Topic – Effect of Cardiac conditioning exercise on heart rate, blood pressure and rate of perceived exertion in lower extremity traumatic amputation.

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Abstract

Background – traumatic causes resulting in amputation of lower limb are less studied in terms of cardiac parameters. 

Objective - Hence in this study we analysed the effect of conventional exercises and cardiac conditioning exercise on cardiac parameters in patients who underwent lower extremity amputation for traumatic cause and who did not had any cardiac risks.

Methods –this quasi experimental design recruited 50 samples into two groups randomly. Group I received conventional physiotherapy and group II received cardiac conditioning exercises (CCE) for 15 consecutive weeks. Heart rate, blood pressure, perceived exertion rate were used as standard outcome measures at the baseline and at the end of the intervention.

Results- both groups showed significant improvement in all the outcome measures from baseline homogeneity. Group II showed significantly better results that group I in the perceived exertion rate (t = 5.078 and p<0.001)

Conclusion - Both conventional and CCE can be better tool in normalising vital cardiac parameters like HR, BP, PER among traumatic lower limb amputees.

(Key words – traumatic lower limb amputation, cardiac parameters, cardiac conditioning exercises, heart rate, blood pressure, perceived exertion rate, Borg’s scale)
1. Introduction

Lower Limb Amputation is a major life changing event that could drastically affect the activities of daily living and functions leading to participation restriction in the community and thereby reducing the quality of life. (Dillingham TR et al, 2002). Achieving the ability of walking in patients with Lower Limb Amputation could definitely be a potential challenge. Despite the problems regarding the pain at the amputee site, presence of wounds, fitting of prostheses, walking with prosthetic limb needs more amount of metabolic type of energy than what is required while walking with two unimpaired lower limb (Houdijk H et al, 2000). Hence cardio respiratory endurance and capacity are vital component of rehabilitation, but unfortunately given less attention, particularly in developing countries like India. Positive effects on aerobic capacity after aerobic training have been observed among traumatic and young amputees (Chin T et al, 2001). These effects are documented, to a greater extent in the non-traumatic amputation or even traumatic amputation patients with cardiac risk or chronic systemic diseases. Because, comorbid conditions which leads to a negative effect on cardiorespiratory fitness before and after the surgery, with some contribution from sedentary lifestyle. There seems to be an increase in the perceived exertion while walking which coincides with decrease in the aerobic capacity (Fiser WM et al, 2010). We have observed that the volume of research and understanding of traumatic amputees without any significant co morbidity in terms of cardiac parameters is very thin. There seems to be a change in hemodynamics among these subjects as well that necessitates attention from rehabilitation specialists. Cardiac conditioning exercises recommended by American college of sports medicine comprises of 30-60 minutes of moderate exercises for 5 days a week, or 20-60 minutes of vigorous exercises 3 days a week which has to be done in short bought of at least 10 minutes each time and accumulated over the day, else as one session. (Pescatello, et al, 2014). Yet there are no specific recommendations for the traumatic subjects without any comorbidity who have a good exercise capacity compared to non-traumatic counterpart or subjects with comorbidity. Hence in this study we analysed the effect of conventional exercises and cardiac conditioning exercise on cardiac parameters in patients who underwent lower extremity amputation for traumatic cause and who did not had any cardiac risks.

