International Journal of Health Sciences and Research
Vol.10; Issue: 9; September 2020
Website: www.ijhsr.org
Case Report *ISSN: 2249-9571*

Energy Consumption during Prosthetic Walking of a Young Individual with Transfemoral Amputation - A Case Report

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ABSTRACT

Background: Amputees are known to spend more energy than able-bodied persons while walking. It is claimed that abnormal movement patterns associated with amputee gait affects the smoothness of the pendular-like movement of the center-of-mass and additional mechanical work is needed for each walking step. The purpose of this study was to measure the various parameters that are related to energy consumption.
Case Description and Methods: A 32-year young male with right side Transfemoral amputation was fitted with Exoskeletal Transfemoral prosthesis with quadrilateral socket with constant friction knee joint. After successful prosthetic training VO2 Max, VCO2, Heart Rate and Respiratory Quotient were measured.
Findings and Outcomes: The VO2 Max was 16.408 ml/kg/min, VCO2 was 209.4512 ml/min, Heart Rate was 119.293 and Respiratory Quotient was 0.179 respectively.
Conclusion: The walking pattern and gait of a young individual with Transfemoral amputation is mainly depends upon the strength of the muscle and control of the prosthetic knee joint. So along with the prosthetic fitment various exercises definitely bring out a good result.
Clinical relevance: This case report shows the impact of prosthesis on energy expenditure and the data can be used for further research.

Keywords: Transfemoral prosthesis, Energy expenditure, VO2 Max, VCO2, Heart Rate and Respiratory Quotient.

INTRODUCTION

Lower limb amputations cause functional, musculoskeletal and cardiovascular changes. The more proximal the amputation level, the greater these changes. At rest, the amputees may have higher levels of catecholamine in blood, increased sympathetic nerve activity, increased blood pressure and increased heart rate (HR) when compared to normal individuals. [1,2] During normal gait, the energy expenditure as a function of speed has the shape of a concave curve up, suggesting the existence of a more economical speed, which requires less oxygen consumption (VO2). [3, 4]

The main purpose of the rehabilitation process is to restore function and to regain an acceptable level of functioning and participation. To reach this goal, prosthesis is used to compensate for the functional losses. [5,6] The increased energy expenditure during the gait with prosthesis has been justified through the

biomechanical changes resulting from the compensatory gait adopted by amputees. [7] Therefore, the aim of this study was to observe the effect of wearing prostheses and gait speed on HR, VO2, VO2 and Respiratory Quotient (RQ) during the ambulation.

- VO2 max (ml/kg/min): The highest rate of O2 consumption attained during exercise of large muscle groups. It is an indicator of physical fitness also called maximal aerobic capacity.
- VCO2(ml/min) : The highest rate of CO2 production during exercise of large muscle groups
- Heart Rate (HR): The number of heart beats per unit of time, usually per minute is called the heart rate.
- Respiratory quotient (RQ): Refers to the ratio of carbon dioxide production to oxygen consumption (VCO2/VO2).

MATERIALS AND METHODS

A 32 year old male subject with Right side Transfemoral amputation was referred to National Institute for Locomotor Disabilities (Divyangjan). The client's cognitive functions were normal, and he was interactive. Prior to assessment and prescription the subject gave written consent to participate in this study. A detailed assessment was performed with demographic data, medical history, amputation level, Muscle power etc.

Findings on the detailassessment are as follows –

- Amputation side – Right Side
- Age – 32 year
- Weight – 54 KG
- Cause of Amputation – Road Traffic Accident
- Length of the stump – 156 mm (from perineum to end of the stump)
- Muscle Power (MMT) – 4 (in Rt hip and 5 in normal side)
- ROM - Normal
- No other conditions like contracture, neuroma etc

Prescription – Right Exoskeletal TF Prosthesis with Quadrilateral socket with constant friction knee joint with Silesian suspension.

The treatment programme planned was to start physiotherapy exercises, strengthening exercises for all four limbs and also including the trunk, stretching exercises for tight muscles, standing Balance.

Fabrication procedure of the Prosthesis – Casting and rectification of the positive mold was done as per the principle of fabrication of Quadrilateral socket design. The laminated socket with the other components was aligned with the principle of TKA alignment method. The client was fitted with prosthesis, gait training was provided inside the parallel bar initially for the 15 days. Then after 3 month of regular use of the prosthesis the data was taken in the Cosmed K4B2 metabolic Analyzer system.

The Subject with Exoskeletal TF prosthesis is shown in Figure 1 and The Subject during data collection is shown in Figure 2 .

Fig 1 - The Subject with Exoskeletal TF Prosthesis

Fig 2 - The Subject during data Collection

RESULT

Result of this case report was shown in (Table - 1).

Table - 1

VO2 Max	VCO2	Heart Rate	Respiratory Quotient
16.408 ml/kg/min	209.4512 ml/min	119.293 Beats per Minute	0.179

DISCUSSION

The measurement of oxygen consumption is an integral part of the evaluation of oxygen metabolism. Oxygen consumption is related to energy expenditure which is the amount of oxygen consumed from the substrate (carbohydrate, lipids, and amino acids) during the process of energy generation. Energy expenditure can be measured and/or estimated from the oxygen consumption and the carbon dioxide production. The normal resting value of oxygen consumption is 3.5 to 4.0 ml/kg/min. [8]

Most of the previous studies explains and shows effect on metabolic process using various types of endoskeletal prosthesis. [9,10] But in developing countries as India the patients are from rural area and low economic group. They are generally fitted with low cost exoskeletal prostheses. Limited no of studies and data are available to show the energy consumption of amputee using exoskeletal prosthesis. So it is required to study on effect of exoskeletal prosthesis on various metabolic processes that will help the clinician to select the component and improve the quality of life of amputee in developing countries.

This study is supported by another study in which they used quadrilateral socket with suction system and flexible webbing type of Silesian belt,3R 20 four bar linkage polycentric knee and multiaxis foot. They compared VO2 of normal subject with unilateral transfemoral amputee at same walking speed and found that VO2 is higher in transfemoral amputee than normal subjects. [11]

CONCLUSION

From this study it can be concluded that the traumatic Transfemoral amputee have higher energy expenditure, increased cardiovascular response and are less economical while walking with prosthesis when compared to normal individuals. The Transfemoral amputees have a higher metabolic and cardiovascular impact when walking, when compared to the transtibial amputees as well. So it can be postulated that proper training with strengthening exercises can give out an excellent result and also increases the satisfaction level of the young individual.

Conflict of Interest:

The author does not have any conflict of interest regarding research, authorship and publication of this article.

ACKNOWLEDGMENTS

This work was supported by the Department of Prosthetics and Orthotics of NILD, Kolkata West Bengal. The authors are thankful to our subjects for their time and interest for participation in this study and to the staffs of R&D department for their support.

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How to cite this article: Mishra S, Sahoo P, Sahoo D et.al. Energy consumption during prosthetic walking of a young individual with transfemoral amputation – a case report. Int J Health Sci Res. 2020; 10(9):256-259.

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