IV. RESULTS AND DISCUSSION

The findings pertaining to the study on **"Accessibility and Adaptability of Limb Prosthesis–An Ergonomic Concern"** are discussed under the following broad headings:

A. Feedback on the Investigatory Studies – Phase I and II

B. User Profile for Functional Capabilities

C. Rehabilitation – the Ergonomic Way

D. Comfort Zone Vs Prosthesis

E. SWOC Analysis on Prosthesis - Access and Adaptability

A. Feedback on the Investigatory Studies – Phase I and II

An investigatory study is a type of field survey where the required information from the concerned sector is obtained by investigating details about the particular sample using specific methods. According to Krishnaswami (1999) survey involves collection of data directly from the population or sample at a particular time. Survey is a 'fact-finding' study enabling gathering of evidences relating to certain social problems and social phenomena. It is a method of research involving collection of data directly from a population or a sample there of at a particular time (Verma, 1989). Hence this part of the findings of the study is discussed under:

1. **Details on Amputees Collected in Phase I**
2. **Micro - level Study on Amputees**

1. Details on Amputees Collected in Phase I

Collection of data on cases recorded about amputees over a specific period of time within a stated geographical area was found necessary; the findings of which are discussed under:

1.1. Empirical Data on Amputees

One of the arguments put forth while framing the study was that the locale selected for the study is overflowing with a different class of dependents (after elderly), the amputees. To support this argument, while framing the Plan and Procedure, secondary data from authentic sources regarding amputees over five consecutive years was collected. To that effect in 2013, as mentioned in the plan and procedure, **3726** cases had been recorded, among whom **3153** were male and **573** were female candidates. Follow up

study was conducted; the findings of which are presented as a combined data of the entire period of data collection under Table.

Table: 3 Empirical data on Amputees

Year of study	Total number of amputees		Gender wise number of amputees			
			Male		Female	
2009	1072		885		187	
2010	846		730		116	
2011	677		585		92	
2012	715		580		135	
2013	416		373		43	
Total	***3726***		***3153***		***573***	
Follow up study						
2014	388		351		37	
2015	540	**928**	468	**819**	72	**109**
Grand total	***4654***		***3972***		***682***	

Figure 16. Coimbatore District

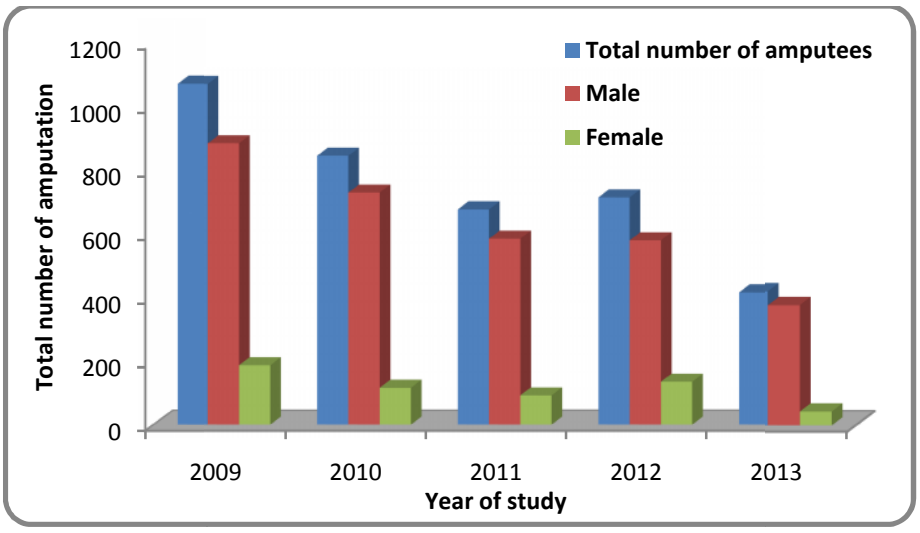


Chart -1. Empirical data on Amputees

Within a span of seven years the selected area has been forced to witness the plight of **4654** reported cases of amputees. The data was collected from a very small segment of the medical service providers (4 Hospitals, 3 Prosthetic centers). Sequel to the follow up study, by March 2015, the total statistic had risen by **928** additional amputees with **819** and **109** belonging to the gender stated respectively. This is quite an alarming statistic. This information is only pertaining to the small geographical locale considered for the study.

Coimbatore district shares (Figure 16) its borders with Tirupur -East and Nilgiris - North. A small portion of Erode district shares the border in the North East. As of 2011, Coimbatore district had a population of 3458045 with a sex-ratio of 1:1 with the geographic area of Coimbatore city enclosing 4850 km^2 (1,870 sq mi).

At the national level the number may be flabbergasting. It is time to wake up to the clarion call to find out the causes at the grass root level and curtail the same if the country should not face another crisis of shouldering the amputees – a particularly vulnerable class.

With this backdrop the Phase II section of the study was formulated. Hence this part of the findings of the study is discussed under.

2. Micro - level Study on Amputees

Permissible details maintained by the authentic sources as case history of recorded cases on amputees was collected after obtaining necessary ethical clearance (Exhibit-8) and ensuring confidentiality by the investigator personally under Phase II aspect of the study. The details are delineated under the following heads:

2.1. Details on Lower Limb Amputees

2.2. Profile of the Amputees using Prosthesis

2.1. Details on Lower Limb Amputees

Similar to phase I, collection of data on lower limb amputees was extended to cover till March 2015, as presented under Table 4

Table: 4. Details on Lower Limb Amputees

Year of study	Total number of lower limb amputees	Gender wise number of amputees			
		Male		Female	
2009	394	331		63	
2010	588	502		86	
2011	480	404		76	
2012	529	416		113	
2013	322	270		52	
Total	***2313***	***1923***		***390***	
Follow up study					
2014	273		225		37	
2015	396	**669**	346	**571**	72	**98**
Grand total	***2982***		***2494***		***488***	

During the planning phase there were **2313** lower limb amputees among whom **1923** and **390** were men and women respectively. Within the following two year span, the number had shot up to **2982** (**669** additional cases), among whom **2494** and **488** belonged to the two genders respectively.

This data projected another alarming statistic. From among the total amputees reported in 2015 (**4654**), more than **65 per cent** (**2982**) were **lower limb amputees**. This indeed is a very big challenge for any country. Considering the minimal topographical area covered for this micro level study, the magnitude of the problem can never be compromised. These facts albeit necessitated finding out the profile of the affected samples, especially those who had gone for an artificial limb – a prosthetic limb.

Follow up studies indicated that only **2182** samples had gone in for a prosthetic limb from among the **2982** reported to have undergone amputation. **Almost 800 (27%) had refused prosthetic limb during the initial stages itself – a finding which highlights on the poor awareness among the genre or the lack of accessibility to prosthesis in the early stages itself.** An overt observation revealed a genuine disinterest in procuring one for reasons obviously known to them, the samples.

2.2. Profile of the Amputees using Prosthesis : This aspect of the study is analyzed under the following headings:

2.2.1. Personal Details of the Sample

2.2.2. Causes of Amputation

2.2.3. Locus of Amputation

2.2.1. Personal Details of the Sample: This aspect of the study is explained through Table 5.

Table: 5 Personal Details of the Sample

Particulars	Details	*Number* (n= 2182)
Age Range (in years)	< 20	133
	21-40	660
	41-60	992
	> 61	397
Gender	Male	1872
	Female	310

The 41- 60 years group (45%), the backbone of a vibrant society ranked high among the victims who had gone in for prosthesis, followed by 21 – 40 years group reported by 30 per cent (660). The most vexing aspect was the 397 who were above 61 years of age and the 133 belonging to the adolescent category who, also were not spared from this predicament. One can see the dreams of a big generation falling to dust.

As found in the first phase of the study, male members predominated, recording approximately 86 per cent of the affected population.

Among the gainfully employed class, workers from the unorganized sector topped the list, followed by the salaried class (**949** and **475** respectively). A considerable proportion from the self employed category too featured (164). Among the non – earning group, students and homemakers ranked high. To be philosophical one can say that nobody is spared in the face of the fate. Unfortunately, can one afford to be philosophical on such a national issue? Naturally, it guided the focus of the study to find out the reasons for their plight.

2.2.2. Causes of Amputation: The following Table illustrates the causes for amputation for the concerned sample

Table: 6. Causes of Amputation

Major Causes	Particulars	*Number* (n= 2182)
Medical	Diabetes	552
	Gangrene	119
	TAO	56
	Infection	20
	Vascular	20
	Leprosy	10
Surgical	RTA	924
	Crush	364
	Machine Accident	56
	Avulsion	45
	Burn	16
	Train accidents	7
	Fracture	6
	Fall	3
Other	Cancer	16
	Congenital	14

The causes recorded for amputation was classified under three major etiological reasons, namely, medical (6 causes), surgical (8 causes) and others (congenital and

cancer). Surgical reasons with RTA and crush injuries (**924** and **364** respectively) were represented in a higher version, closely followed by diabetes and gangrene (**552** and **119**) as medical excuses. Comparatively, causes from other sources were reported in low key. Surgical reasons developed mainly from accidents and trauma therefore can be nailed as the prime reasons for amputation with diabetes and diabetes - induced gangrene falling close in line as medical reasons.

These findings give fool proof evidence that the populace have to be doubly careful – one primarily, not to fall prey to accidents and further trauma and secondly develop a healthy life style fighting against amputation related to medical grounds, where both 'caution' and 'attitude' have to be cherished as one's life time mantra.

2.2.3. Locus of Amputation: Table and Figure present the data pertaining to the sample's status.

Table: 7 Locus of Amputation

Locus of amputation	Number Responded
Transtibial (Below Knee)	1073
Transfemoral (Above Knee)	1022
Bilateral	87
Lateral Side	
Right	1197
Left	898
Bilateral	87

Bilateral Transfemoral Transtibial

Figure- 17. Types of Amputation

Cases with below knee amputation (1073), was found to be higher than above knee cases (1022) - a real blessing in disguise, with 87 reporting to have undergone bilateral amputation. It was pathetic to record 1197 to have lost the right limb vis – a vis, 898 who had lost their left. Of course, the bilateral suffered loss of both the legs. These factors project a very bleak picture of a contemporary generation which had lost a lifetime of normal living. Nevertheless, their efforts, willingness and audacity to go in for prosthesis to regain at least one small proportion of their missing appendage is laudable, commendable and appreciable.

The data obtained for the various attributes was studied for possible associations as stated in Table 18 applying Chi –Square analysis.

Table –8 Cause Vs Attribute studied

Pearson Chi-Square Tests			
Cause	**Value**	**df**	**Asymp. Sig. (2-sided)**
Sex	21.982[a]	11	.025
Age	50.695[a]	22	.000
Level	50.695[a]	22	.000
Side	50.695[a]	22	.000
Occupation	5.093E2[a]	99	.000
Pearson Chi-Square Tests			
Level and Side	2.182E3[a]	4	.000

The analysis showed that cause has strong association with age group, level, occupation and side (p-value is <0.01). But cause and sex of the amputee are not independent (p-value=0.025 <0.05). There is also strong association between level and side (p-value is <0.01).

Having found the data in detail about amputees, that too about lower limb amputees across a seven year duration, the study was streamlined to include an in – depth study of a sample of population who had currently (during the study period), opted to gear up their future with a fitted limb. To this extent **three Prosthetic Centers** popularly approached in the selected locale was chosen and the details regarding the clientele visiting the Centers thereof for prosthesis fitting were collected. On the whole there were **151 samples** among whom, only **142** had opted for prosthetic fitting. These 142 amputees formed the apt sample for the study. The details obtained are analyzed and discussed under the next section of the findings.

B. User Profile for functional Capabilities

Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity (http://www.iea.cc/whats/). Hence, this aspect of the study is discussed under the following heads:

1. **Prosthetic Prescription**
2. **Status – quo of the Amputees**

1. Prosthetic Prescription

Biomechanics and Biomechatronics play a vital role in prosthesis prescription. Biomechanics refers to the study of humans when moving, i.e., dynamic also referred to as functional (Noyes, 2001).Biomechatronics is an applied interdisciplinary science that aims to integrate mechanical elements, electronics and parts of biological organisms (https://en.wikipedia.org/wiki/Biomechatronics).Keeping these points in view, the study analyzed the role of prosthetists - the practitioners in these fields of science - in recommending 'prosthetic wear' to their clients, the samples of the study, in the proper sequence on the following lines:

1.1. Type of Prosthetic Limb Donned

1.2. Biomechanics of Transtibial Prosthesis

1.3. Biomechanics of Transfemoral Prosthesis

1.4. Prosthetic Requirements of the Bilateral

1.5. Type of Knee Prescribed

1.6. Type of Foot Prescribed

1.7. Alignment Techniques Practiced

1.1. Type of Prosthetic Limb Donned: Prosthetic limbs have two basic types of designs, exoskeletal and endoskeletal. Even though they provide many of the same functions, they are made very differently. **Exoskeletal** is defined as those structurally supported by an external frame. These Prostheses are of the older design with an outer plastic laminated skin or shell (Figure-18) and with wood or urethane foam interiors (Bean, 1998). **Endoskeletal** or modular (Figure-19) is defined as structurally supported by an internal pipe/pylon. Prosthesis is constructed from several modular components.

Figure-18 Exoskeleton

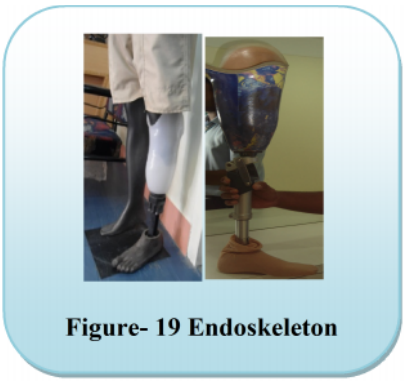


Figure- 19 Endoskeleton

The study revealed 51 per cent among transtibial patients and 28 per cent among transfemoral group to have been fitted with exoskeletal limbs. The below-knee prosthesis has been designed indigenously. The shank is fabricated from locally manufactured, durable, high-quality, high-density polyethylene pipes (HDPE). The socket design used is either total contact, which is vacuum-formed using a polypropylene sheet, or open-ended, using HDPE (Figure-20). This custom-made socket is fitted with the so called Jaipur Foot. A functional below-knee prosthesis looks like a normal limb, allowing for the range of movement required for normal human locomotion. The total contact socket provides better sensory feedback to the wearer and prevents edema. The sockets of above knee are of both ischial bearing and ischial containment types fabricated using HDPE. Rest of the samples had modular prosthesis sockets made of Polypropylene and Resin. The finished prosthesis had custom made socket, a knee joint, a shank section, a torque absorber and an ankle/foot unit. Modern prostheses consist of a variety of parts commonly referred to as components or **biomechatronics**. These components have modular or interchangeable connectors and other components such as knees and feet. The structural strength is from the central, skeleton-like components. The shape or cosmesis is external and removable, usually a soft, foam material covered with nylon hose or flexible, skin simulating, material (Miller, 1998)

Figure - 20 HDPE socket prosthesis

Both types of prostheses should be individually and dynamically aligned to the amputee; however, once constructed and finished, exoskeletal prostheses are permanently set, requiring significant effort and the actual cutting apart of the prosthesis to make changes. On the other hand, endoskeletal prostheses have the ability to be adjusted greatly after construction and finishing and are generally more adaptable to a changing amputee. They tend to be lighter in weight, offer more component options with more adjustability, but the cosmesis is less durable and sometimes they cost more. This is on par with the findings of Schuch (2014).

1.2. Biomechanics of Transtibial Prosthesis

Browsing through vast literature enlightened the investigator on the significance of two different biomechanical elements found imperative in fitting the prosthetic on an

amputee. They are the socket and the suspension. Variations in the type and designs of sockets and suspensions was noticed (explained in the Review of Literature too) as available with the sample prosthetists who designed the prosthesis for the selected sample.

The study group was the same 142 amputees who had gone in for prosthesis among whom 89 per cent - 59 and 30 per cent were Transtibial and transfemoral (unilateral) respectively and 11 per cent were bilateral. Hence this part of the study discusses the findings of the study on:

1.2.1. Transtibial Prosthesis Prescribed: This aspect of the study analyzes the fitment details entailed with prescribing transtibial prosthesis under:

- **Transtibial Sockets Donned**
- **Transtibial Suspension Fitted**

Transtibial Sockets Donned: Table and Figure (9) and (21) enlightens on the concerned topic

Table: 9. Transtibial Sockets Donned

Type of socket	Options available	Prosthetists (Centers) represented			
		Percent responding			
		1 (n=43)	2 (n=32)	3 (n=9)	
Patellar Tendon Bearing Socket (PTB socket)	Silicone Suction Socket (SSS)	-	91	89	 Figure -21 TT socket
	Suction socket (SS)	-	9	11	
	Total Contact (TC)	100	-	-	

An important factor that surfaced was that totally there had been 84 samples with transtibial amputation (during the study period) among whom 51 per cent had preferred to approach Center 1 for their prosthetic needs followed by 38 per cent who preferred Center 2. Obviously the rest went to the third Center. **Among the three Centers approached the third one was less accessed.**

It was evident that the latter two groups preferred SSS type as represented by almost 90 per cent each of them, while the first prosthetist had suggested the total content socket for obvious reasons. The material used, cost of the human –machine unit including fabrication and /or affordability of the sample users could be attributed as reasons.

Further enquiry revealed the TC socket to be the least expensive and the ones fabricated for distribution by Philanthropists either free of cost or on a nominal price to needy people. Silicone suction socket found to be the most expensive was prescribed by the other two prosthetists, though they had also given an option in the other type called SS. These facts make two important points very clear. One, the latter two Centers are run by high tech entrepreneurs and secondly they catered to the specific, sophisticated needs of an affordable clientele. The first Center essentially emerged as the one set by a freelancer (a trained technical person), who fabricated prosthesis for the needy who attended camps organized by philanthropists.

Socket is the part of prosthesis that encloses the stump and forms union between stump and artificial limb. There are five types of socket –conventional, (PTB) Patellar tendon bearing, (SCSP)-Patellar tendon bearing supracondylar suprapatellar socket, bent knee socket and Slip socket. Patellar tendon bearing socket is made of HDPE over a mold of the stump and is kept in 5 to 10 of knee flexion. Three types of sockets were in vogue, namely, Silicone Suction Suspension (SSS), Suction Socket (SS) and Total Contact (TC) under Transtibial Patellar Tendon Bearing Socket (PTB socket). 60 per cent of weight is taken by patellar tendon and 40 per cent by medial tibial flare (Sekar et al., 2010).

ᔓ **Transtibial Suspension Fitted**: The following Table (10) and Figure (22) projects details on the type of suspension fitted by prosthetists to the sample donned with sockets.

Table: 10 Transtibial Suspension Fitted

Type of suspension	Options available	Prosthetists (Centers) represented		
		Percent responding		
		1 (n=43)	**2** (n=32)	**3** (n=9)
Transtibial suspension	Cuff suspension strap/ sleeve	70	78	78
	Waist belt	2	3	11
	Thigh corset	28	19	11

With regard to options given for suspension the prosthetists were not found to differ much. The cuff suspension strap or sleeve was the maximum prescribed one, followed by the thigh corset. Here again the third center tended to showcase a tendency to equally patronize waist and thigh corset, while the first two preferred the thigh corset more. The appropriate suspension system results in safe and well functioning lower extremity prosthesis. Residual limb length, joint ligament stability, and limb volume determine suspension methods. Also activity level, dexterity, success of previous

suspension, and cosmetic requirements were considered in prescribing one. These facts highlight two aspects that gain significance in prosthetic fitting:

- ***The extent of support needed to don the socket such that it can be retained in place by the wearer which is purely an individualistic concept differed from one to the other and is a crucial factor***
- ***The etiology of amputation which lays individualistic constraints in fitting the prosthesis is another.***

Multiple factors and patient preference should be considered when prescribing suspension systems for lower extremity prostheses, cautions Kapp (1999).

The system used to attach prosthesis is called a ***suspension system***. There are several types of suspension systems currently in use, and the choice of which to use is often based on the specifics of the user's residual limb and lifestyle

Thigh Corset

Cuff Suspension

Waist Belt

Figure: 22. Options for Transtibial Suspension

1.3. Biomechanics of Transfemoral Prosthesis

Among the total sample studied 30 per cent were transfemoral amputees (unilateral). Details on the type of prosthesis prescribed by the Centers are explained under:

Figure: 23 TF Socket

1.3.1. Transfemoral Prosthesis Prescribed: As is expected the sockets and suspension provided for this group was entirely different from those provided for their counterparts. Hence this part of the study analyzed the matter in terms of the following:

- **Transfemoral Sockets Donned**
- **Transfemoral Suspension Fitted**

Transfemoral Sockets Donned: Table 11 explains the aspect under consideration

Table: 11 Transfemoral Sockets Donned

Type of socket	Options available	Prosthetists (Centers) represented		
		Percent responding		
		1 (n=12)	**2** (n=5)	**3** (n=26)
Transfemoral socket	Quadrilateral socket	**25**	**-**	**23**
	Ischial Containment	**75**	**100**	**87**

Figure: 24 Quadrilateral and Ischial containment socket

The survey revealed two types of transfemoral sockets to be used by the sample Centers, namely, quadrilateral and ischial containment sockets (Figure-24). Between the two the latter was found to be well recognized as even the first Center which fabricates the basic module (conventional type of prosthesis) was even found to be using them for three fourths of their sample. The second Center was found to resort entirely on this type of socket. Another type called quadrilateral socket was prescribed by 25 and 23 per cent of the first and third Centers respectively. Evidently the reasons can be attributed to the quality variations, functional requirements (based on amputee status), material differences and above all amputee preferences.

