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Energy Expenditure Index (EEI) for Single Limb Stand Non Weight Bearing Stair case Climbing Using Axillary Crutches and Standard Walker in Healthy Individuals

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Abstract

Background: Stair climbing and walking is a part of high level functional activity. Stairs provide a ubiquitous and cost effective opportunity to incorporate physical exercise into the daily routine which in turn increases the quality of life. The choices of assistive ambulatory devices are limited to crutches and walkers, for patients with a NWB gait. **Objective:** To assess Energy Expenditure Index while using Axillary Crutches and Standard Walker single limb stand non weight bearing stair climbing in healthy participants.**Materials and Methods:** There were 340 participants (160 males and 180 females) with age group of 18-25 years and with normal BMI 18-22kg/$m^{2.}$ All the participants had undergone 5 phases of stair climbing using adjustable standard walker and axillary crutches single limb non weight bearing stair climbing. Energy expenditure index of each phase was calculated. **Results:** The results of the study were generated using 'SPSS version 23. The study shows that, the E*n*ergy Expenditure Index during stair climbing on non weight bearing by using standard walker is 10.81±3.14 beats/meter. Stair climbing on non weight bearing by using crutch is 6.76±1.92 beats/ meter. EEI for stair climbing without any assistive device is 1.9±0.39 beats/ meter. **Conclusion:** This study concluded that, energy expenditure during single limb stand non weight bearing stair climbing using standard walker is more than axillary crutch.

Keywords: Energy Expenditure Index; Walker and Axillary Crutch Ambulation; Physiological Cost Index; Stair Climbing.

Introduction

Locomotion is an ability to move from one place to another. Stair climbing and walking is a part of high level functional activity. Phases of walking is similar to stair climbing, involves both swing and stance phases where forward progression of body is brought about by alternating movement of the lower extremities. The stance phase of the stair gait is divided into three sub phase's weight acceptance, pull-up and forward continuance and the swing phases in two sub phases, foot clearance and foot placement[1].

Stairs provide a ubiquitous and cost effective opportunity to incorporate physical exercise into the daily routine which in turn increases the quality of life[2]

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Study has shown that energy expenditure during stair climbing is more than walking[2]Ambulation involves non weight bearing, partial weight bearing and complete weight bearing. Non weight bearing (NWB) means one of the lower extremities is not in contact with the floor and is not permitted to transfer any body weight. NWB can use in conditions like unilateral amputation, fracture and arthroplasty of lower limb. NWB devices are parallel bar, walker, crutches which are used for therapeutic purpose and training. The choices of assistive ambulatory devices are limited to crutches and walkers, for patients with a NWB gait[3]. Walker and crutches are chosen mainly for those patients who have poor balance and coordination, walker provide maximum stability while crutches are chosen for those who do not require as much stability provided by walker and having good upper extremity strength. Non weight bearing walking with crutches requires more energy than normal or unassisted ambulation[3,4]

The Energy Expenditure Index (EEI) is a process of energy production from energy substrates

(carbohydrates, lipids, proteins, and alcohol) combustion, in which there is oxygen consumption and carbon-dioxide production. It is also called as physiological cost index[5]. EEI has traditionally been calculated by measuring oxygen consumption and Co2 production[6]. As an indicators of efficiency and cost of locomotion Speed and Heart rate is used[5,6]. There is a linear relationship between energy expenditure and velocity so walking speed must be consider[3]. Based on the previous research the equation used for the calculation is, **EEI = Walking HR- resting / Walking speed[7-11]**

Studies have shown that energy expenditure in healthy individual while stair climbing is more than walking. Studies have also shown non weight bearing crutch walking requires more energy expenditure than normal walking[5].There is a scarcity in studies to determine the energy expenditure for non weight bearing using walker and crutches while stair climbing in healthy individuals.

Hence the need of the study was to estimate energy expenditure in healthy individual using crutches and walker in non weight bearing while stair climbing.

Aim of the study is to assess the Energy Expenditure Index while using axillary crutches and standard walker during single limb stand non weight bearing staircase climbing in healthy individuals.

Methodology: Permission and approval was obtained from institutional ethical committee. Screening and written Informed consent was taken from the individuals willing to participate as per inclusion and exclusion criteria. 340 healthy individual were included, keeping inclusion criteria as all gender adults, willing to participate, age group between 18- 25 yrs and Body Mass Index(BMI) 18.5-24.9 kg/m^2. The exclusion criteria were Individuals with cardio-respiratory, neurological, and other systemic illness, underwent recently any major surgery and individual under any medication other than over the counter drug (OTC). An outcome measure was Energy Expenditure Index. Each participant were given general instructions one day prior to test like to refrain from alcohol before 12 hours, from caffeine 2 hours, from smoking 24 hours, advised to finish meal before 2 hours and stay well hydrated before performing the test. The investigator demonstrated axillary crutches and standard walker stair case climbing using single limb stand non weight bearing. Radio telemetric heart rate monitor was attached to the subject's chest and made them to rest for 5 minutes and basal heart rate were recorded. The measurements for axillary crutches and standard walker were taken for each participant accordingly walking aid was adjusted. To identify dominant leg, participant was made to perform kick test, where leg use to kick ball was considered to be dominant leg. Task instruction like Leg should not touch floor, only sport footwear was allowed etc.

