Cardiovascular Response to Crutch Walking in Patients with Ilizarov Device

Raheem Sarafadeen[1], Aliyu Musa[2], [1]*Akindele O. Mukadas[2], Isa U. Lawal[2].

[1]*Department of Physiotherapy, National Orthopaedic Hospital, Dala, Kano State, Nigeria.*
[2] *Department of physiotherapy, Faculty of allied health sciences, Bayero University, Kano, Nigeria.*

Abstract

Crutch ambulation has been an accepted way of mobility in patients undergoing limb lengthening with ilizarov device. However, there has been reports increased change in cardiovascular parameters during ambulation (dizziness, fatigue and palpitation). The main objective of this study is to determine the response (changes) in cardiovascular parameters (blood pressure and heart rate) during crutch walking in patients on ilizarov device. The methods employed for this studies were; a total of 15 patients with ilizarov device were recruited using convenient sampling technique, 12(80%) were men and 3(12%) were females. Participants were subjected to crutch ambulation within their self-determined comfortable pace. Each participant covered a total of 91m to and fro. Data was collected pre and post crutch walking. The study design was a quasi-experimental design which was analysed using descriptive statistics of mean and standard deviation to summarise subject's age, while student t-test was used to test the level of significance of the variables of interest at 0.05. The results obtained were: There were significant increase in blood pressure ($p<0.000$) and heart rate ($p<0.000$) in response to crutch walking in patients with ilizarov device. It also showed insignificant gender difference in the parameters. This study found significant changes in cardiovascular parameters during crutch walking, while there was no significant gender variation. In conclusion, clinicians should adopt proper evaluation of subjects prior to crutch walking, and further studies should be carried out to investigate the factors responsible for the changes in the cardiovascular parameters during crutch walking in participant with ilizarov device.

Keywords: *Cardiovascular Response; Crutch Walking; Patients; Ilizarov Device.*

[1]* *Corresponding Author: Akindele O. Mukadis, Department of Physiotherapy, National Orthopaedic Hospital, Dala Kano. Nigeria. Email: mukaakin@yahoo.com*

Introduction

Walking had been considered to be a moderate intensity exercise, by having similar effect on cardiovascular system with other exercise programme tested (Pollock *et al*, 1975). This shows that with normal walking energy is required to some extent. Wagstaff (1984) noted that walking with aids puts considerable burden on patients. Knowledge of such information is of relevance to a better understanding of rehabilitation and response of patients to their care.

The ilizarov external fixator is a complex combination of metal rings, threaded rods and kirschner wires used for the correction of limb deformities, specifically limb length inequalities (Tajana et al, 1989). Ilizarov technique involves any of the group of techniques for bone regeneration, in which a long bone usually of the lower extremity is surgically fractured and held in place for a short period of time, then slowly distracted with an external fixator (Graw and Hill, 2002; Segen, 2011). It is widely used to treat complex and/or open bone fractures, and the method is preferred over conventional treatment options (such as internal fixation of cast) where there is high risk of infection of the fracture is of such severity that internal fixation are unwanted (Robert et al, 2007). While ilizarov is minimally invasive (no large incisions are made), it is not free from complications such as pain which might even be severe, but it is treatable with analgesics, careful hygiene to prevent infections.

Physical therapy is often indicated in the rehabilitation of patients with ilizarov external fixator (Ilizarov et al, 2007). Physical therapy techniques that have been used throughout ilizarov rehabilitation include isokinetic exercise, eccentric exercise, passive exercise on isokinetic equipment, stationary bicycling, walking on treadmill, electrical stimulation, hydrotherapy, massage and growth motor development (Newington et al, 1990). Typically, patients on ilizarov device are placed on non-weight bearing crutch walking post-operatively to aid ambulation. Crutch walking has, however, been reported to have significant effect on cardiovascular parameters even among apparently healthy individuals (Bell et al, 1980; Adedoyin, Opayinka & Oladokun, 2002). Recently, Moran et al., (2015) reported that patients on crutch walking on level ground require higher energy expenditure than normal/apparently healthy adults. Whether or not crutch walking alters cardiovascular parameters in patients ilizarov device has not been reported in the literature.

