Original Article:

Energy Cost and Gait Efficiency of Below-Knee Amputee and Normal Subject with Similar Physical Parameters & Quality of Life: A Comparative Case Study

Durbadal Biswas, National Institute for the Orthopaedically Handicapped, Under Ministry of Social Justice & Empowerment, Govt. of India, B-T Road, Bon Hooghly, Kolkata-700090,
Sukumar Roy, HOD of Biomedical Engineering Dept., NSEC, Garia,
PK Lenka, National Institute for the Orthopaedically Handicapped, Under Ministry of Social Justice & Empowerment, Govt. of India, B-T Road, Bon Hooghly, Kolkata-700090
Ratnesh Kumar, National Institute for the Orthopaedically Handicapped, Under Ministry of Social Justice & Empowerment, Govt. of India, B-T Road, Bon Hooghly, Kolkata-700090.

Address For Correspondence:
Durbadal Biswas,
Department of Research & Development,
National Institute for the Orthopaedically Handicapped,
Under Ministry of Social Justice & Empowerment, Govt. of India,
B.T. Road, Bon Hooghly,
Kolkata-90, India
E-mail: durbadal.bne@gmail.com

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Abstract:
The study focused on the comparative analysis of energy cost and gait efficiency between a below knee (BK) amputee and a reference subject (without amputation). It also attempted to indicate the specific feature responsible for a controlled gait with optimum energy cost for BK amputees. Selection criteria of the subjects were similar physical parameters and quality of life studied with WHOQOL-100 quality of life assessment. A Cosmed k4 b2 Respiratory Analyzer system was used for the measurement of Oxygen Uptake (VO2), Energy Expenditure per minute (EE) and Heart Rate (HR). Gait efficiency (p < 0.0002) was found higher for BK amputee than normal subject. The therapeutic activities and mainly walking rhythm contributed to improve the mobility & balance. This ensures the optimum time & co-ordination of movements and hence improves the gait efficiency for the BK amputee. Comparison with control group was performed to validate the data.

Key Words: Energy Cost; Gait Efficiency; Below knee amputee

Introduction:
The lower extremity amputees have to spend huge effort & time to achieve their lost gait efficiency. Achieving the efficient locomotion plays a major role in the individual development. (1) Ambulation is practically difficult in trans-tibial amputees. Excessive energy cost may be the cause behind that. Earlier studies have shown elevated relation of energy expenditure & decreased gait efficiency in the transfemoral amputees in comparison to the normal subjects with non-pathological gait. (2-9) Gait efficiency is defined as energy cost per distance traveled in previous research papers. (15) The lowest value is considered the Optimum efficiency at the self selected speed. (2, 7) Previous research indicates the higher energy cost in amputees with leg prosthesis than normal at comparable walking velocities. (10-12) Ganguly et al discussed transfemoral amputees consume 33% more energy than the normal subjects at 50 m/min walking speed. (3) In spite of this, most of those amputees achieved their normal gait within their limitation of disabilities. The physical parameters & Quality of life are the factors affecting the performance of the subjects. In this study, the subjects have been selected with similar physical parameters & similar Quality of life.

The purpose of this study was to compare the energy cost, gait efficiency of a physically active person with conventional BK Prosthesis versus a normal person with similar physical parameters (sex, age, height, and weight) & quality of life during their normal locomotion. The similar comparison was also done with reference to a control group for the data validation.

Methods:
One right trans-tibial amputee with conventional prosthesis with patella-tendon-bearing (PTB) socket & a solid-ankle-cushion-heel (SACH) foot for more than five years was selected in this study with his consent to the National Institute for the Orthopaedically Handicapped, Bon-Hooghly, Kolkata-90, India. A normal subject participated as a reference with similarity in age, sex, height and weight data to the trans-tibial amputee. (Table-1) A control group was also selected with 30 normal subjects with non pathological gait. (Table 2) All the participants were physically active & well balanced to complete the protocol in full. The amputee was accustomed to wear the prosthesis and did not suffer from residual limb pain, swelling, or pressure sores. The fitting & alignment of the prosthesis was carried out by the resident Department of Prosthetics & Orthotics of the institute. The amputee was trained by therapeutic activities to improve the mobility with balance & to ensure the optimum time & co-ordination of movements. All the normal subjects were also examined & their fitness was certified. Subjects were asked not to ingest alcohol or caffeine for 24 hours prior to testing. A record of the subjects’ diet was kept & a similar diet was maintained through out the study.
The subjects’ Quality Of Life was studied with WHOQOL-100 quality of life assessment. The assessment would be applicable cross-culturally. In this study the assessment indicates the similar Quality of life for both subjects. (Table 3)

Table 3: Quality of Life Assessment

<table>
<thead>
<tr>
<th>Domain</th>
<th>Average Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subjects with BK Prosthesis</td>
</tr>
<tr>
<td>Physical health</td>
<td>24.66</td>
</tr>
<tr>
<td>Psychological</td>
<td>19.18</td>
</tr>
<tr>
<td>Social relationship</td>
<td>10</td>
</tr>
<tr>
<td>Environment</td>
<td>27.7</td>
</tr>
</tbody>
</table>

The subjects were allowed to practice their usual gait prior to the testing until the normal gait pattern was observed. The subjects were instructed to walk at self selected speed. Throughout this period, breath by breath analysis of the subjects was carried out. A Cosmed® K4 B2 Respiratory Analyzer system (COSMED Srl – Italy) at National Institute for the Orthopaedically Handicapped, Bon-hooghly, Kolkata-90, India was used for the measurement of Oxygen Uptake (VO₂), Energy Expenditure per minute (EE), Heart Rate (HR) for both subjects. (Figure 1)

The print out giving the subjects average VO₂ (ml/Mint) over consecutive 60 seconds interval was processed by calculating the mean and standard deviation. A plane surface of 30 m was fixed for subjects’ walking. The subjects were given sufficient time to become accustomed to the analyzer system before the experiments. Total test time was approximately 25 minutes consisting of a 3-minute warm-up period to ensure that the muscles did not utilize anaerobic sources of energy, 1 minute to prime the airways, and 1 minute of exhaled gas collection. The order of test configurations was maintained, and the consecutive information of the test was recorded at each condition. Fatigue was minimized by allowing subjects to rest dur-
The study will continue and additional research is recommended with more subjects to corroborate the findings of the current study.

**Conclusions:**
Appropriate time & co-ordination of movement resulted in confident gait rhythm & balance with less energy cost for the amputee in this study. Higher Gait efficiency & less Energy Expenditure were found for the BK amputee than the reference subjects with the similar physical parameters & quality of life for identical performances. This advocated that therapeutic practice & proper training for time & co-ordination of movements can help the amputee with below knee prosthesis to perform their ideal gait with less energy consumption.

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