



Comparison of physiological cost index among transtibial amputee and normal individual: An observational study

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Abstract

Background: The physiological cost index (PCI) was established by McGregor (1979) to quantify the energy expenditure associated with walking. The difference between walking and resting heart rates divided by walking pace is known as the physiological cost index. Traumatic below-knee amputees typically use 25% more energy overall when walking than average people. Amputees need more energy when walking than persons in good health, which is one of their most noticeable issues. For example, walking with a transtibial prosthesis raises the body's energy requirements by up to 30%. The aim of study was to compare physiological cost index among transtibial amputee and normal individual.

Methodology: An observational study was carried out at Jaipur Foot Centre, Ahmedabad. In order to evaluate conformity with inclusion and exclusion criteria, the subject is first examined. A total of 36 subjects, both male and female, were included in the study and split into two groups. According to the inclusion criteria, Group 1 consists of 18 transtibial amputees wearing exoskeleton prostheses, while Group 2 consists of 18 normal persons. For both normal individuals and transtibial amputees, the physiological cost index (PCI) was calculated.

Results: According to the study findings, the amputee group shows higher physiological cost index (PCI) value than that of normal people. The mean PCI value for amputees is 0.6 ± 0.2 , which is greater than the mean PCI value for normal individuals, which is 0.3 ± 0.1 . This indicates that amputees have a higher physiological cost index.

Conclusion: Transtibial amputees have a greater physiological cost index value (PCI) than normal people, which indicates that they use more energy during walking.

Key words: Physiological Cost Index, Energy Expenditure, and Transtibial Amputee.

The oxygen uptake has been the conventional measure of energy expenditure. However, this approach is complicated and most clinics might not have the necessary equipment. The Physiological Cost Index was created by Macgregor (1979) to quantify the energy expenditure of walking. The difference between walking and resting heart rates divided by walking pace is known as the Physiological Cost Index. It is simple to measure heart rate in clinics since it does not require heavy equipment and it is not affected by fitness, medicine, disease, mental tension, or outside temperature.^[1] Compared to healthy individuals, amputees need more energy when walking, which is one of their noticeable issues. For example, walking with a below-knee prosthesis raises the body's energy requirements. If the amputee feels uncomfortable while walking due to a variety of factors, such as the heavy weight of the prosthesis, its incorrect direction, insufficient suspension, and inconsistent dimensions and volume of the stump and prosthesis's socket, the heart will work throughout the movement time if the energy consumption exceeds the standard and predicted amounts and the amputee compensates by engaging in more and prolonged muscular activity. If this problem persists over an extended period of time, it may shorten the person's life. In addition to placing an additional physiological burden on the body's cardiovascular system, using more energy results in a drop in kinetic power, early fatigue, a decrease in movement speed, and a reduction in the distance traveled by the person.^[2] Physiological cost index (PCI) values for transtibial amputees, comparisons between transtibial and trans-femoral amputees, and physiological cost index comparisons between normal and amputees with

varying stump lengths have been the subject of numerous studies; however, comparisons of PCI values between transtibial amputees with prostheses and normal individuals have been reported in relatively few studies. The goal of this study is to evaluate the physiological cost index values of unilateral below-knee (transtibial) amputees and normal individuals in the Indian population aged 20 to 40.

Methodology

An observational study was conducted at Jaipur Foot Centre, Ahmedabad. Convenience sampling was used to select the sample. Total number of ($n=36$) subjects both male and female was taken in study, dividing them into two group. Group 1 include ($n=18$) trans-tibial amputee with exoskeleton prosthesis according to inclusion criteria, Group 2 include ($n=18$) normal adults. Informed consent was taken from each subjects before participation. Nature of the study was explained in detail to each participants. Participants was rested in chair for 10 minutes. Resting heart rate (RHR) was calculated. To measure Resting heart rate polar heart rate monitor was used which is considered as next to gold standard measurement of Heart rate measurement. Following resting and RHR measurement, participants were asked to walk on 30 m straight pathway for 6 minute. The turnaround points were marked with a green cone. They were instructed to walk for 6 minutes with their normal walking speed. While walking, the hearing rate was continuously monitored. Walking heart rate was measured 10 seconds after the 6-minute period ended. Walking speed was determined by the subject's distance travelled in that 6 minute time.

PCI= Walking heart rate (beats/min) - Resting heart rate (beats/min) /Walking speed (meters /min)

PCI express in a beats /meter.

