EFFECT OF A SIX-WEEK SUPERVISED AXILLARY CRUTCH WALKING PROGRAM ON SELECTED PHYSIOLOGICAL PARAMETERS IN PATIENTS WITH LOWER LIMB FRACTURES IN ENUGU, NIGERIA

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ABSTRACT

Background: Axillary crutches are commonly prescribed for patients with lower limb fractures to facilitate protected ambulation. Although crutch-assisted gait increases acute metabolic and cardiovascular demand, its longitudinal physiological effects remain unclear. This study investigated whether a six-week supervised axillary crutch walking program would produce measurable changes in selected physiological parameters compared with usual care.

Methods: A randomized pretest–posttest-controlled trial was conducted at the National Orthopaedic Hospital, Enugu, Nigeria. Forty-five patients with lower limb fractures (22 males, 23 females) prescribed axillary crutches were randomized to an experimental group (n = 29), which received supervised crutch walking training three times weekly for six weeks, or a control group (n = 16), which received usual physiotherapy care. Outcome measures included resting systolic and diastolic blood pressure, resting heart rate, estimated VO_2max (derived from resting heart rate), and percentage body fat measured via bioelectrical impedance. Analysis of

covariance (ANCOVA) was used to compare post-intervention outcomes while adjusting for baseline values ($p < 0.05$).

Results: No statistically significant between-group differences were observed after six weeks. Resting systolic blood pressure ($F = 0.363$, $p = 0.64$), diastolic blood pressure ($F = 2.153$, $p = 0.15$), resting heart rate ($F = 0.96$, $p = 0.758$), estimated VO_2max ($F = 0.2$, $p = 0.65$), and percentage body fat ($F = 0.4$, $p = 0.5$) showed no significant group effects.

Conclusion: The six-week supervised axillary crutch walking program did not produce significant cardiovascular or body composition adaptations beyond usual physiotherapy care in patients with lower limb fractures.

INTRODUCTION

Lower limb fractures are among the most common musculoskeletal injuries worldwide and represent a significant cause of functional impairment, reduced mobility, and increased healthcare utilization. Globally, lower limb fractures involving the patella, tibia, fibula or ankle are the most common and burdensome, with incidence rates highest among older adults[1]. Omoke and Ekumankama[2] reported an incidence of 22.6/1000/year for extremity fractures in a Nigerian Teaching Hospital over 12 months from 2016 to 2017, with road traffic accidents and falls from height being the most prevalent causative factors. Following definitive fracture management, such as internal fixation or plaster cast, patients are usually prescribed assistive devices to enable mobility while protecting the healing limb[3, 4].

Axillary crutches are among the most prescribed ambulatory aids in clinical practice, especially for patients with lower extremity injuries requiring non-weight bearing or partial weight bearing on the injured limb. They serve to redistribute body weight from the injured lower limb to the upper extremities, widen the base of support, enhance balance, and reduce ground reaction forces on the affected side[5] Proper crutch fitting is critical to avoid secondary complications such as axillary nerve compression and brachial plexus injury; this is typically 2 inches below the axillary fold, with approximately 30° of elbow flexion, and the tip of the crutch 6 inches away from the fifth toe[6, 5].

The transition from lower-limb to upper-extremity weight-bearing during crutch-assisted gait fundamentally disrupts natural biomechanical efficiency, thereby imposing a significantly higher metabolic and cardiovascular burden[7, 8]. Canter *et al.*[8], reported that, oxygen consumption during axillary crutch ambulation was 7.35 kcal/min compared to 3.06 kcal/min for unassisted walking at a similar pace, representing a 2.4-fold increase in metabolic cost. Heart rate increases are also notable, with post-activity heart rates around 122 bpm for axillary crutches compared to 107 bpm for hands-free crutches and even lower for unassisted walking[7].

Despite these findings, limited evidence exists regarding whether repeated exposure

to crutch-assisted ambulation over several weeks produces measurable chronic physiological adaptations in patients recovering from lower limb fractures. Most studies have focused on acute metabolic responses or gait mechanics in healthy volunteers[9, 8, 10] few have systematically evaluated how sustained crutch ambulation over weeks affects cardiovascular function, body composition indices, or oxygen utilization in patients recovering from lower limb fractures. In clinical practice, crutch use may occur in either structured, supervised formats or as part of routine, unstructured daily mobility. Whether a supervised crutch walking program confers additional cardiovascular or body composition benefits beyond usual care remains unclear, particularly in low-resource settings. Therefore, this study aimed to investigate the effect of six weeks of axillary crutch walking on selected physiological parameters among patients with lower limb fractures in Enugu, Nigeria.

