ERGONOMIC ASSESSMENT OF MUSCULOSKELETAL SYMPTOMS AND ASSOCIATED RISK FACTORS AMONG PINEAPPLE PLANTATION WORKERS

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Malaysia sedang berusaha untuk menjadi salah satu pengeluar buah nanas yang terbesar di Asia Tenggara. Memandangkan terdapat banyak sektor ladang nanas yang baru dibuka, permintaan pekerjaan untuk bekerja di sektor ini juga semakin meningkat. Kerja-kerja pertanian sentiasa dikaitkan dengan kadar permintaan yang tinggi dan kegiatan kerja yang berat dan bersifat intensif. Oleh itu, pekerja di sektor perladangan sentiasa berisiko untuk mendapat Gangguan Muskuloskeletal Berkaitan Pekerjaan. Aktiviti pekerjaan perladangan nanas bermula dengan penanaman, pemeliharaan, merumput secara manual dan penuaian. Kegiatan pekerjaan ini melibatkan corak kerja yang berulang, memakan masa yang lama dan membebankan. Para pekerja bukan sahaja perlu bekerja dalam pelbagai postur canggung yang berpanjangan, malah, terdedah kepada kerja pengendalian manual semasa aktiviti penuaian. Tiga objektif utama kajian ini adalah untuk mengenal pasti kelaziman simptom muskuloskeletal dalam kalangan pekerja ladang nanas; menganalisis penilaian risiko ergonomik dalam kalangan pekerja nanas; dan menguji skor penilaian risiko ergonomik dari segi kesahannya. Proses pengumpulan data telah dilakukan bagi tiga ladang nanas yang berlainan di Pahang selama tiga bulan. Soal selidik yang diubahsuai diadaptasi dari Nordic Musculoskeletal Questionnaire telah digunakan semasa mengenal pasti kelaziman simptom muskuloskeletal dalam kalangan pekerja. Aktiviti dinamik pekerja direkodkan dan dengan menggunakan gambar statik, dua jenis penilaian risiko ergonomik iaitu *Ovako Working Posture Analysis System* (OWAS) dan *Manual Handling Assessment Chart* (MAC) telah dijalankan. Selepas itu, keputusan analisa disahkan menggunakan teknik *Surface Electromyography* (sEMG). Hasil kajian menunjukkan bahawa 62.1% pekerja mengalami sakit bawah belakang, diikuti oleh 58.2% pekerja yang mengalami sakit pinggang dan 33% pekerja merasakan kesakitan pada lutut mereka. OWAS mengenal pasti tiga aktiviti; penanaman (39.8%), merumput secara manual (42.7%) dan penuaian (60.2%) dikategorikan sebagai AC 3. Sementara itu, penanaman (17.5%) dan rumput manual (27.2%) jatuh ke dalam kategori AC 4 yang ditunjukkan sebagai sangat berbahaya. Analisis MAC menunjukkan bahawa aktiviti mengangkat dan membawa beban semasa proses penuaian dianggap berbahaya. Skor akhir aktiviti mengangkat ialah 13-20 (100%) yang menandakan langkah kawalan diperlukan tidak lama lagi. Sementara itu skor akhir aktiviti membawa beban ialah berskor 5-12 (33.3%) yang menandakan langkah kawalan diperlukan dalam masa terdekat dan 13-20 (66.7%) yang menandakan tindakan langkah kawalan diperlukan tidak lama lagi. Hasil keseluruhan dari kajian ini menunjukkan bahawa pekerja perladangan nanas amat terdedah kepada faktor risiko bahaya ergonomik seperti postur canggung dan mengangkat beban yang berat. Kajian ini mencadangkan untuk mengaplikasi prinsip ergonomik, seperti mekanisasi peralatan untuk menghapuskan postur canggung dan tugas pengendalian manual. Jika tidak berupaya untuk melaksanakan sebarang mekanisasi, latihan terus menerus yang mencukupi dan berkesan harusla disediakan. Dengan ini, para pekerja dapat melaksanakan amalam kerja yang selamat.

ABSTRACT

Malaysia is on an attempt to become one of the largest producers of pineapples in Southeast Asia. As there are many new developed pineapple plantation areas, there are high job demands to work in this sector. Agricultural works is always associated with high demand, heavy and labor intensive works. Thus, plantation workers are constantly at risk for developing Work-Related Musculoskeletal Disorders. Pineapple plantation job activities start with planting, maintaining, manual weeding and harvesting. These job activities are known as quite repetitive, long time consuming and laborious in nature. In spite of various prolonged awkward postures, the workers also exposed to heavy manual work during harvesting activity. This study aims to identify the prevalence of musculoskeletal symptoms among workers of pineapple plantations; analyze the postural analysis assessment; and to test the postural scores in terms of its validity. Data collection was conducted in three different pineapple plantations in Pahang which took three months. A modified questionnaire adapted from Nordic Musculoskeletal Questionnaire was used during recognizing the prevalence of musculoskeletal symptoms among the workers. Dynamic activities of workers were recorded and by using stand still photos, two type of postural assessment; Ovako Working Posture Analysis System (OWAS) and Manual Handling Assessment Chart (MAC) were carried out. After that, the results were validated by using Surface Electromyography (sEMG) technique. The survey results showed that 62.1% of workers experienced lower back pain, followed by 58.2% of workers experienced pain on the waist and 33% of workers felt pain on their knees. OWAS identified three activities; planting (39.8%), manual weed (42.7%) and harvesting (60.2%) were categorized mainly in Action Category 3 which indicated distinctly harmful. Meanwhile, planting (17.5%) and manual weed (27.2%) also fell into Action Category 4 which indicated as extremely harmful. MAC assessment for lifting activity showed that 100% were in level 3 (risk level 13-20), signify that action required soon. On the other hand, carrying activity showed that 33.3% were in level 2 (risk level 5-12), signify that action required near future whereas 66.7% were in level 3 (risk level 13-20) which signify action required soon. The overall result from the study shows that pineapple plantation workers are highly exposed to ergonomic hazards risk factors such as awkward postures and heavy lifting. This study suggests that ergonomic intervention such as mechanization of tools and equipment should be implemented in order to eliminate poor postures and manual handling task. In case of incapability for any mechanization, adequate and effective training should be constantly provided. Therefore, workers can implement safe work practices.

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LIST OF ABBREVIATIONS

WMSDs	Work-Related Musculoskeletal Disorders
MSDs	Musculoskeletal Disorder
SPSS	Statistical Package for Social Sciences
LBP	Low Back Pain
OWAS	Ovako Working Posture Analysis System
MAC	Manual Handling Asessment Charts
sEMG	Surface Electromyography

REFERENCES

Abrahão, R. F., Gonzaga, M. C., Frederico, F. & Tereso, M. J. A. (2013). Personal Protective Equipment Design and Ergonomic Work Analysis : Protecting Farm Pineapple Growers. *Proceedings of The 2nd Asian Conference on Ergonomics and Design*, *53*, 552–555.

