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# CORRELATES OF CARDIORESPIRATORY FITNESS AND GAIT PARAMETERS IN YOUNG UNDERGRADUATE SUBJECTS

**[1]AZEEZ T. O., LAMINA S. AND IWUJI S.C.**
Biomedical Technology Department, School of Health Technology,
Federal University of Technology, Owerri, Nigeria

[1]Corresponding Aurthor: **thaophic@yahoo.com**

## ABSTRACT

Physiological studies of healthy individuals suggested that the pattern of walking influenced the oxygen cost of walking in a given distance. It has also been observed that in pathological states, shorter and frequent steps are common and that this inefficient gait might contribute to exercise limitation. The purpose of the present study was therefore to investigate the correlates of cardiovascular fitness and gait parameters in young undergraduate students. A cross sectional independent group design was used in data collection. Forty subjects with age ranged between 20 and 30 years participated in the study. Subjects' cardiorespiratory fitness was assessed using the 1.4 miles run; subjects were group into cardiorespiratory fitness category of high and low. Gait parameters (cadence [CD], step time [ST] & gait speed [GS]) were assessed using the paper-and-pencil method. Student t test and Pearson correlation test were used in data analysis. Findings indicates significant increase in the high fit group over low fit group in CD, ST and GS at $p<.05$. There was a significant positive and negative correlation between $VO_2$max and gait variables respectively: GS (.465), CD (.555) and ST (-.580) at $p<.01$. The present study concluded that cardiovascular fitness could be a positive factor/marker of qualitative pattern of walking in normal young adult. Future studies investigating the effect of physical training on pattern of walking in the healthy, chronic diseases and the disables are recommended.

**Keywords:** Gait; Cardiorespiratory; Fitness; Exercise.

## Introduction

The benefits of physical activity are well established and emerging studies continue to support an important role for habitual exercise in maintaining overall health and well being (Hahn et al, 1990; ACSM, 1995). Earlier physiological studies of healthy individuals suggested that the pattern of walking influenced the oxygen cost of walking in a given distance. However, Minor alteration in normal gait can increase energy expenditure and progress to pathomechanical involvements. It has also been observed that in pathological states, shorter and frequent steps are common and that this inefficient gait might contribute to exercise limitation (Davies et al, 1992).

Theoretical considerations suggest that there should be an optimal speed and pattern of walking for which the mechanical power out is a minimum. Actual observations have shown that oxygen consumption during walking varies with the speed and pattern of gait and that there is an optimal pattern of walking for which oxygen consumption is at a minimum (Davies et al, 1992).

The physical fitness of the citizens has been the prime concern of many countries; several researchers (Musa et al, 2009; Church et al, 2002; Rawson et al, 2003; Shankar et al, 2001) in different countries have assessed the fitness of their children, youth and adults.

Several others researchers (Mead et al, 2007; Salbach et al, 2005; Lin et al, 2004; McClellan and Ada, 2004) have also studied pattern of walking in both the healthy and in pathological states. However, data on the relationship and effects of cardiovascular fitness status and pattern of walking in young adult Nigerians seems scarce. For the purpose of this study, 2 hypotheses were formulated and tested:

(i) There would be a significant difference between the high and low cardiovascular fit groups in $VO_2$ max, SrL, SL, ST, CD and GS.

(ii) There would be a significant correlation between $VO_2$max and gait parameters. To test these hypotheses, we therefore, investigated the effect and correlates of cardiovascular fitness and walking pattern of young adult undergraduate Nigerians.

## MATERIALS AND METHOD

**Research design:** In the present study, a cross sectional independent group design was used in data collection; subjects were group into their fitness category of high and low fit. The study protocol was approved by ethical committee of the Biomedical Technology Department, School of Health Tech., Federal University of Technology, Owerri (FUTO), Nigeria.

**Subjects:** population for the study was students of School of Health, Federal University, Owerri, Nigeria. Subject were fully informed about the experimental procedures, risk and protocol, after which they gave their informed.

**Inclusion criteria:** Only those who volunteered to participate in the study were recruited. Subjects between the age range of 18 and 30 years with no any Orthopedic or cardiovascular disorders/abnormalities or limitations to exercise.