MATERIALS AND METHODS

Study Design

This study employed a randomized pretest–posttest controlled trial design to evaluate the effect of a six-week supervised axillary crutch walking program on selected physiological parameters (resting systolic blood pressure, resting diastolic blood pressure, resting heart rate, VO_2 max and percentage body fat) in patients with lower limb fractures. Participants were age-matched and randomly allocated to either an experimental group or a control group.

Study Setting

The study was conducted at the Physiotherapy Department of National Orthopaedic Hospital Enugu, located in Enugu State, Nigeria. The hospital is a tertiary referral centre for orthopaedic and trauma cases in southeastern Nigeria.

Participants

The target population comprised patients with lower limb fractures prescribed axillary crutches for ambulation at National Orthopaedic Hospital Enugu during the study period (N = 264; 104 males, 160 females).

A total of 45 participants (22 males, 23 females) were recruited. Participants were randomized via simple balloting into the experimental group (n = 29) and control group (n = 16).

Inclusion Criteria

Participants who were;

i. Male and female patients aged ≥12 years
ii. Diagnosed lower limb fracture
iii. Recently mobilized from immobilization
iv. Prescribed axillary crutches for ambulation

Exclusion Criteria

Participants who had:

i. Pathological fractures
ii. Known cardiovascular, pulmonary, neurological, renal, or metabolic disease (such as diabetes, parkinson's disease, chronic obstructive pulmonary disease)

iii. Pre-existing hypertension or coronary artery disease
iv. Active malignancy
v. Degenerative or inflammatory musculoskeletal disorders
vi. Undergone joint replacement surgery

Outcome Measures

i. **Blood pressure:** Resting blood pressure was measured using a calibrated aneroid sphygmomanometer and Littmann stethoscope using the standard auscultatory technique. Measurements were taken in the seated position after 5 minutes of rest.
ii. **Heart rate:** Resting heart rate was measured in beats per minute using a Polar RS800CX heart rate monitor.
iii. **VO_2max:** VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$) was estimated from resting heart rate using established prediction equations (Nieman, 2011):
Males: $VO_2max = 111.33 – (0.42 \times HR)$
Females: $VO_2max = 65.81 – (0.1847 \times HR)$
iv. **Body composition:** Percentage body fat was measured using a bioelectrical impedance analyzer (Omron HBF-306). Height was measured using a stadiometer, and demographic variables (age, sex, weight) were entered into the device prior to measurement.

Intervention Protocol

The experimental group participated in supervised axillary crutch walking training three times per week (Monday, Wednesday, Friday) for six weeks. Each session lasted approximately 45–60 minutes and included:

1. Warm-up Phase
   i. Active mobilization exercises for upper and lower limbs
   ii. Joint range-of-motion activities
2. Skill Acquisition Phase
   i. Wall bar-assisted non-weight-bearing training
   ii. Parallel bar ambulation practice
   iii. Instruction in appropriate crutch gait technique
3. Main Exercise Phase
   i. Ambulation with axillary crutches over 50 meters
   ii. Four repetitions per session
   iii. Controlled breathing exercises
4. Cool-down Phase
   i. Supine relaxation
   ii. Passive and active lower limb mobilization
   iii. Controlled breathing exercises (10 minutes)

The control group received usual physiotherapy care without structured crutch walking training.

Data Analysis

Descriptive statistics (mean ± standard deviation) were calculated for all variables. Analysis of covariance (ANCOVA) was used to compare post-intervention outcomes between groups, adjusting for baseline differences. Statistical analyses were performed using SPSS Version 20.0 (IBM Corp., USA). Significance level was set at $p < 0.05$.

RESULTS

Following 6 weeks of crutch walking, resting systolic blood pressure showed a minimal increase in the experimental group and a larger increase in the control group; however, the between-group effect was not statistically significant ($F = 0.363$, $p = 0.64$). Resting diastolic blood pressure decreased slightly in the experimental group but increased in the control group, with no significant group effect ($F = 2.153$, $p = 0.15$). Resting heart rate declined in both groups, with a greater reduction observed in the experimental group; this difference was not statistically significant ($F = 0.96$, $p = 0.758$). VO_2max improved modestly and similarly in both groups, with no significant between-group difference ($F = 0.2$, $p = 0.65$). Percentage body fat increased slightly in both groups, and the group effect was not statistically significant ($F = 0.4$, $p = 0.5$). This is presented in Table 1.