2. Methodology

This quasi experimental study was conducted in Government institute of rehabilitation Medicine, KK nagar, Chennai. Subjects were recruited from both the out-patient department and the in-patient departments. The study was cleared of any ethical issues from the institutional ethical committee of Saveetha university (certificate no 006/07/2017/IEC/SU).and Madras medical college Chennai (certificate no 39112017 ). . The subject enrolled were patients who came for lower extremity prosthetic fitting following amputation. This study comprised of two groups namely group I and groups II, with an allocation ratio of 1:1 in both conventional and experimental groups. Study included both male and female individuals who had underwent lower extremity amputation for traumatic causes. Subjects within the age limit of 18 years to 72 years were selected. The subjects had a history of lower extremity amputees two months back and they were recruited into the study when they visited the study centre for prosthetic fitting. All the subjects had ability to understand and provide informed consent for participation for the study. Study excluded those with history of congenital cardiac abnormalities, diabetes mellitus, hypertension, chronic respiratory or circulatory disease. Subjects who had BMI ≥30.00 were also excluded from the study. Subjects who had associated traumatic brain injury, already on a consistent and vigorous exercise regimen prior to trauma, significant physical disability or immobility (joint disease, joint replacement, and muscular disorders), chronic smoking and Alcoholism were also excluded from the study. After recruitment they were explained about the exercise regimen by providing information sheet and informed consent was obtained. The study
adopted a convenient sampling for selecting samples from the population using consecutive sampling. A random sampling method using random number table method was employed in randomising the selected sample into two groups namely group I and group II.

2.1. Interventions

Group 1 received conventional physiotherapy in the form of dynamic stump exercise and the emphasise was on maintaining the joint mobility and Musculo skeletal integrity. Specific training included range of motion exercise (10 -15 repetitions) to shoulder, elbow, wrist, hand, hip, knee and ankle of sound lower limb and residual stump of amputated side. Flexibility exercise was provided (10-15repetitions) in the form of sustained stretching of hamstrings and quadriceps for below knee amputees and hip flexors, adductors and abductor for above knee amputee as required. Closed kinematic chain exercises to both upper limb (crutch muscles), resisted exercise using therabands for sound lower limb muscles, resisted exercise to hip flexors, extensors and abductors for above knee amputees using weighted cuffs were provided. In case of below knee amputees Resisted exercise for quadriceps and hamstrings was provided in addition using weighted cuffs. Balance training with Prosthesis on and off, gait training emphasising weight transfer, stepping and quality of gait retraining were also provided.

Group II received Aerobic exercises (AE) as a primary part of Cardiac Conditioning Exercises. There are many types of aerobic exercises that were performed at moderate levels for the study but for an extended period. The exercises incorporated a warm up period, followed a brisk 20 minutes of moderate exercise involving large muscle groups. The Warm-up included 3-5minutes of calisthenics in the form of Neck roll (frontal and sagittal plan movements), Trunk twist (rotation in sitting), active free exercise of all major joints of all three extremities and the residual limb, straight leg raising of lower extremity and residual limb in supine, supported heel raise, 3-5 minutes of stretches (with 5 repetition and 15-20 seconds of hold time). The muscles that were stretched included neck flexors, Shoulder and arm muscles, trunk muscles, Quadriceps, Hamstrings and calf muscle. Dynamic stump exercise was provided along with Circuit training using strengthening (duration – 15min, Repetition 8-12, sets 2-6), 30-60 degrees of squat, Dumbbell press in lying, Dumbbell latissimus dorsi pull down, modified pushups, leg raises with dead weights (unaffected limb). Endurance training was provided to the patients who were walking with prosthesis, for 15mins (60% - 70% of Vo2max) for a duration of 3-5 minutes. Tailoring was not needed as there were no reports of hypersensitivity or pain. No modification was required and performed to the protocol. • Stump strengthening exercise was provided to all the muscles of the stump using manual techniques on visit and using therabands, weight cuffs as a part of home routine. The frequency of exercise was advised for a period 4 days in a week for 15 weeks consisting of 60 minutes duration per session per day. The subjects were instructed not to rest for more than one day and not to exercise on three consecutive days. Example the subjects were given workouts on alternate days like Monday, Wednesday, Friday, Saturday/Sunday.

