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論文内容の要旨

The main purpose of this study is to investigate "*Bending and twisting angle classifications under direct posture observations*". During recent years many industries have focused strongly on reduction of workers workload, low back pain and work related illness, etc. Evaluation of different postural angles and the risks associated with various posture angles have been at the foundation of many studies but, sometimes with conflicting results. To understand risk factors, in the work place, reliable and accurate measurements are needed.

The first chapter of the thesis presented a brief introduction of the current study. As, workers complaints about discomfort and pain come from, most of the times, due to poor, unnatural and awkward postures during work activities and it can be better understood after an analysis of the work postures. Therefore, posture evaluations using various methods have been largely used. Furthermore, this chapter emphasis the past researches contributions relating to the current study, and importance of direct posture analysis and its main advantages are discussed. Then, background of the current research study is also presented in the first chapter. It discusses the research study of "Ergonomics of problems of small-scale strawberry farmers living in Japan" briefly and how it help to identify some of the important ergonomic problems faced by small-scale strawberry farmers in Japan and how it motivated to extended up to the current research study. Especially strawberry farmers picking posture is normally greater than 90^0 angles of bending of back and their working highest are not compatible with the ergonomic practices, etc. Therefore, its negative consequences, how it badly affect to their body, especially Low back pain, stiff in shoulders, fatigue and other health problems are discussed.

Some important ergonomic concepts and definitions are also summarized in the second chapter. It will help to understand theoretical concepts and practical situation of the existing study. Mainly, ergonomic risk factors, posture analysis methods, direct posture observation method, challenges of postural angle estimations and posture recording, observer reliability and so on are discussed. The most commonly used direct posture observation methods i.e. OWAS, RULA and REBA and their postural angle classifications are presented in detail. Finally, in the first chapter, detail descriptions about human body postures are included. The epidemiological literature is important to studying postural low back pain, as it is still common among employees. High incidence rate for work related musculoskeletal disorders for example, have been reported for workers in office, manufacturing, agriculture and numerous manual material handling occupations.

Back posture, what is the good posture, relationship with posture and low back pain, low back pain statistics in Japan, and other countries of the world, factors affecting to low back pain, etc are also presented in this chapter.

Third chapter describes the research methodology of the study. This study was focused to classifications of bending and twisting angles under direct posture observations. In addition, factors affecting to observer correct responses in direct posture observations were investigated. Observers were shown images of both male and female models using power point slides, which consisted of different combinations of postures of bending of back, twisting of trunk and neck directions. To decide optimal observing and recoding time, series of experiments were conducted. Postural aspects were evaluated using slide show and different postures of bending of back, twisting of body trunk and neck directions, were determined by ten observers. Bending angle classification i.e. 0^0, 15^0, 30^0,45^0, 60^0,75^0, 90^0 and over 90^0 were introduced. Since, angle classifications of back, trunk and neck directions and camera position which models were photographed are important in the current study; detail descriptions of above postural angles tested in the current study is presented in the second chapter. Though different researches used different observing and recording time such as 2 seconds, 3 seconds, 30 seconds, etc, it is difficult to find standard observing and recording time under direct posture observations. Therefore, first experiment was designed to investigate "optimal observing and recording time under direct posture observations". In addition the entire experimental layout and conditions, descriptions of male and female models, characteristics of the observers also presented.

The results and discussions are presented in fourth chapter. As we mainly focused on bending, twisting, neck directions and camera angles, results of bending angles, twisted/ not twisted situations; neck directions and camera positions are discussed. In addition, comparative results of male and female models, uniform and casual clothes also presented. In summary, it was found that deciding bending angles using current classifications is difficult and if error range extended to, 15^0 observer performances can be increased from 39.69% to 73.78%, further, in all three conditions, i.e. bending, twisting and neck directions, correct responses were high in female model than male model. Therefore, gender difference has been influenced the correct responses of the observers in direct posture observations. . Further, by analysing the results of casual wear and uniform, it was revealed that, except bending angles, twisting and neck directions indicated higher correct responses for uniform than casual wear. Correct responses for 0^0, 30^0, 45^0, and 60^0 twisting angle classifications are 79.90%, 29.38%, 51.46% and 69.79% respectively; in average it is 57.63%.

Fifth chapter discusses the major conclusions and recommendations of the study. In the current study, using 15^0 interval bending angle classifications and 0^0, 30^0, 45^0, and 60^0 twisting angle classifications, observer correct responses were evaluated. Further, it explored the factors influencing observer correct responses. Since, most of the conclusions were connected and compared with the OWAS and RULA methods as they are the most popular and commonly used direct observation methods among ergonomists and other researchers. It was found that, deciding bending angles correctly was a big challenge to observers. Observer performances were different according to different bending angles, gender of the model, viewing angles and type of cloth. It is concluded that deciding bending angles in direct posture observations require simple, understandable and not too précised classifications. When bending angle classification was extended to 30^0 it generated more consistent and higher performances. Therefore, according to practical situations, human observer characteristics and so on, is was recommended 30^0 bending angles classifications and 0^0, 30^0, 45^0, and 60^0 twisting angle classifications under direct posture observation methods.