PCI value for normal healthy adults is 0.2-0.4^[1]

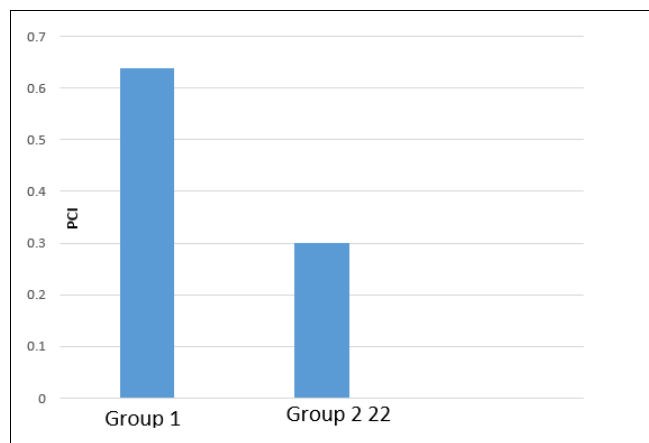


Results

- The collected data was analyzed by the version 16 SPSS software.
- In between group analysis was done by Mann Whitney U test.
- There was increase physiological cost index (PCI) value in amputee group as compared to normal individual.
- Mean value of PCI in amputee is 0.6±0.2 which is higher than mean value of PCI in normal individual, mean=0.3±0.1, which is shows higher physiological cost index in amputee.
- p-value is 0.001 which is suggesting statistical significant difference of PCI among amputee and normal individual.

Table 1: Between group analysis

GROUP	Mean	SD	p-value
GROUP 1	0.6	±0.2	0.001
GROUP 2	0.3	±0.1	



Graph 1: PCI between groups

Discussion

PCI is higher in amputees than in normal people. This could be due to the loss of active dorsiflexion and plantar flexion at the ankle when walking with a prosthesis, which are important aspects of gait.^[3] According to Molen's 1973 study, the slope of the line for the amputee group is significantly larger, even if the relationship between walking speed and energy expenditure during walking with a prosthesis is exactly the same as what occurs in normal

people. Additionally, the loss of muscle, bone, and soft tissue causes each structure to lose its natural loading and strength, which lowers walking speed. In addition, the patient may need to exert more effort when walking, which could result in an elevated heart rate. This variation in heart rate could lead to an increase in PCI.

According to the study's findings, a person with a transtibial amputation has a less efficient walk and needs more energy. These characteristics typically lead to slower ambulation rates and, in certain situations, may determine whether ambulation is practicable, particularly when it comes to higher velocity ambulation like jogging or running or distance walking. It may also be prohibitive to engage in recreational or sporting activity.^[4]

Walking speeds affected the PCI values. As walking speeds increased, the PCI values declined to maximum economy at slower rates. People with transtibial prostheses contend with the lack of active dorsiflexion and plantar flexion because to the loss of the lower extremity. The dorsiflexors give foot clearance during mid-swing and provide eccentric forces as soon as heel contact occurs. The plantar flexors stabilize the knee during midstance and actively push off and accelerate the healing leg forward. It has been proposed that most of the energy produced when walking comes from the ankle plantar flexors. The absence of dorsiflexor and plantar flexor function impairs the gait of an individual with transtibial amputation.^[5] Prasana K. Lenka (2008) conducted a study on gait parameters and dynamic weight bearing in young and older transtibial amputees. The younger group uses more force in the prosthetic limb during the push-off phase to accelerate the body for forward progression or to quickly transfer body weight from the prosthetic limb onto the sound side for faster walking. The functional limitation of the ankle mechanism due to aging may be one of the main explanations for the kinematics difference between the two groups. A similar study in transtibial amputees and normal people discussed the significance of the ankle mechanism and the compensatory actions needed by prosthetic users to overcome the limitation.^[6]

Conclusion

Physiological cost index value (PCI) is higher in trans-tibial amputee than normal individual of 20 to 40 year of age. This suggest that higher energy expenditure and muscular activity than normal individual while walking, which requires strengthening of lower limb muscle to compensate energy demands and avoiding excessive fatigue while walking.

Limitation

- The sample size in the present study was small, and future research is required with more people to validate the findings of the current study.
- In both groups, all individuals did not walk with shoes or without shoes. Therefore, one of the two options— all subjects wearing shoes or not—could be used for future research.

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