**Exclusion criteria:** Obese or underweight (BMI below 20 & above 30 kg/$m^2$), cardiac, renal, respiratory disease subjects were excluded.

A total of 40 subjects satisfied the necessary study criteria. They were fully informed about the experimental procedures, risk and protocol, after which they gave their informed consent in accordance with the ACSM guidelines, regarding the use of human subjects (ACSM, 1995) as recommended by the human subject protocol. Ethical approval was granted by the School of Health, FUTO.

**Physiological measurement:** Subjects resting heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were monitored from the right arm (Walker et al, 1992) using an automated digital electronic BP monitor (Omron digital BP monitor, Model 11 EM 403c made in Tokyo, Japan). These measurements were monitored between 7:00 am and 10:00 am on the test day.

**Anthropometric measurement:** Subjects' physical characteristics (weight [kg] & height[m]) and body composition (body mass index [BMI] (kg.m-2)) assessment was done in accordance with standardized anthropometric protocol (ISAK, 2001).

**Stress test:** 1.5 miles run test protocol was used to assess subject's aerobic power as described (ACSM, 2000). The test was used to predict the subjects $VO_2$ max, subjects ran on a flat surface with the 1.5 miles marked, subjects cover the 1.5 miles in as short a period of time as possible (walking was allowed as necessary). Time taken to complete the 1.5 miles was recorded in minutes. $VO_2$max was estimated as below.

$VO_2$max = 88.02 – (0.1656 x body weight in kg) – (2.76 x time[minutes)] + (3.716 x gender*). For gender, 1was substitute for males and 0 for females.

Subjects were grouped to low or high cardiorespiratory (CRF) fitness based on

age and sex; low CRFF) (poor, fair or average values) or high CRF (good or excellent values) CRF on the classification (McArdle et al, 2001). This classification was preferred to others because it put into consideration the effect of age and sex on CRF.

**Gait parameter assessment:** Paper-and-pencil method (Sekiya et al, 1997; McDonough et al, 2001) was used in gait parameters assessment. This method required researchers to chalked/inked subjects' soles and heels to make an imprint as they walked along a walkway. Footfall imprints are subsequently measured with a measuring tape to assessed step length (SL) (cm) and stride length (SrL) (cm). A stopwatch used to measure step time (ST) (minute) and cadence (CD) (steep/min) (McDonough et al, 2001; Finch et al, 2002). Subjects walked freely along a 15m with the instruction to walk at their "usual comfortable pace". No data were recorded until subjects reached the 5 m mark, to allow them to settle into a rhythm and pace of walking; the time taken and the numbers of strides taken over the final 10 m were recorded. Gait Speed (GS) (m/sec) was derived from the formula (McDonough et al, 2001) as stated by below.

Gait speed ($ms^{-1}$) = step length (m)/ step time (second)

**Statistical analysis**: Following data collection, the measured and derived variables were statistically analyzed. The descriptive statistics (Means and standard deviations) of the subjects' physical characteristics, estimated $VO_2$max, gait parameters were determined. Student's t test and Pearson product moment correlation tests were computed for the variables of interest. All statistical analysis was performed on a Toshiba compatible microcomputer using the statistical package for the social science (SPSS), (Windows Version 16.0 Chicago IL, USA). The probability level for all the above tests was set at 0.05 to indicate significance.

## RESULTS

The subjects' age ranged between 20 and 30years with mean± SD SBP and DBP of 128.18±6.00 and 74.80±4.85 respectively. Subjects' mean± SD age, height, weight and BMI were (23.85±2.52years, 1.68±0.08m, 65.85±8.99kg, 23.43±2.35 $kg.m^{-2}$). Groups' physical characteristics of the subjects are depicted on Table 1.

