Research Article

Biomechanical Affordable Solutions for LBP Prevention of Standing Person

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Abstract: *There are many local studies show the high rate of occurring low back pain (LBP) 12-60% in Malaysia. LBP is a common condition that affects a significant portion of the population at some point in their lives. There are many causes of LBP, including poor posture, muscle imbalances, disc degeneration, spinal abnormalities, and injury. Biomechanics can play a significant role in understanding and managing LBP. It can be through early determination of ground reaction force (GRF) and pressure distribution of footprint for standing person that may represent basic diagnostic procedures and provide significant finding to avoid any possibility of developing LBP. The proposed basic tests may help minimizing the risk factor of occurring LBP if they are being implement effectively in many worksites that involve body movements and standing activities. Determining the values of GRF at different body movements using force plate or weight scale and analyzing the footprint using normal scanner may provide clinical knowledge and solutions for avoiding LBP. They may provide information about abnormality finding results in graph pattern that essential for diagnosis purposes. Any dissimilarities in distributing body weight at each leg and pressure pattern of footprint represent the compression load acting against GRF should be investigated in detail. Early detection of any possibility of developing LBP caused by certain physical activities for a standing person is strongly recommended to avoid its negative progress in the long term.*

Keywords: Footprint; GRF; LBP.

1. INTRODUCTION

Many local studies and the Malaysia report of Ministry of Health show the high rate of occurring low back pain (LBP) 12-60% in Malaysia. Biomechanics or the study of the mechanics of living organisms can play a role in understanding and managing LBP that essential for many professions relate to Physiotherapy, Occupational Safety and Health, and Bioengineering. It is a professional course requires understanding the physics principles in mechanical systems and the human body movements involving musculoskeletal system. Preventing low back pain in long term through graphical analysis of standing person represents one of the applications of biomechanics in healthcare (Abdullah, Norhafizah, Amgad, Ayman, Ahmad, 2020). There are many physical quantities required for analysis in biomechanics to understand human body movements. Some of these quantities are described under

kinematics system and other quantities under kinetics system. The ground reaction force (GRF) is one of these quantities under kinetics system. Determining the acting GRF against body weight is one of applications in healthcare to study a body movement at different positions. GRF is one type of forces that acting upward against body weight. It is usually can be determined by using of a force plate to study different activities of body movements including standing person. Generally, it was found that the high value of GRF may develop low back pain. Standing balance control is very important for negatively influenced following prolonged standing (Kayla, Kaitlin, Samuel, Jack, 2020). Asymmetric lumbopelvic movement patterns may also be a risk factor for low back pain development during prolonged standing (Christopher, Molly, Barbara, Jack, Linda, 2016). Other studies showed that the GRF was high for a standing person that possibility develops low back pain (Patric, Magnus, Stephanie, Christian, 2017; Michael, Ana, Jack, 2017; Peter, & William, 2016). Other factor such as lumbar spine curvature may also develop low back pain for standing person (Daniel, Kaitlin, Michael, Jack, 2017). Early detection of any possibility of developing low back pain caused by certain physical activities may provide health benefit in long term. The objective of this study is to determine the values of GRF at different body movements, analyse the pressure pattern of footprint for both legs, and identify their possibility of causing low back pain particularly for standing activity.

2. METHOD & MATERIAL

Biomechanics is the study of the structure and function of biological systems using the principles of mechanics. GRF represent one type of force in mechanical system that refers to the force exerted by the ground on a body in contact with it, such as the force experienced by a person's foot when walking, running, or jumping. It is a reaction force that occurs in response to the force that the person applies to the ground. GRF and LBP are two concepts that related to each other in the context of biomechanics and the study of human movement. Many factors affect LBP which include poor posture, muscle imbalances, disc degeneration, spinal abnormalities, and injury. By understanding the biomechanics of the spine and analysing how forces and movements affect it and surrounding structures, there is a possibility to gain insights into the factors that contribute to LBP and develop strategies for prevention, management, and rehabilitation. There are many required testing tools to analyse any sort of human movements. It may include three-dimensional motion analysis system with force plates (Yu, Xiu, Jiang, Wai, Ling Chen, Ming, Zhi, Rui, Dong, Le, 2018). Determining the values of GRF at different body movements is very important to identify at which body position that possibility may cause low back pain besides standing position. A force plate is usually used to determine the value of acting GRF against body weight for biomechanical analysis of low back pain for a person in a standing position (Abdullah, Norhafizah, Amgad, Ayman, Ahmad, 2020). Both legs were tested for any possibility of abnormality in standing GRF. The test was conducted in Occupational Safety and Health (OSH) Laboratory at University of Selangor. The test subject requires to perform the test separately by sitting on a chair and placing each of his leg on a different force plates. Next, the body is moved at different positions that include series of events of standing up, standing for a while on force plate, and then sitting down. Then, different values of GRF for both legs were recorded in the form of typical graph pattern as shown in Figure (1). The GRF value was then determined for both legs and analyzed to find the distribution of GRF at each leg. Any dissimilarity in GRF values may indicate the possibility of developing low back pain. The test is also can be done using the weight scale instead of force plate as alternative method for this study. The same test subject also require to stand on modified scanner for 3D image of footprint to analyse at which foot the pressure pattern is high that can support the GRF graph pattern.

