International Journal of Science and Healthcare Research
Vol. 8; Issue: 3; July-Sept. 2023
Website: ijshr.com
ISSN: 2455-7587
Original Research Article

Effect of Leg Length on Physiological Cost Index in Young Adults

Pankti Gajera[1], Dr. Sweety Shah[2]

[1]MPT Student, SBB College of Physiotherapy, VS General Hospital, Ahmedabad, Gujarat, India
[2]PT, Ph.D., SBB College of Physiotherapy, VS General Hospital, Ahmedabad, Gujarat, India

Corresponding Author: Pankti Gajera

DOI: https://doi.org/10.52403/ijshr.20230345

ABSTRACT

Background and need of research: By Physiological Cost Index we estimate the energy cost in walking of healthy people, also it has been reported for persons with different leg length that requires the energy consumption. The Physiological Cost Index (PCI) method requires simply recording of HR at rest and while walking. We undertook this study aiming to present the energy consumption in subjects having different leg length.
Method: A cross sectional study was conducted in 50 individuals of age group 18-25 (young adults) years and normal BMI category according to Asian BMI classification (18.5-22.9Kg/m2). Resting HR Leg length was measured. The subject walked 1 km on treadmill for 6.5km/h speed and walking HR was measured and the physiological cost index was calculated. Data was analyzed using SPSS 20.
Result: Mean age and BMI of participants were (21.66 ± 1.5) and (21.08 ± 1.1) respectively. By using Pearson's test, there is highly statistically significant negative correlation (r= -0.600, P<0.05) between Leg length and PCI. As leg length (80.88 ± 6.85) increases, PCI (0.83 ± 0.11) value decreases.
Conclusion and clinical implication: The present study concluded that individuals with shorter height experiences more energy expenditure. This correlation indicates that there is a relationship between leg length and stride length frequency, which in turn effects on speed and efficiency of walking.

Keywords: Physiological cost index, Leg length, energy expenditure, treadmill walking

INTRODUCTION

The energy expenditure is amount of energy or calories that a person needs to carry out a physical function such as breathing, circulating blood, digesting food, or a physical movement. Total daily Energy expenditure is total number of calories that has burnt each day.[1] Energy expenditure varies from individuals to individuals depending upon their Body weight, walking speed, surface texture, body composition, leg length and height[2].
Heart rate has been shown to be a reliable parameter of energy expenditure. It increases linearly with a workload of up to submaximal levels. Factors other than energy expenditure can affect heart rate, most notably emotional stress. However, when activity is undertaken this effect diminishes markedly.[3] Speed of walking can also be a useful indicator and Waters et al (1988) have demonstrated that, in normal subjects, sped increases from childhood to young adulthood, then declines with age. With each age group, the rate of oxygen uptake increases with gait velocity.[4]

One of the validated methods of estimating of energy expenditure index considering heart rate and walking speed (over a certain meter distance) was put forth by McGregor. He coined this method as Physiological Cost Index (PCI) which is the ratio of heart rate per meter walked expressed as beats/meter.[5]

$$\text{Physiological Cost Index} = \frac{\text{Walking HR} - \text{Resting HR}}{\text{Walking speed}}$$

Physiological cost index is the easiest tool to measure the energy expenditure while walking by using heart rate monitoring. It is easy to apply in clinics, no heavy equipment is required, and influences of emotional stress, fitness, medication, illness, and ambient temperature are very small.[2]

Energy expenditure of any group in a population is determined by the structure of the group (age, gender, body mass, stature), the patterns of physical activity and the climate (Manini 2010). Therefore, although most studies have found different results about differences in energy expenditure (per unit kilogram/time) with regard to physical characteristics and gait parameters, how walking gait should be adapted to minimize energy expenditure and how walking activity should be continuously planned to keep energy cost as low as possible without stopping or early onset of fatigue should be researched.[6]

Measuring the PCI has been the subject of many publications for patients with different locomotion disorders[7-10] and also in lower limb amputees walking with prosthesis[11-14] We undertook this study aiming to present the energy consumption in subjects having different leg length. Shorter leg length had a great impact in increasing of energy expenditure and reducing the walking speed while performing ambulation. The purpose of this study was to analyse the relationship between the PCI values and leg length in normal healthy individual.

MATERIALS & METHODS

This study recruits an observational research design was conducted in cardiopulmonary department of SBB College of physiotherapy, Ahmedabad. Study proposal was submitted to ethical committee and approval was taken. In this, 50 subjects were included in this study aged between 18-25 years old and having normal BMI i.e. between 18.5-22.9 kg/m^2 according to Asian BMI classification. Participates were excluded if they have any musculoskeletal, neurological or cardiorespiratory problems, and the person who cannot walk normally. Individuals doing regular workouts and taking any drugs which can affect HR were also excluded.