2.2 Outcome measures

The outcome measures were used at the baseline and at the end of the intervention period. The resting heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and perceived exertion rate (PER) was assessed using Borg’s perceived exertion rate. The blood pressure was taken using an aneroid sphygmomanometer. Adult cuff was used, the cuff was wrapped around the left arm with the lower edge one inch above the antecubital fossa.it was ensured that the inflatable bladder encircled at least 80% of the arm, but no more than 100% of it. The cuff was placed snugly and neatly onto the patient’s arm, 2cm above the brachial artery, the aneroid sphygmomanometer gauge was clipped to the cuff. To estimate the systolic pressure radial was palpated, the cuff was inflated and the reading was taken.
when the radial pulse disappeared. Then the cuff was deflated. Later the cuff was inflated to 30mmHg above the estimated systolic level, sufficient to occlude the brachial artery. The diaphragm of the stethoscope was gently over the brachial artery, the cuff was gradually deflated at a rate of 2-3mm/second, noting when the Korotkoff sounds appear (systolic) and disappear (diastolic) to the nearest 2mmHg, then cuff was deflated completely and the blood pressure was recorded in units of ‘mm Hg’. Three trails were done and the average was taken.

Later subjects were seated in conventional chair in the upright position with their legs and hips fixed. The arm crank ergometer’s height and fulcrum of the handle adjusted at shoulder of each participant. The arm was slightly bent at the elbow during farthest extension movements. Cycling speeds of 60 to 75 revolutions per minute was maintained. Exercise workload was determined and the test protocol was graded just like treadmill protocol the work load was increased every three minutes like modified Bruce protocol and the RPM was maintained until exhaustion or terminated after fifteen minutes, the subject was asked to rate their exertion on a subjective scale, their exertion rating was based on a 6 to 20 rating scale, this provides a fairly good estimate of your actual heart rate during physical activity.

Allocation concealment mechanism- the allocation details were kept in an opaque cover which was stapled and secured from opening to conceal the sequence until interventions were assigned. A physiotherapist who was not involved in the allocation or intervention delivery was used for outcome analysis. He was a post graduate with minimum 5 years of experience in handling the outcome measures. He was blinded to the intervention and groups to which the subjects belong. The details of the samples and the study procedure are displayed in flow chart 1.

2.3 Statistical analysis
Sigma plot was used for statistical analysis of the study. Shapiro-Wilk test performed to find the normality of the scores. Two Way Repeated Measures ANOVA (one factor repetition) was performed to assess the difference between the groups and the tests. Post Hoc analysis for pairwise comparison was performed using Bonferroni test. The study was done with a confidence interval of 95% and significance level of 0.05.

3. Results
The group wise distribution of age, sex, BMI, side of amputation, type of amputation and duration since surgery are presented in table 5.1. The Shapiro Wilk test done for the outcomes showed that there was a normal distribution as p <0.05 and Brown Forsythe was done to analyse the equality of group variances which was passed with p=0.681, p=0.175, p=0.463, p=0.643 for HR, SBP, DBP and PER respectively. Two Way Repeated Measures ANOVA (one factor repetition) was performed to assess the difference between the groups and the tests which showed that there was no significant difference between them with F value of 1.389 and p value of 0.244 for HR, F value of 0.724 and p value of 0.399 for SBP, F value of 1.583 and p value of 0.214 for DBP. In case of PER there was a significant difference with F value of 6.595 and p value of 0.013. The mean and SE are displayed in table 2 and the pairwise comparison is displayed in figure 1 and 2.
Table 1 – Group wise sample characteristics

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Group I (Mean ± SD)</th>
<th>Group II (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>42 (4.2)</td>
<td>43.4 (3.8)</td>
</tr>
<tr>
<td>Sex</td>
<td>Male – 19</td>
<td>Male – 21</td>
</tr>
<tr>
<td></td>
<td>Female – 6</td>
<td>Female – 4</td>
</tr>
<tr>
<td>Right – 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left – 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>27.2 (1.2)</td>
<td>27.8 (1.4)</td>
</tr>
<tr>
<td>Types</td>
<td>AK – 8</td>
<td>AK – 10</td>
</tr>
<tr>
<td></td>
<td>KD – 4</td>
<td>KD – 3</td>
</tr>
<tr>
<td></td>
<td>BK -13</td>
<td>BK -12</td>
</tr>
<tr>
<td>Duration after surgery</td>
<td>Months -2</td>
<td>Months -2</td>
</tr>
</tbody>
</table>