Another important feature was that despite availability of the sockets from the first Center, which may be accessed at a comparatively lesser cost or free of cost as the case may be, it was found that a majority of 60 per cent from among the 43 reported as transfemoral (above knee) amputees to have approached the third Center. Whether to pin the preference to quality in product preferred, to affordability or to an attitude of neglect (among those groups in the socio economically weaker section) due to reasons best known to them is a big question that looms in the forefront.

ᘓ **Transfemoral Suspension Fitted:** This aspect of the findings is explained under Table 12 and Figure 25.

Table: 12 Transfemoral Suspension Fitted

Type of suspension	Options available	Prosthetists (Centers) represented		
		Percent responding		
		1 (n=12)	**2** (n=5)	**3** (n=26)
Trans Femoral Suspension	Pelvic band/ belt	17	20	15
	Total elastic	83	80	85

There are many types of above knee prostheses. The type that an amputee is fit with depends on the shape of the residual limb, the length of the residual limb, activity level, prognosis, and individual preference. Transfemoral (above Knee) amputee is unable to bear weight on the bottom of his/her residual limb. In order to keep the weight off the bottom of the limb, the amputee must support his body weight on the ischial tuberosity (seat bone), the soft tissue of the limb, and the gluteal tissues.

Unlike wide choice discretion exhibited by the selected Centers for transtibial sockets/ suspensions, opinion of the three Centers on prescribing transfemoral sockets was found to run in unison. A majority had opted for total elastic suspension, probably the one which could give maximum user comfort for the amputees. As transfemoral amputees have exclusive requirements warranted by their anatomical disparities, it could also be argued that they are most preferred to render support on those lines.

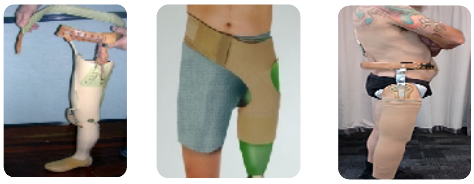


Figure –25 Options for suspension

Pelvic belt is very easy to don for people whose balance is poor. It is also appropriate for people with short residual limbs, because it controls rotation and provides excellent medial-lateral stability (http://moon.ouhsc.edu/dthompso/gait/Pobmk/aksusp.htm).

Total Elastic Suspension belt holds the prosthesis on the user by wrapping around the waist from the front of the socket to the back of the socket. Typically, this is suited for a prosthetic user who is unable to wear either the suction or silicone suction suspension. This is best for a person who needs an additional suspension or rotational control. The belt is made of webbing or elastic material (http://www.aoptinc.com/PDF/Above%20Knee%20Prostheses.pdf)

1.4. Prosthetic Requirements of the Bilateral

If prescribing and donning above or below knee amputees poses a difficult task, it would be all the more difficult to handle the requirements of the bilateral group exhibiting four varied anatomical conditions namely, as given in the following Table:

Figure 26
Bilateral Amputee

Table: 13 Plight of the Bilateral Amputee

Type	Side of body undergone amputation	
	Left	Right
1	Transfemoral (above knee)	Trans femoral
2	Transtibial (below knee)	Trans tibial
3	Transfemoral	Trans tibial
4	Transtibial	Transfemoral

Prescribing a proper fit in prosthetics for the bilateral amputees evidently is a challenging one as anatomical, physiological and biomechanical aspects have to put forth interplay of distinct roles in perfect coordination. Obviously the data obtained regarding prosthesis prescribed for this group is collated under the Table that follows

1.4.1 Types of Sockets Prescribed for Bilateral: This aspect of the study is explained under Table 14 and Figure 27

Table: 14 Bilateral Sockets Donned

Particulars		Prosthetists (Centers) represented							
		Percent responding (n=15)							
		1 (n=55)		2 (n=37)		3 (n=50)			
Bilateral		Percent responding (n=15)							
Options available		TF/TF		TT/TT		TF/TT		TT/TF	
Transtibial PTB	Silicone Suction Suspension	-	-	13	17	-	10	3	-
	Suction socket	-	-	3	-	-	-	13	-
Transfemoral	Quadrilateral Socket	-	-	-	-	3	-	-	-
	Ischial Containment	7	7	-	-	7	-	-	17

Figure: 27

The findings revealed 15 samples with both the limbs amputated. As good as 13 per cent of them had chosen the SSS socket for their limbs, a few had opted for suction socket. Individualistic differences in terms of residual limb and stump had forced them to go in for different sockets for their left and right limbs. Similarly, Ischial containment socket, the most advanced pattern, was the one preferred by maximum numbers. It is evident from the study that the samples were quite aware of their requirements. Another feature noticed was that **only the third center was approached for this dual requirement**.

1.4.2 Suspension Prescribed for Bilateral: Table given below pictures the data on the same.

Table: 15. Suspension Prescribed for Bilateral

Particulars		Prosthetists (Centers) represented							
		Percent responding (n=15)							
		TF/TF		TT/TT		TF/TT		TT/TF	
Transtibial Suspension	Cuff Suspension strap/sleeve	-	-	7	17		3	17	-
	Waist belt	-	-	10	-	-	3	-	-
Transfemoral Suspension	Thigh Corset		-	-	-	-	3	-	-
	Pelvic band/Belt	3	-	-	-	7	-	-	-
	Silesian bandage	3	-	-	-	-	-	-	
	Total elastic	-	7	-	-	3	-	-	17

Preference for two types of suspension for the transtibial amputees and four types of suspension for the other group came to light. As with sockets, the samples were found to have donned different suspensions for each limb based on the residual limb length, and limb volume. Their physical activity determined suspension methods demanded. All these factors deliver that ample research and development activities happen before the parts reach the consumer.

1.5. Type of Knee Prescribed : This aspect of the study is explained in the following Table

Table: 16 Type of Knee Prescribed

Type of Knee fitted	Options available	Prosthetists (Centers) represented		
		Percent responding		
		1 (n=12)	**2** (n=5)	**3** (n=26)
Transfemoral Prosthesis	Crustacean /Conventional	100	-	-
	Modular	-	100	100

Various types of knee joints were fitted in the modular prosthesis by the selected three prosthetist Centers. In the prosthetist Centre -1, prosthesis provided to the users were Crustacean type because it is composed of a shell that replicates the external shape of the limb, and eventually contains functional components inside. Where two or more segments of a limb are substituted, the corresponding shells are joined by hinges or other connecting mechanisms (IRMA, 2013).

Prosthetist Centers 2 and 3 were providers of modular prostheses. Hence the knee provided to their customers was modular knee which is vital to the overall performance of prosthesis (Exhibit-9 and 10). During stance phase knee stability is the key, and the knee must not buckle at heel strike. During swing phase, the motion of the prosthetic lower leg must be controlled. Prosthetic knees can be categorized as single axis or polycentric. The single axis knee is a simple, low maintenance hinge design generally lightweight and low profile. The other knees provided at the Centers were polycentric; cadence control knees like pneumatic/hydraulic/Magnet/orheologic and microprocessor knee and motorized knee. Kapp and Miller (2010) have also spoken about additional knee features like - stance flexion and geometric lock. Older prosthesis users with lower mobility required a higher degree of knee stability. Easy handling and wearing comfort were more important than dynamic function. The knee joint and prosthetic feet being viewed as one functional unit; these components must therefore work in harmony with each other and so were tested to ensure the best function possible

Figure:28 Crustacean Knee

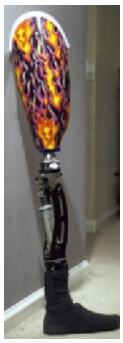


Figure: 29 Modular Knee

If the above-knee amputee is to have a normal appearance while walking, the prosthesis must have a knee joint that will not buckle as he rolls over the artificial foot during the stance phase of walking. The simplest way to achieve this is to use mechanical friction about a bolt that connects the socket (thigh) to the shank. The bolt is located behind the path of the weight of the body to the floor so that it will not buckle when the user is standing straight. The mechanical friction, which may be a simple adjustable brake, keeps the shank from swinging forward too fast as the user swings the artificial leg through to the next step. The chief limitation in the single-axis, constant friction design is that appearance is normal at only one speed of walking for a given setting of friction, the amputee must be very careful in walking, especially on uneven surfaces, to avoid stumbling. A great deal of effort has been spent over the years developing knee systems which overcome the limitations of the single-axis, constant friction knee. Many designers have been successful to some degree, but because of the simplicity of the constant friction design, no new system has totally displaced it.

Prosthetic knee stability with a single axis knee relies heavily on alignment of the knee in relation to the socket and foot, and on the volitional control of the patient. The single axis design is coupled with constant friction, fluid, and microprocessor or powered stride control features. It is used for any level of patient ability The selection of the appropriate mechanically or electronically controlled knee joint is based on the patient's amputation level, the condition of the residual limb, their activity level and health, their weight as well as his/her surrounding environment and living conditions

1.6 Type of Foot Prescribed: This aspect of the study is explained in the Table given below

Table: 17 Type of Foot Prescribed

Type of foot fitted	Options available	Prosthetists (Centers) represented		
		Percent responding		
		1 (n=12)	**2** (n=5)	**3** (n=26)
Transfemoral and Transtibial Prosthesis	Jaipur Foot	100	-	-
	Modular Foot	-	100	100

A variety of artificial foot designs are available, each having its advantages and disadvantages. Feet currently available can be divided into two classes: articulated -those with moving joints, and non-articulated. Those with moving joints generally require more maintenance and are slightly heavier than most of the non-articulated kind. An articulated foot includes single-axis foot and multi-axis foot; non-articulated foot- SACH foot (http://www.oandp.com/resources/patientinfo/manuals/ak10.htm).

The prosthetist Centre -1 provided their prosthesis with Jaipur Foot that is made of polyurethane, and is superior to its SACH mainly in the range of movements it offers. The articulation at the 'ankle' allows not only inversion-eversion movements but also dorsiflexion (essential for squatting, standing up from prone position, etc.) and a shorter keel helps achieve this. Also, the materials used at the foot-end are waterproof and they moderately mimic a real foot.

In the other two prosthetist Centers the foot was selected based on the individual's activity level, age and requirements. The Dynamic Motion foot is fitted for people with transtibial, transfemoral amputation with a low to moderate level of activity, and who require a foot with comfortable heel strike, physiological rollover, and good energy return.

Carbon feet is prescribed for amputees who walk at various speeds, run, and young customers who wished to climb hills or descending stairs with a secured feeling. Greissinger Plus was designed to imitate the multiaxial function of the human foot so that it more easily adjusts to uneven surfaces. The foot also provides flexibility for pronation, supination and rotation. Type of SACH (Solid Ankle Cushion Heel) feet, provides the user a comfortable and safe heel strike. They are therefore most suitable for less active individuals requiring a high level of safety. In addition, SACH plus feet appear similar to natural feet and are inconspicuous during daily use due to their smooth surface, an abducted large toe and shaped toes. This foot is provided for amputees with a low-activity level.

Jaipur Foot

Modular Feet

Figure: 30 Jaipur Foot and Modular Feet

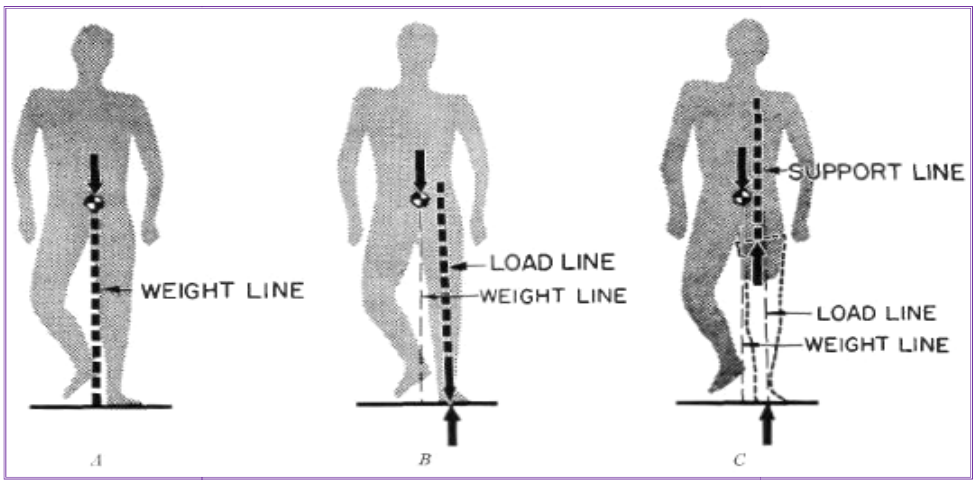
The steps practiced in prescribing prosthesis follows this sequence, choice of type (exoskeletal or endoskeletal), socket, suspension (based on transfemoral, transtibial), knee and foot. After deciding on these and once when the fabrication is completed, the samples are donned with the prosthesis to prepare them for the next stage- a very important stage- which determines the success of the prosthesis that is their ability to walk/ ambulate -called alignment.

1.6. Alignment Techniques Practiced

Alignment of prosthesis is defined as the position of the socket relative to the other prosthetic components of the limb (Zahedi et al., 1984). It refers to the spatial relationship between the prosthetic socket and foot. The main purpose of alignment is to position the prosthetic socket with respect to the foot so that undesirable patterns of force

applied to the residual limb are avoided. A second purpose is to produce a normal pattern of gait (Bowker et al., 2002). Figure (31) below and the Box explains the significance.

If an acceptable alignment of lower-limb prosthesis cannot be achieved, the limb may be rejected by the wearer. Often the patient complains of discomfort or pain associated with the socket when in fact the alignment of the prosthesis is the root cause. On supply of a new prosthesis, the patient is often aware that, not only is the socket different, but the alignment is also different ; this occasionally causes the amputee to consider the new prosthesis as inferior to the old one. Failure to provide a satisfactory alignment may result in problems for the amputee, such as difficulty in walking, stump pain, or tissue breakdown. It is therefore important to make every endeavor to provide an acceptable alignment to the patient on every occasion that the need arises and that the alignment arrived at be the "optimum alignment" (Zahedi et al., 1984).

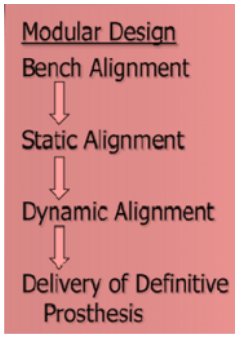


A: The "*center of gravity"* of the body is a point at which all *body weight* can be assumed to be *concentrated*. The effective body weight passes through the center of gravity and acts vertically downward along the "weight line."

B: The *"load line"* is a line along which the *force between the foot and the floor acts*. In general, it is not perpendicular to the floor surface, since this force has two effects. First, it *supports the body weight in a vertical direction,* and second, it provides the *horizontal forces* necessary to cause *motion of the body in the forward and medial directions*.

C: The *"support line"* is a vertical line along which the effective supporting force exerted *between the rim of the socket and the stump of the amputee is assumed to act*. In general, the support line does not pass through the center of gravity or through the center of foot pressure (http://www.oandplibrary.org/al/1955_01_035.asp

The study revealed the prosthetists in the selected Centers to be practicing three different techniques for aligning the socket to foot fit before finalizing the prosthesis prescribed for every client (here, the selected sample). The findings revealed the first Center to be practicing only Bench alignment, while the other two Centers practiced all the three types on their samples at different times.



They are:

1.7.1 Bench alignment

1.7.2 Static alignment

1.7.3 Dynamic alignment

1.7.1 Bench Alignment:

Prosthesis is so aligned, as it has been for a great many years, by the simple expedient of "aligning by eye" in the Prosthetists Centre -1 (that is, simply by trial and error and by observation of the static and dynamic ambulatory behavior of the amputee-prosthesis combination). A single line plumb line is used to visually match two identified points, one point on the socket and another on the ankle bolt when viewed from the patient's lateral side and on the center of the heel when viewed from the patient's dorsal side. This single-line plumb line approach allowed the prosthetist to view the alignment from slightly varied angles. The plumb line falls from the patellar tendon to the ankle to meet the line extending from the second toe. Bench alignment (Figure 32) is performed prior to an initial fitting which served as a starting point for the patient to bear weight. Bench alignment is conducted according to information from the patient's previous prosthesis alignment as well as a prosthetists general knowledge about prostheses.

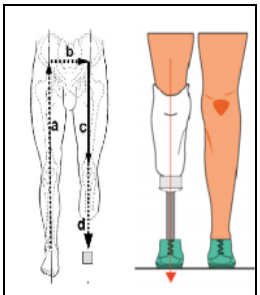


Figure: 32 Bench alignment

The other two Prosthetist Centers possessed the L.A.S.A.R. Assembly that is designed for bench alignment of modular lower limb prostheses (Floor model 743L200/20 and as a Bench Top model 743L300/30). In sagittal and frontal views, three laser lines are projected medially, laterally and anteriorly on the prosthesis as alignment reference lines. For the three-dimensional alignment of modular lower limb prosthesis, the knee joint was fixed in the apparatus, while the prosthetic foot, other prosthetic components

and socket were mounted in accordance with the alignment recommendations. The knee joint was fixed with joint-specific brackets (adapter inserts) at the alignment reference point (single axis joints = rotation axis; polycentric joints= anterior upper axis).

The recommended position of the alignment reference point was 20 mm above the medial tibial plateau. The socket was positioned so that its sagittal proximal center coincided with the alignment reference line. The socket flexion was set to a 3-5 degree angle, though it varied in different situations (e.g. in the case of hip joint contractures). The center of the foot was normally placed 30 mm in front of the alignment reference line and mounted with plantar flexion. They added 5 mm to the effective heel height. The outer position of the foot was adjusted freely. The frontal alignment was based on the anterior projection of the laser beam. Many additional factors other than the purely geometrical relationship of the components also had to be considered for the above-knee patient like their age and ability, both physical and mental condition, length and muscle power of the stump and the type of knee mechanism employed. Thus bench alignment itself differed among the sample prosthetist.

1.7.2 Static Alignment

Static alignment is the condition of the machinery at rest. This process of alignment is adopted by the Prosthetist Centers 2 and 3, where modular prosthesis was being fitted to the amputees. The L.A.S.A.R. Posture (743L100) was used to optimize the static alignment of modular limb prosthesis during trial fitting, as it helped to visualize the position of the body´s center of gravity line, or load line while standing. The procedure is given in the box and Figure (34).

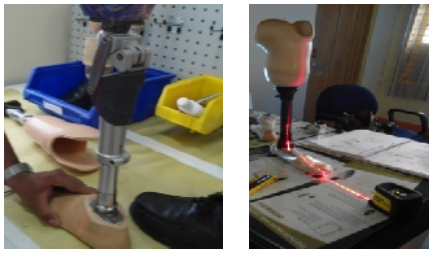


Figure: 33 Static alignment

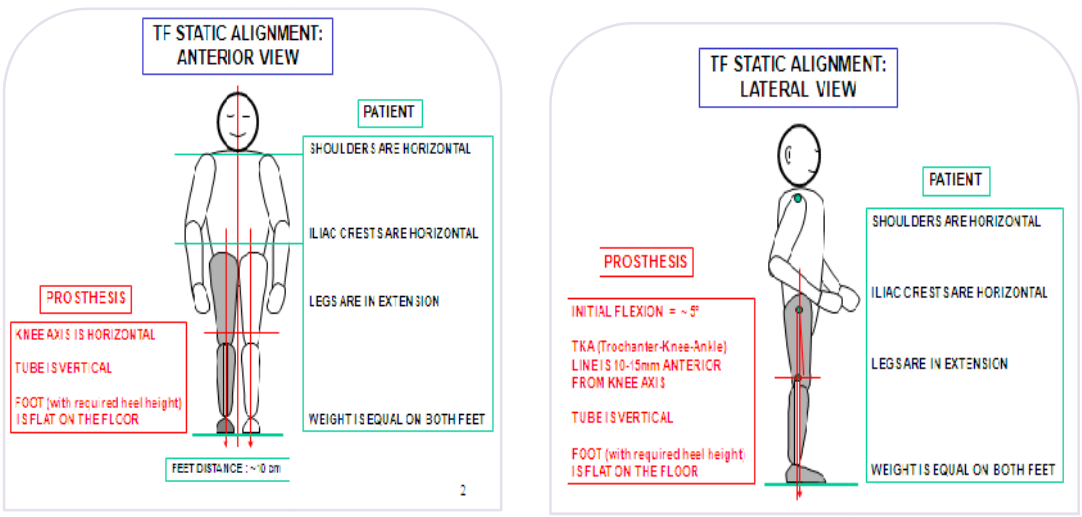


Figure: 34 Static Alignment with patient

To measure the load line, the amputee steps onto the force sensor platform and places his/her contralateral leg on the leveling step plate. A laser projects the measured ground reaction force as the body´s center of gravity line/load line on the body. Classification of the body posture in the sagittal plane is visualized by comparing the distances between the ground reaction force and joint points or body points. The alignment of the prosthesis is then optimized based on this load line. The transfemoral prosthesis is adjusted in relation to the knee. When force is transferred correctly between the socket and the residual limb, particularly in the proximal region, the distance between the knee and the load line was adjusted through appropriate plantar flexion only. Finally, dynamic optimization takes place between parallel bars.