3. FINDINGS

Estimating the values of ground reaction force (GRF) represents one of the practical methods in biomechanics to identify any possibility of health hazard. The test subject in this study has unequal value of GRF at right and left leg. The GRF's values vary from standing up, standing on force plate, and sitting down time. The results of the study showed noticeable dissimilarities in the values of GRF for both legs as illustrated in Figure (1). It was found that different activities of body movements have different value of GRF. In general, the left leg has more GRF values compare to right leg during standing time on force plate. The result of the study showed that the determined values of GRF for left leg was high and exceed half of body weight. In some cases, this GRF value was high and represent 165% of body weight during standing time in a moving bus (Patric, Magnus, Stephanie, Christian, 2017). The GRF values is also may increase if the same person holding an external load of 10% of body mass that cause changing in postural instability (Leonardo, Edgar, André, Cynthia, Mariana, Leandro, Marcio, Rubens, 2017). There is a possibility of developing LBP for the presented case because of unequal distribution of GRF in both legs that should be avoided its long-term effect. Imbalances in load distribution such as excessive loading on certain spinal segments or uneven muscle activation can contribute to LBP. Understanding load distribution patterns can help identify risk factors and guide interventions to improve spinal stability and reduce LBP. Poor posture may also become a result of imbalances in load distribution that cause excessive curvature of the spine and put increased stress on the structures of the lower back leading to LBP. It is important to note that GRF alone cannot definitively diagnose or predict LBP. The way the foot interacts with the ground also influences the load distribution through the lower extremities. Alterations in load distribution due to abnormal foot mechanics or footprints as illustrated in figure (1) may result in imbalanced loading on the joints and structures of the spine, potentially leading to LBP.

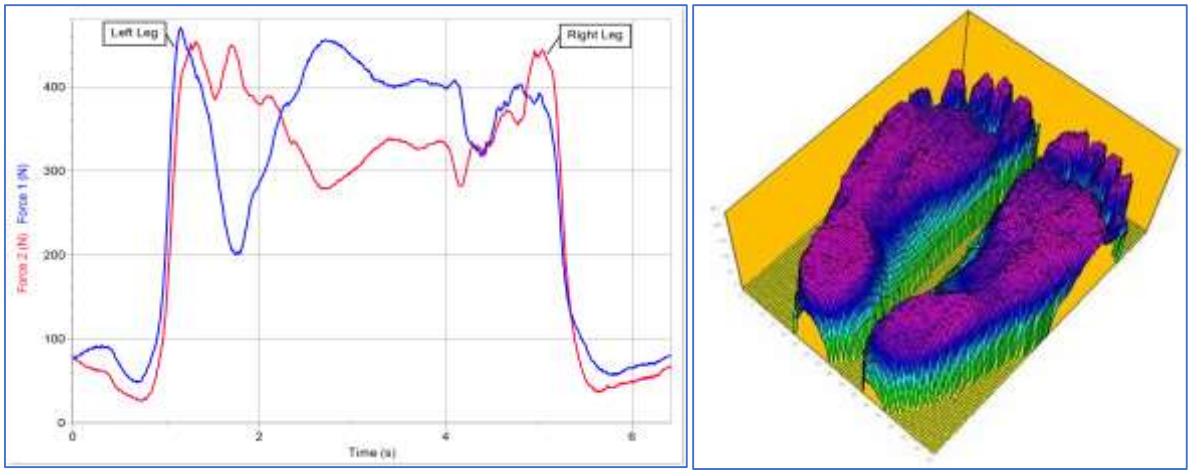

Figure 1. GRF graph and 3D pressure pattern of footprint for both legs.

4. DISCUSSION

LBP is a complex condition causes by many factors including body posture, load imbalances, spinal health, and footprint pattern. A comprehensive assessment including a thorough examination of foot structure and GRF analysis of body segment movement are necessary to understand the potential relationship to LBP. Early determination of GRF for standing person and his footprint pattern have a significant role of avoiding any possibility of developing LBP in long term. The dissimilarities in distributing body weight at each leg represent the compression load acting against GRF that should

be avoided and need to be investigated in details. There is a possibility of monitoring the GRF for standing person using weight scales instead of force plate to reduce the cost of test. The introduced method may provide clinical knowledge and solution of avoiding LBP that should be examined for different movements to investigate its impact on the human spine.

5. CONCLUSION

Biomechanical analysis for GRF and footprint can help identify optimal spinal alignment and provide guidance on maintaining good posture to reduce the risk of LBP. A comprehensive approach that considers various aspects of LBP is usually recommended that involve healthcare professionals from different disciplines. Consulting with a healthcare professional can provide a more accurate evaluation and appropriate management strategies for addressing LBP.

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