Adissi, P. J. & Almeida, C. V .B. (2002). Pineapple plantation risk–the case of the low Paraiba. *Proceedings of the National Meeting of Production Engineers*, *22*, 18-26.

Andersen, V., Fimland, M. S., Haslestad, L. R., Lundteigen, M. S., Skalleberg, K., & Saeterbakken, A. H. (2014). Muscle activation and strength in squat and bulgarian squat on stable and unstable surface. *International Journal of Sports Medicine*, *35*(14), 1196–1202.

Andersen, J. H., Haahr, J. P., & Frost, P. (2007). Risk factors for more severe regional musculoskeletal symptoms: a two-year prospective study of a general working population. *Arthritis Rheum, 56*(4), 1355-1364.

Arezes, P. M., Miguel, A. S., & Colim, A. S. (2011). Manual materials handling: Knowledge and practices among Portuguese Health and Safety practitioners. *Work, 39*(4), 385–395.

Baker, P., Reading, I., Cooper, C. & D. Coggon. (2003). Knee Disorders in the General Population and Their Relation to Occupation. *Occupational and Environmental Medicine, 60*(10), 794–797.

Balasubramanian, V., Adalarasu, K. & Regulapati, R. (2009). Comparing dynamic and stationary standing postures in an assembly task. *International Journal of Industrial Ergonomics, 39* (5), 649-654.

Bank Negara Malaysia. (2016). Economic and Financial Developments in Malaysia in the Fourth Quarter of 2015 (online). http://www.bnm.gov.my/files/publication/qb/2015/Q4_en.pdf.

Baker, N. A., Jacobs, K. & Tickle-degnen, L. (2003). The association between the meaning of working and musculoskeletal discomfort. *International Journal of Industrial Ergonomics, 31*, 235–247.

Backé, E. M., Seidler, A. U, Latza, K., Rossnagel, B. & Schumann. (2012). The role of psychosocial stress at work for the development of cardiovascular diseases: A systematic review. Int. Arch. Occup. Environ. Heal, 85 67–79.

Baron, S., Hales, T., & Hurrell, J. (1996). Evaluation of symptom surveys for occupational musculoskeletal disorders. *American Journal of Industrial Medicine, 29*(6), 609–617.

Beach, T. A. C., Frost, D. M., & Callaghan, J. P. (2014). FMS^{TM} scores and low-back loading during lifting - Whole-body movement screening as an ergonomic tool?. *Applied Ergonomics*, *45*(3), 482–489.

Beeck, J. L. Van, Versfeld, K., & Ehrlich, R. (2018). Deep vein thrombosis following prolonged kneeling : a case report, (March), 305–307.

Beheshti, M. H., Firoozi chahak A., Alinaghi Langari, A. A & Poursadeghiyan M. (2015). Risk assessment of musculoskeletal disorders by OVAKO Working posture Analysis System OWAS and evaluate the effect of ergonomic training on posture of farmers. *Journal of Ocucpational Health and Ergonomics, 4*(3), 131–138.

Bejjani, F. J., Gross, C. M. & Pugh, J. W., (1984). Model for static lifting: relationship of loads on the spine and the knee. *Journal of Biomechanics, 17*, 281–28.

Bergerud, W. A. (1996). Introduction to Regression Models: with worked forestry examples. Biom. Info. Hand. 7. Res. Br., B.C. Min. For., Victoria, B.C. Work. Pap

Bhattacharyya, N. & Chakrabarti, D. (2012). Ergonomic basket design to reduce cumulative trauma disorder in tea leaf plucking operation. *Work*, *41*(1), 1234-1238.

Bida, O. (2005). *Influence of Electromyogram (EMG) Amplitude Processing in EMG-Torque Estimation* (Master's thesis). Worcester Polytechnic Institute Massachusetts.

Brian N. Craig, Jerome J. Congleton, Eric Beier, Carter J. Kerk, Alfred A. Amendola & William G. Gaines. (2013). Occupational Risk Factors and Back Injury. *International Journal of Occupational Safety and Ergonomics, 19*(3), 335-345.

Bridger, R. S., Ashford, A. I., Wattie, S., Dobson, K., Fisher, I. & Pisula, P. J. (2018). International Journal of Industrial Ergonomics Sustained attention when squatting with and without an exoskeleton for the lower limbs. *International Journal of Industrial Ergonomics, 66*, 230–239.

Bolghanabadi, S. (2016). Risk assessment of musculoskeletal disorders in sugar factory worker by manual handling assessment chart. *Beyhagh, 20* (1), 1-10.

Buckle, P. W., & Jason Devereux, J. (2002). The nature of work-related neck and upper limb musculoskeletal disorders. *Applied Ergonomics*, *33*, 207–217.

Burgess-Limerick, R., (2003). Squat, stoop, or something in between. *Int. J. Ind. Egonomics 31*, 143–148.

Carlo, M. (2013). Normality tests II (Chapter 194). *NCSS Statistical Software*. pp.1–7.

Carayon, P., Smith, M. J., & Haims, M. C. (1999). Work Organization, Job Stress, and Work-Related Musculoskeletal Disorders. Hum. Factors J. Hum. Factors Ergon. Soc., 41, 644–663.

Carneiro, P., Martins, J. & Torres, M. (2015). Musculoskeletal disorder risk assessment in home care nurses. *Work*, *51*(4), 657–665.

Castroflorio, T., Farina, D., Bottin, A., Debernardi, C., Bracco, P. & Merletti, R. (2005). Non-invasive assessment of motor unit anatomy in jaw-elevator muscles. *J Oral Rehabil, 32,* 708–13.

Chander, D. S. & Cavatorta, M. P. (2017). An observational method for Postural Ergonomic Risk Assessment. *International Journal of Industrial Ergonomics*, *57*, 32–41.

Chao, E. L. & Henshaw, J. L., (2002). Job Hazard Analysis. OSHA Publication 3071 2002 (Revised). Occupational Safety and Health Administration, US Department of Labor, Washington.

Chan, Y. K. (2000). Status of the Pineapple Industry and Research and Development in Malaysia *Proc. III International Pineapple Symp*, pp. 77-82.

Chapman, L., & Meyers, J. (2001). Ergonomics and Musculoskeletal Injuries in Agriculture: Recognizing and Preventing the Industry's Most Widespread Health and Safety Problem, *Proceedings National Agriculture Health & Safety Conference, Baltimore, MD.*

Chapanis, A. (1995). Ergonomics in product development: a personal view, 38.

Chung, L. (1999). Assessment of postural load for lower limb postures based on perceived discomfort. In *In: The Second International Cyberspace Conference on Ergonomics, Perth, Australia*, pp. 597–607.

Chung, M. K., Lee, I. & Kee, D. (2003). Effect of stool height and holding time on postural load of squatting postures. *Ergonomics*, *32*, 309–317.

Chung, M. K., Lee, I. & Kee, D., (2005). Quantitative postural load assessment for whole body manual tasks based on perceived discomfort. *Ergonomics*, *48*(5), 492–505.