Table 1. Groups mean± SD physical characteristics (N=40)

| Variables | Low fit group n =24 X±SD | High fit group n= 16 X±SD |
|---|---|---|
| Age(years) | 23.13 ±2.17 | 24.94 ±2.67 |
| Weight (Kg) | 64.42 ±9.25 | 68.00 ±8.41 |
| Height (m) | 1.65 ±0.08 | 1.71 ±0.09 |
| BMI ($Kg/m^2$) | 23.59 ±2.67 | 23.18 ±1.81 |

Groups mean ± SD for $VO_2$max $ml.kg^{-1}.min^{-1}$, SrL, SL, ST, CD and GS are depicted in table 2. Students' 't test results (table 2) indicated a significant increased in the high fit group over low fit group in $VO_2$max (p= .000), CD (p= .001), ST (p= .001) and GS (p= .017) at p< .05.

There was a significant positive correlation between $VO_2$max and gait variables: GS (.465), ST (.580) and CD (.555) at p< .01 (Figures 1 & 2).

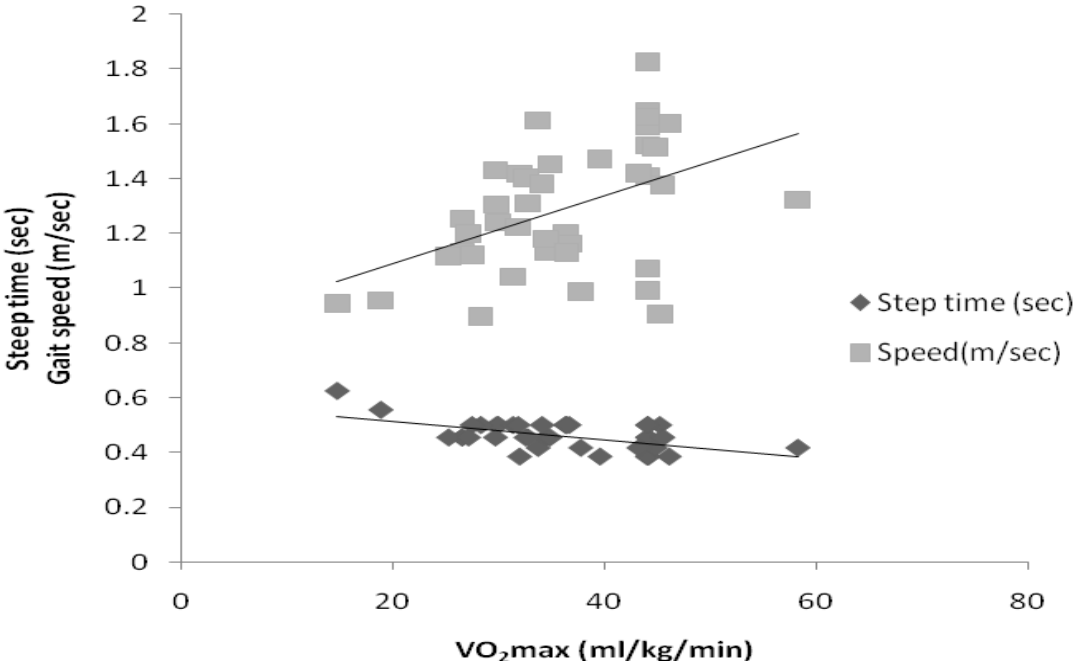
## DISCUSSION

The purpose of this study was to test the hypotheses that: (1) There would be a significant difference between high and low cardiovascular fit groups in $VO_2$ max and gait parameters assessed. (2) There would be a significant correlation between $VO_2$max and gait parameters of interest. Both hypotheses were supported by the results of the present study. Findings of the present study indicated significant higher values of ST, CD & GS in the high fit group over the low fit group.