1.7.3 Dynamic Alignment

Dynamic alignment is the condition of the machinery during sustained operation. This process of alignment was adopted by the Prosthetist Centre -2 and 3, where modular prosthesis was fitted to the amputees. Dynamic alignment begins when the coupling is reassembled and "locked" in the neutral position. This procedure (Figure 35) ordinarily followed a fixed sequence, making the linear adjustments first and the tilt adjustments second.

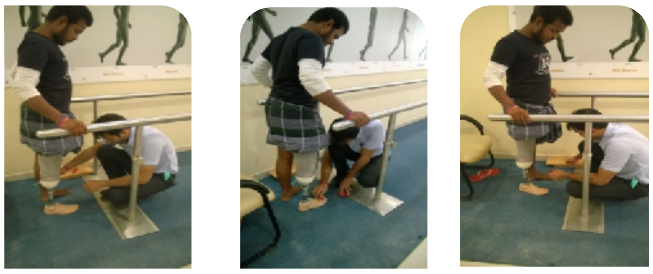


Figure: 35 Dynamic Alignment done

Procedure adopted:

Figure: 36 Dynamic Alignment adjustments

- With the amputee seated, the two front tilt screws were loosened and anteroposterior adjustment was made. The two front screws were tightened.
- With the amputee seated, the two front tilt screws were loosened and mediolateral adjustments were made. The two front screws were tightened.
- With the amputee standing, tilt adjustment was provided by turning down one of the two tilt screws on the side to be depressed (The screw was turned down only as far as needed for the angular adjustment desired). Then the screw was tightened till it was diagonally opposite to establish the desired angular adjustment. Next (the same amount) the second screw was loosened on the side to be depressed and later tightened diagonally" opposite to complete the angular adjustment and to "lock" the coupling (Figure: 36)

Rotation was established or reestablished before the screws were completely tightened in any of the above three adjustments. The rotation scale reading was recorded before making any adjustment so that the position of rotation was readily restored.

These facts enabled to understand the precision involved in getting prosthesis, sequence followed from anthropometric variables to fabrication and fitting and the challenge taken by the prosthetist team to see that their patients successfully ambulate in a job of social-relevance and responsibility. The ensuing chapter focuses on how the beneficiaries had taken it in their stride.

2. Status – quo of the Amputees

Understanding how the selected sample accepted a revival in their life styles sequel to prosthesis fitting was found necessary. Hence, this part of the study is discussed

under the following scores, by way of which the sample's status on relevant aspects are brought to light.

2.1. Socio – economic Profile
2.2. Details on Amputation
2.3. Adaptation to Domain – Specific Activities

2.1 Socio – economic Profile

This aspect of the study is explained under:

2.1.1. Personal Details

2.1.2. Livelihood attributes

2.1.1. Personal Details: Table 18 presents details on the same

Table: 18 Personal Details

Particulars	Personal Details			*Percent responding n=142*
Age Range* (in years)	< 20			7
	21-40			37
	41-60			43
	> 61			13
Gender	Male			86
	Female			14
Marital Status	Married and living with spouse			51
	Widow/Widower			10
	Divorcee			12
	Single	Adolescent	26%	27
		Adult	74%	
Education	Literate	Graduate (n=45)	36%	89
		High School (n=45)	36%	
		Primary school (n=36)	28%	

*(Stages: Adolescent: 12-18 years; Young adult hood: 19-40 years; Middle adulthood- 40-65 years; Maturity-65-Death. Erikson's Stages of Psychological Development (1963)

The study revealed a maximum of 43 per cent to be in the productive age range between 41-60 years followed by those in the young adulthood (37%) while a minimum of seven per cent fell in their prime age (age range below 20 years). Thirteen per cent were senior citizens. A majority of 80 per cent unfortunately were the victims of impairment at an age anybody would wish to be enthusiastic, energetic and proactive.

Among the group surveyed a greater proportion (86%) belonged to the male gender. However, the weaker sex too was not spared as is evident from the 14 percent who were amputees. Considering the marital status of the samples the study made evident 73 per cent to be married among whom only 51 per cent lived with their spouse. A minority of ten and twelve per cent were either widowed/ widower or divorcees respectively. Among the 27 per cent who were reportedly single, adults predominated. These facts bring to light the proportion of samples those who had landed themselves into a pitiable situation, namely "dependents".

It was disheartening to record a good 11 percent to be illiterates among the selected samples. Among those who were educated 36 per cent were graduates, while 36 per cent who had completed high school followed. Almost 28 per cent had done only up to primary school. Education wise the samples were not found to be very satisfactory. The personal parameters revealed the heterogeneity of the samples.

2.1.2. Livelihood Attributes: Information pertaining to this aspect of the study is presented under Table 19.

Table: 19 Livelihood Attributes

Particulars	**Details**			***Percent responding* n=142**
Employment	Employed	Business (n=36)	43%	58
		Salaried (n=27)	33%	
		Professional (n=20)	24%	
	Not gainfully employed	Jobless (n=15)	26%	42
		Student (n=22)	37%	
		House wife (n=9)	15%	
		Retired (n=13)	22%	
Income of the family /month in ₹	Below 10, 000			22
	10,000-25,000			34
	25,000- 45,000			27
	Above 45,000			17

Among the samples studied 58 per cent were gainfully employed, where samples indulged in business were higher (43%) followed by the salaried class (33%). Professionals were comparatively less (24%). Nevertheless among the group who were not gainfully employed (42 %), 37 per cent were students, 22 per cent were retired, and 15 per cent were housewives. A negligible populace of 26 per cent was jobless. These

facts made it clear that approximately only 60 per cent belonged to the earning class. Except for the 22 per cent who earned below ₹ 10,000 per month, all others were found to be comparatively sound financially. An amputee's requirement necessarily warrants appreciable financial commitments. The findings to a certain extent support such assumptions.

2.2. Details on Amputation

By default, all the samples chosen for the study happened to be amputees. The site of amputation was found to differ from one another. Hence, data collected in this connection is detailed under:

2.2.1. Locus of Amputation
2.2.2. Etiology of Amputation
2.2.3. Duration of Disability

2.2.1. Locus of Amputation: Details pertaining to this aspect of the study are discussed under Table 20

Table: 20 Locus of Amputation

Particulars		***Percent Responding* (n =142)**			
		Locus of Amputation			
		Transfemoral n=43 (30%)	Transtibial n=84 (59%)	Bilateral n=15 (11%)	
Gender	Male	91	87	67	
	Female	9	13	33	
Age	< 20	2	8	13	
	21-40	28	40	47	
	41-60	49	42	33	
	< 61	21	10	7	
Lateral Side	Right	72	68	-	
	Left	28	32	-	
	Bilateral	Right		TF/TT	33
		Left		TF/TF	21
		Both		TF/TF	13
				TT/TT	33

As regards status of amputation, more than one half of the samples (59%) were reportedly **Transtibial** (below knee) as against 30 per cent who underwent **Transfemoral** (above knee) amputations. Rest of them, unfortunately had incurred loss of both the lower limbs (**bilateral**). Gender wise men outnumbered women in impairment. Ironically equal half with bilateral amputation was women.

Age groups maximum represented by both Transfemoral and Transtibial was at 80 years (a very problematic range for adjustment) as against the next group in the 21-40 years range (age range with futuristic dreams). Representations in all the three groups from the budding adolescent and senior citizens (about one fifth of the sample) was quite an alarming statistic. Again bilateral among the 21-40 age groups was also depressing. These findings highlight the presence of a section of the vibrant population forced into rehabilitation within a small geographical area. A majority of 72 and 68 per cent among those with Transfemoral and Transtibial amputation respectively had lost their right limbs while the rest evidently had a severed left limb. Among bilateral an equal proportion (33% each) endured bilateral transfemoral/transtibial and bilateral transtibial amputation respectively; the former being the most affected lot.

2.2.2. Etiology of Amputation: Etiology is the study of all factors that may be involved in the development of a disease, including the susceptibility of the patient, the nature of the disease agent, and the way in which the patient's body is invaded by the agent (http://www.medicinenet.com/script/main/art.asp?articlekey=2166).This aspect of the study is explained under Table 21

Table: 21 Etiology of Amputation

Particulars		**Percent responding (n=142)**					
		Major causes					
		Medical		**Surgical**		**Others**	
		Peripheral Vascular disease		*Accidents*		*Congenital*	*Malignancy*
		DM*	TAO**	Crush injury	Avulsion injury		
Total under each cause		n-33 (23%)	n- 24 (17%)	n-51 (36%)	n-27 (19%)	n-2 (1%)	n-5 (4%)
Gender	Male	79	100	88	81	100	60
	Female	21	-	12	19	-	40
Age (in Years)	<20	-	-	8	15	100	-
	21-40	-	4	59	70	-	60
	41-60	85	42	33	15	-	40
	>61	15	54	-	-	-	-
Level	TF	33	45	24	30		80
	TT	61	42	62	63	50	20
	Bilateral	6	13	14	7	50	-

* DM-Diabetes/dysvascularity **TAO – Thromboangitis Obliterans

From among the samples studied 40 per cent had lost their lower limb because of medical grounds, while the lion's share, whereof 60 per cent attributes to surgical reasons. Men especially those above forty found a niche among those affected with medical reasons (diabetes or thromboangitis obliterans, with the former well indentified), who had landed with amputation. Though was expected, the findings of the study proved the surmise and the statement by many other authors that the younger generation and those in the productive age to fall prey to amputation because of surgical reasons, that too affected by crush injury (accidents). Avulsion injury leading to amputation was reported by 70 per cent of the 21-40 years age groups as surgical reasons. Congenital reasons surfaced among male, depressingly in the adolescent category. The study has proved the assumption stated ***earlier that the elderly population endure amputation due to medical reasons while younger generation end up in amputation due to surgical grounds***.

1.Traumatic amputations can be classified as partial or complete.

- A *partial amputation* occurs when some bone, tissue, or muscle keeps the amputated part attached to the body. Partial amputations are more common among civilians and usually do not require surgical amputation.
- A *complete amputation* involves a complete sever from the body.

2. Amputations can also be classified according to the degree of soft tissue, nerve, bone, and vascular injury.

- A *jjjjjjjjjjjjjjjjjjjjjjjjjjjjjjj* of separation. Limb salvage is unlikely due to the extensive damage (Dillingham, 2002)

Transtibial and bilateral also attributed to all the three reasons. Unfortunately above knee amputations were undergone primarily because of Thromboangitis Obliterans (medical reason) and non injury (surgical). These facts also highlight and support the statistic given earlier that incidence of amputee has increased multifold and the factor is directly proportional to the magnitude of accidents reported in the recent years.

2.2.3. Duration of Disability

World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF), (2001) jn/which uses 'disability' as an umbrella term for any or all of the following components:

- Impairments—problems in body function or structure
- Activity limitations—difficulties in executing activities

- Participation restrictions—problems an individual may experience in involvement in life situations.

Sustaining a disability where mobility is a question mark is quite arduous and cumbersome. This created a genuine interest to find out the duration for which the selected samples have been enduring this condition prompted this analysis (Table- 22).The samples had ultimately fallen prey to many, co-morbidities that endanger their status of stress and crisis.

Table: 22 Duration of Disability

Particulars		Percent Responding (n = 142)			
		Duration of disability (in months)			
		Less than12	12-60	61-120	More than 121
n		**36**	**57**	**37**	**12**
Overall percent		25	40	26	9
Gender	Male	86	82	89	83
	Female	14	18	11	17
Age (in years)	< 20	19	6	-	-
	21-40	42	47	30	-
	41-60	39	47	54	-
	>61	-	-	16	100
Level	TF	31	21	38	50
	TT	58	65	57	42
	Bilateral	11	14	5	8

A good proportion (40%) endured trauma for almost five years, while 26 and nine percent had suffered recording up to ten years and above respectively. Living with an amputated limb is never an issue of compromise. But a section of the population has been existing so. Obviously the male gender predominated. It was really agonizing to record almost 50-70 per cent under 41-60 years age range to be suffering with the condition for five years or a decade or more respectively. Living with, sort of a confined dependent life style would have added much to their mental trauma. Considerable representation from the bilateral group enduring for more than above five years buttresses the fact.

Another finding reflecting the recent happenings is the presence of 42 and 19 per cent of samples (21-40 years and adults respectively) who are fresh generation amputees with less than a year's experience with the physical condition. Of course, 39 per cent among the 41-60 years also had joined the group. Such findings all the more portray a

bleak picture, which demonstrates very well the entry of the younger generation in the category of amputee which, till almost a decade ago was attributed to the vocational or geriatric problems. Now it projects the impact of accidents, their frequency, on leaving tell tale marks of the younger and productive generation on a negative note. All of them are forced to endure stress and stressful events or crisis.

The span of time since the incidence of amputation varied from zero months to more than 10 years. As the duration of amputation has indirect influence over the Quality of life and the satisfaction level of the rehabilitative individual it necessitates investigating. Gailey et al (2008) authenticate the above statement in their research as, the concern in having an amputation for a long period of time is associated with secondary physical conditions, including osteoarthritis, osteoporosis, back pain, and other musculoskeletal problems. These conditions are believed to result from increased forces on the intact limb and altered body mechanics that occur secondary to limb loss and/or prosthesis use.

2.3.Adaptation to Domain (Component) – Specific Activities

According to Deacon and Firebaugh (1981), the cost of human resource input may be considered to have four components, namely, the affective, cognitive, temporal and physical. These domains explain how an individual responds and reacts to the given circumstances which they perceive in a way as stressors, stressful events or crisis, meanwhile exposing one's physiological, psychological and spatial states of body, mind and spirit. Complying with this fact details pertaining to these components were enquired of and the responses received are presented under:

2.3.1. Response to Affective Components
2.3.2. Cognitive Coping Strategies
2.3.3. Temporal Adjustments
2.3.4. Reaction to Physical Components
2.3.5. Adaptation leading to Resiliency

2.3.1. Response to Affective Components: All actions taken in an effort to manage stress, regardless of whether they are successful, are referred to as coping. Affective components in coping reflect in a person's attitudes, preferences, interests and dislikes expressed relating to something. The findings pertaining to this part therefore are discussed under:

(a) Perception on Use of Prosthesis

(b) Personality Style

(a) Perception on Use of Prosthesis: Table presents details on how the samples perceived use of the prosthesis

Table: 23 Perception on Use of Prosthesis

Particulars*		Percent Responding (n =142)	
		Perception on Use of Prosthesis	
		Comfortable	Perceived as good as healthy limb
Gender	Male (n=121)	47	67
	Female (n=21)	67	93
Age in years	< 20 (n=10)	50	70
	21-40 (n=53)	68	70
	41-60 yrs (n=61)	28	61
	>61 (n=18)	56	78
Level	TF (n=43)	49	67
	TT (n=84)	48	73
	Bilateral (n=15)	40	27

***Figures in parenthesis indicate number of sample**

Rehabilitation goal for an amputee is simply to restore the ability to perform everyday activities in an easy, natural, and comfortable manner. The most important factors for the successful use of prosthesis are **comfort, function, and appearance**. Unless prosthesis is reasonably comfortable, the amputee will not access it. More than accepting it comfortable samples opined that the fitted limb was as good as their healthy limb. Among qualities of prosthesis like weight, socket-interface comfort, power, agility, color, and shape, the most important factor for a unilateral amputee is socket-interface comfort than weight. Function is considered to be the most important factor for a bilateral amputee, with agility considered more important than power. Cosmesis was consistently reported as being less important than comfort and function, and shape was considered more important than color. The findings are on par with the statements of Schultz et al (2007)

(b) Personality Style: This is an important aspect capable of differentiating one individual from another. Loss of a limb and further the use of prosthesis would have affected their true feelings of identity, if their kith and kin and the macro environment at

large had not accepted them as they are. This drove finding out their nature / trait – a significant aspect permitting them to cherish their self esteem (Table 24).

Table: 24 Personality Style

Particulars*	Overall percentage*	***Percent responding* (n =142)**		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Narcissistically Invested	25	21	14	93
Dependent	50	35	52	80
Depressed	25	19	26	33
Timid And Self-Conscious	15	7	7	87
Rigid Personality Style	56	47	67	27
Pessimistic or Paranoid Outlook	37	58	25	33

*Multiple Responses

It was quite interesting to analyze the personality traits stated by the samples' themselves in a self interrogative statement-which helped in categorizing them. Those who labeled themselves as with rigid personality style out witted others, followed by dependent (50%). An equal proportion was found either to be narcissistically invested or depressed, both negative qualities. A population of 37 per cent was found to be pessimistic or had paranoid outlook. All these personality traits obviously helped to classify them under groups which can and cannot be tolerated. The expressions were comparatively more among transtibial and bilateral samples.

These feelings undoubtedly can have negative influence on their value systems - driving away the zeal to be on their own, value health and well being, make adjustments and making the situation amicable which in the long run can lead to a condition when they cannot overcome this impairment and find alternate measures. To live long with renewed vigor this may affect the amputees and the family's mental balance too**. Accessibility and adaptability to prosthesis in a larger measure can also get affected- a reason for lack of accessibility and adaptability to prosthesis.** Perception of the "self" was not found to be encouraging. They had started wearing to " body image and " embodiment" clouts.

2.3.2 Cognitive Coping Strategies

Coping involves cognitive and behavioral components and is considered a process, not an outcome. Coping is a cognitive process in decision making. So, it is named as cognitive coping. Cognitive coping and crisis or stress management decisions are affected by stressor, resources, demands, definition of situation and crisis/stress. Decisions are made to manage stress process in order for an individual to cope with the stressor events. Critical decision making is made towards the use of resources, seeking for information, clarifying values, planning, considering alternatives and setting goals - the examples of cognitive processes for resources management. **These end up in adaptation by the person, further refinement of which portrays his resiliency.** According to Siegel (1984), adaptations happen when change and growth are due to environments that need to be met. Hence this part of the study analyzes the problem based on the cognitive components put to use in tackling related issues under the following headings:

a. **Adaptive Measures**
b. **Daily Duration of Use of Prosthesis**
c. **Length of Service of the Prosthesis**
d. **Time Gap between Prosthetic Changes**
e. **Use of Mobility Devices**
f. **Managing Personal Activities**
g. **Cost Factor**

a. Adaptive Measures: The major adaptive measure accepted by the samples was changing their life style with the use of the prosthesis. This aspect of the study is explained under:

i. **Description of Prosthesis**
ii. **Adaptive Measures Post – prosthesis Use**

i. Description of Prosthesis: The major components making up the prosthesis is the socket and suspension elements. Hence this part of the study is discussed under:

- **Socket of Prosthesis Accepted**
- **Auxiliary Suspension of Prosthesis Accepted**

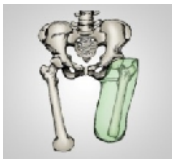
Socket of Prosthesis Accepted: The following Table presents details on the same

Table: 25 Socket of Prosthesis Accepted

Particulars		Percent Responding (n = 142)			
		Transtibial Patellar Tendon Bearing		***Transfemoral***	
		Silicone Suction Suspension	**Suction socket**	**Quadrilateral Socket**	**Ischial Containment socket**
Gender	Male (n=121)	57	10	7	26
	Female (n=21)	56	10	5	29
Age in years	< 20 (n=10)	30	10	-	60
	21-40 (n=53)	59	14	2	25
	41-60 (n=61)	60	-	7	33
	> 61 (n=18)	50	-	28	22
Level	TF (n=43)	-	-	21	79
	TT (n=84)	90	10	-	-
Bilateral (n=15*2=30)	Right Above	-	-	-	23
	Left Above	-	-	4	13
	Right Below	23	3	-	-
	Left Below	17	17	-	-

Ischial Containment Socket

Quadrilateral Socket



Patellar Tendon Bearing

Figure 37 Sockets

As explained in the literature review, patellar tendon bearing, belonging to two types, namely, silicone suction suspension and suction socket were the ones recommended for transtibial amputees, while for the transfemoral group, two other types namely, quadrilateral socket and ischial containment socket were the ones prescribed. Socket designs ensure optimum fit between the user and the device (prosthesis), that is, it acts as an interface between the human – machine system. Evidently they differ based on the nature (site) of amputation and the stump details. Irrespective of the factors taken for consideration, the findings revealed high preference for silicone suction suspension for transtibial amputees and ischial containment socket for the other group. The reasons attributed vested with use of ischial containment socket where the amputee essentially is 'sitting' while walking because they are bearing the majority of their body weight through their ischial tuberosity. The goals of the transfemoral prosthesis were to provide a comfortable prosthesis, that enable the amputee to regain stability during walking and any other balance related activities, and a prosthesis that was cosmetically appealing. Well planned socket designs and careful

consideration of stump presentation had set an achievement platform for the prosthetic user by maximizing range of motion, stability during the performance of daily activities, and comfortably distributing the forces exerted on the residual limb during movement and suspension. In contrast, poor socket design often drove people to abandon their prosthesis. The foundation for all prosthetic procedures is a well designed and considerate prosthetic socket (Lake, 2008). Plate-1 shows the fabrication process of socket

Amputation to some extent leads to muscle loss which can slow down the rate at which the body burns calories. If amputee doesn't reduce their calorie intake as they get older, they may gain weight. The energy cost of ambulation is greater for amputees than for non amputees. A lack of energy balance also most often causes overweight and obesity (http://www.nhlbi.nih.gov/health/health-topics/topics/obe/causes).