Table 1: Effect of crutch walking on physiological parameters after 6 weeks of crutch walking

	Pre-test	Post-test	Mean Diff.	F	p-value
Resting Systolic BP (mmHg)					
Experimental	124.9 ± 18.5	125.3 ± 13.9	0.4	0.363	0.64
Control	121.5 ± 21.3	128.7 ± 16.1	7.2		
Resting Diastolic BP (mmHg)					
Experimental	81.7 ± 9.7	80.9 ± 10.6	0.8	2.153	0.15
Control	78.0 ± 10.9	83.8 ± 11.9	5.8		
Resting HR (bpm)					
Experimental	73.9 ± 7.8	66.9 ± 4	7	0.96	0.758
Control	70.6 ± 8.2	66.9 ± 5.3	3.7		
Estimated VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)					
Experimental	69.6 ± 14	71.4 ± 14.7	1.8		
Control	65.4 ± 14.7	67.1 ± 15	1.8	0.2	0.65
Percentage Body Fat (%)					
Experimental	25.8 ± 10	26.6 ± 11.8	1.7	0.4	0.5
Control	30.5 ± 14.5	31.7 ± 14.6	1.2		

DISCUSSION

This study evaluated whether a six-week supervised axillary crutch walking program produced measurable changes in resting cardiovascular parameters, estimated VO_2max, and percentage body fat among patients with lower limb fractures. The findings demonstrated no statistically significant between-group differences in resting systolic blood pressure, resting diastolic blood pressure, resting heart rate, estimated VO_2max, or percentage body fat following the intervention period. These results suggest that supervised crutch ambulation, as implemented in this study, did not confer additional cardiovascular or body composition benefits beyond usual physiotherapy care. Studies on the effect of crutch-assisted walking on physiological parameters have largely focused on its acute effects[11, 8, 10], thereby limiting direct comparison of the findings of our study with existing literature.

In the present study, although modest reductions in resting heart rate and diastolic blood pressure were observed in the experimental group, these changes were not statistically significant. The absence of meaningful between-group differences may be explained by several factors. Firstly, both groups were prescribed axillary crutches as part of routine care. The control group therefore continued ambulating during daily activities, potentially reducing the contrast between both groups. The training stimulus may also be insufficient to elicit long-term cardiovascular adaptation. While crutch walking increases acute metabolic demand, the total workload performed during each session was relatively modest. Cardiovascular adaptation typically requires sustained moderate-to-vigorous aerobic stimulus, which may not have been achieved under the present protocol[12].

Both groups demonstrated small, similar increases in estimated VO_2max, with no statistically significant group effect. Given the modest training load, the absence of significant improvement in aerobic capacity is not unexpected. Hands-free crutch gait has been linked with acute elevation in peak oxygen uptake compared to normal gait following a 6-minute walk test, indicating a higher aerobic demand[13]. For chronic effects, training primarily increases VO_2max through adaptations such as increased stroke volume, cardiac output, and enhance muscle capillarization which are influence by factors such as training volume, intensity and duration[14, 15].

Percentage body fat increased slightly in both groups without significant between-group differences. Changes in body composition typically require either sustained caloric deficit or prolonged higher-intensity aerobic training. The six-week duration and the relatively low exercise volume likely limited the potential for measurable changes in fat mass. While crutch use increases cardiovascular demand acutely, its impact on long-term changes in body fat has not been directly studied. Walking as a form of physical activity has been shown to reduce body fat percentage[16]. However, such programs typically involve sustained moderate-intensity activity performed for longer durations than the crutch ambulation protocol implemented in the present study. The minimal ambulatory

volume and the clinical context of fracture recovery, which may involve prolonged periods of reduced mobility outside supervised sessions, likely limited the potential for favourable changes in body composition. Additionally, dietary intake and overall physical activity levels were not controlled, which may have influenced body fat outcomes.

CONCLUSION

This study found that six weeks of supervised axillary crutch walking did not result in statistically significant changes in resting systolic blood pressure, resting diastolic blood pressure, resting heart rate, estimated VO_2max, or percentage body fat compared with usual care.

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