The entire reference list is presented according to alphabetical order of the author's name, in sixth chapter. Finally, five appendixes i.e. detail of images, selection of images, answer sheet, Chronic Fatigue Symptoms Index (CFSI) and general questioner are attached at the end of the dissertation.

論 文 審 査 結 果 の 要 旨

業務上疾病件数の発生において腰痛が大きな割合を占めている．職業に関連した腰痛の原因は様々であるが，不自然な作業姿勢が深く関与しているといわれており，職務設計において考慮しなければならない要因である．「職場における腰痛予防対策指針」(基発第 547 号　平成 6 年)では，作業において腰部に負担のかかる中腰，ひねり，前屈，後屈ねん転等の不自然な姿勢をなるべく取らないようにすることが求められている．近年，センサーや画像処理技術等の発達により作業姿勢をより詳細に記録することが可能になってきた．しかし，機器の使用においては使用場所の制約や機器の費用といった問題があり，測定にあたって作業者の抵抗感も強い．

作業姿勢を容易に記録する方法として作業姿勢の直接観察法が広く使われている．しかし，作業姿勢を分類し記録する方法は様々である．分類方法が体系的にまとめられている手法もあるが，その分類の妥当性や観察者が記録した結果の信頼性についてはほとんど言及されていない．特に作業改善の手がかりとなる腰曲げ角度や腰のひねりについて詳細に観察・記録したくとも，人間の目でどの程度まで詳細に分類可能であるか明確ではない．

本論文では，この作業姿勢観察手法のもつ問題点に関して文献を整理し，さらに人間の目を使って姿勢を観察する際に影響すると思われる要因や結果の信頼性を実験により求め，作業姿勢観察手法における腰の曲げ角度等に関する新たな分類方法を提案している．

まず，論文では農作業従事者の作業面高の改善前と改善後における負担を比較した調査事例を取り上げ，腰部負担と作業姿勢との関係の重要性と本論文をまとめるに至った経緯について説明している．そして，これまでよく使われてきた作業姿勢観察手法として OWAS 法，RULA 法，REBA 法を取り上げて作業姿勢の分類方法を説明するとともに，その信頼性についてまとめている．これまでの作業姿勢観察手法における作業姿勢の分類方法に関する研究をみると，その多くが分類方法とそれを用いて観察した結果の信頼性を言及するには観察者の数が不十分であり，その条件設定において問題があると思われるものがあることを述べている．次に，文献をもとに作業姿勢と腰痛との関係について説明している．実験では，動的な姿勢の変化を観察・記録させると観察者によって観察時点が異なり，観察結果の信頼性を検証できないことから，静止画像を短時間提示する方法を用いている．提示画像では性別と着衣を変え，腰の曲げ角度，腰のひねり角度，そして首の向きを変化させ，さらに観察者の観察位置を考慮してそれぞれ 4 方向から撮影した画像を用いている．腰の曲げ角度は 0 度から 90 度まで 15 度刻みで変化させ，さらに 90 度以上曲げた条件を加えた画像を用いている．画像の提示にあたっては，静止画像の提示時間と提示間隔に関する実験を行った結果に基づき，静止画像の提示時間を 2 秒とし，10 名の観察者を用いて実験し，その正答率を比較・検討している．

最後に，作業姿勢観察手法の正答率は被観察者の性別，観察位置，そして腰の曲げ角度等により異なるが，作業姿勢観察手法における簡単で，わかりやすく，信頼ある結果が得られる姿勢の分類方法として，腰の曲げ角度の分類は 0 度から 30 度刻みとし，腰のひねりについては 0 度，30 度，45 度，そして 60 度に分類することが適切であると結論づけている．また，将来の課題として，作業観察の教育・訓練や観察者の観察意欲などの要因について検討する必要性を示唆している．

以上のように，本論文では，作業姿勢観察手法における観察結果の信頼性について実験的に比較・検討し，その結果をもとに新たな姿勢の分類方法を提案している．この提案は作業姿勢を容易にかつ安価に記録できる手法の一つとして職務設計等で広く使われている作業姿勢観察手法の観察結果の信頼性を検討する上で有効であり，作業姿勢観察手法における姿勢分類を拡張する際にも大いに役立つと考えられる．よって，本論文は博士（工学）の学位論文に値するものと認める．