Socket is an important part of every prosthetic limb as an interface between the residual limb and prosthetic components. Biomechanics of socket-residual limb interface, especially the pressure and force distribution, have effect on patient satisfaction and function (Pirouzi et al., 2014). The degree to which the prosthesis fits the stump will make all the difference claims Lake (2008) and adds that the most determinant factor of prosthetic use lies in the design of the prosthetic socket. The Patellar Tendon Bearing design has demonstrated the concept of concentrated weight bearing for transtibial amputees. Concentration of force can cause stretch on skin which is one of the consequences of injury of residual limb and hence found not suitable for short residual limbs. Usual prosthetic sockets are a combination of PTB and TSB. However, the popularity of this method paved the way for the innovation of silicon suction socket (3S) say, Pirouzi et al (2014).

Auxiliary Suspension of Prosthesis Accepted: The Table (26) and Figure (38) given below explains the details

Plate -1 Socket fabrication process

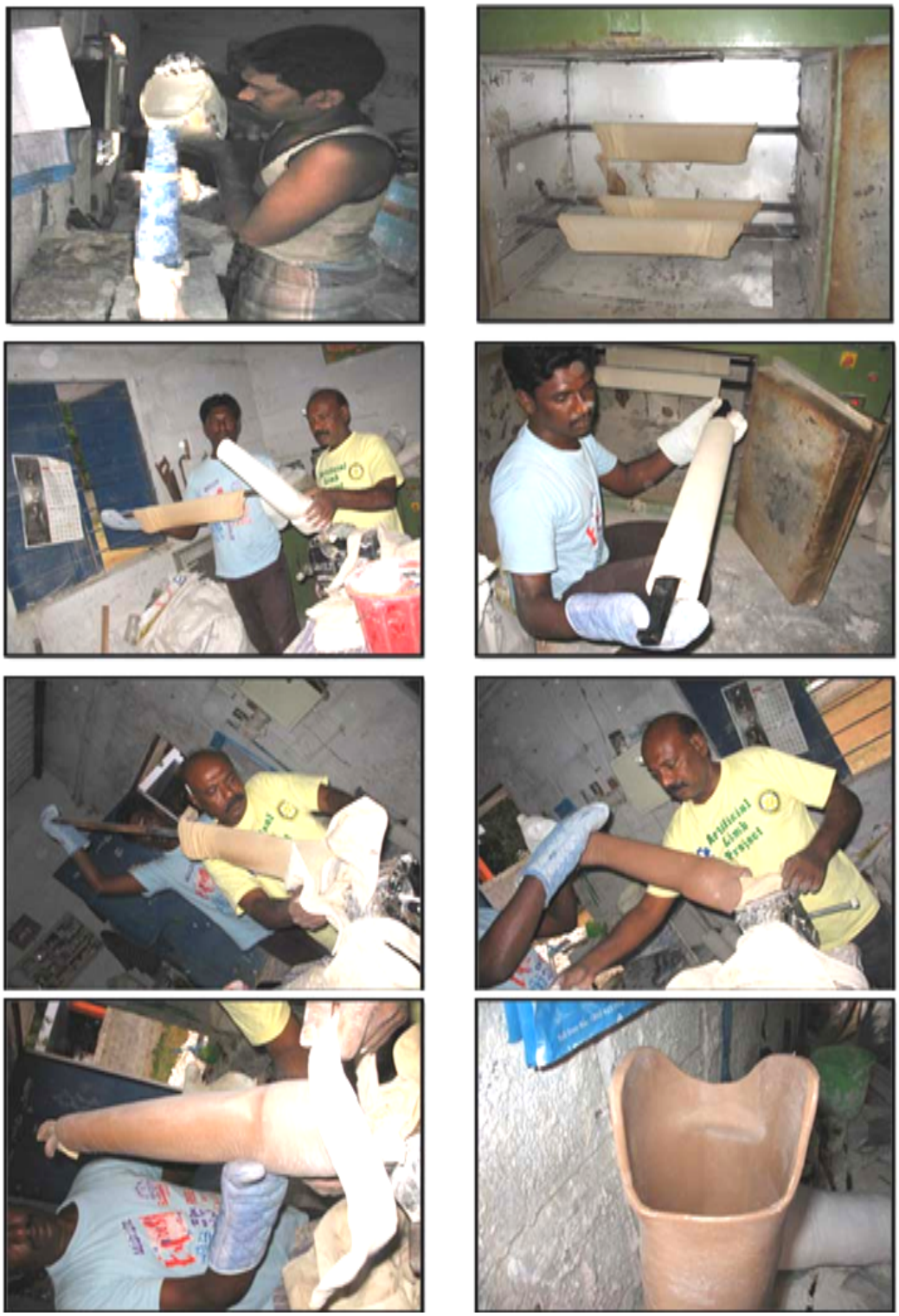


Plate -1 Socket fabrication process

Table: 26 Auxiliary Suspension of Prosthesis Accepted

Particulars		Percent Responding (n = 142)					
		Transtibial			*Transfemoral*		
		Cuff Suspension strap/sleeve	Waist belt	Thigh Corset	Pelvic band/Belt	Silesian bandage	Total elastic suspension
Gender	Male (n=121)	48	2	14	6	1	29
	Female (n=21)	57	14	-	10	-	19
Age	< 20 (n=10)	90	-	-	-	-	10
	21-40 (n=53)	67	4	-	4	-	25
	41-60 (n=61)	39	-	21	-	2	38
	> 61 (n=18)	6	22	22	39	-	11
Level	TF (n=43)	-	-	-	16	-	84
	TT (n=84)	76	4	20	-	-	-
	Bilateral (n=15)	45	14	3	7	3	28

To ensure safety and instill confidence in the users, various auxiliary suspension devices have been developed. For transtibial amputees, cuff suspension straps/ sleeves, waist belts and thigh corsets were promoted. The selected samples were also found to use these devices, where cuff suspension strap/ sleeves ranked high overriding the other two. To further increase stability of the socket, a cuff strap was added which assisted by holding the residual limb more firmly into the socket and also prevented hyperextension of the knee. In lieu of a cuff strap, suspension sleeve is also added to the socket. A suspension sleeve is a knee sleeve that slips over the outside of the prosthesis, and covers the amputee's knee, to extend towards the thigh. Prosthetic suspension sleeves are excellent at providing auxiliary support and concealing prosthetic trim lines.

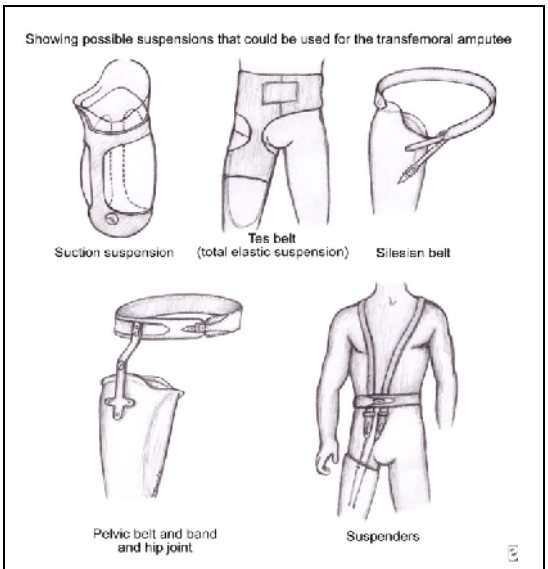


Figure: 38 Suspension Methods

Another feature noticed was the use of thigh corsets by the 41 – 60 age groups. Similarly, senior citizens were found to use both waist belt and thigh corset compared to those in the lesser age range. Probably, lacking confidence in the prosthesis during

Figure:39 Suspension System

movement by virtue of their age factor may be attributed as a reason. While total elastic suspension remained the auxiliary suspension device reported to have been fitted on those with transfemoral amputation, the senior citizen group in this category too showcased a difference, as a good 39 per cent had gone in for a pelvic band/ belt. It provided more comfort and stability as the wide belt wraps around the pelvis and closes with Velcro.

Having accepted to go in for prosthesis is enough proof to accept that the samples had responded to the stressful event in a positive way. Having cooperated with the prosthesis and had accepted the limb as a part of their life style has proved that they had tackled stress which would otherwise have ended up in a crisis for the family.

ii) Adaptive Measures Post – prosthesis Use: The following Table illustrates the adaptive measures accepted by the samples to sustain use of prosthesis despite their aversion if at all there, to use one.

The appropriate suspension system results in safe and well functioning lower extremity prosthesis. Suspension methods are determined by residual limb length, joint ligament stability, and limb volume. Other factors which influence the method of suspension include activity level, dexterity, success of previous suspension, and cosmetic requirements. The s*upracondylar* suspension cuff, prosthetic sleeves, and gel liners with locking mechanisms generally are indicated for the *average to long transtibial* (below knee) amputation level. *Short* limbs are better fitted with *supracondylar and suprapatellar* suspension. Waist belts generally are indicated for patients with new amputations or those with vascular compromise. Suction suspension is the most desirable form of transfemoral (above knee) suspension and is recommended for most standard to long residual limbs. Roll on silicone liners with or without locking pins and the hyperbaric sock offer the patient, systems that are easier to don yet still provide unencumbered suspension. The total elastic suspension belt offers excellent auxiliary suspension and can be applied to the prosthesis by the patient. Hence as Kapp (1999) said multiple factors and patient preference should be considered when prescribing suspension systems for lower extremity prostheses

Table: 27 Adaptive Measures Post – prosthesis Use

Particulars			*Percent responding (n = 142)*	
			Frequent changing of prosthesis	Modification in prosthesis
Gender	Male	n=121)	47	40
	Female	(n=21)	48	43
Age in years	< 20	(n=10)	30	30
	21-40	(n=53)	47	34
	41-60	(n=61)	46	41
	> 61	(n=18)	61	61
Level	TF	(n=43)	53	98
	TT	(n=84)	11	1
	Bilateral	(n=15)	60	53

Only 47 per cent among men and 48 per cent among women were found to change the prosthesis every now and then. Similarly only 40 per cent among both the groups approached the centers for modification. Tendency to change was more among the senior age groups, though the others also had approached them in a lesser proportion. Reasons cited were change in stump size due to growth among adolescents, while obesity -induced difference in size was quoted by the middle aged group. Damages to the device also were stated as reasons. Shrinking stump had also forced the senior citizens to go for change of the device. With regard to modification, the above knee group and bilateral registered more, citing lack of compatibility as a concrete reason.

b. Daily Duration of Use of Prosthesis: Details given in Table explain the same

Table: 28 Daily Duration of Use of Prosthesis

Particulars			**Percent Responding (n = 142)**			
			Daily use in hours			
			< 3	3 - 6	6 - 9	> 9
Gender	Male	(n=121)	31	20	34	15
	Female	(n=21)	19	14	43	24
Age (Years)	< 20	(n=10)	-	-	50	50
	21-40	(n=53)	17	17	51	15
	41-60	(n=61)	33	26	26	15
	> 61	(n=18)	66	17	11	6
Level	TF	(n=43)	35	21	30	14
	TT	(n=84)	27	20	35	18
	Bilateral	(n=15)	21	13	53	13
Gainfully Employed	Business	(n=36)	39	33	25	3
	Salaried	(n=27)	-	18	67	15
	Professional	(n=20)	10	15	50	25
Others	Jobless	(n=15)	87	13	-	-
	Student	(n=22)	-	10	45	45
	House wife	(n=9)	23	11	33	33
	Retired	(n=13)	77	23	-	-

Gender wise classification revealed both majority of men and women respectively to be using prosthetic limb for ambulation for more than six solid hours; some beyond nine hours too. Experience in use, need, occupation held and the extent of mobility desired, may be attributed for this variation in response to hours of use. Similarly hours of use was found to be longer among the first generation users, probably a forced necessity to overcome impairment had driven them so. Contrarily the time based use of prosthetics was found to lessen with increase in age projecting feeling of reluctance among the group, towards sustained use. Almost the same responses were recorded for the business class group too, while 75 per cent of professional and 82 per cent of salaried population agreed to be on prosthetic limb for a longer duration. Necessity evidently had enforced compulsion to use prosthesis among the students and housewife category.

For participants with lower limb prosthesis, greater prosthesis use (more hours per day) was associated with full-time or part-time employment or schooling reports, Raichle (2008). Pohjolainen et al (1990) in their study showed that, half of all the above-knee amputees and 79 per cent of the below-knee amputees used their prosthesis throughout the day or over seven hours a day. Many amputees (68%), who had been fitted with prosthesis made extensive and regular use of it, with 60 per cent wearing it either all day or using it for a major part of the day (8 hours). Further many (16 %) used it for about half of the day, while five per cent used it for only a part of the day or occasionally and 11 per cent never used their prosthesis at all. If this is the condition in foreign countries one cannot expect Indians to be more patronizing.

c. **Length of Service of the Prosthesis:** The Indian Psychology, to make a rough estimate of the duration for which a product will serve the consumer is an important factor guiding consumer behavior. Hence, this aspect of the study analyzed the concept presented as under

Table: 29 Length of Service of the Prosthesis

Particulars		Percent Responding (n =142)					
		Length of service in months					
		<3	3-6	6 -12	12-18	18-24	> 24
Gender	Male (n=121)	31	20	9	16	50	25
	Female (n=21)	19	14	14	19	43	24
Age (years)	< 20 (n=10)	-	-	10	60	30	-
	21-40 (n=53)	17	17	9	8	62	21
	41-60 (n=61)	33	26	11	15	48	26
	> 61 (n=18)	66	17	11	22	22	45
Level	TF (n=43)	35	21	16	19	37	28
	TT (n=84)	27	20	4	17	55	24
	Bilateral (n=15)	21	13	26	7	47	20
Employment	Business (n=36)	39	33	11	9	69	11
	Professional (n=20)	10	15	5	15	60	20
	Salaried (n=27)	-	18	7	4	59	30
Others	Jobless (n=15)	87	13	20	27	23	40
	Student (n=22)	-	10	14	36	18	32
	House wife (n=9)	23	11	-	11	56	33
	Retired (n=13)	77	23	16	23	38	23

Gender never stood as a criterion for maintaining prosthesis for longer duration. Growth phase in adolescence, and the energetic groups in the two age ranges between 20 60 years agreed to be using the prosthesis for an extended time. Growth retention during the former phase and the thickening of the bones preventing further stump adjustments for the latter are attributed as reasons. Frequency of change was found to be maximum for the senior citizens (>61 years) and the below knee group. Almost all employed groups tended to go in for change in the device only rarely (18 to 24 months and more). **The findings prove an excellent example for coping as the temperament of the samples is portrayed through their choice to switch over often. (**Plate-2)

d. Time Gap between Prosthetic Changes: A prosthesis once fitted cannot be retained for users due to various reasons. An attempt was made to pinpoint the time frame of use, the details of which are presented below (Table 30)

Plate 2. Reasons for Refit of Prosthesis

Table: 30 Time Gap between Prosthetic Changes

Particulars		Percent Responding (n = 142)			
		Gap between prosthetic changes (in months)			
		< 6	6-12	12-18	> 18
Gender	Male (n=121)	13	12	48	27
	Female (n=21)	19	5	43	33
Age in years	< 20 (n=10)	10	40	30	20
	21-40 (n=53)	11	4	62	23
	41-60 (n=61)	18	10	42	30
	> 61 (n=18)	11	17	28	44
Level	TF (n=43)	18	12	37	33
	TT (n=84)	11	11	52	26
	Bilateral (n=15)	20	6	47	27

The prosthetists were not found to suggest a time frame within which the samples were supposed to change the human – machine system as it was entirely an individual affair. The prospect to change depended on many factors specific to the user needs like outgrowing the socket size due to growth phase especially for the below 20 age range as against those in the above 61 who had inherent problems in terms of age –related bone degenerative changes. Problems in fabrication in terms of improper fit, broken socket/ exoskeletal limb,(Figure-40) damage to external cover, use of materials of inferior quality and mishandling emerged as reasons.

Figure: 40 Broken Socket

Physiological aspects like obesity or shrunken stump because of delay in approaching the centers requiring change in socket accounted for the rest. Nevertheless those who used prosthesis for more than a year irrespective of any of the variable influences like gender, age or level of amputation can be recorded as unique features.

e. Use of mobility devices: Mobility devices used by amputees with prosthesis can be of two types, namely self - maneuvering and mechanical - maneuvering. Hence this aspect pertaining to the findings are delineated under:

i. Self –propelling / manual ambulation devices used

ii. Mechanical maneuvering device used

i. Self –propelling / manual ambulation devices used: This is an important aspect in coping strategies practiced, as a lot of thinking goes into it. Table presents the data

Table: 31 Self –propelling ambulation devices used

Mobility devices used	overall %	Percent Responding (n = 142)		
		Amputee types		
		TF (n-43)	TT (n-84)	Bilateral (n-15)
Use no mobility device	55	23	75	33
Assistance with device (n= 64)	45			
Use one cane	36	24	62	20
Use two canes	5	9	-	-
Use one crutch	22	6	38	40
Use two crutches	6	9	-	10
Use walker	31	52	-	30

It was heartening to record 55 percent to endorse 'auto – stimulus' for moving around, requiring no additional supportive devices, while the rest of the group necessarily needed some kind of mobility device as they depended on some assisted living. Devices like canes, crutches and walkers were the common devices recorded as used for self navigation. Single cane or walkers were popularly used by unilateral transfemoral, while single cane and crutches were preferred by unilateral transtibial. Contrarily the options of bilateral were from mono crutches, walkers and double crutches. Twenty per cent of bilateral even had practiced moving around with single canes – a very pathetic condition to compromise with.

Mobility aids are selected based on the type and extent of injury; the support it provides; difficulty in using the aid; and overall fitness. High level amputees rely on mobility aids like crutches, canes and walker to get around faster and easier along with or without the use of prosthesis. The choice of a mobility aid or any combination of assistive devices is the decision of the user. Some sort of combination works best rather than arbitrarily getting into using only one assistive device. By canes and crutches the findings do not necessarily mean only those factories made sophisticated ones. Use of waylaid sticks as cane and crutches (crude ones) among the vulnerable groups was also sighted. They simply imply the plight of such amputees who were destined to pull along even in such conditions of hardships.

Figure: 41 Cane and Crutches

An individual with a single leg amputation is able to hop with a support device. Possible devices include one or two crutches, a walking frame, and possibly two sturdy canes or a large stick. For most people with bilateral amputations the only safe option for mobility is with a wheelchair or wheeled cart. Mobility is done using the hands to move the wheels. An individual who is able to lift his body weight easily may be able to hop up and down a step or curb using canes or crutches (WHO, 2004).

ii Mechanical Maneuvering Device Used: A wheel chair is a mechanized device enabling ambulation within the house and in the exterior. The sample's nature to make use of this device was studied and the findings are presented under Table 32

Table: 32 Mechanical Maneuvering Device Used

Mechanical Maneuvering Device Used	Overall %	Percent Responding (n=142)		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Wheel chair not used	69	35	92	33
Use wheelchair	31			
Purpose of use *				
Office alone	20	32	-	40
Outdoor/Travel	62	54	100	60
Indoor/residence	18	14	-	-

*Multiple Responses

The factors that determine the use of wheel chair includes age, co-morbidities/medical history, cardiovascular tolerance, skin integrity and circulation, upper-body strength, strength of the intact leg, fitness level, body weight and body type states, Gurwitz (2012).

Mechanization for movement in the form of wheel chairs is a welcome development in engineering science. Yet, a majority of 69 per cent of the sample dissented use of the chair. Among those who used, unilateral transfemoral and bilateral were found to be good promoters. Affordability automatically emerges as the fundamental criteria. For long distance walking and mobility, prosthetic users cannot be expected to be with a cane, crutches or walker on the one hand. Secondly, moving around in these may be restricted in many areas where public gather. Thirdly, it can come as a boon for the prestige conscious.

Evidently, the gainfully employed (business people too), who resorted to long time use of prosthesis and home makers who had to be on their heels to do household chores were the ones who basically preferred wheel chairs, which could help them in easy ambulation. This suited well even when they had to use restrooms at night times, without seeking assistance. Being in the exterior and during travel, they agreed the mechanical device to be of much use as they could stay and mingle with their family or friends and keep up with their pace of movement. This was yet another measure practiced, so that they could keep themselves on their tracks of socializing.