Table 2- Group wise performance of outcome measures

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Groups</th>
<th>Mean</th>
<th>SE</th>
<th>Statistical analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats/min)</td>
<td>Group 1-Pre-test</td>
<td>85.1</td>
<td>2.4</td>
<td>Given in figure 1</td>
</tr>
<tr>
<td></td>
<td>Group I- Post-test</td>
<td>82.4</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group II-Pre-test</td>
<td>90.0</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group II-Post-test</td>
<td>84.8</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>Group 1-Pre-test</td>
<td>127</td>
<td>2.2</td>
<td>Given in figure 2</td>
</tr>
<tr>
<td></td>
<td>Group I- Post-test</td>
<td>124</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group II-Pre-test</td>
<td>126</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group II-Post-test</td>
<td>121</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>Group 1-Pre-test</td>
<td>84.8</td>
<td>1.5</td>
<td>Given in figure 2</td>
</tr>
<tr>
<td></td>
<td>Group I- Post-test</td>
<td>83.4</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group II-Pre-test</td>
<td>8.8</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group II-Post-test</td>
<td>79.6</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Borg’s perceived exertion</td>
<td>Group 1-Pre-test</td>
<td>13.5</td>
<td>0.5</td>
<td>Given in figure 1</td>
</tr>
<tr>
<td></td>
<td>Group I- Post-test</td>
<td>12.3</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group II-Pre-test</td>
<td>13.6</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group II-Post-test</td>
<td>8.9</td>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1: Effectiveness of both interventions on heart rate and BORG of lower limb amputees.

Values are mean ± SE (n = 25 each) Con = group I; Exp = Group II.

The ‘F’ and ‘P’ values are by 2 way RM ANOVA with Bonferroni ‘t’ test for groups (control and experimental), tests (pre-test and post-test) and the interactions.

*aSignificantly different from the respective pre-test (within groups).

*bSignificantly different from the respective control group (between groups).
Figure 2: Effectiveness of both interventions on Blood pressure of lower limb amputees.

Values are mean + SE (n = 25 each) Con = group I; Exp = Group II.

The ‘F’ and ‘P’ values are by 2 way RM ANOVA with Bonferroni ‘t’ test for groups (control and experimental), tests (pre-test and post-test) and the interactions.

aSignificantly different from the respective pre-test (within groups).

bSignificantly different from the respective control group (between groups).
Flow chart 1 – The study procedure and sample recruitment chart

**SBP** – Systolic blood pressure, **DBP** – diastolic blood pressure and **PER** – perceived exertion rate
Discussion

We preferred lower limb amputation (above knee, trans-tibial and below knee amputations) than the upper limb because of two main reasons. The first being the proportion of circulation to lower limb is much greater than the upper limb and because of the differences in hydrostatic pressure exerted along the blood vessels when a person assumes erect posture. These parameters clearly explain blood vessels in leg are exposed to higher trans-mural pressures than arm vessels, which can keep increased demand in the myocardium. (Eiken O et al, 2004) hence we believed that loss of lower limb portion can cause a significant impact in cardiac muscle compared to upper limb amputation.

The second reason being, the increased incidence of myocardial disease among patients with lower limb amputation reported worldwide and the relatively increased mortality rates in lower limb amputees (Kaptein S, et al, 2017 and Seker A, et al, 2016) emphasized the need for a closer look into the scenario to understand what exactly happens to the internal and external construct of heart following lower limb amputation to plan for prophylactic measures.

Apart from these literature evidences, the primary researcher was working predominantly with lower limb amputation and has developed a set of hypothesis which was subjected to testing in this study. This study was conducted in the government hospital, the past records of which showed a proportion 1:11 for upper limb and lower limb amputation in the past 3 years. As this can significantly influence the study feasibility, the researcher preferred to go with the maximum prevalent condition for his research which is time bound as it was his doctoral work. However a similar analysis following upper limb amputation will be a major recommendation for future studies.

