

**PERFORMANCE OPTIMISATION
THROUGH THE USE OF
COMPRESSION GARMENTS AND
BIOSENSORS**

By

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Author Declaration

I certify that the present study of the dissertation has not been submitted for a degree nor is a part of the requirements for other qualification. This excludes the full acknowledgment in this thesis.

I also certify that this thesis has been completed by myself. Any other support for my current study and in the dissertation itself has been fully acknowledged. Additionally, I certify that all literature and sources of information are cited in this thesis.

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Abbreviations

| | |
|---------------|--|
| A | : Ankle |
| AT | : Anterior Thigh |
| ATP | : Adenosine Triphosphate |
| BF | : Biceps Femoris |
| Bla- | : Blood Lactate |
| BRS | : Baroreflex Sensitivity |
| C | : Calf |
| CCGs | : Correct Size Compression Garments |
| CGs | : Compression Garments |
| CK | : Creatine Kinase |
| CLBCGs | : Well Fitted Lower Body Compression Garments |
| CMJ | : Countermovement Jump |
| CMVJ | : Countermovement Vertical Jump |
| C-RP | : C-Reactive Protein |
| CS | : Compression Stocking |
| CWBCGs | : Corrected Size Whole Body Compression Garments |
| DBP | : Diastolic Blood Pressure |
| DOMS | : Delayed Onset Muscle Soreness |
| DVT | : Deep Vein Thrombosis |
| E | : Exercise |

| | |
|--------------|--|
| ECG | : Electrocardiogram |
| EEG | : Electroencephalography |
| EIMD | : Exercise Induced Muscle Damage |
| ES | : Effect Sizes |
| FAST | : Fabric Assurance by Simple Testing |
| FFT | : Fast Fourier Transform |
| FVC | : Forearm Vascular Conductance |
| G | : Gluteus |
| GM | : Gastrocnemius Medialis |
| GM | : Gluteus Maximus |
| H | : Hip |
| HF | : High Frequency |
| HR | : Heart Rate |
| HRV | : Heart Rate Variability |
| Hz | : Hertz |
| K | : Knee |
| KES-F | : Kawabata Evaluation System for Fabrics |
| LBCGs | : Lower Body Compression Garments |
| LF | : Low Frequency |
| LFHF | : Rate of Low Frequency and High Frequency |
| LSCGs | : Long- Sleeve Compression Garments |
| MA | : Medial Ankle |
| MAP | : Mean Arterial Blood |

| | |
|----------------------|--|
| MC | : Medial Calf |
| Mean | : Mean Value |
| Mean NN | : The Mean Of RR Intervals |
| MECS | : Medical Elastic Compressive Stockings |
| MM | : Medial Malleolus |
| MSA | : Mid-shank Anterior |
| MSP | : Mid-shank Posterior |
| MTA | : Mid-thigh Anterior |
| MTP | : Mid-thigh Posterior |
| MVC | : Maximal Voluntary Knee Extension |
| MVIC | : Maximal Voluntary Isometric Contraction |
| NCGs | : Non Compression Garments |
| NCS | : Non Compression Stocking |
| NN50 | : Number Of Successive RR Interval Pairs More Than 50 ms |
| nTHI | : Tissue Haemoglobin Index |
| O₂ | : Oxygen |
| OLBCGs | : Loose Fitted Lower Body Compression Garments |
| OWBCGs | : Over Size Whole Body Compression Garments |
| PC | : Posterior Calf |
| PDE | : Skeletal Muscle Intracellular Phosphodiester |
| PME | : Muscle Metabolites Phosphomonoester |
| PMS | : Perceived Muscle Soreness |
| pNN50 | : Percentage Of All Sequential RR Deviations Exceeding 50 ms |