Method:

Patients

Fifteen (15) patients, (13 men and 2 women) undergoing limb lengthening with ilizarov device were recruited in to this study using convenient sampling technique, all patients being ambulated in ward and those attending physiotherapy department of the National Orthopaedic Hospital, Dala, Kano State, were primarily the population for this study. All participants gave written/informed consent to participate in the study that was approved by the ethical committee of the hospital.

Inclusion criteria are:

- Age ranged from 15 to 55 years of age
- All patients were undergoing limb lengthening with ilizarov apparatus
- No other neurological or orthopaedic disease impairing walking
- Able to understand the purpose and content of the study

Participants were subjected to crutch walking using axillary crutches following clinical evaluation, and they walked within their self-determined comfortable speed and covered a distance of 91m. They were informed to report any discomfort or fatigue, and were not under obligation to complete the task.

Data Collection

✧ *Blood pressure*

Blood pressure was measured from the subject in comfortable position using mercury type sphygmomanometer and stethoscope. The subject's arm was exposed and the cuff of the sphygmomanometer was wrapped round the arm at approximately 2.5-5cm above the cubital fossa, the centre of the cuff was in line with the brachial artery, the earpiece of the stethoscope was placed into the ears while the diaphragm of the stethoscope was placed over the brachial artery, the valve of the pressure cuff was closed and pump until it reached optional level.

The cuff was deflated carefully allowing air to escape at the rate of 2-3mmHg per heartbeat. The manometer was watched closely and the point at which the first sound that appear was recorded as the systolic blood pressure and the point on the manometer when the sound disappear recorded as diastolic blood pressure (Guyton, 2003). This was measured before and after the experiment.

✧ *Heart rate*

The heart rate was taken before and after crutch walking in accordance with Plowmann and Smith (1997) that showed pulse was connected from zero for a set of period of 15 seconds which was then multiplied by 4, so that per minute rate was obtained.

Statistical analysis
Descriptive statistics of mean and standard deviation was used to summarise the subject's age. While related t-test was used to test the level of significance of the variables of interest (systolic blood pressure, diastolic blood pressure and heart rate). Level of significant is set at 0.05.

Results:
The mean age and standard deviation of our participants are shown in table 1 below. The overall mean±SD age was 25.4±5.8 years and number of male participants is 12(80%).

Table 1. *Demographic Characteristics of Patients*

Variables	**M±SD**	**n(%)**
Age	25.4±5.8	
Gender		
Male	12	(80)
Female	3	(20)

Table 2. *Changes in Blood Pressure and Heart Rate of Patients with Ilizarov Following Crutch Walking*

Variable	**Pre M±SD**	**Post M±SD**	**%Δ**	**t**	**probability**
SBP(mmHg)	112.2±7.4	147.6±9.6	14.40	14.401	0.000*
DBP(mmHg)	76.0±6.6	76.6±6.9	0.7	0.521	0.610
HR(b/min)	72.3±5.7	100.3±10.0	38.7	10.605	0.000*

Significant at 0.05 α-level, tdf =2.145.

From the result shown in table 2 above, there is significant increase in systolic blood pressure and heart rate following crutch walking, with an insignificant increase in diastolic blood pressure. SBP=systolic blood pressure, DBP= diastolic blood pressure, HR+ heart rate, %Δ= mean percentage change.

Table 3*. Gender differences in HR, SBP and DBP following the use crutches in patients on Ilizarov device*

Variable	**Male(n=) M±SD**	**Female(n=) M±SD**	**T**	**Significance**
SBP(mmHg)	36.6±10.2	38.6±6.3	0.636	0.412
DBP(mmHg)	0.83±5.5	0.0±0.0	0.252	0.805
HR(b/min)	27.4±11.2	30.3±4.5	0.429	0.062

tdf= 2.160
SBP= Systolic blood pressure, DBP= diastolic blood pressure, HR= heart rate.