Table 2. Groups mean± SD variables of interest and Independent t-test (N=40)

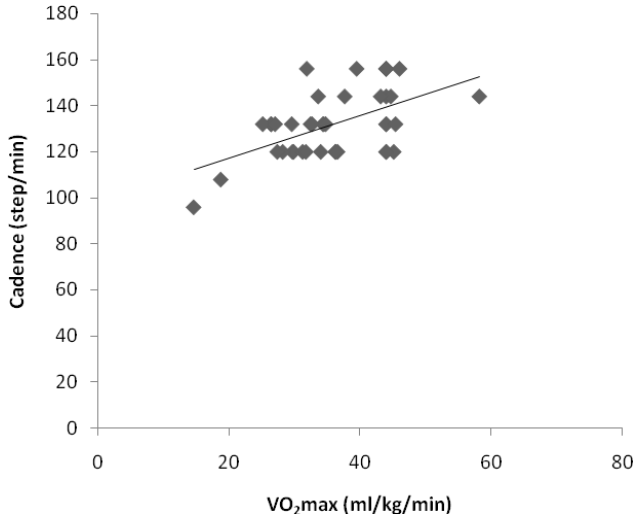
| Variables | Low fit group n= 24 X±SD | High fit group n= 16 X±SD | t-values | p-values |
|---|---|---|---|---|
| $VO_2$max (ml/kg/min) | 30.17±5.36 | 44.49±4.21 | -8.976 | .000* |
| Stride length(m) | 1.16±0.12 | 1.18±0.20 | -0.456 | .651 |
| Step length(m) | 0.58±0.06 | 0.59±0.10 | -0.456 | .651 |
| Step time(second) | 0.48± 0.05 | 1.13±0.13 | 3.483 | .001* |
| Cadence(step/min) | 126.00±11.74 | 141.00±13.51 | -3.729 | .001* |
| Gait speed(m/s) | 1.22±0.17 | 1.39±0.27 | -2.485 | .017* |

*Significant, p< 0.05




Step time (ST) r= -.580*, Gait speed (GS) r= .465* , *significant at p< 0.01

Fig 1: correlation between $VO_2$max, ST and GS (N=40).




Cadence r= .580*
*significant at p< 0.01

Fig 2: correlation between $VO_2$max and cadence (N=40).

Also, the present study reported a significant correlation between cardiorespiratory ($VO_2$max) fitness and gait (ST, CD & GS) variables.

Results of the present study are in line with the findings on the effect of exercise on gait performance in 14 people with hemiparesis after cerebrovascular injury (Jorgensen et al, 1995) though in pathological condition and reported a significant increased in gait speed. Another similar study conducted on the effect of exercise on gait parameters in subjects with hemiparesis following stroke (Silver et al, 2000) reported significant increased in mean gait speed and cadence.

A recent study conducted on the effect of physical exercise combined with wearing Med-Reflex shoe insoles on the gait performance in older adults (Hartmann et al, 2010). Twenty-eight independent living, older adults aged 65-91 years were randomly assigned to either an insole group (IG; n=14) or a training group (TG; n=14) or control group (CG; n=14[no exercise]). The IG and TG completed the same training program consisting of aerobic exercises, progressive resistance strength training and stretching exercises twice per week for 12 weeks, whereas, the IG wore the insoles during everyday life and during training sessions. The report shows significant group gait speed and step length difference. The results of their study provide evidence of significant improvements in gait performance and muscle power after a conventional training program in independent living, older adults.

A contrary finding was reported by Buchner et al, 1997; they investigated the effect of strength and endurance training on gait tests in older adults. One hundred and five (105) subjects age ranged between 68 and 85 participated. Exercise groups included strength training using weight machines (n = 25), endurance training using bicycles (n = 25), and strength and endurance training (n = 25) and control group (n=30). They reported no effects of exercise on gait performance. Other studies (Kerrigan et al, 2003; Johnsson et al, 2006) have also reported contrary notions; they failed to detect significant gait changes in response to stretching exercises. The probable reasons for this disparity in findings might possibly be as a result of the differences in the types of exercise and gait parameters assessed, types of subjects involved and subjects' compliance with the program.

## CONCLUSION

The present study concluded that cardiovascular fitness could be a positive factor/marker of qualitative walking pattern in normal young adult. Thus regular participation of young adults and the society at large in physical fitness programme is highly advocated for. However, there are limitations of the study, including lack of actual physical training and the absence of control group. These factors warrant attention in future studies. Also, though, paper and pencil method remains the mainstay of gait assessment; however, data from digitalized methods seem more valid and

reliable. This shortcoming required future attention.

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