The entire procedure was divided into 5 phases; **Phase 1**: Participant was made to climb stair complete weight bearing without using assistive device and with self selected speed. **Phase 2**: axillary crutch were used during stair climbing by keeping dominant leg as non weight bearing. **Phase 3**: axillary crutch were used during stair climbing by keeping non dominant leg as non weight bearing. **Phase 4**: standard walker was used during stair climbing by keeping dominant leg as non weight bearing. **Phase 5**: standard walker was used during stair climbing by keeping dominant leg as non weight bearing.

The Resting Heart Rate was measured prior to the test and working heart rate was recorded immediately after 5 minutes of demonstration of the test and was documented for all the five phases. Each phase of test procedure was performed on different day in order to avoid fatigue stage of muscles.

Each participant's stair climbing distance was measured using inch tape and number of steps were calculated by the investigator and documented.

The obtained resting heart rate, working heart heat and distance were used in order to find Energy Expenditure Index (EEI) of each participant using formula EE= Walking HR - Resting HR / Walking speed [12-17]

Statistical analysis: Study results were generated, using 'SPSS version 23'.

For Demographic Data, mean and standard deviation was taken and Repeated Measure Design two tailed ANOVA was used for analysing the EEI for Non Weight Bearing Stair Climbing for each phases and task.

Results: There was no significant changes between the non dominant leg and dominant leg of the study population ($p<0.05$) from each other. Thus the dominant and non dominant variables were clubbed together for the analysis.

Table 1 Showing demographic data of all the subjects. The total numbers of the participants were 340 out of which 160 male and 180 female. All participants were right side dominance 100%. The Mean and standard deviation of age, height, weight and BMI were 20.20 ±2.11 years, 157.5 ± 3.98 cm, 58.35 ± 1.87 kg and 21.47 ± 2.08 kg/m^2 respectively.

Table 2 the energy expenditure during stair climbing on non weight bearing by using standard walker is (10.81±3.14) more than using axillary crutch (6.76±1.92). EEI for stair climbing without any assistive device is 1.9±0.39. On comparison of EEI between without assistive device, axillary crutch and Standard walker, F value = 79.19 and p value <0.001.

Discussion: The study shows that, there was significant difference in Energy Expenditure Index and distance covered during non weight bearing Stair Climbing using Standard walker and Axillary crutch with respect to normal Stair Climbing without any assistive device. EEI for Non Weight Bearing Stair Climbing using Axillary Crutch and Standard Walker is 3.5 times and 5.6 times more than normal stair climbing without any assistive devices respectively.

This could be due to biomechanical changes that occur during non weight bearing and transfer of upper body weight via assistive device to the ground.

On comparison, EEI of non weight bearing stair climbing using Standard walker was 1.59 times more than using Axillary Crutch. A similar finding was reported by Gottschall et al[19]. for treadmill walking on a representative incline at voluntarily selected paces for one- and two-step stair climbing Full weight bearing.The physical properties of Standard Walker and Stair climbing using standard walker requires height appropriate railing and continuous lifting up of walker and placing it for propulsion. The distance covered by participant was significantly less during Non Weight Bearing stair climbing using Standard walker compare to Axillary crutches. The distance covered during NWB stair climbing using standard walker is more than twice the distance (2.44) and nearly half the distance (0.47) while using of Axillary crutches than Normal stair climbing. Failure of completion of 5 minutes task using standard walker were 14, while 9 in use of axillary crutch NWB stair climbing. Studies have shown incline treadmill walking and stairway ascending have similar energy costs and evoke similar muscle utilization this could be because both of these activity requires centre of mass to raise against gravity on repetitive basis[18,20,21,22]. In this study, single lower limb with the help of walking aid was used for stair climbing that in turns increases energy cost and repetitive nature of stair climbing increases fatigue level in muscle.