A written consent was taken from each participant for participating in this study and they were explained about proposal and procedure of the study. Participants were asked to wear comfortable clothing and shoe for treadmill walking and also not consume heavy diet, tea, coffee and any alcoholic substances. Demographic information was taken verbally. Height was measured through stadiometer and weight was measured by weight scale. After categorised into normal BMI, participants were given rest for 5 min and then resting HR was recorded through pulse oximeter. Leg lengths were measured by measure tape from greater trochanter to lateral malleolus on both sides. During measurement, subjects were instructed to sit on the measuring table with their legs straight and the angle of 90° line joining anterior superior iliac spine. This means that the trunk-leg position is 90° and the legs is 15 to 20 cm apart and parallel to each other.[6] For treadmill walking they had to walk for 1 km at 6.5 km/h i.e. 108.33 meter/min. During the treadmill walking, HR was continuously measured by a pulse oximeter with a finger probe attached to the finger of participant. After completing 1 km, rest was given until HR returned to resting heart rate. The person could stop walking on treadmill in between if they have any unusual feeling.

STATISTICAL ANALYSIS

Statistical analysis was done using SPSS version 20.0. Data was checked for normal distribution using Shapiro-Wilk test. As data was normally distributed, data analysis was performed using the Pearson's correlation test for correlation between leg length and PCI.

P<0.05 was considered as statistically significant.

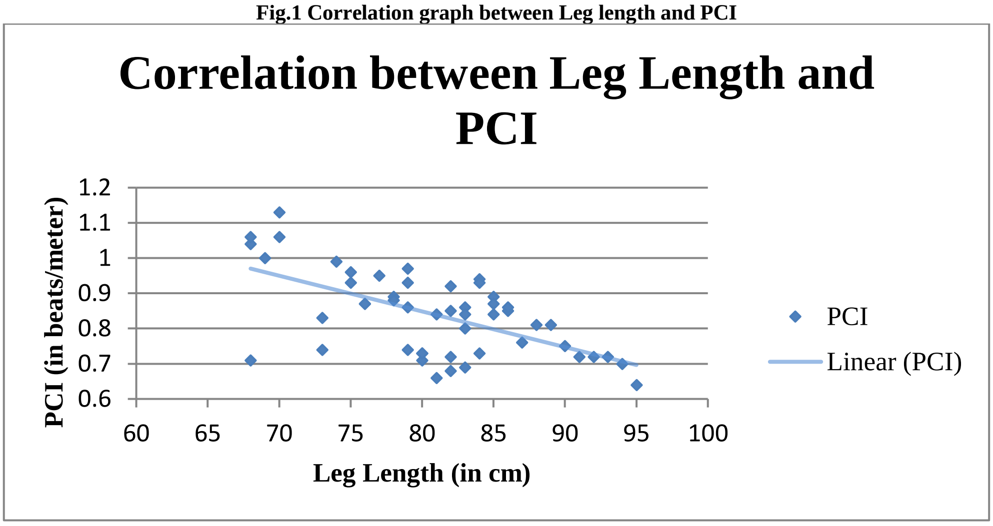
RESULT

The data were analyzed in 50 participants in this study. All 50 participants could complete treadmill walking at speed of 6.5 km/h for 1 km. Participants of age between 18-25 years having normal BMI (18.5-22.9 kg/m²). Table 1 shows the mean age and BMI of participants were (21.66 ± 1.5) and (21.08 ± 1.1) respectively and also leg length (80.88±6.8) and resting heart rate (81.06±4.8) that was recorded before the test. There is highly statistically significant negative correlation (r = -0.600, P<0.05) between Leg length and PCI. Result shows that as leg length increases, PCI value decreases.

Table 1. Demographic information

Parameters	Mean±SD
Age	21.66±1.5
BMI	21.08±1.1
Leg Length	80.88±6.8
Resting HR	81.06±4.8

Fig.1 Correlation graph between Leg length and PCI



DISCUSSION

This study examined the correlation between leg length and physiological cost index in age group of 18–25-year-old through walking on treadmill at 6.5km/h speed for 1 km. And it was observed that PCI values increased as leg length decreased in young adults although speed of walking remained constant. In present study, there is statistically significant negative correlation found between leg length and physiological cost index means as leg length increases energy expenditure decreases. Smaller people expend more energy because they take more steps to cover the same distance as taller people. So, to cover the distance they compensate their stride length, it becomes shorter. As we walk faster, muscle requires more oxygen to meet increased energy demands. So, increase in respiratory rate and heart pumps faster to get oxygen rich blood into working muscles that increases heart rate. At each speed we use the stride length that minimized energy cost and at any particular speed we seem to choose our stride length, step length, width step and shape factor to minimize energy cost.[16]

There was a study done by Norlena salamuddin et al(2014) in agreement of this study, they shows the relationship between leg length and energy expenditure during walking that was performed for 8 minutes at two speeds of 4.6km/h and 5.4km/h. Result shows there is a significant correlation between energy expenditure and leg length at both walking speeds which concluded that varying leg length in different speeds, age and fitness level in empirical studies will allow a clearer picture of effectiveness of leg length on energy expenditure during walking.[13] Dave McGovern (1997) studied on The Link between Stride Frequency, Respiration Rate and Heart Rate, he shows the linear relationship between stride frequency, respiratory rate and heart rate stated as breathing will get faster as stride rate gets faster, until you reach that critical point where respiration rate and heart rate begin to level off. Fariba Hossein Abadi et al (2010) studied about energy expenditure through walking stated that The amounts of energy used by the muscle depend upon the force and rate of contraction and the number of contraction used during each phase of locomotory cycle. walking in economical speed which minimizes energy expenditure by stride length, step length and width step.[16]

In summary, the Physiological Cost Index provides a valuable perspective on the energy expenditure and efficiency of human movement, and leg length is one of the factors that can contribute to its variation. However, the relationship between leg length and the PCI is multifaceted, and further research is needed to better understand how different biomechanical and physiological factors interact to influence energy expenditure during locomotion.