Cheng, K. H. Y., Cheng, C.Y. & Ju, Y. Y. (2013).Work-related musculoskeletal disorders and ergonomic risk factors in early intervention educators. *Applied Ergonomics, 44*(1), 134-141.

Coggon D., Croft P. & Kellingray S. (2004). Occupational physical activities and osteoarthritis of the knee. *Arthritis Rheum*, *43*, 1443–1449.

Coluci, M. Z. O., Alexandre, N. M. C., & Rosecrance, J. (2009). Reliability and validity of an ergonomics-related Job Factors Questionnaire. *International Journal of Industrial Ergonomics*, *39*(6), 995–1001.

Craig, B. N., Congleton, J. J., Beier, E., Kerk, C. J., Alfred, A. & Gaines, W. G. (2013). Occupational Risk Factors and Back Injury Occupational Risk Factors and Back Injury, *Internatonal Journal of Occupational Safety and Ergonomics, 19*(3), 335-345.

Crawford, J. O. (2007). The Nordic Musculoskeletal Questionnaire. *Occupational Medicine*, *57*(4), 300–301.

Das, B. & Gangopadhyay, S. (2011). An ergonomics evaluation of posture related discomfort and occupational health problems among rice farmers. *Occupational Ergonomics*, *10*(1–2), 25–38.

Da Costa, B. R. & Vieira, E. R. (2010). Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. *Am. J. Ind. Med, 53*(3), 285-323.

Das, B., & Gangopadhyay, S. (2011). An ergonomics evaluation of posture related discomfort and occupational health problems among rice farmers. *Occupational Ergonomics*, *10*(1–2), 25–38.

David, G. C. (2005). Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. *Occupational Medicine*, *55*(3), 190–199.

Davis, K. G. & Kotowski, S. E. (2007). Understanding the ergonomic risk for musculoskeletal disorders in the United States agricultural sector. *Am J Ind Med, 50*, 501–511.

DeForest, B. A., Cantrell, G. S. & Schilling, B. K. (2014). Muscle Activity in Single- vs. Double-Leg Squats. *International Journal of Exercise Science*, *7*(4), 302–310.

Deka, B., Sharma, S., Choudhury, S. & Pal, R. (2008). Development of packaging system for distant transportation of'Kew'pineapple (Ananas comosus). *Indian Journal of Agricultural Sciences*, 340–342.

Dempsey, P. G., Wogalter, M. S. & Hancock, P. A. (2006). Defining Ergonomics / Human Factors, Taylor & Francis Group (2006).

Deros, B. M., Daruis, D. D. I. & Basir, I. M. (2015). A Study on Ergonomic Awareness among Workers Performing Manual Material Handling Activities. *Procedia - Social and Behavioral Sciences*, *195*, 1666–1673.

Department of Statistics Malaysia. The Office of Chief Statistician Malaysia Department of Statistics, Malaysia. (2018). Press Release Gross Domestic Product Fourth Quarter 2017. Retrieved from https://www.dosm.gov.my/v1/index.php?r=column/pdfPrev&id=emUyMzI4eElNK0hZQzRyaEgyZGhlZz09

Dickinson, C. E., Campion, K., Foster, A. F., Newman, S. J., O'Rourke, A. M. T., & Thomas, P. G. (1992). Questionnaire development: an examination of the Nordic Musculoskeletal questionnaire. *Applied Ergonomics*, *23*(3), 197–201.

Dormohammadi, A., Amjad-Sardrudi, H., Motamedzade, M., Dormohammadi, R. & Musavi, S. (2012). Ergonomics Intervention in Tile Industry: Case of Manual Material Handling. *Journal of Research in Health Sciences*, *12*(2), 109-113.

DOSH. (2017). *Guidelines On Ergonomics Rick Assessment At Workplace 2017*. Department of Occupational Safety and Health Ministry of Human Resources Malaysia.

DOSH. (2008). *Guidelines for Hazard Identification, Risk Assessment and Risk Control*. Department of Occupational Safety and Health Ministry of Human Resources Malaysia.

Duraj, V., Miles, J. A., Meyers, J. M., Faucett, J. A., Jan-owitz, I. L., Tarter, M. E., Tejeda, D. G., Smith, R. H. & Weber, E. A. (2000). Harvesting aids for reducing ergonomics risk factors in wine grape hand harvesting. University of California Agricultural Ergonomics Research Center (online). http://research.engineering.ucdavis.edu/agergo/wpcontent/uploads/sites/68/2015/07/2000AsaeVineInterven.pdf

D'Souza, J. C., Werner, R. A., Keyserling, W. M., Gillespie, B., Rabourn, R. & Ulin, S. (2008). Analysis of the third national health and nutrition examination survey (NHANES III) using expert ratings of job categories. *Am J Ind Med, 51*, 37–46.

Earl-Richardson, G., Jenkins, P., Fulmer, S., Mason, C., Burdick, P. & May, J. (2005). An ergonomic intervention to reduce back strain among apple harvest workers in New York State. *Applied Ergonomics, 36*, 327–334.

Faber, G. S., Kingma, I. & Van Dieen, J. H., (2011). Effect of initial horizontal object position on peak L5/S1 moments in manual lifting is dependent on task type and familiarity, *Ergonomics, 54*(1), 72-81.

Falla, D., Dall'Alba, P., Rainoldi, A., Merletti, R. & Jull, G. (2002). Location of innervation zones of sterno-cleidomastoid and scalene muscles – a basis for clinical and research electromyography applications. Clin Neurophysiol, 11(3), 57–63.

Farley, B. G. & Koshland, G. F. (2000). Trunk muscle activity during the simultaneous performance of two motor tasks. *Experimental Brain Research, 135*(4), 483–496.

Fathallah, F. A. (2010). Musculoskeletal disorders in labor-intensive agriculture. *Applied Ergonomics, 41*(6), 738–743.

Farahpour, N., Ghasemi, S., Allard, P. & Saba, M. S. (2014). Electromyographic responses of erector spinae and lower limb's muscles to dynamic postural perturbations in patients with adolescent idiopathic scoliosis. *Journal of Electromyography and Kinesiology, 24(5)*, 645–651.

Florimond, V. (2010). Basics of Surface Electromyography Applied to Physical Rehabilitation and. *Thought Technology Ltd, 1*, 1–50.

Fraenkel, J. R. & Wallen, N. E. (2009). *How to Design and Evaluate Research in Education.* Retrieved from https://rezkyagungherutomo.files.wordpress.com/2016/09/how-to-design-and-

evaluate-research-in-education.pdf

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). Educational research: An introduction (6th ed.). White Plains, NY, England: Longman Publishing.

Gallagher, S. (2005). Physical limitations and musculoskeletal complaints associated with work in unusual or restricted postures: A literature review. *Journal of Safety Research, 36,* 51–61.