There are no significant differences ($p>0.05$) between male and female participants when their cardiovascular parameters are compared as seen in table 3 above.

Discussion:

This study investigated the changes in cardiovascular parameters (blood pressure and heart rate) to crutch walking in patients with ilizarov apparatus. The result of this study showed that there was an increase in the systolic blood pressure and heart rate but no increase in the diastolic blood pressure. Also, there were no differences in cardiovascular parameters between male and female participants. A total of 15 patients with ilizarov device participate in this study thirteen of which were males while two of them were females. Their overall mean±SD for age was 25.4±5.8 years.

Previous studies have shown increase in cardiovascular parameters with non-weight bearing crutch walking among apparently healthy individuals. Hilton and Cullen (1982) reported an increase in heart rates during ortho crutch ambulation and axillary crutch ambulation when compared with unassisted ambulation. In a study investigating the cardiovascular response of apparently normal individuals to crutch walking, Adelugba (1991) reported marked increase in systolic blood pressure and heart rate with slight increase in diastolic blood pressure. Similarly, in their evaluation of cardio-respiratory response to crutch walking in normal individuals, Hinton and Cullen (1982) reported that moderate intensity exercise such as crutch walking at constant speed is associated with rapid increase in systolic blood pressure and heart rate, but diastolic blood increases slightly or remain relatively stable. This significant increase in heart rate has been assumed to be caused by the greater percentage of isometric arm and leg exercise during non-weight bearing ambulation on axillary crutches (Katharine and O'Sullivan, 1984). It is also pertinent to point out that isometric exercise has been shown to lead to abnormal increase in heart rate and systolic blood pressure when compared with isometric work (Imms, MacDonald & Prestige, 1976). Among apparently healthy undergraduate students, Adedoyin, Opayinka and Oladokun (2002) reported an increase in energy expenditure during crutch walking in both stair climbing and level round. Adedoyin, Opayinka and Oladokun (2002) and few other studies have reported energy expenditure during crutch walking using either rate pressure product (RPP) or oxygen consumption but we are reporting the cardiovascular responses of participants on Ilizarof devices during axillary crutch walking. Rate pressure product was derived from multiplication of systolic blood pressure and heart rate which are cardiovascular indices.

Since velocity of walking had been said to always influence the stress on cardiovascular system (Blessey *et al* 1976; Hinton and Cullen 1982; Friedman 1988) ambulation was performed at the patient's self-determined comfortable speed at a predetermined distance so as to minimize stressful effects on their cardiovascular systems. Lehman and Delateur (1990) observed that character of the movement of the centre of gravity influence stressful effects it has on body during walking. Therefore, all participants underwent similar pattern of walking (swing through).

From the kinesiological point of view an increase in weight to the lower limb and consequent shift of centre of gravity due to poor postural control and coordination during crutch ambulation in patients with ilizarov create an increase in energy expenditure (Gullickson, 1979). This increase in energy expenditure may have a dramatic impact on functional capabilities of the patients due to physical inactivity and functional loss. Furthermore, energy cost of movement may increase due to low endurance. According to Nielsen *et al*, (1982), gait abnormalities alter walking efficiency and oxygen uptake value. The most important variable influencing energy consumption is the character of the movements of the centre of gravity (Lehmann & Delateur, 1990). During walking, the centre of gravity changes with movement of the body, the amplitude of this excursion essentially determines the amount of energy consumption during walking. Lehmann and Delateur (1990) cited Fisher and Gullickson (1979), who reported that the energy cost of ambulation with crutches using 3-0 point gait is twice as great as normal. The swing through and 3-point non-weight bearing gait requires about 78% more energy. This shows there is increase in work done and as such increase more demand on the heart and subsequent increase in cardiovascular parameters. According to Plowmann and Smith (1997) and McArdle (2001) cardiovascular responses to dynamic aerobic exercise such as walking and cycling depend on factors that include exercise modality (crutch), intensity and characteristics of the exerciser.

