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The implication of backward walking in the rehabilitation of neuro-musculoskeletal conditions: systematic reviews and a biomechanical movement analysis

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ABSTRACT

The neuro-musculoskeletal gait impairments have an enormous and growing impact in the world. Estimation shows that one in four people suffer from gait impairments as a major limitation. It reduces the quality of life with poor balance, muscle fatigue, joint stiffness and deformity. To treat neuromuscular gait impairments proper rehabilitation training is crucial. Walking is one of the functional training used by therapist for rehabilitation. Though, walking refers a forward walking (FW) in our daily life backward walking (BW) was reported for an effective functional exercise in rehabilitation. The underlying biomechanical characteristics such kinetic and kinematic parameters of both FW and BW were studied to understand and predict the clinical benefits.

Biomechanical characteristics of FW were studied extensively with respect to speed, inclination, and surface. Whereas, limited reports on BW were found with level and uphill walking with comfortable/fixed speed on both ground and treadmill. It is important to study biomechanical characteristics with respect to speed and inclination to understand neural control strategies and musculoskeletal activities during BW. This helps to evaluate their clinical worthiness before implementing on patients. The comparison of FW with BW as a systematic review is an optimum way to reveal their clinical benefits and unique changes in locomotion task. As there is no systematic review is available in the literature, the present thesis designed with two systematic reviews and an experimental study.

In brief the methodologies followed in this thesis were as follow: The two systematic reviews identified existing literature based on a structured search strategy applied to various databases. The outcomes were statistically analysed by RevMan software. For experimental study, 3Dkinematic movements were tracked by reflective markers using Qualisys cameras. Force plate integrated treadmill was used to measure GRF and muscle activities were recorded by wireless EMG. These Qualisys camera, treadmill and EMG were synchronised with QTM software. The collected data were analysed and processed through Visual3D software. The processed data were used to simulate an anthropometric model via OpenSim software. This software was used to calculate the kinematic and kinetic parameters.

The first systematic review in Chapter-3 explores the clinical effectiveness of BW as a functional training for neuro-musculoskeletal gait impairment condition. This review dealt with six types of comparison with BW as an experimental group. The systematic search strategy finalises the eight trials with three conditions such as knee osteoarthritis (OA), stroke,

and diabetic peripheral neuropathy. The primary outcome measures were the pain, functional disability, muscle strength, gait parameters, balance and plantar pressure. The results show BW with CPT was significantly effective in reducing knee OA pain (total SMD: -0.87), lowering functional difficulties (total SMD: -1.39) and improving muscle strength (SMD: 1.51). In conclusion BW with CPT is an effective and clinically worthwhile training for rehabilitation of knee OA.

The second systematic review in Chapter-4 deals with biomechanical characteristics BW through comparison of FW for healthy participants to understand neuromuscular contributions. Twenty trials were found through systematic search strategy for kinematic and kinetic outcomes. The results show that BW significantly different from FW with lower hip flexion, knee flexion, tibiofemoral joint reaction force, ankle joint power, hip joint power, GRF and temporal gait parameters. The muscles GM, BF, RF, and LGAS are more active in BW than FW. Hence, the modified neural control strategies were required to produce BW from FW. The absence of visual cues in BW improves the neuromuscular control, proprioception and protective reflexes. Among the trials, BW in water found to be safer and yields better results than ground and treadmill. The experimental study in Chapter-5 analysed biomechanical characteristics of FW and BW with controlled speed and inclination. Ten healthy participant were chosen for FW and BW in three inclinations (-5%, 0% and +5%) and speeds (0.28 m/s, 0.69 m/s and 1.11 m/s). The study concludes that, walking speed is directly related to energy requirements. Increasing the speed requires higher magnitudes of the joint moment, joint power and muscle activity irrespective of inclination and direction. In FW and BW, uphill and downhill task produces opposite joint moment with a variety of flexor and extensor muscles contributions. These indicate that the motor control task requires different control strategies for inclined walking. The anatomical constraint and visual cues give additional features in biomechanical parameters of BW. Hence, a simple time reversal is not sufficient to distinguish between BW and FW. Interestingly, the similarities were observed between FW uphill and BW downhill or FW downhill and BW uphill in hip/knee joint moment and muscle activities. Such as during FW uphill and BW downhill an extension moment was present at the hip joint and a flexion moment at the knee joint. Here, the biarticular muscles BF was active in both types of walking. But we cannot conclude both types of walking were controlled by the same neural network as power patterns were distinctly different. The distributions of total power flow among joints were found to be related to the posture associated with the inclination in both FW and BW. Ankle contribution is more in both FW uphill and BW downhill (leaned trunk)

whereas hip contributes for FW downhill and BW uphill (erected trunk). In level walking ankle dominates in both FW and BW irrespective of speeds. The ankle joint had main propulsion at all inclination and speed during FW and BW except FW uphill.