton, A. J. (2000). Efficacy of injected liquid silicone in the diabetic foot to reduce risk factors for ulceration: A randomized double-blind placebo-controlled trial. *Diabetes Care*, 23(5): 26-30.

Vaghela, N., & Parekh, S. (2017). Prevalence of the musculoskeletal disorder among school teachers. *National Journal of Physiology*, *Pharmacy and Pharmacology*, 8:1. Doi:10.5455/njppp.2018.8.0830218082017.

Veselinovic, S. P., Hedge, A., & Veselinovic, M. (2016). An ergonomic expert system for risk assessment of work-related musculoskeletal disorders. *International Journal of Industrial Ergonomic*, 53:130-139.

Vieira, E. R., & Kumar, S. (2004). Working postures: A literature review. *Journal of Occupational Rehabilitation,* 14(2):143-159.

Vignoli, M., Guglielmi, D., Balducci, C., & Bonfiglioli, R. (2015). Workplace bullying as a risk factor for musculoskeletal disorders: The mediating role of job-related psychological strain. *Biomed Res Int*., 712642.

Villemure, C., & Bushnell, M. C. (2002). Cognitive modulation of pain: How do attention and emotion influence pain processing. *Pain,* 95(3):195-199.

Wafai, L., Zayegh, A., Woulfe, J., Aziz, S. M., & Begg, R. (2015). Identification of foot pathologies based on plantar pressure asymmetry. *Sensors*, 15:20392-20408. DOI:10.3390/s150820392.

Wahab, D. A., Manan, N. F. A., Hannan, M. A., Abdullah, S., & Hussain, A. (2008). Designing for comfort and reliability in an intelligent car seat. *American Journal of Applied Sciences,* 5(12):1787-1792.

Wanderley, F. S., Alburquerque-Sendin, F., Parizotto, N. A., et al. (2011). Effect of plantar vibration stimuli on the balance of older women: A randomized controlled trial. *Arch Phys Med Rehabil.*, 92: 199-206.

Wang, C. C., & Yang, W. H. (2011). Using detrended fluctuation analysis (DFA) to analyze whether vibratory insoles enhance balance stability for elderly fallers. *Arch Gerontol Geriat*, 55:673.

Waters, T. R., & Dick, R. B. (2015). Evidence of health risks associated with prolonged standing at work and intervention effectiveness. *Rehabilitation Nursing*, 40(3):148-165. DOI:10.1002/rnj.166.

Weijers, R. E., Walenkamp, G. H., Van Mameren, H., & Kessels, A. G. (2003). The relationship of the position of the metatarsal heads and peak plantar pressure. *Foot Ankle Int*., 24:349-353.

Wells, C. et al. (2005). Touch noise increases vibrotactile sensitivity in old and young. *Psychol Sci,* 16:313-320.

West & Barnett (1999). Plantar pressure measurement: Which system?. *The Diabetic Foot*, 2(3).

Whitehead, A. L., Julious, S. A., Cooper, C. L., & Campbell, M. J. (2016). Estimating the sample size for a pilot randomised trial to minimise the overall trial sample size for the external pilot and main trial for a continuous outcome variable. *Stat Methods Med Res*., 25(3):1057.

Woodburn, J., & Helliwell, P. S. (1996). Observations on the F-Scan in-shoe pressure measuring system. *Clin Biomech*., 11:301-304.

World Health Organization (WHO) (2010). European Agency for safety and health at work, preventing work-related musculoskeletal disorders in Luxembourg, Belgium: Office for Official Publications of the European Communities. Retrieved from https://osha.europa.eu/en/tools-and-publications/publications/reports/TERO09009ENC. [Accessed on 23rd March 2018].

World Health Organization (WHO) (2020). Global database on Body Mass Index: BMI classification. Retrieved from https://www.who.int/data/gho/data/themes/theme-details/GHO/body-mass-index-(bmi). [Accessed on 19th March 2020].

Yazuli, Z. A., Karuppiah, K., Kumar, E., Tamrin, S. B. M., & Sambasivam, S. (2019). Discomfort, fatigue and work-related musculoskeletal disorders associated with prolonged standing among Malaysian manufacturing workers: A mini review. *Songklanakarin J. Sci. Technology*., 41(2):271-275.

Yu, M., Piao, Y. J., Kim, S. H., et al. (2010). Effects of tendon vibration during one-legged and two-legged stance in elderly individuals. *Int J Precis Eng Manuf,* 11: 969-977.

Yue, P., Liu, F., & Li, L. (2012). Neck/shoulder pain and low back pain among school teachers in China, prevalence and risk factors. *BMC Musculoskelet Rehabil*., 25(1):5-12.

Yue, P., Xu, G., Li, L., & Wang, S. (2014). Prevalence of musculoskeletal symptoms in relation to psychosocial factors. *Occup Med (Lond).,* 64:211-6.

Zainal Abidin, N., Rohani, J. M., Nordin, A. N., Zein, R. M., & Ayak, A. S. A. (2018). Financial impact and causes of chronic musculoskeletal disease cases in Malaysia based on social security organization of Malaysia claims record. *International Journal of Engineering & Technology,* 7(3.24):23-27.