This was the first study known to examine blood pressure and heart rate responses following crutch walking in patients with ilizarov devices. The outcome of the study showed increase in blood pressure and heart rate following crutch walking in those patients. The normal physiological change following dynamic aerobic exercise is described as rapid increase in cardiac output following increases in both stroke volume and heart rate, and consequently leads to increase in systolic blood pressure (SBP) in a similar pattern to the cardiac output which may not necessarily be associated with obvious change in diastolic blood pressure (DBP) (Plowmann & Smith, 1997; Mc Ardle, 2001; Guyton, 2006).

Based on the findings from this study, it is concluded that crutch walking have significant effect on cardiovascular system of the body. Crutch walking by patients with ilizarov from the result shows an appreciable and significant increase in heart rate, systolic blood pressure but no significant increase in diastolic blood pressure. Therefore, clinically it can be concluded that crutch walking will put more stress on cardiovascular parameters in patients with ilizarov. It is therefore, recommended that:

- Patients with cardiovascular disorders who present with orthopaedic problems (such as fractures, deformities, limb length discrepancies etc.) should be adequately evaluated before subjecting them to crutch walking.
- Further studies should be carried out to include height, weight, BMI, walking distance and cadence as part of the physical characteristics of the patients as they can adjust the response of cardiovascular system.
- Further studies should be carried out in Patients with other devices to detect changes in cardiovascular and respiratory systems.
- Further studies are needed to look into energy expenditure of orthopaedic patients during crutch walking with Ilizarof device and other external fixators.

Figure 1: Ilizarov External Fixator

References

Adedoyin, R. A. Opayinka, J. A. & Oladokun, Z. O. (2002). Energy expenditure of stair climbing with elbow crutches. *Physiotherapy*, 88(1). pp. 47-51.

Adelugba, J. K. (1982). Comparative cardiovascular stress of crutch and normal walking in young adults: Study investigating the cardiovascular response. University of Ibadan.

Alexeev, B. K. (2005). *Effect of exercise on energy expenditure* (3rd Ed). London: Churchill Livingstone. pp. 150-165.

Amosun, S. L. (1990). Keeping fit in the depressed economy changes in cardiovascular parameters. *Journal of the Nigeria Society of Physiotherapy.* Vol X (2).

Amundsen, L. R. Takahashi, M. Carter, C. A. & Nielsen, D. H. (1979). Energy cost of rehabilitation callisthenics. *Journal of* Physical *Therapy,* (7). pp. 855-858.

Aronson, J. Harp, J. (1990). Factors influencing choice of external fixation for distraction osteogenesis. *American Academy of Orthopaedic Surgeons,* (39). pp. 175-183.

Bassey, E. J. & Fentem, P. H. (1981). *Work physiology*. In Edholm, O. G. & Welner, J. S. (ED). *The principles and practice of human physiology*. London, Academic Press Inc.

Beam, W. F. (1997). Exercise effect on the cardiovascular system. *Physical Therapy,* (32). pp. 98-102.

Bell, G. H. Ems-lie-Smith, D. & Patterson, C. R. (1980). *Textbook of physiology*. London, William Clowes Limited.

Ganong, W. F. (1999). *Review of medical physiology*. London. Prentice-Hall International.

Guyton, A. C. & Hall, J. E. (2002). *Pocket companion of textbook of medical physiology* (10th Ed). New Delhi: Harcourt Company Limited. pp. 136-142.

Hinton, C. A. & Cullen, K. E. (1982). Energy expenditure during ambulation with orthocruthes and axillary crutches. *Physical Therapy.* 62(6). pp. 813-819

Hoffbrand, B. I. (1982). *Post external hypo-tension. A valuable physical sign.* BMJ. pp. 285-1242.