All amputees would opt for wheelchairs since it permits extensive activities. People elect to use wheel chair on three states of affairs; disuse prosthesis relying exclusively on mobility devices, on selective occasions and ambulating on a wheel chair with the prosthesis. To start with, they choose to put their limb off secondary to a chronic illness in their residual limb and poor prosthetic fit. On occasions relating to their personal space and activities like night time trips to the bathroom, showering etc, if prosthetic problems arises it may require leaving their prosthesis off for any length of time. On the other end of the spectrum they ambulate on a wheel chair with the device in their residual limb on rationale like: during their nascent period of adaptation trying to build strength, balance, stability and endurance with the prosthesis, shopping precinct to use between stores and getting to walk the short distances between the aisles, amputation levels that require more energy as above knee prosthesis and bilateral amputees, elderly patients with co- morbidities and when they have lost all weight-bearing capability. Wheelchairs save energy for other functions, promote independence, enhance safety and get prosthetic user back into participation in business and family functions (Bury, 2012)

f. Managing Personal Activities

Personal activities majorly include those related to a person's habits on personal hygiene, grooming, toileting and other regular activities (eating, household/ office, dressing up etc.). How far the samples were successful in performing these chores being doubtful, they were asked to explain the same. The findings on management tactics adopted are presented under:

i. **Personal Activities**
ii. **Posture While Bathing**
iii. **Donning and Doffing**

i. Personal Activities: Among personal activities, personal cleanliness activities like brushing, toileting and the like were efficiently managed by the samples themselves. They required minimum assistance. Self indicted principles to do them with the least assistance, and that too absolutely until only when indispensable drove them to carry them out on their own. Regular activities also were found to be completed without assistance. Self propelling nature using even ordinary sticks by those groups who were left on their own are symbols of autonomic living, a factor to be admired.

ii. Posture While Bathing: The following Table gives details on the same

Table: 33 Posture While Bathing

Bathing	**%**	**Percent Responding (n = 142)**		
		TF (n - 43)	TT (n - 84)	Bilateral (n -15)
Sit on floor	23	28	21	33
Standing Posture	17	-	29	-
Sit on a stool	60	72	50	67

Sitting on a raised stool while bathing was practiced by more than 60 per cent of the samples, even though a considerable number practiced sitting on the floor. Standing under the shower was practiced by 29 per cent of the transtibial amputees. Almost 65 per cent of the samples agreed to be dressing up on their own. Many of them were also found to accept partial assistance from partners (spouse, paid assistants, nurses). Albeit, the plight of the samples to give away with their rights to privacy, freedom to choose timings for personal care, choice of dress and such other assorted things renders them sympathetic in the eyes of an observer.

Sitting and standing balance are of major concern when assessing the amputee's ability to maintain the CoG over the base of support (http://www.oandplibrary.org/alp/ch ap23-01.asp).Only adequate alignment training could facilitate this. This group probably had successful training.

iii Donning and Doffing Prosthesis: Table presents details on the sample's status on this score.

Table: 34 Donning and Doffing Prosthesis

Donning and Doffing Prosthesis	Overall %	Percent Responding (n-142)		
		TF (n- 43)	TT (n- 84)	Bilateral (n- 15)
Dress and undress on their own	49	7	73	27
Need absolute help in getting dressed and undressed	39	77	17	53
Partial assistance needed	12	16	11	20

Forty nine per cent of the samples reported to be independent in donning and doffing the prosthesis, (Figure 42) a good sign of being on their own even after their predicament – a real pep to their conscience. Here too the transtibial group recorded high incidence. Absolute dependence on a partner for doing these activities was stated by 77 and 53 per cent of transfemoral and bilateral groups respectively, highlighting their vulnerable status of well being. Nevertheless, there also existed a small section among all groups who resorted to partial assistance for performing the activity

Donning a prosthesis refers to the application of a prosthetic device to the user's body. **Doffing** is the act of removing the prosthetic device. There are several ways for an amputee to put on prosthesis, depending on the prosthetic design, the individual's anatomy and the individual's preference

Facing the predicament of **donning prosthesis** in itself was a major bone of contention between the amputees and the prosthetist. Requiring assistance in addition to that stress of perfectly fitting it day in and day out undoubtedly added 'fuel to fire'. The stress factor at times cascaded and left them highly irritated the whole day. Obviously all these cumulative factors were a great concern for their feelings of becoming obligatory to others and for upholding feelings of being a burden on others. Ultimately, for some at least it had led to feelings of self hatred or self pity, which the selected samples were not ready to disclose.

Amputees applied the prosthesis with or without the use of lotion. Lotion tends to facilitate an easier and less irritating donning process; however, some amputees disliked the feel of the lotion once the prosthesis was on. Donning with the use of lotion is referred to as a 'wet' fit; donning without lotion is referred to as a 'dry' fit.

Suction Method

Silicone interface

Figure:42 Donning Prosthesis

- **Push-In**: For amputees with longer above knee residual limbs, some prefer to simply push the residual limb into the socket, usually using a lotion or powder. This approach is quick and simple; however, the extra tissue near the groin may not get contained in the socket and a bulge of flesh at the top of the socket may result.
- **Pull-In**: To ensure all the necessary tissue is contained inside the suction socket, most above knee amputees prefer to pull-in using a donning device, called donning sock. Though more time consuming than the push-in approach, the result is a more effective socket fit

g. Cost Factor: It is the main contender in any market situation. It cannot be otherwise here. Hence the details about their feelings on cost of the devices is explained through Table 35

Table: 35 Cost of prosthesis

Particulars*	Overall percentage	***Percent responding (n =142)****		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Cost effective	49	23	38	33
Cost is a constraining factor	51	63	43	60
Maintenance and replacements are expensive	55	74	44	60

*Multiple Responses

Maintenance and replacement as being expensive, by virtue of the components incorporated in prosthesis was fully highlighted by as many as 55 per cent, when questioned on cost of expenditure of the prosthesis. For 51 per cent the cost of the prosthesis itself was a constraining factor. This again is another factor affecting **accessibility** and **adaptability** to prosthesis.

Besides traumatic injury, conditions like heart disease, cancer, and high blood pressure and Type 2 diabetes can lead to amputation. These conditions are all ranked among the nation's ten most expensive medical conditions. The financial cost of these conditions to individuals is high appends McNutt (2008).The projected lifetime health-care cost for the patients who had undergone amputation was three times higher than that for those treated with reconstruction (Mackenzie et al.,2007). **Those who had undergone amputation due to medical grounds and those who had developed co –morbidities expressed their concern over the hike in personal expenses.**

2.3.3 Temporal Adjustments: This component relates to one's ability in managing personal time. Therefore this part of the findings throws light on the following:

a. Lag Period Prescribed
b. Gait Training Undergone
c. Time spent on Leisure

a. Lag Period Prescribed: Lag period is the time delay in limb fitting after amputation and duration of preprosthetic and prosthetic training (Gauthier-Gagnon, 1998). It is the duty of the surgeon and the consulting orthopedic Doctor to prescribe this as it is dependent on patient – specific realities or, co-morbidities like cardiovascular disease, pulmonary disease, stump pain, the availability of rehabilitation facilities and surgeon's preference (Moffat , 2006)The data on this score is given under Table:

Table: 36 Lag period Prescribed

Particulars		**Percent Responding (n=142)**		
		Lag period prescribed (in days)		
		< 120	121 -180	> 181
Gender	Male (n=121)	29	53	18
	Female (n=21)	52	29	19
Age (in years)	< 20 (n=10)	50	20	30
	21-40 (n=53)	30	49	21
	41-60 (n=61)	27	52	21
	> 61 (n=18)	11	83	6
Level	TF (n=43)	32	63	5
	TT (n=84)	30	51	19
	Bilateral (n=15)	-	33	67

Prerequisite for a prosthetic measurement and fitting is complete wound healing with non edematous stump accomplished by exercise and rehabilitation. Proper shape as well as increased strength and function of the stump is arrived at the end of the stage. The average time interval between amputation and fitting is **145 days**. Delays are significantly longer for nonusers. Hence, early prosthetic fitting and training is insisted opine, Gagnon et al (1998).

The findings revealed one half of the male population to have complied with the prescribed period as against 29 per cent of women. Satisfying the norms was taken up religiously by the elder members than the younger blood. Probably by virtue of their age they were prescribed quite lesser number of days, it is believed – a topic that needs a healthy argument. Likewise the transfemoral (above knee) and the bilateral group who were the enforced lot on prosthesis also were found to have stuck to the prescribed time. It is evident therefore that the level of amputation, its degree of intensity and the Doctor's advice decided this factor. Compliance helped the patient's to reap good benefits, while they had to pay at a later date for negligence.

b. Gait Training Undergone: Like lag period, this also was projected as an important determinant of the success felt with prosthesis. Lag period took care of the healing aspect of the amputated site and gait training decided the ease with which the samples could regain their lost gait even when using an artificial limb. Hence it is an important factor determining the QoL of an amputee after the predicament. The following Table (37) and figures (43) throws light on this issue

Table: 37 Gait Training Undergone

Particulars		**Percent Responding (n=142)**			
		Gait training imparted (in days)			
		No training	< 15	16 -30	31-60
Gender	Male (n=121)	25	49	21	6
	Female (n=21)	5	66	5	24
Age (in years)	< 20 (n=10)	40	40	10	10
	21-40 (n=53)	11	64	14	11
	41-60 (n=61)	25	49	23	3
	> 61 (n=18)	33	28	22	17
Level	TF (n=43)	2	49	47	2
	TT (n=84)	36	62	1	1
	Bilateral (n=15)	-	-	33	67

The choice of female candidates to undergo training for less than 120 days is quite evident. Their willingness to learn faster or an involvement in household chores can be attributed as probable reasons. Similarly the responses to longer training period undergone by 41 and above age groups can either be taken in the positive as a behavioral concept reflecting a fight against dependent living and sincere obligation to prescribed time norms and on the other can also be related to an adamant behavior, complaining that their training is not perfect. Either way age wise the groups had exhibited commendable heterogeneity.

Scheduled training was adhered to by both the groups with transfemoral (above knee) and transtibial (below knee) amputation for fifteen days. Bilateral especially those of longer endurance of amputation by virtue of the condition evidently had opted for prolonged training period.

Prosthetic training is a process that can last up to a full year. It begins with pre - prosthetic weight bearing training. In reality, most new amputees require months of practice with their prosthesis. Oftentimes, repetitive gait training and precise refinements are necessary before a person's gait is smooth, stable and most importantly safe. Also, it typically takes 3-9 months for a patient to regain the strength and flexibility in their leg

Figure: 43 Gait Training

This is the responsibility of prosthetists to impart good gait training as its importance cannot be undermined. Role of prosthetist team and co operation of patients is of great significance here because this decides how an amputee regains lost mobility at least partially.

c. Time Spent on Leisure: The samples were a mixed group with one section employed and earning and the other jobless. Hence, the need to find out how effectively or otherwise their spent their extra time, led to the following findings presented in Table 38.

Table : 38 Times Spent on Leisure

Particulars*	Overall percent	*Percent responding (n=142)*		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Indoor games	41	35	45	47
Outdoor games	8	-	13	-
Watch television	92	93	94	80
Listen to radio	69	53	77	73
Read books	35	42	36	13

*Multiple Responses

Watching television, listen to radio and indoor games to a certain extent was preferred as leisure time activity by 92, 69 and 41 per cent of the samples respectively. All three groups had responded unanimously for these three past times. It reflects the mentality of the selected samples to remain sedentary during leisure. Either dislike for other pursuits or lack of awareness to take up active life can be attributed as reasons. These leisure time activities can turn detrimental to health in due course of time, considering their predominance. It can lead to overweight or obesity induced prosthesis incompatability.

2.3.4. Reaction to Physical Components: This aspect of the study explains the approach practiced by the sample in coping the stressors and the eventual crisis caused. Hence this part of the findings explains the following factors used as coping measures:

a. Status of Independence
b. Job Integration
c. Values Revisited

a. Status of Independence: The samples were well aware of their position in terms of their dependency either on people or on inanimate supportive devices. Table explains the same.

Table: 39 Status of Independence

Particulars	*Percent responding (n=142)*			
	Overall percentage* (n=142+9=151)	TF n=48	TT n=88	Bilateral n=15
Class I — Totally independent	50	31	64	33
Class II — Independent with one cane or crutches	25	40	20	7
Class III — Independent at home ambulating with prosthesis, but need wheelchair for outdoor activities	13	17	3	53
Class IV — Non-ambulatory except in wheelchair	6	2	9	7
Class V — Independently ambulant with crutches, but not wearing a prosthesis (n=9)	6	10	5	-

It was very encouraging to record almost half the sample state that they remained totally independent even after amputation (class I category) Dependence on supportive devices like crutches and canes further threw light on the sentiments they attached to the value of living on their own. This also reflects the extent to which the samples had accepted the predicament and had ushered in feasible solutions to make their life more acceptable, peaceful and worth living. Similarly, one can also assume the confidence they had on the devices used for support – products of research – which came in handy during a dire need. The findings all the more bring out the efforts put up by the samples to reduce the stress caused to the family members' sequel to the amputation they suffered.

The table throws light on the nine samples met in the Centers who had rejected prosthesis (belonging to class V) but being independently ambulant with crutches –living examples, who had access to but could not adapt to prosthesis.

b. Job Reintegration: While the previous section dealt with how the samples managed on the physical aspect, this part describes their temperament to establish themselves in the economic front (Table 40).

Table: 40 Job Reintegration

Particulars	% (n=83)	Job	*Percent responding*		
			TF (n=24)	TT (n=49)	Bilateral (n=10)
Continue same job (n=47)	57	Business	11	21	0
		Salaried	9	21	0
		Professional	4	30	4
Change in job (n= 36)	43	Business	28	28	3
		Salaried	11	22	2
		Professional	0	0	6
Nature of job (n= 83)	28	Part time work	42	29	30
	72	Full time work	58	71	50

Only 58 per cent among the entire sample (142) had resumed job after amputation, among whom 57 per cent got reintegrated with the same job and 43 per cent had sought a new one. It was quite surprising that more than 30 per cent among transtibial had continued with the previous job, while 67 per cent among transfemoral had sought for a change in job.

Age at the time of amputation, wearing comfort of the prosthesis, and education level were significant indicators of successful job reintegration. Subjects with physically demanding jobs who changed type of job before and after the amputation more often successfully returned to work than subjects who tried to stay with the same job. Older patients with a low education level and problems with the wearing comfort of the prosthesis were the population at risk who required special attention during the rehabilitation process in order to return to work. Lowering the physical workload by changing to another type of work enhances the chance of successful reintegration opines, Schoppen (2001). The decision by 67 percent of transfemoral amputees to change their job is thus justified.

The shift in employment patterns of samples post-amputation followed identifiable trends. The physical demands of the jobs to which amputees returned also changed in a predictable fashion. Amputees, who were employed in a light to moderate job prior to injury, continued the same job or secured a sedentary job post-amputation. The factors influencing the job pattern included nature of employment, age at the time of amputation, level of amputation and education level.

The vocational guidelines for Social Security disability define work activity as medium, light, or sedentary.

Sedentary work means that you are able to sit for up to 6 hours in an 8 hour day and lift up to 10 lbs. occasionally during a day.

Light work means that you can stand and walk for up to 6 hours in an 8 hour day and lift 10 lbs. frequently and 20 lbs. occasionally

Medium work means that you can stand and walk for up to 6 hours in an 8 hour day and lift 25 lbs. frequently and 50 lbs. occasionally (http://www.disabilitysecrets.com/blog/2010/05/social-security-disability-lig.html).

Post-amputation jobs were generally more complex with a requirement for a higher level of general educational development than pre-accident jobs. A trend emerged as about 75 per cent of employed amputees returned to a job that was less heavy than their former job, but required greater intellectual ability. Millstein (1985) had documented amputees to report that the accident employer often offered continuing employment. He had also reported other changes in employment post-amputation. Here the story was different.

More than half of the amputees were found to identify negative repercussions of their amputation including reduced potential for salary increases and fewer opportunities for job promotion. Job security was adversely affected by amputation. Few of them had experienced periods of unemployment lasting more than six months since the amputation before reintegration. Interestingly, each additional day in acute care resulted in an average decrease of ten days of disability report (Herbert et al., 2006). In general as duration of sick leave increases, the chance of return to work decreases. Barriers in returning to work often arise from personal, work or family-related problems, rather than from the original health condition itself (Health and Safety Executive [HSE] Guidance 2005). Blue collar workers with injuries took longer to return to work than white collar workers. Self-employment also influenced one's return to work (Amick and Gustafsson, 2004).

h. Values Revisited: Personal values provide an internal reference for what is good, beneficial, important, useful, beautiful, desirable, constructive, etc. Values generate

behaviour, state, Rokeach, (1973) and help solve common human problems. (https://en.wikipedia.org/wiki/Value_(personal_and_cultural)s) Hence an attempt was made to find out the values the sample cherished through their accommodative behaviour consequent to using of the prosthesis.

Table: 41 Values Revisited

<table>
<tr><th>Components considered</th><th>Action to cope with stressor events/ crisis</th><th>Adaptation strategies/ coping responses</th><th>Values cherished</th></tr>
<tr><td rowspan="4">Physical</td><td rowspan="4">Informed decision making</td><td rowspan="4">Use of biomechanical device
Reduction in contact/ mechanical stress through customized fabrication
Avoiding awkward postures, excessive force
Prevention of static muscle loading</td><td>Positive</td></tr>
<tr><td rowspan="3">Health
Safety
Comfort
Satisfaction
General well being
Passion to change
Adaptability
Accommodation
Wishful thinking
Resilience
Dignity
Integrity
Self –respect / self - esteem</td></tr>
<tr><td>Cognitive</td><td>Cognitive decision making</td><td>Safety and product quality
Information to interact with the device
Adapted motor response</td></tr>
<tr><td>Ergonomic</td><td>Conscious decisions/ Seasoned approach</td><td>User – centered approach
Better use of technology
Health consciousness
Desire to be productive
Participatory approach</td><td>Negative</td></tr>
<tr><td colspan="3"></td><td>Egoistic
Adamant behavior
Inferiority complex
Self pity
Body image
Embodiment</td></tr>
</table>

Despite giving multiple evidences for adapting to their plight and exposing many admirable positive values, the samples were found to retain a few negative traits. Being left on their own without any assistance, financial insecurity, joblessness coupled with an aimless future probably had prompted them to give vent to such sentiments. Not all could take it as a sugar coated pill.

2.3.5. Adaptation Leading to Resiliency

Any change in an individual's self carriage can entail life style modifications. Provision of an entirely strange appendage can even be demoralizing for the user. For

those who had accepted the predicament, changing their lifestyle would come fairly easier. A close look at the major modifications enlisted are analyzed and presented under:

a. **Adaptation to Sitting Habits**
b. **Enforced Walking / Mobility Traits**
c. **Use of Mobility Devices**
d. **Preference to Transportation**
e. **Managing Personal Activities**
f. **Family support and Social Life**
g. **Social Acceptance**

a. Adaptation to Sitting Habits: Use of prosthetics would have demanded changes in the user's day to day personal habit maintenance, especially sitting comfort. Hence, this aspect of the study is analyzed under:

i. **Sitting/ getting up from the floor**
ii. **Preference for type of chairs**

i. Sitting/getting up from the floor: A salient characteristic among South Indians, especially natives of Tamil Nadu is their preference for sitting on the floor for all occasions, including daily chores. This necessitated enquiring the sample on the ease with which they sat on the floor. The findings are presented in Table

Table: 42 Sitting/ getting up from the Floor

Getting up from the floor	**%**	**Percent Responding (n =142)**		
		TF (n =43)	TT (n= 84)	Bilateral (n=15)
Avoid sitting on the floor	44	58	35	47
Need Assistance (n=81)				
Do not need assistance	65	67	65	63
Need assistance for both	35	33	35	37

India being a country which still clings to traditional life styles, sitting on the floor is quite a common scenario. When questioned how they tackled the issue brought forth 44 per cent of the total samples (58, 35 and 47% belonging to unilateral transfemoral and transtibial and bilateral respectively) to be blatantly avoiding sitting on the floor. Among those who sat on floors a good proportion (65%) sought no assistance for getting up, especially the transtibial topping the list (65%). The rest of the samples needed assistance

for getting up from the floor. These facts show that there exists inter and intra variant differences among the samples studied.

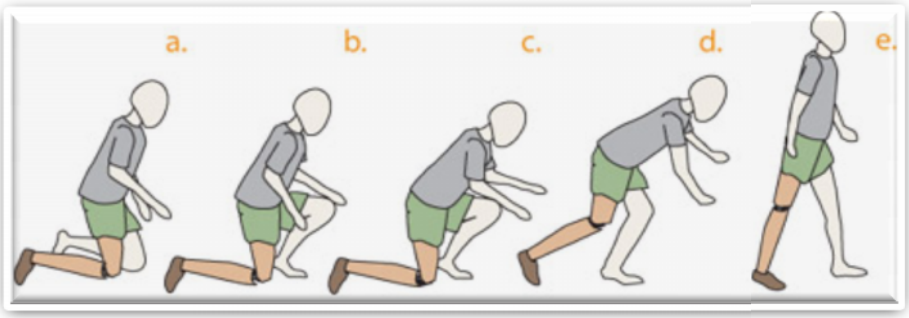


Figure: 44 Amputee getting up from the floor- Proper sequence

ii. **Preference for Type of Chairs:** Preference for chairs with arms to enable ease in use was enquired of. The responses received revealed the following as presented in Table

Table: 43 Preferences for Type of Chairs

Type of chair preferred	%	Percent Responding (n = 142)		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Do not need chair arms	61	9	93	33
Need arms (n= 55)	39			
Need arms on low sunken chairs	47	44	83	30
Need to use arms on all chairs	53	54	17	70

Using a chair is an unconscious, routine, habitual endeavor handled at ease by those who are gifted with healthy limbs. Unfortunately, the samples, being those with fitted limbs, details on the type of chairs they felt as their 'comfort zone' was enquired of through the survey. Majority of 61 per cent stated that they could lift themselves up or assume a seat in a chair without arms among whom the transfemoral group ranked first. Thirty three per cent among bilateral too expressed so. Sitting on and or rising from a sunken chair had forced 44 and 30 per cent of unilateral transfemoral and bilateral groups respectively to seek a chair with arms. Irrespective of the type of chair, the two groups (54 and 70% respectively) again preferred those with arms.