Galappaththi, H. K. A. & Arambepola, C. (2017). Prevalence of work-related musculoskeletal disorders among male paddy/ chena cultivators in the Medical Officer of Health area, Kanthale. *Journal of the College of Community Physicians of Sri Lanka,* 23(3). Retrieved from https://docplayer.net/61468313-Journal-of-college-of-community-physicians-of-sri-lanka.html

Gamet, D. & Fokapu, O. (2008). Electromyography. In *Encyclopedia of Biomaterials abd Biomedical Engineering* (pp. 956–967).

Gangopadhyay S., Ghosh T., Das T., Ghoshal G., & Das B. B. (2007). Prevalence of upper limb musculoskeletal disorders among brass metal workers in West Bengal, India, *Industrial Health,* 45, 365-370.

Gangopadhyay, S., Das, B., Das, T., & Ghoshal, G. (2005). An Ergonomic Study on Posture-Related Discomfort Among Preadolescent Agricultural Workers of West Bengal , India. *Int J Occup Saf Ergon*, *11*(3), 315-22.

Gasibat, Q. & Simbak, N. B. (2017). Moderation of Back pain by Rehabilitation Exercises ; Multifidus Muscle ' Perspective. *Journal of Sports and Physical Education*, *4*(1), 14–18.

Ghasemkhani, M., Mahmudi, E. & Jabbari, H. (2008). Musculoskeletal symptoms in workers. *International Journal of Occupational Safety and Ergonomics, 14,* 455–462.

Genaidy, A. M., Al-Shedi, A. A. & Karwowski, W. (1994). Postural stress analysis in industry. *Applied Ergonomics*, *25*(2), 77–87.

Ghofrani, M., Olyaei, G., Talebian, S. & Bagheri, H. (2017). Reliability of SEMG measurements for trunk muscles during lifting variable loads in healthy subjects. *Journal of Bodywork & Movement Therapies*, *21*(3), 711–718.

Giat, Y., & Pike, N. (1992). Mechanical and Electromyographic Comparison Between the Stoop and a the S & at Lifting Methods. *Journal of Safety Research, 23,* 95–105.

Goldsheyder, D., Nordin, M., Weiner, S. S. & Hiebert, R. (2002).Musculoskeletal symptom survey among mason tenders. *Am J Indus Med, 42*(5), 384–96.

Gomez, M. I., Hwang, S., Stark, A. D., May, J. J., Hallman, E. M. & Pantea, C. I. (2003). An analysis of self-reported joint pain among New York farmers. *J Agric Saf Health, 9*,143–157.

Govindu, N. K. & Babski-reeves, K. (2014). Effects of personal , psychosocial and occupational factors on low back pain severity in workers. *International Journal of Industrial Ergonomics*, *44*(2), 335–341.

Gonzaga, M. C., Tencarte, A. P. R., Vieira, A. F. P. & Barreira, P. C. S. (2014). Evaluation of tasks in the cultivation of pineapple and personal protective equipment. Report Fundacentro of São Paulo.

Guo, Y., Wang, B., Lee, C., & Wang, J. (1996). Prevalence of dermatoses and skin sensitisation associated with use of pesticides in fruit farmers of southern Taiwan. *Occupational And Environmental Medicine*, *53*, 427–431.

Hägg, G. M., Luttmann, A., & Jäger, M. (2000). Methodologies for evaluating electromyographic field data in ergonomics. *Journal of Electromyography and Kinesiology*, *10*(5), 301–312.

Harris, D. (2013). Engineering Psychology and Cognitive Ergonomics: Understanding Human Cognition.

Hancock, P. A. (2012). *Human Factors/Ergonomics*, 2nd ed. Elsevier Inc.

Hashemi Habibabadi, R., Mohammadi M., Zare Mehrani E. & Ansari Moghaddam A. (2016). Risk Assessment of Musculoskeletal Disorders in Bandar-Abbas Charging Berth Workers Using MAC Method in 2011. *JRUMS*, *15* (6), 527-536.

Hassan, Z. A., Schattner, P., & Mazza, D. (2006). Doing A Pilot Study: Why Is It Essential?. *Malaysian family physician: the official journal of the Academy of Family Physicians of Malaysia*, *1*, 70-73.

Harkness, E. F., Macfarlane, G. J., Nahit, E. S., Silman, A. J. & McBeth, J,. (2003). Risk factors for new-onset low back pain amongst cohorts of newly employed workers. *Rheumatology, 42*, 959-968.

Health and Safety Executive. (2002). *Manual handling assessment charts*: 1–13.
Health and Safety Executive. (2013). *Ergonomics and human factors at work*, pp. 1–10.

Henry, L. J., Jafarzadeh Esfehani, A., Ramli, A., Ishak, I., Justine, M. & Mohan, V. (2015) Patterns of Work-Related Musculoskeletal Disorders Among Workers in Palm Plantation Occupation. *Asia-Pacific Journal of Public Health*, *27*(2), 1785-1792.

Holt, A. S. J. (2001). Principles of Construction Safety. *Blackwell Science*, London.

Holmström, E. B., Lindell, J. & Moritz, U. (1992). Low back and neck/shoulder pain in construction workers: occupational work- load and psychosocial risk factors. Part II: relationship to neck and shoulder pain. *Spine, 17*, 672–7.

Humantech. (2016). Definition of Occupational Ergonomics, pp. 1–4, Retrieved from https://www.humantech.com/wpcontent/uploads/2016/06/Definition-of-Occupational-Ergonomics-Position-Paper.pdf

Hwang, S., Kim, Y. & Kim, Y. (2009). Lower extremity joint kinetics and lumbar curvature during squat and stoop lifting. *BMC Musculoskeletal Disorders*, *10*, 15.

International Labour Office, (1998). 15, pp. 93

Jamal, A. A (2017, May 13). Pineapple export increase by 2020. *Berita Harian Online*. Retrieved from https://www.bharian.com.my/node/282205.

Jastrzebowski, W. (1857). An Outline of Ergonomics or the Science of Work Based on the Truths Drawn from the Science of Nature, 29 (reprinted by the Central Institute for Labour Protection, Warsaw, Poland).

Jensen, L. K., Rytter, S. & Bonde, J. P. (2010). Exposure Assessment of Kneeling Work Activities among Floor Layers. *Applied Ergonomics*, *41*(2), 319–325.

Jin, S., McCulloch, R. & Mirka, G.A. (2009). Biomechanical evaluation of postures assumed when harvesting from bush crops. *International Journal of Industrial Ergonomics*, **39**(2): 347–352.

Joseph, C., Imbeau, D. &Nastasia, I., (2011). Measurement consistency among observational job analysis methods during an intervention study. *Int. J. Occup. Saf. Ergon, 17* (2), 139-146.

Kabir-mokamelkhah, E., Aghilinejad, M., Bahrami-ahmadi, A. & Abbaszadeh, S., Moslemi, S., Shahnaghi, N. and Nassiri-kashani, M.H. 2015. Role of Rice Farming in Development Risk of Musculoskeletal Disorders Among Rice Farmers : a Prospective Study in 2013. *Iranian Journal of Health, Safety & Environment*, *3*(1), 489–494.