Ilizaro, V. G. A. & Frankel. V. (1988). The ilizarov external fixator. The physiologic method of orthopaedic reconstruction and skeletal correction. *Orthopaedic Review,* (17). pp. 1142-1154.

Imms, F. J. Mac Donald, I. C. & Prestidge, S. P. (1976). Energy expenditure during walking in patients recovering from fractures of the leg. *Scandinavian Journal of Rehabilitation,* Medical. (8). pp. 1-9.

Katharine, B. P. & O'Sullivan S. D. (1984). Cardiovascular responses during non-weight bearing and touchdown ambulation. *Physical Therapy*, 64(1). pp. 14-18.

Littell, E. H. (1981). Support responses of the cardiovascular system to exercise. *Physical therapy,* 61(9). pp. 1260-1264.

Mc Ardle, B. B. *et al.* (1996). Exercise heart rate: *Journal of Research in Health and Sports Science.* (5). pp. 162-166.

Mc Donald, E. B. Kasch, F. W. & Haslet, M. O. (2001). Effect of exercise on heart parameters. *Physical Therapy,* (221). pp. 1668-1671.

Montaye, D. G. Metzer, D. T. & Keller, M. M. (1972). Exercise and its effects. *British Medical Journal.* 302.

Moran, J. Murphy, A. Murphy, D. Austin, A. Moran, D. Cronin, Guinan, E. & Hussey, J. (2015). The energy expenditure of non-weight bearing crutch walking on the level and ascending stairs. *Gait & Posture.* 42(1). pp. 23-26.

Newington. (1990). *Children's hospital for ilizarov procedures.* pp. 1-15

Nielsen, D. H. Gertleman, D. G. Amundsen, L. R. & Hoeper, D. A. (1982). Clinical determination of energy cost and walking velocity via stop watch or speedometer cane and conversion graphs. *Physical Therapy,* 62 (5). pp. 591-596.

O'neill, M. E. Cooper, K. A. Hunyor, S. N. & Boyce, S. et al. (1993). Cardiorespiratory response to walking in trained and sedentary pregnant women. *The Journal of Sports Medicine and Physical Fitness,* 33(1): 40-43.

Phinmen, J. B. Lagrange, H. O. & Darfarth, T. (1988). Exercise and heart rate. *American Journal of Hypertension,* 77 (62). pp. 100-108.

Pickering, T. G. Harshfield, G. A. Kleinert, H. D. Blank, S. & Laragh, J. H. (1982). Blood pressure during normal daily activities, sleep and exercise; comparison of value in normal and hypertensive subjects. *JAMA,* (247). pp. 992-996.

Plowmann, S. A. & Smith, D. L. (1998). Exercise physiology for health fitness and performance. Boston. Allyn and Bacon.

Pollock, M. L. Dimmick, J. Miller, H. S. Jr. Kendrick, Z. & Linnerud, A. C. (1975). Effect of mode of training on cardiovascular function and body composition of adult men. *Medicine and Science in Sports*.(7) pp.139-145.

Pollock, M. L. Miller, H. S. Jr. Janeway, R. Linnerud A. C. Robertson, B. & Valentino, R. (1971). Effects of walking on body composition and cardiovascular function of middle aged men. *Journal of Physiology,* 30(1). pp. 126-130.

Tajana, G. F. Morandi, M. (1989). The structure and development of osteogenic repair tissue according to ilizarov technique in men. *Orthopaedics*. (12). pp. 515-523.

Victor, L. O. (1996). Effects of exercise on heart rate. *American Journal of Hypertension* 66, (60). pp. 70-80.

Wagstaff, P. (1984). Energetic of walking using axillary crutches and the pro-type of a new design termed the Dublin crutch. *Physiotherapy,* 70(11). pp. 422-424.

Yoffey, J. M. (1987). Cardiovascular system. In Hamilton, W. F. *Textbook of Human Anatomy*. London. Macmillan Publishers Limited. pp. 512-610.