Activities of daily living and functional capabilities with the lower limb prostheses were analyzed by Narang et al (1984) and the study showed that, support was not required. Of the below-knee amputees, 67 per cent did not require any support, while in above-knee group about 67 per cent did need support.

b. Enforced Walking / Mobility Traits (Rehabilitation induced walking habits):

After a lower limb amputation, the main goal of rehabilitation is to restore mobility, which is considered as the most relevant ability for their quality of life. Mobility rehabilitation with a prosthesis initially focuses on being able to rise and sit down, followed by standing (for longer periods), walking and climbing stair (Geertzen, 2001). For mobility in walking, lower-limb amputees have to be able to rise, stand and maintain balance, initiate gait, walk, terminate gait, and to sit down. Therefore, rising and sitting down are important aspects of mobility in lower-limb amputees. Climbing stairs is one of the most demanding tasks for maintaining mobility. Although many lower-limb amputees consider climbing stairs to be an important issue, many of them are unable to do so (Rommers, 2001). Rehabilitation and subsequent use of prosthetics for mobility would have brought in definite changes in one's walking traits. Hence, this part of the study is analyzed under:

i. **Limitations Enforced (Permissible Range of movement)**
ii. **Tackling Curbs/ Obstacles**
iii. **Managing Stairs/ Steps**
iv. **Use of Ramps**

i. Limitations Enforced (Permissible Range of movement): Table describes the required data

Table: **44 Limitations Enforced (Permissible Range of movement)**

Extent of walking	**%**	**Percent Responding (n =142)**		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Do not walk	9	23	-	20
Mobile (n=129)	91			
Home walker	13	58	5	17
Restricted outside walker	13	33	11	40
Unrestricted outside walker	21	9	36	40
Unrestricted outside walker with very high demands	23	-	49	-

Resuming walking after rehabilitation and prosthesis fitting and the extent of walking allowed rests with the physician's discretion. Regarding the selected samples, an equivalent proportion expressed to have been enduring enforced restricted walking within the house and in the exterior respectively (17% each); while transfemoral amputees

predominated in the former, bilateral ranked high in the latter. Between unilateral transfemoral and transtibial, the latter enjoyed unrestricted walking in the exterior, for which bilateral also seemed to be qualified. A majority of transtibial were found to be allowed unrestricted walking in the exterior, despite expressing high demands for movement. **A negligible nine percent agreed not to be walking at all comprising unilateral transfemoral and bilateral groups**. Natural walking, a fundamental right of a human being, thus is found to be restricted purely because of the use of prosthesis.

Mobility is a key component to regain independent living, enabling the performance of activities of daily living (Remes, 2009).Regardless of age, patients with more medical problems had poor ambulation. Coronary artery disease, diabetes mellitus, cerebrovascular disease, and the combinations of these diseases negatively influence ambulation. However, the impact of multiple comorbidities in this patient group can make regaining mobility a particularly challenging task (Fortington, 2012). The key to emancipation for this group is their walking ability and their ability to move in and around their homes (Collin and Collin, 1995). Restricted indoor walking ability allows transfers from wheelchair to bed or toilet facilities to ensure independence and self-esteem. Older patients have more problems and poorer ambulation (Rommers, 2001). Excess weight compounds the orthopedic and cardiovascular effects on an amputee. It has been shown that it is 40 to 100 percent more with transtibial (below-knee) amputation(s) and 90 to more than 200 percent more metabolically demanding to walk with transfemoral (above-knee) amputation(s) state Kahle and Highsmith (2008). The group who agreed to be walking are really gifted.

ii. **Tackling Curbs/ Obstacles:** Table presents the discussion on the findings of this part of the study.

Table: 45 Tackling Curbs/ Obstacles

Crossing curb	**%**	**Percent Responding (n = 142)**		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Avoid Curb	9	23	1	20
Tackle Curb (n= 128)	91			
Without assistance	60	42	64	83
Need assistance	40	58	36	17
Going up- Forward Method	80	84	73	100
Going up-Backward Method	20	16	27	-

Only 91 per cent among the samples had to tackle curbs / obstacles while walking because nine per cent among the samples never attempted walking after rehabilitation. More than one half of the sample tackled curbs without assistance, while 36 per cent needed assistance to do so. Curbs were effectively/ effortlessly tackled adopting forward/ backward method by 36 per cent. Between the two methods forward was found to be more prevalent; hence practiced more.

Balance and good single limb support with walking up and down stairs limb sequence is ideal to cross curb with ease. Walking aids are also helpful for assisting with curbs. Advanced transtibial (below knee) prosthetic limb will help the amputee to ascend curb and control descent without any assistance (http://emedicine.medscape.com/article/ 1237638-overview).

Trans femoral Amputees: Step over Step

Climbing requires timing and coordination. Prosthetic limb by rapid acceleration of hip flexion with slight abduction is the first to ascend the stairs. Toe of the prosthetic foot is hit the step to achieve adequate knee flexion. Residual limb exerts a great force to fully extend the hip that, the sound foot advances to the step above with the prosthetic foot firmly on the step, the toe against the step riser is usually followed. Sound-side hip extends, the prosthetic-side hip flexes at an accelerated speed to achieve sufficient knee flexion to place the prosthetic foot on the next step above.

Descending stairs is achieved by placing only the heel of the prosthetic foot on the stair below and then shifting the body weight over the prosthetic limb, thus passively flexing the knee. The sound limb must quickly reach the step below in time to catch the body's weight (http://www.oandplibrary.org/alp/chap23-01.asp).

iii. Managing Stairs/ Steps: This aspect is presented under Table

Table: 46 Managing Stairs/ Steps

Ascending and Descending Stairs	%	Percent Responding (n = 142)		
		TF (n=43)	TT (n=84)	Bilateral (n-15)
Avoid climbing stairs	17	40	2	34
Climb stairs (n= 118)	83			
Do not need help	60	15	76	50
Need hand rails or other assistance	*40*	*85*	*24*	*50*
Step over step	74	77	65	-
One step at a time	26	23	35	50

Unilateral transfemoral and bilateral were confident enough to climb or descend stairs without assistance, as stated by 15 per cent and 50 per cent respectively. It is more precise to say that almost one half of the samples refused to seek assistance to ascend or descend stairs. Presence of hand rails or some other kind of assistance was a felt need expressed by 83 per cent of the total samples for undertaking the activity, within which 51, 24 and 33 per cent of unilateral transtibial, transfemoral and bilateral became enlisted.

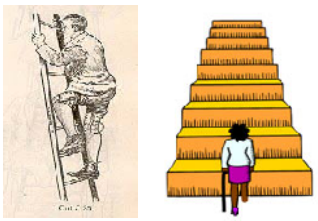


Figure: 45 Climbing Stairs

Ascending and descending stairs is most safely and comfortably performed one step at a time (step by step). Strong transfemoral (above knee) amputees ascend and descend stairs step over step with or without a railing, or by the "jackknifing"(one part moves around so far towards the other part, that it cannot be moved) method. Most transtibial (below knee) amputees had the option of either method. Transfemoral amputees who mastered the skill descend stairs at an extremely fast pace, much faster than would be considered safe for the average amputee.

Lack of dorsiflexion components in the ascending is always a phenomena. While descending is an additional prodigious task as they require plantar flexion in the assembly of foot/ankle of their prosthesis. Moreover the knee joint fixed prosthesis (above knee) poses a setback in their weight line falling posterior to their knee joint, resulting in a flexion moment reports, Gailey (2002).

Trans tibial Amputees: Step over Step

Climbing stairs: Generating a stronger concentric contraction of the knee (shortens the muscle to generate the force needed to counteract gravitational pull) and hip extensors enable the body weight to be successfully transferred over the prosthetic limb; as the trans-tibial amputee does not have the ability to dorsi-flex his foot/ankle.

Descending stairs is very similar to normal descent with one exception: only the prosthetic heel is placed on the stair. This compensates for the lack of dorsi-flexion within the foot/ankle assembly (http://www.oandplibrary.org/alp/chap23-01.asp).

iv. Use of Ramps: The following Table explains the same

Table: 47 Use of Ramps

Use of Ramps	%	Percent Responding (n =142)		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Do not need assistance	11	2	17	-
Need assistance	89			
Need assistance absolutely	31	12	50	-
Can only go up ramp with help	16	-	21	33
Use them with a wheelchair	53	88	29	67

Use of ramps though found more comfortable to ascend stairs by normal individuals was found to be discomforting for the prosthesis users. Only a meager 11 percent could use them without assistance, where again only the transtibial groups recorded high. With assistance too, they only predominated. Even with some kind of assistance the transfemoral group had found it difficult. Evidently use of ramps on a wheel chair emerged as the best option especially for unilateral transtibial (29%) and bilateral (67%) groups. This is probably because of the sample's inability to maintain normal stance and adjust to regular centre of gravity.

d. Preference to modes of transportation: India has not developed as much as to take into consideration the unique needs of amputees in public transportation. Neither special infrastructural facilities been developed in public places to cater to the needs of such people. Private vehicles, of late are fabricated enabling some modifications to suit individual variations. Preference of the concerned sample on modes of transportation was elicited as given under Table.

Table: 48 Preference to modes of transportation

Transportation	%	Percent Responding (n =142)		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Self Driving	62	70	63	33
No previous driving experience	38	30	37	67
Other Transportation means*				
Train	40	18	76	3
Bus	40	13	68	4
Taxi	54	40	79	1
All modes	37	11	65	5

*Multiple Responses

It was agonizing to record 62 per cent - a good proportion – were used to self driving before being put on a prosthetic. This added appendage had left them handicapped on this score. Evidently, this was a cause of agony for the group, though the others who never practiced driving before, had little hint on the mental trauma their counterparts endured. Similarly the victims of accidents, the surgical method amputees – could overcome feelings of reliving the moments only after a long time, speaking on their reluctance to use some kinds of commuting facilities.

Figure: 46 Self Driving

Considering the present situation, more than one half had to depend on private taxis for commuting (with the unilateral transtibial again topping the list); while 40 per cent each could travel by bus. There also existed samples who could adapt to any mode of travel.

The process-oriented definition indicates a difference between coping and automatic behavior states Bomer (2004). Coping represents efforts with reference to situations of psychological stress that call for mobilization and involve all efforts to manage regardless of outcome. So managing may include avoiding, denying, minimizing, tolerating, accepting the stressful situation or striving for change. ***Here the samples had "managed" their stressful situation in an exemplary way by following all these strategies. Similarly they have also proved that through such adaptation they have molded their resilience*** which it radiates in the form of their commitment, communication, cohesion, adapting , connectedness, time allocation for being together and is problem solving as National Network on Family Resiliency (1996) declare.

f. Familial Support and Social life: This part of the findings is presented under Table

Table: 49 Familial Support

Particulars	Overall %	***Percent responding (n =142)***		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Living alone	23	28	21	20
Living with family	65	63	69	47
Home	12	9	10	33

Suggestive evidence in research and literature are there to vouch that amputees are welcomed by their family members. Except the gifted 65 per cent it was agonizing to record 23 and 12 per cent of the selected sample to be living either alone or in Homes. Representation was almost equal among the three groups (transfemoral, transtibial and bilateral) who stated to be living alone.

Despite the disappointment felt with 35 per cent who were left to fend for themselves, more modification in living facilities were intentionally made by some families giving an overarching importance to the comfort and convenience of the amputees. –Construction of ramps, fixing rods for enabling ease in walking for holding in restroom modifying commodes /kitchen cabinets and the like (Figure

Figure: 47 Modifications made in residents

Losing a family and their support during a disability/ impairment definitely had left tell tale marks of depression, stress and an abandoned feeling. These facts may all the more end up in raising a generation of "unwanted population"

g. Social Acceptance: Neglect is a very bad concept which can isolate a person. This will be all the more pronounced if the social setting in which they belong don't accept them. For many in the vulnerable sections of the society, such non acceptance especially for amputees is quite common. Table 50 presents the concerned data.

Table: 50 Social Acceptances

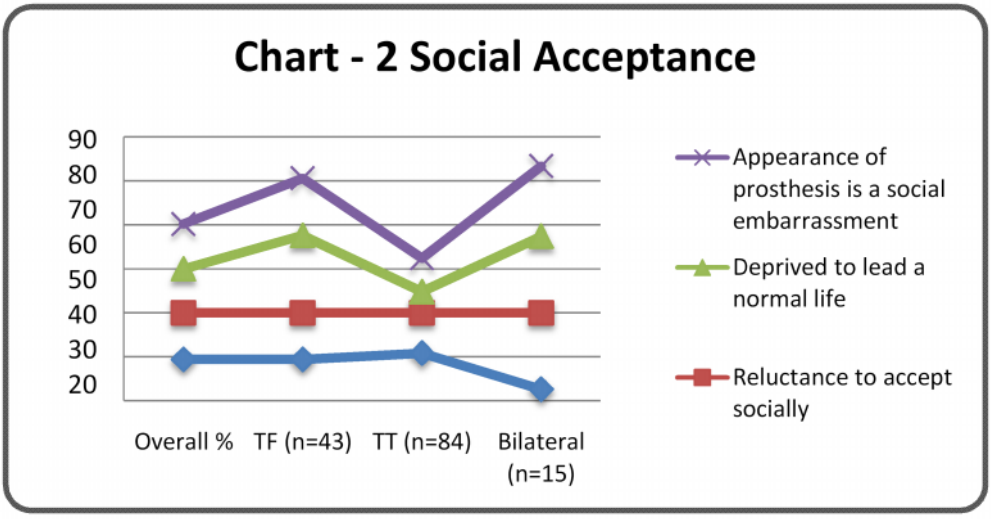
Particulars*	Overall %	***Percent responding (n – 142)***		
		TF (n=43)	TT (n=84)	Bilateral (n=15)
Acceptance as an amputee	47	47	54	13
Reluctance to accept socially	53	53	46	87
Deprived to lead a normal life	50	88	24	87
Appearance of prosthesis is a social embarrassment	51	65	38	80

*Multiple Responses

The responses recorded on this score projected two ways to analyze this concept. Among the four points stated with regard to social acceptance, two grounds on societal view and two others on their personal view to face the society their perception about society to view. While 47 per cent felt that the society ingrained a dislike towards the group by virtue of being an amputee, 53 per cent lamented that the society was reluctant to accept them in social settings. Either way their presence in the public was not welcomed.

From the samples' explanation it was clear that amputation had deprived their opportunities for leading a normal life (50%). An equivalent population also had stated that they with their prosthesis on had presented selves as elements of embarrassment in social settings. These feelings had nothing to do with their level of amputation. Hence the responses received for this can be attributed to the stigma existing towards these groups with society on one hand, and their own perception and misgivings on the part of the samples about the society's view points. These facts can be associated to their feelings/ sentiments on being self – conscious. Another argument is that when one group of amputees expects sympathy and compassion from society, another group totally detests it by establishing their self confidence and independent behavior. Hence one cannot be judgmental about this issue.

From the responses recalled for coping measures it was clear that the transtibial adapted better than the counter parts. Hence the hypothesis is accepted.



Though a major portion of the society shows reluctance to accept them in their study the amputees need to understand that there is a "guiding star" in the Prosthetist

team who welcome them with an open heart and lend to reinstate them into ambulation. Hence this aspect has been included to familiarize people on the roles assumed by prosthetist teams in helping a vulnerable section of the society.

C. Rehabilitation – the Ergonomic Way

This aspect of the findings of the study introduces the selected prosthetic Centers on the one side and the rehabilitative measures practiced by them for their clients on the other. They are explained under the following headings:

1. **Prosthetic Centers – the Rehabilitation Service Providers**
2. **Outcomes of the Participatory Rehabilitative Process**

1. Prosthetic Centers – the Rehabilitation Service Providers

Three prosthetic centers functioning in the City were selected for conduct of the study as they were the ones approached by the sample for their prosthetic needs. The essence of the humanitarian service they rendered was found to be laudable.

The forth coming Exhibits (10, 11 and 12) present a bird's eye view of the Centers, followed by a narration of the rehabilitation process practiced by them. The facts entail the tedious, but high precision work performed by the prosthetic teams to render the needed artificial appendage for a person for comfortable ambulation. In Management parlance they can also be called ***Crisis Interveners***.

Having known their background of services and dedication they attend to in the service of the amputees, it was felt necessary to describe the rehabilitation process each of the centers adopt in their schedule of service

1.1. Stages in Rehabilitative Process

The stages involved in rehabilitative process is uniform across centers, with mild variations in the way they are recorded, as measurements are exclusively need based and differ from one client to another. The data are documented as an exhibit (13). A summarized version of the different parts and the assembling methods are presented to give a vivid explanation on prosthesis.

Center 1

In the year 1995 a service organisation of the locale in fusion with the similar organisation in the Capital City of the State planned and initiated a joint venture sensing the urgent need to reinforce the existing rehabilitation facility available to the amputees and thus to bring back those from the unfortunate lot into the main stream of society, in and around South India. Till 1998, this service endeavor had to face a finiancial stress and storm,as the amputees moved to the city from various parts of the state as beneficiaries. Meeting their weekly needs till they were fitted with the prosthesis was a herculian effort for the organisation. The prosthesis of olden days were then manufactured in aluminium unlike today HDPE pipes, also made their service efforts difficult. With the advent of new technology in the field of prosthetics and orthotics in 1999 -2000, the service organisation picked up its momentum afresh with its support from its Foundation and International Organisation. Mobile prosthetic providing facility was infused to provide prosthesis to the amputees residing in the nook and corner of the southern states of the country.

Centre - 1

The prosthesis provided used the conventional technology, using indigenous materials and simple method that was light weight, easily and quickly fabricated,very economical as compared to similar prosthesis manufactured by other organisations. It restore the natural appearance, consumes lesser energy on the part of amputee and is water-resistant. The materials are procurred from Gujurat and Hyderbad. The entire project granted by the organisation and philanthropist of the city had been successfully providing its service since its inception, that its wings fly high to extend it for servicing of the amputees on international locales too.

Exhibit 10. Center - 1

Center 2

It is an ISO 9001:2008 Company established in Dec 1995. The Company, is a joint venture between two high tech Groups, the former is a manufacturer and exporter of hi-tech prosthetic and orthotic products and providing low-cost products and solutions to NGOs across the world as a part of the social initiatives of the Group and the second is a global supplier of prosthetic and orthotic products and services, offering lower limb prosthetic component manufacture and distribution worldwide.

This Company has been in service for more than two decades, acting as a products division of the second Group, which for generations has supported individuals with limb loss and mobility impairment to achieve their dreams and goals.

It is a Rehabilitation Services Company focused on Prosthetic & Orthotic services through its Company run clinics and dealers. It has its clinics in all major cities of the Country combined with a network of over 250 franchises. The Company's branded range of lower extremity prosthetic products cover all levels of amputation of the lower limbs and includes microprocessor controlled prosthetics knee and variety of dynamic yet stable foot pieces and Dynamic Response foot etc. to provide great degree of freedom to the users.

Exhibit 11. Center - 2

Center 3

It is a 90 year old German multinational and the global leader in provision of innovative services and products for people with limited mobility. It was first founded in Berlin, Germany in 1919 by a prosthetist. His vision of restoring mobility lives till the day, growing every day to serve the world with more than 46 locations spread across 100 countries.

In the early 20th century, he transformed the way artificial limbs were made. Instead of carving wood to fit a patient, he applied manufacturing techniques and created separate components (like knees and feet) that could be combined, altered or customized to create a limb that was still unique to each patient – but wasn't built from scratch. His pioneering work enabled meeting the demands caused by World War I and help veterans stay as active as possible. Since 1998, in India the national network of International Standard Rehabilitation Facilities provides patients with sophisticated, high-tech artificial limbs (prostheses) for leg and hand amputations, supportive devices (orthoses / calipers / braces), customized wheelchairs and seating and posture control solutions. The Centers in India, (like the center chosen for the study) networks with the parent Company and combines its global cutting edge technology with extensive local experience to provide artificial limbs, supportive devices and mobility solutions that help improve the quality of life of amputees. These Centers have recorded more than 16 years of experience in India. Considered as one of the National Experts to restore mobility they feel proud of their satisfied users numbering more than 5000 who can vouch for their service quality

Exhibit 12. Center - 3

Center - 2 **Center - 3**

Plate 4. Prosthetics Center

Stages in Fabricating a Prosthesis (Basic Concept)

Negative wrap cast

A moistened cast sock is pulled over the stump. The stump is placed in an attitude of flexion. Using indelible pencil, the important features of the stump are marked, such as the outline of the patella, a horizontal line at the mid-patellar tendon, the head of the fibula, the tubercle of tibia, the border of the tibia and the medial and lateral flares. The Plaster of Paris bandage is wrapped around the stump carefully with firm, even tension. Once the cast is hard, the sock is rolled over the stump to remove the cast. Sometimes a small cut behind the knee may be required to remove the cast.

Measurements : remaining leg

The measurements of the sound leg and foot are taken. The length measurement allows construction of a socket of the correct length. Amputated side: Measurements of the stump length, medio lateral and anteroposterior distances at patellar level are taken.

Modification

The measurements of the sound leg and foot are taken. The length measurement allows construction of a socket of the correct length. Amputated side: Measurements of the stump length, medio lateral and anteroposterior distances at patellar level are taken.