Karhu, O., Kansi, P., & Kuorinka, I. (1977). Correcting working postures in industry: A practical method for analysis. *Applied Ergonomics*, *8*(4), 199–201.

Karwowski, W. (2006). International Encyclopedia of Ergonomics and Human Factors, 2, Boca Raton, FL: CRC Press.

Keyserling, W. M. (1986). Postural analysis of the trunk and shoulders in simulated real time. *Ergonomics*, *29* (4), 569-583.

Kee, D. & Karwowski, W. (2017). A Comparison of Three Observational Techniques for Assessing Postural Loads in Industry. *International Journal of Occupational Safety and Ergonomics*, *13*(1), 3-14.

Kee, D., Chung, M. K., & Kim, J. (2011). Legal system and its effect for prevention of work-related musculoskeletal disorders in Korea. *International Journal of Industrial Ergonomics*, *41*(3), 224–232.

Kerr, M. S. (1998). Workplace Psychosocial Factors and Musculoskeletal Disorders: A Discussion Paper.

Keskin, S. (2006). Comparison of Several Univariate Normality Tests Regarding Type I Error Rate and Power of the Test in Simulation Based Small Samples. *Journal of Applied Science Research, 2*(5), 296-300.

Koekoeh, R., Wibowo, K. & Soni, P. (2016). Farmers ' Injuries , Discomfort and Its Use in Design of Agricultural Hand Tools : A Case Study from East Java , Indonesia. *Italian Oral Surgery*. **9**: 323–327.

Kilroy, N. & Dockrell, S. (2000). Ergonomic intervention: its effect on working posture and musculoskeletal symptoms in female biomedical scientist. *British Journal of Biomedical Science, 57*, 199–206.

Kirkhorn, S.R., Earle-Richardson, G. & Banks, R.J., (2013). Ergonomic Risks and Musculoskeletal Disorders in Production Agriculture: Recommendations for Effective Research to Practice. *Journal of Agromedicine, 15*(3), 281-299.

Kim, J.-W., Kwon O.-Y., Kim,T.-H., An, D.-H. & Oh, J.-S. (2014). Effects ofexternal pelvic compression on trunk and hipmuscle EMG activity during prone hip extension in females with chronic low back pain. *Manual Therapy, 19*(5), 467–471.

Kim, S. H & Chung, M. K. (1995). Effects of posture, weight and frequency on trunk muscular activity and fatigue during repetitive lifting tasks. *Ergonomics, 38,* 853-863.

Koltan, A. (2009). An ergonomics approach model to prevention of occupational musculoskeletal injuries. *International Journal of Occupational Safety and Ergonomics*, *15*, 113–124.

Konrad, P. (2006). *The ABC of EM: A practical introduction to Kinesiological Electromyography,* U.S.A: Noraxon Inc.

Kumar, P. & Chakrabarti, D. (2011a). Design development of a pineapple eye removing device. *International Conference on Ergonomics and Human Factors* (p. 51). Chennai.

Kuorinka, I., Jonsson, B., Kilbom, a, Vinterberg, H., Biering-Sørensen, F., Andersson, G. & Jørgensen, K. (1987). Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics*, *18*, 233–237.

Kuta, Ł., Cież, J. & Młotek, M. 2015. Musculoskeletal load assessment of farmers during selected agricultural works. *Procedia Manufacturing*, *3*, 1696–1703.

Krejcie, R. V & Morgan, D. W. (1970). Determining Sample Size For Research Activities. *Educational And Psychological Measurement*, *30*, 607–610.

Kroemer, K. H. E. & Grand jean, E. (2009). Fitting the Task to the Human: A Textbook of Occupational Ergonomic, Taylor & Francis, Bristol, PA.

Lau E. C. C. (2000). Factors associated with osteoarthritis of the hip and knee in Hong Kong Chinese: Obesity, joint injury, and occupational activities. *Am J Epidemiol, 152*(9), 855-862.

Lavrakas, P. J. (2008). Encyclopedia of survey research methods. Sage Publications, Inc., Thousand Oaks.

Lee, T. (2016). The effects of arm posture and holding time on holding capability and muscle activity. *International Journal of Occupational Safety and Ergonomics,* 1–5.

Lee, D., Kim, Y., Yun, J., Jung, M. & Lee, G. 2016. A comparative study of the electromyographic activities of lower extremity muscles during level walking and Pedalo riding. *Journal of Physical Therapy Science*, *28*(5), 1478–1481.

Lee, T. (2013). Analysis of Working Postures at a Construction Site Using the OWAS Method. *Applied Ergonomics*, *19*(2), 245–250.

Lee, T. H. (2003). Minimal acceptable handling time intervals for lifting and lowering tasks. *Appl Ergon*, *34*, 629–634.

Lee, C. G. (2012). Work-related musculoskeletal disorders in Korean farmers. *Journal of Korean Medical Association*, *55*, 1054−62.

Lee, D. & Ferreira, J. J. (2003). Reliability and usability evaluation of the Manual handling Assessment Charts (MAC) for use by non-regulatory professionals, Health and safety laboratory, *44*, 1–13.

Legault, É. P., Cantin, V., & Descarreaux, M. (2014). Assessment of musculoskeletal symptoms and their impacts in the adolescent population: Adaptation and validation of a questionnaire. *BMC Pediatrics*, *14*(1), 1–8.

Lin, M., Liang, H., Lin, K., & Hwang, Y. (2004). Electromyographical assessment on muscular fatigue - An elaboration upon repetitive typing activity. *Journal of Electromyography and Kinesiology*, *14*, 661–669.

Lomo-Tettey, D., Campbell-Kyuregha, N. & Balke Johnson, K.B. (n.d.). Leg and Torso Muscle Response to Prolonged Kneeling. *Spine Biomechanics Laboratory of University of Wisconsin-Milwaukee, WI, USA*, *16*, 1–2.

Luttmann, A., Jager, M., Griefahn, B., Caffier, G., & Liebers, F. (2003). Preventing Musculoskeletal Disorders in the Workplace, *Protecting Workers' Health Series* No. 5.

Lyons, J. (2002). Factors contributing to low back pain among professional drivers: a reviewof current literature and possible ergonomic controls. *Work*, *19*, 95–10.

Maity, P., De, S., Pal, A. & Dhara, P.C. (2016). An experimental study to evaluate musculoskeletal disorders and postural stress of female craftworkers adopting different sitting postures. *International Journal of Occupational Safety and Ergonomics*, *22*(2), 257–266.

Manninen, P., Heliövaara, M., Riihimäki, H. & Suomalainen, O. (2002). Physical Workload and the Risk of Severe Knee Osteoarthritis. *Scandinavian Journal of Work, Environment and Health, 28* (1), 25–32.

Malaysia External Trade Development Corporation (MATRADE). (2016). Trade Performance for the Year of 2015 and the Month of December 2015, Malaysia External Trade Statistics. Retrieved from http://www.matrade.gov.my/en/malaysia-exporters-section/235-trade-performance-2015/4518-trade-performance--december-2015-and-january-december-2015.