Table 1: Demographic Data of the Study

Age (yr) Mean ± SD	Height (cm) Mean ± SD	Weight (Kg) Mean ± SD	BMI (Kg/m2) Mean ± SD	Gender N	Dominance % (side)
20.4 ± 2.11	157.5 ± 3.98	58.35 ±1.87	21.47 ±2.08	Male:160 Female: 180	100% (Right)

Table 2: Comparison of EEI during single limb stand NWB Stair case Climbing

EEI during NWB Stair Climbing	EEI Mean ± SD	Distance(Km) Mean ± SD	F Value	p Value
Stair Climbing without any Walking Aid	1.90 ±0.39	1.676±0.377	79.18	<0.001*
Stair Climbing on **NWB** with Axillary Crutch	6.76 ±1.92	1.141±0693		
Stair Climbing on **NWB** with Standard Walker	10.8±3.14	0.685±0.891		

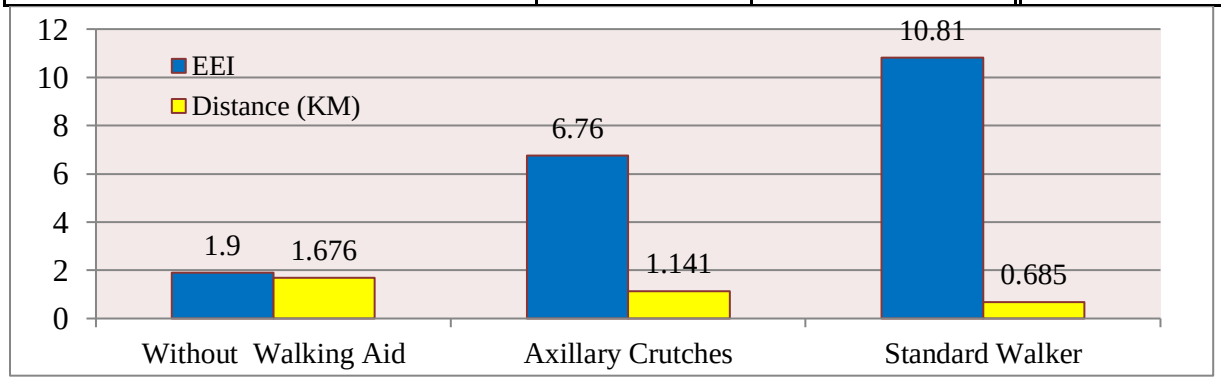

Fig 1: Comparison of EEI and Distance covered during Single Limb non weight bearing stair climbing

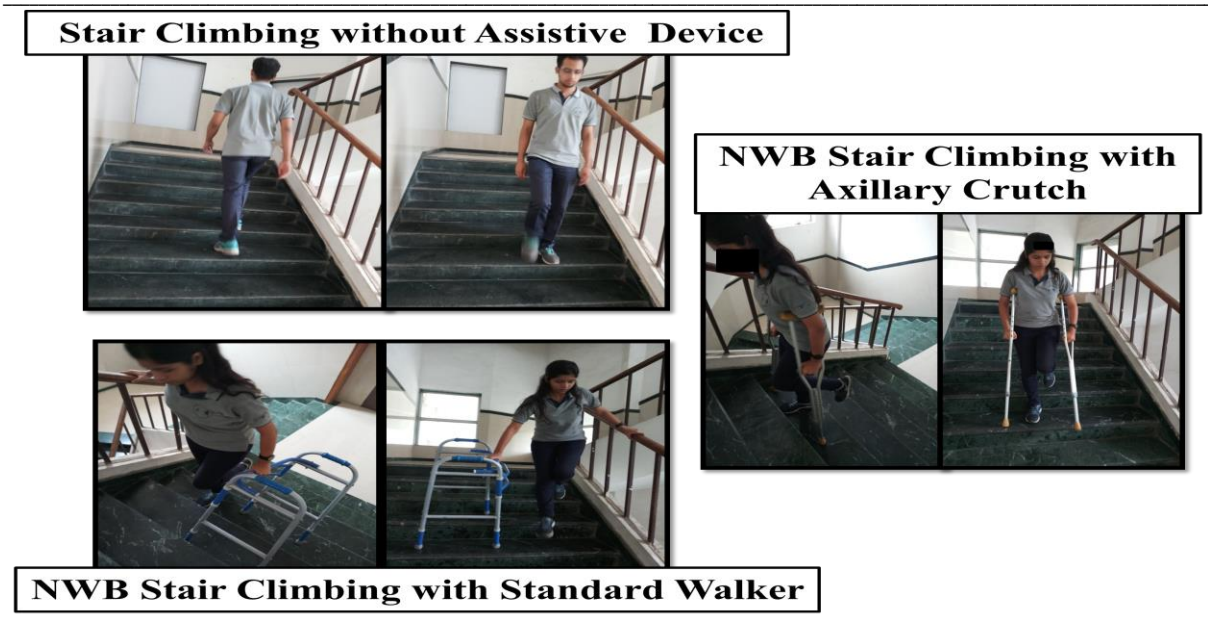

Fig 2: Procedure and phases of the study

Conclusion

Energy Expenditure Index during single limb stand non weight bearing stair climbing using standard walker is 5 times more and axillary crutches 3 times more than without any assistive device. Energy Expenditure Index during single limb stand non weight bearing stair climbing using standard walker is 1.5 times more than using Axillary crutch. There was no significant difference in EEI while comparing with dominant and non dominant leg during non weight bearing stair climbing for both Standard walker and axillary crutches.