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| PRE | : Rating of Perceived Exertion |
| PT | : Posterior Thigh |
| QT | : QT intervals |
| QTc | : Corrected of QT intervals |
| R | : Recovery |
| RER | : Respiratory Exchange Ratio |
| RF | : Rectus Femoris |
| RFD | : Rate Of Force Development |
| RMSSD | : The Root Mean Square Of Subsequent Deviation |
| RPE | : Rate Of Perceived Exertion |
| RR | : RR intervals |
| S | : Shank |
| SBP | : Systolic Blood Pressure |
| SCGs | : Compression Shorts |
| SD | : Standard Deviation |
| SDNN | : A Standard Deviation Of RR Intervals |
| SE | : Standard Error |
| SLCGs | : Sleeveless Compression Garments |
| SSLCGs | : Short-Sleeved Compression Garments |
| ST | : ST intervals |
| STD | : Standard Deviation |
| TES | : Esophageal Temperature |
| TOI | : Tissue Oxygenation Index |

| | |
|--------------|-----------------------------------|
| UCGs | : Undersize Compression Garments |
| ULF | : Under Low Frequency |
| VLF | : Very Low Frequency |
| VO2 | : Oxygen Consumption |
| YRS | : Years |
| WBCGs | : Whole Body Compression Garments |

Abstract

It is well known that exercise-induced muscle damage and the disruption of metabolic processes occur in individuals who are not accustomed to intensive physical activity. Disruption in the muscles' contractile elements and metabolic processes results in a reduction in sports performance and muscle power output alike. There were three main aims of the current study, and the first aim was to determine whether compression garments (CGs) affected cardiovascular function during exercise of running trainers. The second aim was to establish whether electrocardiogram (ECG) signals are affected by wearing CGs on the recovery phase. The last purpose was to investigate the relationship between brain activity and the application of CGs.

Subjects randomly performed the experiments in different garments including compression garments and non-compression garments. ECG and EEG sensor collected the electrical signals based on the electrodes attached to the body. The sensors of ECG-Flex/Pro were used for the collection of cardiovascular signal through lead II position. Besides, the raw EEG signal were collected from the surface of head via O1 position using Flexcomp Infiniti Monitor. Parameters were compared based on paired t-tests. Statistical significance was reported when the p-value was lower than 0.05.

As part of the study, participants completed the designed protocols for data collection. In Experiment 1, eight subjects (women, n=3; men, n=5; 25.1 ± 3.8 yrs; 61.4 ± 13.7 kg; 165.9 ± 8.3 cm; 19.6 ± 4.4 kg.m⁻²) completed a running protocol for ECG collection wearing non-compression garments (NCGs), under-size compression

garments (UCGs) and correct-size compression garments (CCGs). Experiment 2 (n=14; 24.7±4.5 years, 166.0±7.6 cm; 60.9±12.0 kg) concentrated on the recovery phase. In Experiment 3, ten subjects (men, n=5; women, n=5; 24.1 ± 4.5 yrs; 58.7 ± 11.0 kg; 163.6 ± 7.7 cm; 21.77 ± 2.63 kg.m⁻²) completed the tests with electroencephalography (EEG) collection wearing no-compression garments (NCGs) and fitted compression garments (CCGs). Electrocardiogram (ECG) and electroencephalogram (EEG) signals were collected using wearable bio-sensors.

In Experiment 1, results obtained indicated significant alteration ($p < 0.05$) in heart rate between both correctly fitted compression garments (CCGs), undersize compression garments (UCGs), and non-compression garments (NCGs). QT intervals (QT), corrected of QT intervals (QTc) was demonstrated significant difference in UCGs compared with NCGs. The results of Experiment 2 indicated a significant difference between CGs and NCGs at the end of the running test and from 90 minutes onwards during the recovery phase ($p < 0.05$). ECG parameters showed some significant difference in heart rate (HR), ST interval and corrected QT (QTc) interval ($p < 0.05$). Moreover, there were significant differences in alpha, beta and theta power spectral density between CCGs and NCGs in Experiment 3 ($p < 0.05$). The findings of this research conclude that the utilization of CGs during exercise produces positive effects on cardiovascular function and brain activity.