Marras, W. S. (1990). Industrial Electromyography (EMG), *6*, 89–93.

Mayer, J. M., Graves, J. E., Manini, T. M., Nuzzo, J. L., & Ploutz-Snyder, L. L. (2013). Lumbar muscle activity during common lifts: A preliminary study using magnetic resonance imaging. *Journal of Applied Biomechanics*, *29*(2), 147–154.

McCrum-Gardner, E. (2008). Which is the correct statistical test to use? *British Journal of Oral and Maxillofacial Surgery*, *46*(1), 38–41.

McCurdy, S. A., Samuels, S. J., Carroll, D. J., Beaumont, J. J., & Morrin, L. A. (2003). Agricultural injury in California migrant Hispanic farm workers. *American Journal of Industrial Medicine, 44*(3), 225-235.

McKeown, C. (2008). A Guide to Human Factors and Ergonomics. *Ergonomics, 51*(6), 949-951.

Mcmillan, G. & Nichols, L. (2005). Osteoarthritis and meniscus disorders of the knee as occupational diseases of miners. *Occup Environ Med*, *62*, 567–575.

Meksawi, S., Tangtrakulwanich, B. & Chongsuvivatwong, V. (2012). Musculoskeletal problems and ergonomic risk assessment in rubber tappers : A community-based study in southern Thailand. *International Journal of Industrial Ergonomics*, *42*(1), 129–135.

Melrose, A. L., Graham, M. K., Graveling, R. A., George, J. P. K., Cowie, H. , Hutchison, P. A & Mulholland, R. E. (2006). *Assessing the effectiveness of the manual handling assessment chart (MAC) and supporting website.* Prepared by the Institute of Occupational Medicine. Health and Safety Executive.

Mendes, M. & Pala, A. (2003). Type I Error Rate and Power of Three Normality Tests. Pakistan. *Journal of Information and Technology 2*(2), 135-139.

Messing, K., Tissot, F. & Stock, S.R., (2006). Lower Limb Pain, Standing, Sitting,Walking: The Importance of Freedom to Adjust One's Posture. *The International Ergonomics Association, Maastricht, Netherlands.*

Meyer, R.H. &Radwin, R. (2007). Comparison of stoop versus prone postures for a simulated agricultural harvesting task. *Applied Ergonomics, 38,* 549–555.

Meyer, J.-P., Flenghi, D., & Deschamps, J.-P. (1998). Effects of Manual Handling, Posture, and Whole Body Vibrations on Low-Back Pain. *International Journal of Occupational Safety and Ergonomics*, 4(4), 449–470.

Miranda, H., Viikari-Juntura, E., Martikainen, R. & Riihimaki, H. (2002). A prospective study on knee pain and its risk factors. *Osteoarthritis Cartilage, 10*, 623–630.

Montero-Calderón, M., Rojas-Graü, M.A. & Martín-Belloso, O. (2009). Mechanical and chemical properties of Gold cultivar pineapple flesh (Ananas comosus). *European Food Research and Technology*, *23*(4), 675–686.

Monnington, S.C., Pinder, A.D.J. & Quarrie, C. (2002). *Development of an inspection tool for manual handling risk assessment*. (Sheffield: Health and Safety Laboratory). HSL Internal Report ERG/02/20; HSL Report HSL/2002/30.

Moreira, H. S. B., Moreira, M. B., Vilagra, J. M., Galvão, I. M., De Oliveira Júnior, A. S., & De Lima, A. C. (2012). Analysis of the compensatory postures adopted by day caregivers through Ovako Working Posture Analysing System. *Work*, *41*(1), 5746–5748.

Musto, F., Rosati, R., Sforza, C., Toma, M., & Dellavia, C. (2017). Standardised surface electromyography allows effective submental muscles assessment. *Journal of Electromyography and Kinesiology*, *34*, 1–5.

Nadzirah, K. Z., Zainal, S., Noriham, A., Normah, I., Siti Roha, A. M. and Nadya, H. (2013). Physico- chemical properties of pineapple variety N36 harvested and stored at different maturity stages. *International Food Research Journal*, *20***(**1), 225–231.

Nawi, N. S. M., Deros, B. M., Rahman, M. N. A., Sukadarin, E. H. & Nordin, N. (2016). Malaysian oil palm workers are in pain: Hazards identification and ergonomics related problems. *Malaysian Journal of Public Health Medicine*, *16*, 50–57.

Nazri, A. M. & Pebrian, D. E. (2017). Analysis of Energy Consumption in Pineapple Cultivation in Malaysia: A Case Study Pertanika. *J. Sci. & Technol, 25* (1), 17-28.

Nejad, N. H., Choobineh, A., Rahimifard, H., Haidari, H. R. & Tabatabaei, S. H. R. (2013). Musculoskeletal risk assessment in small furniture manufacturing workshops. *International Journal of Occupational Safety and Ergonomics*, *19*, 275–284.

Ng, Y. G., Tamrin. S. B. M., Yusoff, I. S. M., Mori, I. & Hashim, Z. (2013). Ergonomics observation: Harvesting tasks at oil palm plantation. Journal of Occupational Health, *55*, 405–414.

Ngomo, S., Messing, K., Perrault, H. & Comtois, A. (2008). Orthostatic symptoms, blood pressure and working postures of factory and service workers over an observed workday. *Applied Ergonomics 39* (6), 729– 736.

Nou, D., Miller, B. J. & Fathallah, F. A. (2012). Low back muscle fatigue measurements of cyclic and prolonged stooped work. *Proceedings of the Human Factors and Ergonomics Society,* pp. 1196–1200.

Nonnenmann, M. W., Anton, D., Gerr, F., Merlino, L. and Donham, K. (2008). Musculoskeletal symptoms of the neck and upper extremities among Iowa dairy farmers. *Am J Ind Med, 51*, 443–451.

Nurmianto, E., Ciptomulyono, U. & Kromodihardjo, S. 2015. Manual Handling Problem Identification in Mining Industry: An Ergonomic Perspective. *Procedia Manufacturing. **4***: 89–97.

Nwe, Y. Y., Toyama, S., Akagawa, M., Yamada, M., Sotta, K., Tanzawa, T. & Ogiwara, I. (2012). Workload Assessment with Ovako Working Posture Analysis System (OWAS) in Japanese Vineyards with Focus on Pruning and Berry Thinning Operations. *Journal of the Japanese Society for Horticultural Science*, *81*(4), 320–326.

Olendorf, M. R. & Drury, C. G. (2001). Postural discomfort and perceived exertion in standardized box-holding postures. *Ergonomics, 44* (15), 1341–1367.

Osborne, A., Blake, C., McNamara, J., Meredith, D., Phelan, J. & Cunningham, C. (2010). Musculoskeletal disorders among Irish farmers. *Occup Med, 60*, 598–603.

OSHA. (2000). Ergonomics : The Study of Work, US.

Oy, O. (2009). OWAS (Ovako Working posture Assessment System), *1*, 1–6.