Limitation

As this study included healthy individual for stair climbing single leg stance using axillary crutches and standard walker, results may vary on patient population, there may be increase in energy cost than healthy individual depending on age BMI etc. Also dominant and non dominant leg can show difference while stair climbing in patient population. Future scope of the study could be to estimate the energy expenditure index in patient population single leg limb stair climbing.

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Reference

1. Levangie P, Norkin C. Joint structure and function – A Comprehensive analysis. 5th Edition.Philadelphia: F.A Davis;2011
2. Halsey Lewis et al. The energy expenditure of stair climbing one step and two steps at a time: estimations from measure of heart rate. Plos one. 2012;7(12)51213:1-
3. Cullen E , Hinton A. Energy Expenditure During Ambulation With Ortho Crutches And Axillary Crutches.Journal Of Apta.2016; 62:813-81
4. Vanwala JJ et al. Effect of ankle foot orthosis on energy expenditure index and gait speed in spastic cerebral palsy children: an observational study Int J Contemp Pediatr. 2014 May;1(1):17-1
5. Volp P et al. Energy Expenditure: Components And Evaluation Methods.Nutr Hosp.2011; 26(3):430-440
6. Raja K, Joseph B et al. physiological cost index in cerebral palsy its role in evaluating the efficiency of ambulation. Journal of paediatric orthopedics.2007;27(2):130-136
7. Hood VL et al. A New Method of Using Heart Rate to Represent Energy Expenditure: The Total Heart Beat Index Arch Phys Med Rehabil Vol 83, September 2002

8. Villasolli O et al. Physiological Cost Index And Comfort Walking Speed In Two Level Lower Limb Amputees Having No Vascular Diseases.Acta Informa Med.2015 Feb 23;1:12-1
9. Waters RL, Mulroy S. The energy expenditure of normal and pathologic gait. Gait Posture. 1999 ;9(3):207-31.
10. Plasschaert F et al. The effect of simulating weight gain on the energy cost of walking in unimpaired children and children with cerebral palsy. Arch Phys Med Rehabil. 2008 Dec; 89(12):2302-8
11. Balaban B et al. The effect of hinged ankle-foot orthosis on gait and energy expenditure in spastic hemiplegic cerebral palsy. Disabil Rehabil. 2007 Jan 30;29 (2):139-44.
12. Graham C et al. Reliability and Validity of the Physiological Cost Index in Healthy Subjects While Walking On 2 Different Tracks. Arch Phys Med Rehabil.2005; 86:2041.
13. Ijzerman J, Nene V. Feasibility of the Physiological Cost Index as an Outcome Measure for the Assessment of Energy Expenditure During Walking. Arch Phy Med Rehabil.2002; 83:1772-8.
14. Danielsson A et al. Measurement Of Energy Cost By The Physiological Cost Index In Walking After Stroke. Arch Phys Med Rahabil.2007;88:1298-30.
15. Rose J et al. The Energy Expenditure Index: a method to quantitate and compare walking energy childrens and adolescents. J Pediatr Orthop. 1991; 11(5): 571-8.
16. Rana et al. Estimation of Physiological Cost Index as an Energy Expenditure Index using MacGregor's Equation: A Cross-Sectional study. JNMA 2015 53 (3) : 174-179.
17. Rose J et al. Energy Expenditure Index of Walking For Normal Children And For Children With Cerebral Palsy. Dev Med Child Neurol. 1985;27:485-49
18. Lephart K et al. Estimating Energy Expenditure for Different Assistive Devices in The School Setting. Paediatr Phys Ther.2014; 26(3):354.
19. Gottschall J, Aghazarian G, Rohbrach E. The metabolic and muscular differences between two stair-climbing strategies of young adults. Journal of Strength and conditioning research. 2010; 24: 2558–63.
20. Minetti AE, Cazzola D, Seminati E, Giacometti M, Roi G. Skyscraper running: physiological and biomechanical profile of a novel sport activity. Scandinavian journal of medicine and science in sports. 2011; 21: 293–301.
21. Biewener A. Energy cost of locomotion. Animal Locomotion. New York: Oxford University Press 2007.
22. Bassett D, Vachon J, Kirkland A, Howley ET, Duncan G, et al. Energy cost of stair climbing and descending on the college alumnus questionnaire. Medicine and Science in Sports and Exercise. 1997; 29: 1250–54.

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