The study was a quasi-experimental study as random sample section was not performed; a consecutive sampling was only feasible in the research set up. To compensate for this a random allocation was done using a Physiotherapist (assessor 1) who had minimum 5 years of clinical experience in treating lower limb amputation, who was not related to the study and was not having any idea about the objective and expected outcome of the study. The age group was limited to 18 to 72 years because, there is literature that state that there are drastic changes in cardiac muscle after 7th to 8th decade of life. (Nicholas S et al, 1998). The myocardium gets matured at 18 years only, with its standard size and internal construct, following which there will not be a significant change in the dimensions. (Yuxuan, et al, 2020) Thus the age inclusion criterion was arrived at 18 to 72. There are no documented evidences that claim difference in cardiac remodelling among gender hence we didn’t prefer any particular sex.

The objective of the study was to understand and analyse the effect of conventional and cardiac conditioning exercises on the cardiac parameters in patients with lower extremity amputation due to traumatic causes. The analysis of cardiac parameter was performed by analysing heart rate, blood pressure, perceived exertion rate. The analysis of heart rate showed that groups were similar at the time of recruitment which clearly states that the difference that happens to the dependent variable is purely due to the independent variable. As the mean difference in both the groups is not too high there was no difference in the improvement gained in both the groups, yet both groups showed a significant improvement following the intervention.

This clearly explains that the cardiac conditioning exercises do not have an advantage compared to conventional exercises in the management of heart rate. The same have been proved in previous studies done by Pitetti KH et al, where heart rate has been decisively controlled by aerobic exercises. Aerobic exercises was proved not only to Facilitate
cardiovascular fitness but also improved the economy of walking among subject with amputation of unilateral or bilateral lower limb. (Pitetti, et al, 1987)

The analysis of blood pressure has shown the same trend similar to the heart rate. Though systolic and diastolic BP data showed a significant improvement in both the groups from homogeneity, the improvement gained was no different from each other. This can be explained by the fact that both heart rate and BP were in the near normal range in both the groups and hence a drastic change was not expected. The same study should be done on lower limb amputees with hypertensive and subjects with tachycardia to see the effectiveness of cardiac conditioning exercises in future. People performing prolonged exercise programs have shown a significant improvement in cardiovascular function. This is true in the case of healthy subjects and also among those with hypertension or cardiovascular risk factor (Haskell W, et al, 2007). Even among subjects over 70 years, similar to our study, exercise training can normalize or reduce systolic, diastolic, and median blood pressure. (Cononie C, et al, 1991). Most of the studies in the past have adopted 6 months of intervention to show a significant change in heart rate and BP, hence in the current study a long term follow up after 6 months may give a different scenario. We strongly feel that this improvement may even be delayed in case of lower limb amputees, for whom a long intervention period may be recommended in future.

Exertion during exercises has always been an issue with amputees that has reduced their exercise capacity and an apprehension to exercise. (Ward et al, 1995). The analysis of perceived exertion rate data of our study showed that subjects who were trained using cardiac conditioning exercises experienced less exertion compared to the conventional exercise group after intervention. But both the intervention has reduced the exertion rate significantly. There are many external factors that can influence the exertion rate, particularly the functional energy expenditure, psychological factors and so on. (Czerniecki et al, 2017) Hence we included RAND scale to analyse the quality of life of the study subjects.

Though the study deals with a novel research question, there are some minor unavoidable limitations as per the researcher. The first being the small sample size. The second limitation of the study is non-random sample selection from the population. As we were not able get access to large population we were unable to select samples randomly. The next possible limitation is the intervention duration which was less compared to the contemporary studies. But when comparing the similar results of the previous literature and the current study it can be very well said that this may not have an impact on the results. And finally the lack of long term follow up rendered the outcome of the rehabilitation incomplete.

Conclusion
This study concludes that both conventional and CCE can be an useful tool in normalising vital cardiac parameters like HR, BP, PER among traumatic lower limb amputees. However CCE can effectively reduce the PER compared to conventional exercise. Further the results needs to be objectively analysed using objective outcome tools like eco cardiogram for analysing the structural changes in the myocardium, further studies should concentrate on long term follow up for such intervention and repeat the study with more number of samples.

References


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