Pope, M. H., Goh, K. L. & Magnusson, M. L. (2002). Spine ergonomics. *Annu Rev Biomed Eng*, *4*, 49–68.

Peng, C. J., Lee, K. L. & Ingersoll, G. M. (2002). An Introduction to Logistic Regression Analysis and Reporting. *The Journal of Educational Research*, *96*(1), 3-14.

Pirouzi, S., Emami, F., Taghizadeh, S. and Ghanbari, A.. (2013). Is Abdominal Muscle Activity Different from Lumbar Muscle Activity during Four-Point Kneeling?. *Iran J Med Sci December*, *38*(4), 327-333.

Podniece, Z. (2007). Work-related musculoskeletal disorders: Back to work report. *European Agency for Safety and Health at Work*. Retrieved from (http://osha.europa.eu)

Punnet, A. L & Wegman, D. H. (2004). Work-related musculoskeletal disorders : *The epidemiologic evidence and the debate*, *14*, 13–23.

Rajesh, R. (2016). Manual Material Handling: A Classification Scheme. *Procedia Technology*, *24*, 568–575.

Rani, N. H., Abidin, E. Z., Ya'acob, N. A. & Karuppiah, K. (2016). Musculoskeletal Symptoms Risk Factors and Postural Risk Analysis of Pineapple Plantation Workers in Johor. *Journal of Occupational Safety and Health*, *13*(1), 17–26.

Ranavolo, A., Varrecchia, T., Iavicoli, S., Marchesi, A., Rinaldi, M., Serrao, M. & Draicchio, F. (2018). Surface electromyography for risk assessment in work activities designed using the "revised NIOSH lifting equation. *International Journal of Industrial Ergonomics*, *68*, 34–45.

Razali, N. M. & Wah, Y. B. (2011). Power comparisons of Shapiro-Wilk , Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. *Journal of Statistical Modeling and Analytics*, *2*(1), 21–33.

Reid, C. R., McCauley Bush, P., Karwowski, W. & Durrani, S. K. (2010). Occupational postural activity and lower extremity discomfort: A review. *International Journal of Industrial Ergonomics*, *40*(3), 247–256.

Richardson, G. E & Jenkins, P. (2005). An ergonomic intervention to reduce back strain among apple harvest workers in New York State. *Applied Ergonomics*, *36*, 327–334.

Roffey, D. M., Wai, E. K., Bishop, P., Kwon, B. K., & Dagenais, S. (2010). Causal assessment of awkward occupational postures and low back pain: results of a systematic review. *Spine Journal*, *10*(1), 89–99.

Rogers, E. L. & Granata, K. P. (2006). Disturbed paraspinal reflex following prolonged flexion– relaxation and recovery. *Spine*, *31***(**7), 839–45.

Rosecrance, J., Rodgers, G. & Merlino, L. (2006). Low back pain and musculoskeletal symptoms among Kansas farmers. *Am J Ind Med*, *49*, 547−560.

Saeterbakken, A. H., & Fimland, A. M. S. (2013). Muscle Force Output And Electromyographic Activity In Squats With Various Unstable Surfaces. *Journal Of Strength And Conditioning Research*, *27*(1), 130–136.

Sandmark, H., Hogstedt, C. & Vingard, E. (2000). Primary osteoarthrosis of the knee in men and women as a result of lifelong physical load from work. *Scand J Work Environ Health*, *26*, 20–5.

Salvendy, G. (1997). Handbook of human factors and ergonomics, 9, pp. 3

Salvendy, G. (1985). Has ergonomics the same meaning in Europe and North America? In I.D. Brown, R. Goldsmith, M.A. Sinclair (Eds.), Ergonomics international London: Taylor & Francis, 85, 97–98.

Sauter, S. L. & Swanson, N. G. (1996). An ecological model of musculoskeletal disorders in office work. In Beyond biomechanics: Psychosocial Aspects of musculoskeletal disorders in office work, Bristol, PA: Taylor and Francis, pp. 3–22.

Sett, M. & Sahu, S. (2012). Study on work load and work-related musculoskeletal disorders amongst male jute mill workers of West Bengal, India. *Work*, *42*(2), 289–297.

Shan, C. L., Adon, M. Y., Rahman, A. B.A ., Hassan, S. T. S. & Ismail, K. (2011). Prevalence of Neck Pain and Associated Factors with Personal Charateristics, Physical Workloads and Pyschosocial Among Male Rubber Workers in FELDA Settlement Malaysia. *Global Journal of Health Science*, *4*(1), 94–104.

Shin, G. & Mirka, G. A. (2007). An in vivo assessment of the low back response to prolonged flexion: interplay between active and passive tissues. *Clin. Biomech*, *22*, 965–971.

Shultz, S., Averell, K., Eickelman, A., Sanker, H. & Donaldson, M. B. (2015). Diagnostic accuracy of self-report and subjective history in the diagnosis of low back pain with non-specific lower extremity symptoms: A systematic review. *Manual Therapy*, *20*(1), 18–27.

Sobhani, A., Wahab, M .I. M. & Neumann, W. P. (2017). Incorporating human factors-related performance variation in optimizing a serial system. *European Journal of Operational Research*, *257*(1), 69–83.

Solomonow, M., Baratta, R. V., Banks, A., Freudenberger, C. & Zhou, B. H., 2003. Flexion relaxation response to static lumbar flexion in males and females. *Clin. Biomech.* **18**(4): 273-279.

Shokria, S. & Varmazyarb, S. A. (2015). Manual material handling assessment and repetitive tasks with two methods MAC and ART. *Scientific Journal of Review*, 116–123.

Stankevitz, K. (2015). *Prevalence and Risk Factors of Work Related Musculoskeletal Disorders and Injuries in Sri Lankan Rubber Tappers*. Master Thesis. Graduate School of Duke University.

Stevens, V. K., Vleeming, A., Bouche, K.G., Mahieu, N. N., Vanderstraeten, G. G. & Danneels, L. A. (2007). Electromyographic activity of trunk and hip muscles during stabilization exercises in four-point kneeling in healthy volunteers. *European Spine Journal*, *16*, 711-718.

Stevens, V. K., Coorevits, P. L., Bouche, K. G., Mahieu, N. N., Vanderstraeten, G. G, Danneels, L. A. (2007). The influence of specific training on trunk muscle recruitment patterns in healthy subjects during stabilization exercises. *Man Ther*,

1227, 1-9.

Stegeman, D. & Hermens, H. (2007). Standards for surface electromyography: The European project Surface EMG for non-invasive assessment of muscles (SENIAM) (online). http://www.seniam.org/%5Cnhttp://www.med.uni-jena.de/motorik/pdf/stegeman.pdf. (5 May 2018).

Sukadarin, E. H., Deros, B. M., Ghani, J. A., Ismail, A. R., Mokhtar, M. M. & Mohamad, D. 2013. Investigation of Ergonomics Risk Factors for Musculoskeletal Disorders among Oil Palm Workers Using Quick Exposure Check (QEC). *Advanced Engineering Forum, 10*,103–109.