Zammit, G. V., Menz, H. B., & Munteanu, S. E. (2010). Reliability of the Tekscan Matscan® system for the measurement of plantar forces and pressures during barefoot level walking in healthy adults. *Foot Ankle Res*., 3:11.

Zamri, E. N., Moy, F. M., & Hoe, V. C. W. (2017). Association of psychological distress and work psychosocial factors with self-reported musculoskeletal pain among secondary school teachers in Malaysia. *PLoS ONE* 12(2):e0172195. DOI:10.1371/journal.pone.0172195; 2017.

Zermatten, P., & Crevoisier, X. (2011). Avulsion fracture of the peroneus longus tendon insertion at the base of the first metatarsal: Report of a case. *Foot Ankle Surg*., 17: e10-e12.

Zizoua, C., Benbakhti, A., Boukhenous, S., & Attari, M. (2014). Wireless foot plantar pressure measurement instrument for Medical Diagnostic. *Biomedical Engineering International Conference*, DOI:10.13140/2.1.1881.4726.

Zulkifli, S. S., & Loh, W. O. (2020). A state-pf-the-art review of foot pressure. *Foot and Ankle Surgery*, 26(1):25-32.

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LIST OF PUBLICATIONS

Alias, A. N., Karuppiah, K., Vivien, H., Perumal, V. (2021). Feet plantar pressure distribution among female school teachers. Research Square. DOI:10.21203/rs.3.rs-115018/v1 (Preprint)

Alias, A. N., Karuppiah, K., Vivien, H., Perumal, V., Sambasivam, S., Tamrin, S. B. M., & Naeini, H. S. (2020). The perception on school footwear comfort among primary school female teachers in Terengganu. International Journal of Pharmaceutical Research, 12(3). DOI:https://doi.org/10.31838/ijpr/2020.12.03.288.

Alias, A. N., Karuppiah, K., Vivien, H., & Perumal, V. (2020). Does prolonged standing at work among teachers associated with musculoskeletal disorders (MSDs)?. Malaysian Journal of Medicine and Health Sciences, 16(2):281-289.

Alias, A. N., Karuppiah, K., Vivien, H., & Perumal, V. (2020). Prevalence of musculoskeletal disorders (MSDs) among primary school female teachers in Terengganu, Malaysia. International Journal of Industrial Ergonomics, 77:102957.

Sivasankar Sambasivam, Adriana Abdul Aziz, Karmegam Karuppiah, Emilia Zainal Abidin, Shamsul Bahri Md Tamrin, Hassan Sadeghi Naeini, Kulanthayan K.C. Mani, Puvanasvaran Perumal, **Ayuni Nabilah Alias** (2020). Prevalence of safety equipment and helmet use among school students commuting to school in South Selangor, Malaysia. Songklanakarin Journal of Science and Technology, 42(3):721-724.

Ayuni Nabilah Alias, Karmegam Karuppiah, Vivien How, Velu Perumal (2019). A Systematic Review for Musculoskeletal Disorders (MSDs) among School Teachers in Malaysia. Research Journal of Recent Sciences, 9(1):1-8.

Alias A.N., Karuppiah K., How V., Perumal V., Sambasivan S., Tamrin SBM (2019). Are teachers standing too much? Ergonomic Int J., 3(5):000216.

Ayuni Nabilah Alias, Karmegam Karuppiah, Shamsul Bahri Mohd Tamrin, Emilia Zainal Abidin, Umi Kalsom Mohd Shafie and Sivasankar Sambasivam (2016). Risk factors of muscular discomfort among motorcyclists – Review article. *Iran J Public Health*, pp. 45(1): 35-43.

Ayuni Nabilah Alias, Karmegam Karuppiah, Shamsul Bahri Mohd Tamrin, Emilia Zainal Abidin and Umi Kalsom Mohd Shafie (2015). A systematic review of intervention to reduce musculoskeletal disorders: Hand and arm disorders. *Jurnal Teknologi (Sciences and Engineering),* 77 (27), pp. 97-103.

Umi Kalsom Mohd Shafie, Karmegam Karuppiah, Shamsul Bahri Mohd Tamrin, Emilia Zainal Abidin and **Ayuni Nabilah Alias** (2015). The effectiveness of new model of motorcycle seat with built-in lumbar support. *Jurnal Teknologi (Sciences and Engineering),* 77 (27), pp. 97-103.

Umi K.M.S., Karmegam K., Shamsul B.M.T., Irniza R. and **Ayuni N.A.** (2014). Interventions to reduce musculoskeletal disorders among motor vehicle workers. A review. *Advances in Environmental Biology,* 8(5), pp. 219-224.

Ayuni N.A., Juliana J. and Ibrahim M.H. (2014). Exposure to PM_{10} and NO_2 and association with respiratory health among primary school children living near petrochemical industry area at Kertih, Terengganu. *Journal Medical and Bioengineering*, 3(4), pp. 282-287.

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