Extension of mould & Preheating

The mould is extended to a length equal to the length of the sound leg. For this purpose, a cone made of ethaflex sheet (3mm in thickness) is placed over the positive mould and given a 5 degree anterior and 5 degree medial tilt. It is filled with PoP paste. When the plaster is hardened, the cone is removed and the extended mould is given the shape of a leg and properly finished. The distal end of the extended mould corresponds to the ankle portion of the Foot for proper fit of the socket on the foot.

The HDPE pipe is heated in a pre-heated oven for 30 minutes at 180 degree Celsius.

Exhibit 13. Stages in Fabricating a Prosthesis

Processing

The softened pipe is stretched over the mould. Pressure is applied on the weight-bearing areas to make inward bulges and the pipe is rubbed smoothly to remove wrinkles. The pipe is then cooled.

Removing

Plaster of Paris is removed from the socket by hammering

Trimming and finishing

The socket is trimmed and its edges are smoothened to give maximum comfort to the user and allow a range of motion for squatting and sitting cross-legged.

Assembling of the Foot with socket

The distal end of the socket is heated uniformly from all sides with the help of a heater. When the lower 600 mm of the socket is sufficiently malleable, it is attached to the Foot and allowed to cool. After cooling, the distal end of the socket grips the Foot tightly. It is further secured with screws.

Suspension belt

A supra condylar suspension belt made of leather is pasted with a hard glue on the socket.

Further refinement and sophistication with multiple high-end components and even microprocessors are done by the high tech Centers, absolutely based on customers' requirements.

Exhibit 13. Stages in Fabricating a Prosthesis

1.2. Manufactured Components Making up the Prosthesis -Biomechatronics

Modern prostheses consist of a variety of parts commonly referred to as components. Prosthetists and their technicians use a series of manufactured components to assemble an entire prosthesis. Some aspects of the prosthesis still are custom fabricated or manufactured within the prosthetists laboratory, but most of the components of prosthesis are readily available from manufacturers, suppliers, and distributors of prosthetic supplies and components. There are two basic types of prosthetic designs, exoskeletal and endoskeletal. Even though they provide many of the same functions, they are made very differently

The components that make up prosthesis vary from one to another, depending on the level of amputation and the needs of the individual amputee. All prostheses have certain fundamental components: however, some prostheses have extra or supplemental components. ***The fundamental components*** are required for the prosthesis to do its essential job. The ***supplemental components*** may allow some special function or provide an enhancement. For example, virtually all prostheses must have a foot component.

Transfemoral (above the knee) prostheses require a knee in addition to the foot. Both are fundamental components for the level of amputation and the amputee could not adequately ambulate without them; however, the transfemoral level amputee may also benefit from a knee rotation unit, allowing him or her to rotate the knee and shin of the prosthesis and cross the prosthetic leg over their other leg or perhaps sit cross-legged on the floor. This rotation unit certainly provides a benefit, but is not necessary for basic ambulation; therefore, the knee rotator is a supplemental component. Higher the level of amputation, more components becomes necessary, which includes both fundamental components and supplemental components.

Fundamental Components

All lower limb prosthesis generally has the following components**:**

- **Socket** is the custom made, top portion of the prosthesis that fits around the residual limb. Most sockets are custom fabricated directly from molds or empirical data about an amputee's residual limb (Figure 48)

Figure: 48 Socket

ᔓ **Foot** is the bottom or terminal portion of the prosthesis that contacts the ground. There is an abundance of prosthetic foot designs available, with a range of functional characteristics to suit the needs of most amputees (Figure 49).

Figure: 49 Modular Foot

❖ **Prostheses for transtibial (below the knee) amputees include:**

ᔓ **Shank** (shin): It is the portion connecting the foot (and ankle if used) to the upper prosthesis, usually to the socket or the knee unit (Figure 50)

❖ **Prostheses for knee disarticulation (through the knee) amputees include:**

ᔓ **Knee**: It is the component that bends (flexes) and straightens (extends) to allow for standing, normal walking, sitting, and kneeling.

Figure: 50 Prosthesis with shank and Knee

❖ **Prostheses for transfemoral (above the knee) amputees include:**

ᔓ **Thigh**: It is the component between the top of the knee and bottom of the socket in transfemoral amputees, or to the hip joint in higher level amputees.

❖ **Prostheses for hip disarticulation (at the hip) amputees include:**

ᔓ **Hip joint**: It is the hinged component that bends (flexes) and straightens (extends) to allow for standing, walking, and sitting.

The study thus has proved two aspects

✓ The **dedicated services of many invisible hands in the fabrication of prosthesis for an individual.** It highlights not only about the human resource involved in bringing out a product, **but also prospects for appreciable entrepreneurship coupled** with green pastures for innovation on the one hand and service orientation on the other.

✓ Though amputees are just referred to as Transfemoral/ Transtibial/ Bilateral they come with multiple requirements.

The following chapter introduces one to the rehabilitative process each prosthetic Centre adopts, as it is now clear that, without active participation from the amputee the prosthesis cannot be brought out.

2. Outcomes of the Participatory Rehabilitative Process

The National Research Council (NRC, 1983) had stated that human factors engineering can be defined as the application of scientific principles, methods, and data drawn from a variety of disciplines to the development of engineering systems in which people play a significant role. Keeping this in mind the study on finding out the factors considered in designing the prosthesis was taken up. Evidently, cooperation from the Centers and the sample amputees surfaced as most essential elements in carrying out the study. All the Centers though were approached **only one center agreed to comply with the request.** The concept being concerned with the two domains of ergonomics namely, affective and cognitive ergonomics, launching on a collective participatory endeavor was thought of as something worthwhile.

Based on the light of these viewpoints this part of the study was framed, the findings of which are discussed under:

1.1. Profile of the Sample Opted for Rehabilitation Process

1.2. Ergonomic Concerns in Prosthetic Fabrication

1.3. Alignment Techniques Adopted by the Center

1.4. Prosthesis –A symbol of Amputees " Empowerment"

1.1. Profile of the Sample Opted for Rehabilitation Process

For this study as stated in Plan and Procedure **100 sample amputees** who had been visiting the selected Center for prosthetic fitting during **2014 -2015** were chosen adopting purposive sampling. Only those who were approaching the Center and had enrolled for rehabilitation by the prosthetist were enlisted. The profile of the samples was studied and is discussed under the following headings:

1.1.1. Personal Details

1.1.2. Etiology of Amputation

1.1.3. Year of Amputation

1.1.1. Personal Details: The personal details of the sample is given in Table

Table: 51 Personal Details of the Sample

Particulars	Details	Percent responding (n=100)
Age range (in years)	< 20	4
	21-40	35
	41-60	47
	>61	14
Gender	Male	82
	Female	18

The vulnerable group again was found to be the 41 - 60 age and the 21 – 40 age groups respectively with 47 and 35 per cent falling in these ranges. One can attribute two reasons for this finding. Primarily the onset of diseases like diabetes or vascular which can within a limited time frame spread leading to amputation among the samples is not only on the rise but also strikes them at an early age, which in turn can be pinpointed to their unhealthy living styles. Secondly, the disproportionate increase in accidents, a major cause, is also found to leave a generation lament on their lost limb(s).

1.1.2. Etiology of Amputation: The reasons cited for amputation are presented under Table 52

Table: 52 Etiology of Amputation

Etiology	Causes	Percent responding (n=100)
Surgical	Accidents	66
Medical	Diabetes mellitus	28
	Vascular	4
Others	Cancer	2

This data was in no way different from the statistic found out in 2013 -2014. The reasons being practically the same, it was agonizing to record the incidence of accidents as a cause had increased by six per cent more. With a greater proportion who had opted for rehabilitation in the concerned year bounces another alarming fact, that a large group of senior citizens have already joined the vulnerable group of existing geriatric citizens awaiting a different kind of assistance. This aspect necessitated finding out the year in which they underwent amputation.

1.1.3. Year of Amputation: The following Table explains the same

Table: 53 Year of Amputation

Year of amputation	Percent responding (n=100)
Before 1998	7
1998 - 2000	25
2001 - 2005	27
2006 - 2010	34
2011 - 2015	7

This data was quite relieving in that except a few who were fresh amputees all others were of long stand and **they were approaching the Center for refit**. This factor is really very encouraging as only 41 feature as new entries in the last decade. The findings also highlight that having set a trend to revisit the prosthetist for refit indeed is a good sign of having awakened the sample to reintegrate them into the mainstream of normal living.

1.2. Ergonomic Concerns in Prosthetic Fabrication

Ergonomics is the design and engineering of human-machine systems for the purpose of enhancing human performance state, Dempsey et al (2000). The disciplines that can be applied to a particular problem include psychology, cognitive science, physiology, biomechanics, applied physical anthropology, and industrial and systems engineering. The systems range from the use of a simple tool by a consumer to multi person-socio technical systems. They typically include both technological and human components (http://www.nsc.org/issues/ergo/define.htm).

Rehabilitation in terms of the amputees refers to putting them comfortably on the prosthesis. Obviously it involves all the disciplines listed by NRC. It goes without saying that the samples have to render an active role for a successful fit of the limb. Hence this part of the study discusses the findings on the major issues that go into the fabrication of the same on the following aspect

1.2.1.Participatory Ergonomic Activities

Participatory ergonomics is defined as “involving people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desired goals” (Wilson 1995).

The samples were involved in getting their anthropometric measurements as the prosthetists did not fabricate limbs on a "one size fits all" principle. Being customized, those in needs had to cooperate with the prosthetists/ technicians in measuring their basic anthropometry required for making the limb and foot. To this effect the measurements of the samples were recorded for the following parameters:

a. **Dimensions of Transtibial Amputees**
b. **Dimensions of Transfemoral Amputees**
c. **Correlation and Regression Analysis of the Data**

a. Dimensions of Transtibial Amputees: Following Table gives the pertinent data.

Table: 54 Dimensions of Transtibial Amputees

Particulars	Dimensions (in Inches)	Percent responding (n=66)			
		Age range of samples (years)			
		< 20 (n=4)	21 – 40 (n= 20)	41 – 60 (n=33)	> 60 (n=9)
Total length	15 -17	50	35	24	89
	17.1 - 19	-	55	55	11
	19.1 - 21	50	10	21	-
Foot length	6	-	10	6	11
	7	25	35	22	11
	8	25	25	36	67
	9	50	30	36	11

By total length is meant the length of the leg from mid – knee to heel of good leg, that is, medial tibial plateau to bony end or to the floor. It is measured with the amputee sitting with knee flexed at 90^0. Shoe size was considered for foot length. There were 66 samples strewn across the different age groups who cooperated in recording the data. It was evident that the samples were totally heterogenic and was proof enough to highlight the challenge the prosthetist faces in fabricating each design.

Figure: 51 Anthropometric Measurements

While these are the measurements taken for below knee amputees, the same factor for above knee patients differed as discussed below.

b. Dimensions of Transfemoral Amputees: The following Table pictures the data on anthropometry required for a transfemoral prosthesis

Table: 55 Dimensions of Transfemoral Amputees

Parameters measured	Dimensions (in Inches)	Percent responding (n=34)		
		Age range of samples (years)		
		21 – 40 (n =15)	41 – 60 (n=14)	> 60 (n=5)
Stump length	5 - 8	27	29	-
	8.1 - 11	53	50	80
	11.1 - 14	13	14	-
	14.1 - 17	7	7	20
Total length	21.1 - 23	7	21	-
	23.1 - 25	-	36	-
	25.1 - 27	-	43	-
	27.1 - 29	60	-	-
	29.1 - 31	33	-	20
	31.1 - 33	-	-	80
Foot length	6	7	-	-
	7	20	-	-
	8	40	43	20
	9	33	43	80
	10	-	14	-

Stump length, total length and foot length were the measurements required for fabricating prosthesis for an above knee amputee. Stump length is measured from ischial tuberosity to stump end or to floor measurement. This is thus very critical in determining socket fit and correct prosthesis length. While taking measurement, care should be taken to position the stump in the mid line. Position to be adopted for measurement insists on standing with knee of the sound limb extended. Shoe size remains the length of foot.

With regard to this group too ample variation was observed with the measurements recorded – a proof of the range of anthropometric variations existing, which forms the basis of physical ergonomics.

Correlation and Regression Analysis of Data

To comprehend the personal factors which have a stake in deciding the fabrication was statistically analysed for both the group transfemoral and transtibial and the relationships are projected individually under Tables given for correlation and regression.

Table: 56 Correlation for Above Knee Amputee Data.

Variable	*Sex*	*Age*	*Refit*	*Duration*	*Side*	*TL*	*Foot*	*SE*	*SL*
Sex	1								
Age	-0.129	1							
Refit	-0.112	**-0.291*** **	1						
Duration	-0.282	-0.048	**0.417*** **	1					
Side	0.000	0.070	-0.123	0.264	1				
TL	0.250	**0.142*** **	**-0.107*** **	-0.053	0.350	1			
Foot	0.394	**0.269*** **	-0.068	-0.270	0.139	**0.720*** **	1		
SE	-0.236	**0.222*** **	**0.107*** **	**0.190*** **	0.060	**0.298*** **	0.342	1	
SL	**0.197*** **	**0.179*** **	**-0.264*** **	**-0.600*** **	0.006	**0.391*** **	0.559	0.021	1
*** -Correlation is significant at 0.01level (1%), ** Significance at 0.05(5%).									

The Pearson Product-Moment Correlation Coefficient (r) or correlation coefficient is a measure of the degree of linear relationship between two variables. Correlation coefficient may take on any value between plus and minus one. The sign of the correlation coefficient (+, -) defines the direction of the relationship, either positive or negative. A positive correlation coefficient means that as the value of one variable increases, the value of the other variable increases; as one decreases the other decreases. A negative correlation coefficient indicates that as one variable increases, the other decreases, and vice-versa (Stockburger, 2001).

The analysis of the correlation matrix of above knee indicates that few of the observed relationships were very strong. A strong relationship exists between the duration and refits (0.41); total length with age (0.14); foot length with age (0.26) and total length (0.72); Stump end circumference with age (0.22), duration (0.19), total length (0.29) and refit (0.10); and stump length with age (0.17) and total length (0.39). Any changes in the above mentioned variables, if used bring about change in the other directly. With increase in the age of the individual there are important growth changes taking place in the body size and proportions, as extremities grow faster than the trunk, leading to a gradual change in relative proportions (http://www.coachr.org/growth_and_ development.htm). This concept is evident in the study, as age increases there is a variation in the total length of the limb and the foot length also changes. In case of young amputee growth related changes are likely to bring about variations in the stump circumferences and length that influences total length and foot length indicating frequent

change in the prosthesis due to socket refits. Regardless of etiology, the residual limb of adults with lower-limb amputation undergoes substantial change in shape and volume (Sanders and Fatone, 2011). In the mature residual limb, both daily changes and long-term changes over weeks or months can occur. Shape and volume changes in the residual limb are believed important to changes in limb-socket interface pressure and shear stress distributions, which may in turn lead to socket fit problems, The findings are on par with the statements of Sanders etal ., (2005). Strong correlation between the duration and the socket refit proved in this study validates this concept. Both growth changes in young amputees or maturity changes over period of time influences the socket refit. ***So, age does influence the anthropometry in prosthesis design. Hence the null hypothesis is rejected, as there is association.***

The strong relationship mentioned above is proved again through the existing negative correlation relation with total length (0.10) and age (0.29) versus refit; stump length changes over period of time (0.60) and leading to socket refits (0.26). This proves that the age related changes leads to change in volume and shape of the stump, likely to cause variation in the total length of the limb enforcing the prosthetic users to change their socket fit.

Table: 57 Regression analyses for Above Knee Amputee Data

	Coefficients	*Standard Error*	*t Stat*	*P-value*	$\mathbf{r^2}$
Intercept	-0.599	4.904	-0.122	0.903	
age	0.023	0.030	0.756	0.455	
sex	-0.321	1.052	-0.305	0.762	
Refit	0.336	0.772	0.436	0.666	
Duration	**-0.260**	**0.068**	**-3.817**	**0.000**	
Side	0.250	0.716	0.349	0.729	
TL	**0.362**	**0.161**	**2.238**	**0.033**	**0.50**

Regression coefficients represent the mean change in the response variable for one unit of change in the predictor variable while holding other predictors in the model constant (http://blog.minitab.com/blog/adventures-in-statistics/how-to-interpretregression -analysisresultsp values-and-coefficients).The regression equation was fitted, as per the procedure given in Annexure-2 The results of the fitted regression equation co efficient and other parameters are presented in the above table. ***From the table it can be inferred that total length of the limb and duration of the amputation are strongly associated***.

Hence the hypothesis set for the study is proved. The co efficient of stump length (0.3620) shows that, one inch increase in stump length will increase in 0.36 inch in total length. Regression coefficient of duration implies that with the passage of every year of usage of the prosthesis the stump length decreases by 0.26 inches. Stump length is significant with duration and total length (P<0.05). The effect size is called the coefficient of determination and is defined as r^2. For r = 0.711, the coefficient of determination is 0.50 which means that 50 per cent of the variation in mean stump length scores among the above knee samples can be predicted from the relationship between duration and total length of the limb.

Table: 58 Correlation for Below Knee Amputee Data

	Sex	**Age**	**Refit**	**Duration**	**Side**	**Foot**	**TL**
Sex	1						
Age	0.370	1					
Refit	-0.065	**-0.234*** **	1				
Duration	0.316	**0.254*** **	**0.328*** **	1			
Side	0.205	0.0316	-0.164	0.093	1		
Foot	**0.508*** **	**0.117*** **	0.047	0.392	0.014	1	
TL	**0.599*** **	0.056	0.066	**0.196*** **	0.043	**0.705*** **	1

From the above correlation matrix table, it is evident that the following variables are strongly associated with each other positively, Duration with age (0.25) and refit (0.32); foot with gender (0.50) and age (0.11); total length of the limb with gender (0.59), duration (0.19) and foot (0.70). Relationships existing between duration, total length foot length and age are strong as that seen with above knee amputees as explained earlier. Once the growth phase is complete and long duration of amputation matures they modify the shape of the residual limb indicating that the need for socket refit is reduced.

Table: 59 Regression analysis of Below Knee Amputee Data

	Coefficients	*Standard Error*	*t Stat*	*P-value*	$\mathbf{r^2}$
Intercept	10.6075	1.0944	9.6927	0.0000	
sex	**0.9692**	**0.3128**	**3.0983**	**0.0030**	
age	-0.0056	0.0077	-0.7229	0.4726	
Refit	0.0994	0.2258	0.4401	0.6615	
Duration	-0.0059	0.0147	-0.4013	0.6896	
side	-0.2972	0.2209	-1.3455	0.1836	
Foot	**0.8971**	**0.1403**	**6.3950**	**0.0000**	0.631

The regression Table above clearly shows that one inch increase in total length is seen in male amputee as compared to female total length that is, there exists a one inch difference between male and female total length. The co efficient of total length indicates that every one inch increase in it will increase the foot length by 0.89 inches. Total length is significant with gender and foot length ($P<0.05$). For r = 0.79, the coefficient of determination is 0.63 which means that 63 per cent of the variation in mean total length scores among the below knee samples can be predicted from the relationship between gender and foot length of the limb.

These data holds enough proof to conclude that empirical data on individual anthropometry is highly significant in prosthesis designing and therefore rejects the null hypothesis set that the prosthesis preference is not based on individual anthropometry.

1.3. Alignment Technique Adopted by the Center: The alignment technique adopted by the selected Center was the basic technique, namely, bench alignment, which experts call as the most conventional type (explained under review).

The findings presented in this part of the study speak of the precision and focus required on the part of the prosthetists on the one side and the patience, perseverance and tenacity expected of the amputees to tolerate the rehabilitative process schedules to get fitted with the right type of human – machine system, an ergonomic product on the other.

The yeomen service rendered by the prosthetist community, hence need to be acknowledged and appreciated.

After undergoing a traumatic phase and further in the rehabilitative phase, unless the prosthesis fitted does not satisfy for the ergonomic objectives of comfort and well being, the human-machine interface cannot be deemed as successful. Hence the follow up part of the study analyses the comfort zone in which sample's have found a slot.

D. Comfort zone Vs Prosthesis

According to Bardwick (1995) comfort zone is a behavioral state where a person operates in an anxiety – neutral position. Alasdair (2009) also considers comfort zone as a psychological state in which a person feels familiar, at ease, in control and experiences low anxiety and stress, by which a steady level of performance is possible. Hence the status quo of the sample with regard to their feelings on comfort zone sequel to use of

prosthesis was found out using an opinionnaire and a rating scale. The findings of the study are presented under:

1. **Perceptive Evaluation of Fitted Prosthesis**
2. **Parameters Perceived as Satisfactory by Prosthesis users**
3. **Objective Ranking of Centers**

1. Perceptive Evaluation of Fitted Prosthesis : This aspect of the study on perceptive evaluation is discussed under the following headings:

1.1. Details on Amputation Site

1.2. Condition of Stump

1.3. Condition of the Contra - lateral Limb

1.4. Prosthesis- A symbol of Amputee Empowerment

1.1.Details on Amputation Site: This session of the results are explained under:

1.1.1. Phantom Feel

1.1.2. Sensations of Phantom

1.1.1. Phantom Feel: Table describes the general concept felt by the selected amputees

Table: 60 Phantom feel

Particulars	***Percent responding* (n=142)**	
	Male	**Female**
Phantom feel present	81	67
Phantom feel NOT present	19	33

A phantom limb is the sensation that an amputated or missing limb is still attached to the body and is moving appropriately with other body parts. A majority of 19 per cent among men, and 33 per cent among the women samples had accepted the phenomenon and answered in the negative for feeling of phantom.