Sukadarin, E. H., Deros, B. D., A.Ghani, J. & Ismail, A. R. 2013. A Review of Work Related Musculoskeletal Problems In Agricultural Industry. *Australian Journal of Basic & Applied Sciences*, *8*(19), 56-59.

Sukadarin, E. H., Md Deros, B., Mohd Nawi, N. S., A. Ghani, J., Ismail, A. R. & Zakaria, J. 2016. Back Pain and the Observed Factors among Oil Palm Workers. *International Journal of Engineering Technology and Sciences (Ijets)*, *5*, 70–78.

Sung, P. S., Lammers, A. R., & Danial, P. (2009). Different parts of erector spinae muscle fatigability in subjects with and without low back pain. *Spine Journal*, *9*(2), 115–120.

Sultan-Taïeb, H., Lejeune, C., Drummond, A. & Niedhammer, I. (2011). Fractions of cardiovascular diseases, mental disorders, and musculoskeletal disorders attributable to job strain. Int. Arch. Occup. Environ. Health, 84, 911 – 925.

Suyasning, H. I. & Oka Suprapta, I. G. M. (2007). Workload and musculoskeletal disorders of planting paddy in Tabanan Regency, Bali. *Proceedings of Agriculture Ergonomics Development Conference*: Kuala Lumpur (Malaysia), 152-156.

Swangnetr, M., Kaber, D. B., Puntumetakul, R. & Gross, M. T. 2014. Ergonomics-related risk identification and pain analysis for farmers involved in rice field preparation. *Work (Reading, Mass.)*, *49*(1), 63–71.

Syuaib, M. F. (2015). Ergonomic of the manual Harvesting tasks of oil-palm plantation in Indonesia based on anthropometric, postures and work motions analyses. *International Agricultural Engineering Journal*, *17*(3), 48–262.

Tamrin, S. B. M. & Aumran, N. (2014). A comparison of the hazards, the risks, and the types of control in three selected agricultural industries. *Occupational Safety and Health in Commodity Agriculture: Case Studies from Malaysian Agriculture Perspective. 1*, 93–146.

Taechasubamorn, P. (2011). Prevalence of low back pain among rice farmers in a rural community in Thailand. *Journal of the Medical Association of Thailand*, *94*(5), 616–621.

Takala, E-P., Pehkonen, I., Forsman, M., Hansson, G-å., Mathiassen, S. E., Neumann,

W. P., Sjøgaard, G., Veiersted, K. B., Westgaard, R. H. & Winkel, J. (2010). Systematic evaluation of observational methods assessing biomechanical exposures at work. Scand J Work Environ Health, *36*(1), 3–24.

Tourism Pahang Malaysia. (2018). *Maps of pahang.* Frase's Hill Development Cooperation.

Thambyah, A., Goh, J. C. H. & De S. D. (2005). Contact stresses in the knee joint in deep flexion. *Medical Engineering and Physics*, *27*, 329–335.

Udom, C., Janwantanakul, P. & Kanlayanaphotporn, R. (2016). The prevalence of low back pain and its associated factors in Thai rubber farmers. *Journal of Occupational Health*. *58*(6), 534–542.

Ulrey, B. L. & Fathallah, F. A. (2013). Effect of a personal weight transfer device on muscle activities and joint flexions in the stooped posture. *Journal of Electromyography and Kinesiology*, *23*(1), 195–205.

Van Vuuren, B. J., Becker, P. J., Van Heerden, H. J., Zinzen, E., & Meeusen, R. (2005). Lower back problems and occupational risk factors in a South African steel industry. *American Journal of Industrial Medicine*, *47*(5), 451–457.

Velásquez, S., Valderrama, S. & Giraldo, D. (2016). Ergonomic assessment of natural rubber processing in plantations and small enterprises. *Ingeniería Y Competitividad*, *18*(2), 233–246.

Villarejo, D. & Baron, S. L. (1999). The occupational health status of hired farm workers. *Occup. Med*, *14*(3), 613-635.

Wahlstedt, K., Norbäck, D., Wieslander, G., Skoglund, L. & Runeson, R. (2010). Psychosocial and ergonomic factors, and their relation to musculoskeletal complaints in the swedish workforce. *International Journal of Occupational Safety and Ergonomics*, *16*, 311–321.

Walker-Bone, K. & Palmer, K. T. (2002). Musculoskeletal disorders in farmers and farm workers. *Occup Med (Lond)*, *52*, 441–450.

Weaver, T. B., Glinka, M. N., & Laing, A. C. (2017). Stooping, crouching, and standing – Characterizing balance control strategies across postures. *Journal of Biomechanics*, *53*, 90–96.

Xiao, J., Gao, J., Wang, H., Liu, K. & Yang, X. (2015). The Surface EMG Characteristics between Erector Spinae and Vastus Lateralis during Bending Forward and Squatting Down Tasks. *Physiological Journal*, 1-6.

Yip, Y. B, Ho, S. C. & Chan, S. G. (2004). Identifying risk factors for low back pain (LBP) in Chinese middle-aged women: a case-control study. *Health Care Women Int*, *25*(4), 358-369.

Ya'Acob, N. A., Abidin, E. Z., Rasdi, I., Rahman, A. A., & Ismail, S. (2018). Reducing work-related musculoskeletal symptoms through implementation of Kiken Yochi

training intervention approach. *Work*, *60*(1), 143–152.

Yılmaz, Ö. & Bodur, H. (2015). Bilateral Peroneal Nerve Palsy Due to Prolonged Squatting in a Farmer. *J PMR Sci*, *18*, 40–43.

Yoon, J. G. (2013). The Correlation between the Muscle Activity and Joint Angle of the Lower Extremity According to the Changes in Stance Width during a Lifting Task. *Journal of Physical Therapy Science*. **25**(8): 1023–5.

Yoshimura, N., Nishioka, S., Kinoshita, H., Hori, N., Nishioka, T. and Ryujin M. (2004). Risk factors for knee osteoarthritis in Japanese women: heavy weight, previous joint injuries, and occupational activities. J Rheumatol. **31**(1): 157-162.

Yue, P., Liu, F. and Li, L. (2012). Neck/shoulder pain and low back pain among school teachers in China, prevalence and risk factors. *BMC Public Health*, **12**(1): 789.

Yusuff, R. M., Doi, M. A. C., Khalid, M. R., Chia, Y. P., & Muslim, M. A. M. (2007). Work posture risk analysis of mechanical loader operators in oil palm plantation. *Proceedings of Agriculture Ergonomics Development Conference*, (November). Retrieved from http://agris.fao.org/agris-search/search.do?recordID=MY2014001197

Zadry, H. R., Dawal, S. Z. M. & Taha, Z. (2011). The relation between upper limb muscle and brain activity in two precision levels of repetitive light tasks. *International Journal of Occupational Safety and Ergonomics*, *17*, 373–384.

Zhu, X. & Shin, G. (2013). Kinematics and muscle activities of the lumbar spine during and after working in stooped postures. *Journal of Electromyography and Kinesiology*, *23*(4), 801–806.