CONCLUSION

This study presents the empirical evidence of effect of leg length on physiological cost index in young adults. The result showed that there is significant negative correlation present between leg length and physiological cost index. This indicates that there is a relationship between leg length and stride length, which in turn effects on speed and efficiency of walking.

Declaration by Authors

Ethical Approval: Approved

Acknowledgement: None

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. Mehta JN, Gupta AV, Raval NG, Raval N, Hasnani N. Physiological cost index of different body mass index and age of an individual. National Journal of Physiology, Pharmacy and Pharmacology. 2017;7(12):1313-7
2. Wu CH. Physiological Cost Index of walking for normal adults. 特殊教育與復健學報. 2007 Jun 1(17):1-9
3. Astrand PO, Rodhal K. Textbook of work physiology. New York: McGraw Hill, 1977.
4. Bailey MJ, Ratcliffe CM. Reliability of physiological cost index measurements in

walking normal subjects using steady-state, non-steady-state and post-exercise heart rate recording. Physiotherapy. 1995 Oct 1;81(10):618-23.
5. Rana BS, Pun M. Estimation of Physiological Cost Index as an Energy Expenditure Index using MacGregor's Equation. Journal of the Nepal Medical Association. 2015 Jul 1;53(199).
6. Salamuddn N, Harun MT, Abadi FH. Relationship between leg length and energy expenditure during walking. Journal of Physical Education and Sport. 2014 Dec 1;14(4):604.
7. Ijzerman MJ, Baardman G, van't Hof MA, Boom HBK, Her-mens HJ, Veltink PH. Validity and reproducibility of crutch force and heart rate measurements to assess energy expenditure of paraplegic gait. *Arch Phys Med Rehabil.* 1999; 80:1017–1023.
8. Kavlak Y, Uygur F, Korkmaz C, Bek N. Outcome of orthoses intervention in the rheumatoid foot. *Foot Ankle Int.* 2003 Jun;24(6):494–499.
9. Danielsson A, Willén C, Sunnerhagen KS. Measurement of energy cost by the Physiological Cost Index in walking after stroke. *Arch Phys Med Rehabil.* 2007; 88:1298–1303.
10. Raja K, Joseph B, Benjamin S, Minocha V, Rana B. Physiological cost index in cerebral palsy: its role in evaluating the efficiency of ambulation. *J Pediatr Orthop.* 2007 Mar; 27(2): 130–136.
11. Hachisuka K, Umezu Y, Ogata H, Ohmine S, Shinkoda K, Arizono H. Subjective evaluations and objective measurements of the ischial-ramal containment prosthesis. *J Uoeh.* 1999;21(2):107–118.
12. Chin T, Sawamura S, Fujita H, Nakajima S, Ojima I, Oyabu H, Nagakura Y, Otsuka H, Nakagawa A. The efficacy of physiological cost index (PCI) measurement of a subject walking with an Intelligent Prosthesis. *Prosthet Orthot Int.* 1999;23(1): 45–49.
13. Hagberg K, Tranberg R, Zügner R, Danielsson A. Reproducibility of the physiological cost index among individuals with a lower-limb amputation and healthy adults. *Physiother Res Int.* 2011; 16:92–100.
14. Sokhangoei Y, Abbasabadi A, Akhbari B, Bahadoran MR. Investigating the relation of walking speed changes with the metabolic energy consumption index in traumatic unilateral below knee amputees. *Euro J Exp Bio.* 2013;3(3):173–177.
15. Vllasolli TO, Orovcanec N, Zafirova B, Krasniqi B, Murtezani A, Krasniqi V, Rama B. Physiological cost index and comfort walking speed in two level lower limb amputees having no vascular disease. Acta Inform Med. 2015 Feb;23(1):12-7. doi: 10.5455/aim.2015.23.12-17. Epub 2015 Feb 22. PMID: 25870485; PMCID: PMC4384862.
16. Fariba Hossein Abadi, Tajul Ariffin Muhamad, Norlena Salamuddin, Energy Expenditure through Walking: Meta Analysis on Gender and Age, Procedia - Social and Behavioral Sciences, Volume 7, 2010, Pages 512-521, ISSN 1877-0428

How to cite this article: Pankti Gajera, Sweety Shah. Effect of leg length on physiological cost index in young adults. *International Journal of Science & Healthcare Research.* 2023; 8(3): 329-333. *https://doi.org/10.52403/ijshr.20230345*

******