UNIVERSITI PUTRA MALAYSIA

CONCEPTUAL DESIGN, DEVELOPMENT AND FABRICATION OF A PROTOTYPE ERGONOMIC LUMBAR SUPPORT FOR MOTORCYCLISTS

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By

KARMEGAM KARUPPIAH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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Chair: Mohd Sapuan Salit PhD, PEng

Faculty: Engineering

This study was conducted with the intention to investigate the need, design, develop, fabricate and testing a prototype of an ergonomic lumbar support for motorcyclists. The development process began with identifying the importance and the problems of existing motorcycles in the market. Motorcycle is the second common modes of transportation in Malaysia. As a relatively cheap and reliable mode of transportation, it is widely used by a large cross section of peoples. However, the current motorcycle design does not accommodate a back posture support and motorcyclists are more exposed to musculoskeletal disorders (such as low back pain). This study was undertaken in 5 stages (methods) in order to achieve its objective; survey on motorcyclists discomfort, anthropometric data collection, design, develop and fabricate the prototype using Pugh's Total Design Process Model, Testing 1 (using Borg's Scale) and Testing 2 (using Electromyography (EMG)) . The whole study was conducted in Polytechnic Sultan Azlan Shah, Perak, using the students (motorcyclists) as the sample. Their age ranges 18 to 24 years old. The results (survey) indicate that, majority (>50%) of the motorcyclists experienced discomfort in their body parts during the riding process. Higher discomfort rate was reported on the motorcyclist's upper body parts (neck or head, shoulder, upper back, arms and hands, low back and buttocks) and correlated with their the riding posture. The critical design dimensions for the prototype (height, width, adjustable range and thickness) were obtained from the anthropometric dimensions of motorcyclists and

were used in the design process. The subjective method results highlight that the rate of discomfort level (in all body parts) decreased over time during the testing period with the prototype (lumbar support). In terms of the discomfort 'break point', the motorcyclists identified low back and upper back as the most affected body parts prior to comfort changes during the testing period with the use of the prototype. Meanwhile, the electromyography results show a reduction of muscle activity in the lumbar region in term of the average EMG values, maximal voluntary contraction (%MVC) of EMG activities at the 10th, 50th and 90th percentile and EMG change over time (mean % change per measurement period). Overall, the use of prototype provides a protective mechanism (provides postural stability and integrity) for the motorcyclist's musculoskeletal system, particularly the spinal column (from exposures to intensity, duration and frequency of physical risk factors which contribute to the low back pain). Therefore, this prototype is capable of providing ideal posture while simultaneously enhancing the comfortability (reduce discomfort) of the motorcyclist during the riding process. However, further evaluation on the prototype needs to be conducted to determine their stability, solidity, durability and safety over prolonged use.

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

REKABENTUK KONSEPTUAL, PEMBANGUNAN DAN FABRIKASI SATU PROTOTAIP ERGONOMIK BAGI PENYANDAR POSTUR LUMBAR UNTUK PENUNGGANG MOTOSIKAL

Oleh

KARMEGAM KARUPPIAH

Disember 2011

Pengerusi: Mohd Sapuan Salit PhD, PEng

Fakulti: Kejuruteraan

Kajian ini dilaksanakan dengan bertujuan untuk menyiasat keperluan, rekabentuk, pembentukkan, fabrikasi dan pengujian satu prototaip ergonomik bagi penyandar postur lumbar untuk penunggang motosikal. Proses pembentukan bermula dengan mengenalpasti keperluan dan masalah pada motosikal yang sedia ada di pasaran. Motosikal merupakan sejenis pengangkutan yang kedua terbesar di Malaysia. Berbandingkan dengan kos and kebolehpercayaan pada jenis pengangkutan ini, ianya digunakan secara meluas oleh pelbagai kumpulan pengguna. Walaubagaimanapun, rekabentuk motosikal yang sedia ada sekarang tidak mempunyai penyandar postur belakang dan penunggang motosikal banyak terdedah kepada ganguan rangka-otot (*musculoskeletal disorders*) (seperti sakit tulang belakang bawah). Kajian ini dilaksanakan dalam 5 peringkat (kaedah) bagi mencapai objektifnya; soal selidik pada ketidakselesaan penunggang motosikal, pengumpulan data anthropometrik, rekabentuk, membina dan fabrikasi prototaip dengan menggunakan Model Rekabentuk Menyeluruh Pugh, Pengujian 1 (kaedah Skala Borg) dan Pengujian 2 (kaedah menggunakan elektromyografi (EMG)). Keseluruhan kajian ini dijalankan di Politeknik Sultan Azlan Shah, Perak, dengan menggunakan pelajar (penunggang motosikal) sebagai sampel. Perbezaan umur mereka adalah di antara 18 hingga 24 tahun. Hasil keputusan (soal selidik) menunjukkan, majoriti (>50%) penunggang motosikal melalui pengalaman ketidakselesaan pada bahagian tubuh badan mereka semasa dalam proses menunggang.

Kadar ketidakselesaan yang tinggi dilaporkan berlaku pada bahagian atas tubuh badan penunggang motosikal (leher atau kepala, bahu, bahagian atas belakang badan, lengan dan tangan, bahagian belakang bawah and punggung) dan terdapat kolerasi dengan jenis postur menunggang. Ukuran kritikal bagi protaip (tinggi, lebar, jarak pelarasan dan ketebalan) diperolehi daripada ukuran anthropometric penunggang motosikal dan digunakan didalam proses rekabentuk. Keputusan kaedah subjektif menunjukkan pengurangan kadar tahap ketidakselesaan (pada semua bahagian badan) sepanjang tempoh masa pengujian dengan prototaip (penyandar lumbar). Dari segi 'titik putus' ketidakselesaan, penunggang motosikal telah mengenalpasti belakang bawah dan belakang atas sebagai bahagian pada tubuh badan yang paling banyak terjejas sebelum perubahan keselesaan semasa ujian dengan menggunakan prototaip. Sementara itu, hasil keputusan kaedah objektif menunjukkan pengurangan pada aktiviti otot di bahagian lumbar dari segi nilai purata EMG, kontraksi sukarela maksimum (%MVC) dari aktiviti EMG di persentil 10, 50 dan 90 dan perubahan EMG dengan masa (purata % perubahan pada tempoh pengukuran). Secara keseluruhan, penggunaan prototaip menyediakan mekanisme perlindungan (menyediakan kestabilan postur dan integriti) untuk sistem tulang otot penunggang motosikal, terutama tulang belakang (dari pendedahan terhadap intensiti, tempoh masa dan kekerapan faktor risiko fizikal yang memberikan sumbangan pada sakit bawah belakang). Oleh kerana itu, prototaip ini mampu memberikan postur yang ideal sekaligus meningkatkan keselesaan (mengurangkan ketidakselesaan) penunggang motosikal semasa proses menunggang. Namun, penilaian lebih lanjut tentang prototaip perlu dilakukan untuk menentukan kestabilan, kepadatan, ketahanan dan keselamatan pada penggunaan dalam jangka panjang.

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APPROVAL

I certify that an Examination Committee met on 1.12.2011 to conduct the final examination of Karmegam Karuppiah on his Doctor of Philosophy thesis entitled "Conceptual design, development and fabrication of a prototype ergonomic lumbar support for motorcyclists" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the Doctor of Philosophy.

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

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institution.

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KARMEGAM KARUPPIAH

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