1.1.2. Phantom Sensations: Table describes the phantom sensations experienced by majority of amputee**.** Phantom pain and walking distance are confounders in their relation to health-related quality of life. Walking distance appears to be higher in those without phantom pain (Schans et al., 2002).

Table: 61 Sensations of Phantom

Particulars		*Percent responding* (n=121)
		Phantom painful and requires medicine
Age (in Years)	< 20 (n=7)	100
	21-40 (n=40)	93
	41-60 (n=50)	78
	>61 (n=15)	93
Level	TF (n=34)	76
	TT (n=68)	84
	Bilateral (n=14)	100

Approximately 60 to 80 per cent of individuals with an amputation experience phantom sensations in their amputated limb, and the majority of the sensations are painful (Sherman et al 1984). Previous studies conducted by The Limb Loss Research and Statistics Program (2014) in collaboration with Amputee Coalition of America brought out that 80 per cent of amputees had phantom pain (Kegel et al 1977).

Phantom limb sensations were more pronounced among bilateral group and transtibial amputees as stated by 100 and 84 per cent respectively, though 76 per cent among the transfemoral too experienced it.

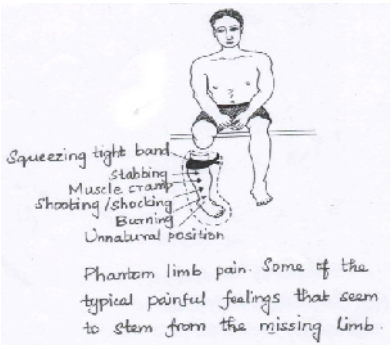


Figure: 52 Phantom Pain -Feeling

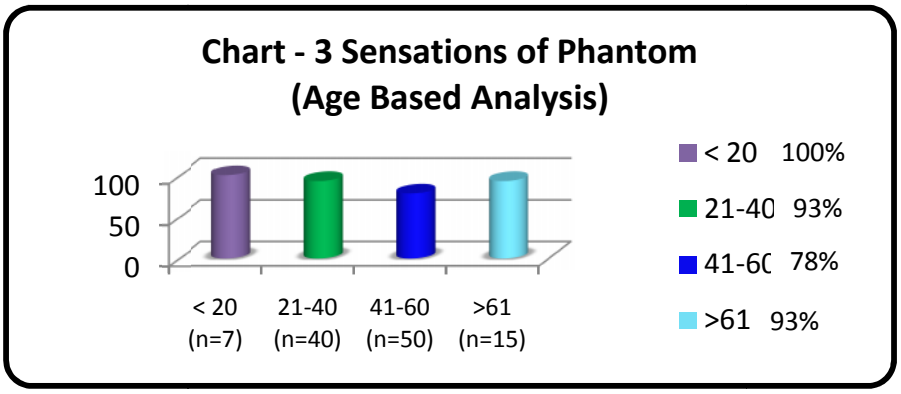
The others had expressed their feelings through their statements that they felt phantom painful (Figure 52) and require medical support. For this aspect age was not a factor. Irrespective of their age, those who had feelings of phantom explained them in different versions as felt as part of missing limb/entire missing limb, use of phantom while walking and the like. Similarly the level of amputation was a most deciding factor. Another potential determinant of health related quality of life in amputees is pain (Schans et al., 2002).In addition, patients with a lower limb amputation may have musculoskeletal pain (low back, hip, and knee pain) as a result of poor body mechanics or arthritis (Kurichi et al., 2015). Amputees with phantom pain have a considerably poorer health related quality of life than amputees without phantom pain (Schans et al., 2002). A relationship exists

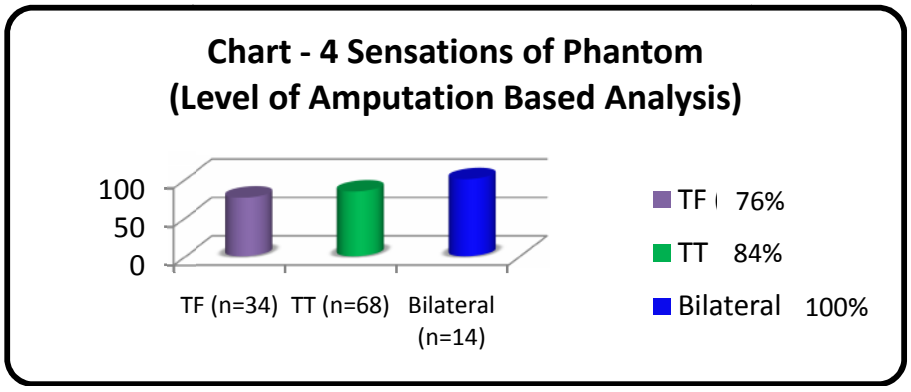
between phantom pain and emotional problems. *Three different* relationships exist between phantom pain and stress:

(a) ***Isomorphic relationship: time increases in pain lead to same time increases in stress and vice versa***

(b) Consequence relationship: increases in pain precede increases in stress

(c) Precursor relationship: increases in stress precede increases in pain.





1.2 Condition of Stump: Table describes the condition of the stump of the amputees

Stump is the part of a limb that remains after amputation. It is the part of the residual limb that snuggly fits into the prosthesis and enables the amputee access the prosthesis if found user friendly. One of the potentially troublesome sequelae of lower limb amputations is the development of stump neuroma at the severed ends of major nerves. The ability to define them and to distinguish them from other causes of stump pain is of considerable clinical significance.

A neuroma is a tumour-like thickening of a nerve stump in the region of the scar after amputation of a limb and is tender to pressure. Even a mild stimulation, causes the neuroma transmit strong pain signals. If local measures to relieve pain are inadequate, it may be worth considering a surgical removal of the painful neuroma. This condition makes it virtually impossible to mould a well-fitting prosthesis socket (Sehirlioglu et al., 2009).

Table: 62 Condition of stump

Particulars		Stump felt when walking	Percent Responding (n=142)			
			Condition of stump			
			Surgical scar	Scar adhering to bone	Fluid draining	Painful stump
Gender	Male (n=121)	55	48	32	13	73
	Female (n=21)	71	67	52	14	81
Age (in Years)	< 20 (n=10)	60	100	40	-	80
	21-40 (n=53)	55	53	26	23	58
	41-60 (n=61)	59	56	52	25	79
	>61 (n=18)	56	61	33	83	100
Level	TF (n=43)	51	42	33	33	79
	TT (n=84)	56	51	37	20	70
	Bilateral (n=15)	80	80	40	33	80

Comparatively for Transtibial (below knee) amputee and bilateral the presence of surgical scar and or scar adhered to the bone was quite disturbing, though the other group also felt so. Major complaints like fluid drainage or painful stumps prima facie emerged from the senior citizen group as problems associated with stump. Irrespective of the three variables studied, "painful stump" surfaced as a major stump feeling, as women, adolescents, senior citizens- all were found to be complaining about it

1.3 Condition of the Contralateral Limb: Table describes the condition of their healthy limb or contralateral limb

Table: 63 Condition of Contralateral Limb

Particulars		Percent Responding (n=142)		
		Cramping, without problems	Ulcers	Sustained pain
Gender	Male (n=121)	26	18	25
	Female (n=21)	33	33	29
Age	< 20 (n=10)	30	-	-
	21-40 (n=53)	25	11	21
	41-60 (n=61)	39	36	23
	>61 (n=18)	33	28	28
Level	TF (n=43)	26	23	19
	TT (n=84)	21	18	23
	Bilateral (n=15)			

Earlier studies indicate that the contralateral limb is more prone to amputation in high risk, aged patients coupled with low socioeconomic profile and illiteracy. Glaser (2013) indicates that rates of contralateral limb amputation are high and predicted by renal disease, atherosclerosis, and atherosclerosis with diabetic neuropathy. It is clinically valuable to understand the role of the contralateral limb in amputee gait since, if the joint forces in the contralateral limb exceed natural limits, the individual may be predisposed to premature degenerative arthritis (Lewallen et al., 1986). In an attempt to equalize step length, improve balance and ensure knee stability, the prosthetist strives to achieve a symmetrical gait pattern when aligning and fitting an amputee with prosthesis. Evaluating lower limb symmetry may therefore contribute to a better understanding of the role of the contralateral limb (Hurley et al, 1990).

Opinion on the condition of healthy limb revealed mixed feelings. Female category had more complaints than their counter part; likewise age had a say in the way they perceived the condition. The above knee group felt more unsatisfactory because of the first two problems comparatively, but pain wise the proportion was found to be more among the below knee group.

The medically-induced amputees (Diabetes, Peripheral Vascular Disease etc), and the aged expressed concern as they were more prone to endure amputation of the contralateral limb too as the propensity /likelihood was very high .They expressed to be very conscious in practicing " self-care".

Amputees apply more weight to their dominant limb. After a unilateral amputation has occurred, their contra lateral limb generally becomes their dominant limb. This weight-shift seemingly provides them with greater coronal stability (Carroll, 2014).

2. Parameters Perceived as Satisfactory by Prosthesis Users

Responses received for the 38 pointers given in the rating scale to evaluate the prosthesis for given parameters was analyzed for the extent to which the statements recorded were satisfactory. The details on the rating awarded for each item, Center - wise was analyzed. The first Center offered exoskeletal system while the other two Centers fabricated a much sophisticated endoskeletal system. The findings are summarized under the following headings:

2.1 Product

Customized fabrication was well appreciated by all the samples. The selected samples irrespective of the Center from which they fitted prosthesis, in unison stated that they were happy with regard to the fit, weight and resilient (noiseless) nature of the product as a system, though use wise samples using the one from the third center commented as satisfactory. Similarly, donning was found to be easy for those using the first two, while for the third type the samples needed assistance. The first center's product was not appreciated cosmesis wise, while the other two felt it excellent. The damaged status of the external cover was produced as a reason for the feeling by those using the first type. An enquiry on whether they felt that their quality of living had improved with the use of the system, the first group stated as to have perceived as happy, second as satisfactory, but the third had no comments about it.

2.2 Personal Experience

An important truth surfaced from the study in that the "option" for going for the prosthesis was rather enforced upon the above knee amputees and the bilateral group as they could seldom ambulate without some kind of support. Instead of moving with other assistive devices they had accepted an artificial limb

Despite using different fabrications, none of the samples had experienced complaints as rashes, blisters, sores in ingrown hair and the like on their residual limb with the use of them. This is an encouraging feature as the responses vouch for the quality of the materials used and their personal health status in not contracting any allergic reactions to the materials. Albeit in different ways, all of them felt feelings of increase in temperature and sweat within the socket and the subsequent tendency for foul smell from the prosthesis. While comfort in standing was found to be satisfactory sitting was a discomforting situation for the first group, though the other two groups agreed to have got adjusted to it. The third group alone felt working with the prosthesis as consuming more energy, by virtue of the weight they carried and the strain experienced while working, as against the other two groups who complained of developing swelling. It is clear therefore that the samples did not find the prostheses user – friendly in their work places.

Difficulty in wearing shoes, engaging in office job, domestic work and hard labor (as the case may be), was frequently felt as uncomfortable by all the groups when using the artificial extremity. Regarding feeling at ease and being comfortable when engaged in recreational activities and in social settings the groups had mixed feelings. Obviously the findings picture their adaptability to real life situations was not bright.

Evidently, it was clear that when the samples had compromised with many of the problems felt and had borne the brunt – a good sign of adaptability – they also had to take in their stride certain additional discomforts by virtue of donning the prosthesis like extra sweat, rise in temperature, smell etc which they had to tolerate too. Though one can summarize the advantages and state that they could partially regain their own living styles, when considered in terms of satisfaction of QoL standards, they appear to face many limitations and constraints.

Such personal experiences coupled with dissatisfaction felt with the fabrication (heavy, misfit, etc), had led many to go in for multiple refits. One physiological aspect stated further was to have aggravated the problem; that is, the change in stump length /girth due to the sample turning obese, shrinking of stump etc which again forced them to go in for a refit.

2.3 Phantom

All the samples felt phantom sensation and pain daily on a frequent basis. The intensity extended from bearable to moderate among the groups. Though the sensations felt were moderately bothersome, pain felt was extremely bothersome. These feelings tended to affect their activity levels and productivity to a large measure stealing their time more for personal aspects. Though stated to be a psychological factor, it has been proved beyond doubt by many researchers that the perception of phantom by the amputees can never be underestimated or understood nor mitigated. This in many ways affected their daily living.

2.4 Experiences on Pain

It was unfortunate that all the samples experienced pain in the residual limb, contralateral limb and lower back as they had to balance their gait while walking and performing other activities only on the support of the contralateral limb on the one hand and the pressure or force exerted by the socket or other components on the residual limb

on the other. It is an inevitable concept. Depending upon the duration for which the pain extended, reports state that to be endured from a mild nagging pain to a moderately bearable one. Such painful experiences occurring every now and then was felt as highly bothersome since they were not put on any medication, which left them frustrated and listless sometimes and losing interest in the job taken up – may it be office, personal or domestic. Hence the intensity of pain also was felt as extreme, especially by the first group. These aspects partially explain that donning the prosthesis proves never as an end to their agony or trauma, but only a temporary transition to forget their plight.

These facts had forced majority of the below knee amputees to forego use of the prosthesis and start walking with crutches. The weight of the device, especially offered by the third center, though very sophisticated, was found to be more, which had forced many of them to discard that expensive fitment and opt for the one from the first center, a comparatively low priced one.

2.5 Miscellaneous Factors

Use of prosthesis was found to put limitations for all the samples on the choice of clothing and the type of shoes able to be worn, (irrespective of the type of device). Those who considered public appearance as important and those narcissistic personalities suffered an assault to their self esteem because of these limitations. Constraints on affordability to access those devices with appreciable cosmesis were a significant factor raised by many. Similarly the ego – bolstered group felt highly intimidated because of their obvious dependence on others. Those who were emotionally affected suffered dependence syndrome with their predicament to seek assistance. Many of them expressed their feelings of guilt experienced for no reason. A blatant aversion to the fitted appendage and cursing one's fate was also observed.

2.6 Features Expected as significant in Prosthesis

Total weight of the product, provisions for donning ease, and durability of cosmesis and other components and range of motion facilitated were stated as highly significant in deciding the fit of prosthesis. While the first group whose gait was the best among the three, attested to gait satisfaction also as a factor, the other two for whom the prosthetists had given alignment adopting three different techniques never said so, though despite the training they accepted that their gait was not proper. Probably, even after varied trainings

their understanding of gait was not adequate and they had taken this gait they were used to now as proper gait.

Fabricating devices which were cost effective enabling affordability by all was a unique factor pointed out by all (projecting prospects for refitting concerns with expensive models).

From all the information gathered it is clear that prosthesis has to be fabricated incorporating these important practical issues to offer devices with more user – friendly attributes like:

- **Ease of donning without assistance**
- **Appreciable cosmesis (especially for exo – skeletal models)**
- **Durability of materials**
- **Light weight designs compatible for activities done**
- **Designs enabling temperature, sweat and smell control**
- **Clothing suitable for them by apparel designers**
- **Social – cost – benefit strategy**

3. Objective Ranking of Centers and Prosthesis by Users

A ranking is a relationship between a set of items such that, for any two items, the first is either 'ranked higher than', 'ranked lower than' or 'ranked equal to' the second (https://en.wikipedia.org/wiki/Ranking). Rank order questions provide participants a unique opportunity to specify how items or concepts stack up against each other. **Box ranking** was chosen to know the preferences of the selected samples towards their prosthetist Centre based on the above mentioned factors. The scores were provided to each rank. The highest score of 4 was awarded to rank 1 to a score of 1 to rank 4 in descending order.

Table: 64 Objectives Ranking of Centers and Prosthesis by Users

Particulars	Number Responded N= 142											
	Ranking Scale											
	Prosthetist 1				Prosthetist 2				Prosthetist 3			
Rank	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
General Factors	1276	708	314	223	1196	312	270	106	1276	558	396	132
Prosthesis Related	632	231	140	80	368	201	128	36	460	249	208	48
Non Painful Sensations	136	132	108	33	104	102	48	27	156	105	90	19
Painful sensations	1188	705	382	159	684	480	306	110	932	708	392	131
Expectations	624	201	66	74	220	162	108	59	408	213	136	59
Total	3856	1977	1010	569	2572	1257	860	338	3232	1833	1222	389
Overall Total	**7412**				**5027**				**6676**			
Average	**151**				**103**				**136**			
Rank	**1**				**3**				**2**			

The above Table vividly picturizes the fact that the ***most preferred prosthetist was Centre -1*** followed by prosthetist Centers 3 and 2. This indicates that sophistication and technical advancement alone cannot capture the market, ***Consumer satisfaction with respect to comfort, safety and function-objectives of Ergonomics is more important in case of rehabilitation.*** Amputees are individuals who wish to *focus on their ergonomic functioning as that can only give them their future.* ***It is well expressed by the words of Phyllis Bottome,***

"There are two ways of meeting difficulties
You alter the difficulties or you alter the way you meet them."

Amputees desire to alter their way of meeting their disability with a functional prosthesis, is very evident from this study. ***The null hypothesis is rejected.*** Accessibility is therefore dependent on the extent of comfort, safety and function that the device can ensure along with availability. Evidently they have found their "Comfort Zone"

1.4 Prosthesis –A symbol of Amputee "Empowerment"

"Empowerment" is the process of individuals directed towards taking charge of such a process of promoting informed self-care efforts realms as health promotion and health protection. To this effect the prosthetist team was found to collaborate, teach, counsel and intervene with clients, as Pender et al (2002) state, mainly to facilitate their

active involvement in making rational and informed choices about health, health care, well being and mastery of their environment. The rehabilitation process in fact had been a common ground for both the prosthetic team and beneficiary to reap mutual benefits. This phase-the participatory ergonomic phase definitely had left the amputees "Empowered".

E. SWOC Analysis on Prosthesis – Access and Adaptability

The success of any endeavor relies on a two way process where the consumers have an access to it and the way they accept it. It is all the more pronounced with those who have a disability. Then accessibility refers to the design of the products, devices, services or environments for people with disabilities, which they try to adapt. Adaptability then exhibits the ability of the person to learn from experiences which in the long run improves the fitness on the learner. Therefore for any product to be accepted, both accessibility from the giving end, the entrepreneurs and adaptability from the receiving end, the consumers have to be ensured. Once done the consumers can state they are in a **comfort zone**.

The first concept refers to a product and or the service available for access, while the second reflects the trait of an individual to access the product or service and the way they use it once it is accessed. Either way the opinions of the concerned individuals receive priority. With this backdrop the opinion of the selected sample on the following factors was deduced to understand how far the prosthesis is **accessible** and to what extent they have **adapted** to it. Hence an enquiry was made on the following lines:

1. **Motivation to Go in for Prosthesis**
2. **Details on Samples gone for Refit**
3. **Pointers for Accessibility**
4. **Experiences on Adaptability**
5. **SWOC Analysis**

1. **Motivation to Go in for Prosthesis:** This aspect of the findings is presented under:

   1.1. **General Motivators**

   1.2. **Role of the Prosthesis Centers**

1.1. General Motivators:

The surgeons, family members, hospital staff, friends, relatives and a score of information gathered from media emerged as the common motivators for all the sample amputees. The surgeons and hospital personnel had gone one step further in introducing them to the Centers with whom they either had contacts or were an annex to the hospital. Practical advice to go in for prosthetics basically was given to all, but not forced upon, as preference to go for one ultimately was vested with the amputee.

Almost 40 per cent of the said sample was further motivated when attending camps conducted by ***philanthropists and NGOs*** with the good intentions of making the system accessible to the non – affordable. A large portion of the sample stated to have benefitted from these camps and donned one either free of cost or for a nominal value.

The role of family members in giving assurance for assistance and or financial support had taken a key role in motivating the samples greatly. Another factor of significance is the ***possibility to access prosthetists and the Centers in the City*** (the colloquial home town).

1.2. Role of Prosthesis Centers:

The role played by the prosthetists and the concerned Centers can never be underestimated as far as the selected sample is concerned, for instilling in them the much required confidence and mind set to get fitted with an artificial limb. Their product mobilization measures by highlighting the system components and their merits and the rehabilitative process adopted by them have been highly influential in getting a positive nod from the samples to get fitted with one. ***These are pointers to indicate that the samples really enjoyed interpersonal relationships for exchange of resources a theory much advocated by Foa (1974) and Caplan (1974) for social support***.

2. Details on Samples Gone for Refit

It is rightly said that the success of the pudding is in the eating. Hence an attempt to find out if the samples had returned to the Center for a refit after the initial fit, revealed the following:

Table: 65 General Details on Samples Come for Refit

Particulars	Details	Percentage responding (n=42)
Age range (years)	< 20	10
	21-40	31
	41-60	45
	>61	14
Gender	Male	83
	Female	17
Level of amputation	TF	71
	TT	29

The findings pointed to representation from all age groups to appear among those who had come for refit of prosthesis, among whom 59 per cent were above 40 years of age. Domination of male and transfemoral amputees was also noticed. Hence, the year they got amputated was found and is presented in the following Table

Table: 66 Year of Amputation of Samples Come for Refit

Year of amputation (In range)	Percentage responding (n=42)	
	Trans femoral (n=30)	Trans tibial (n=12)
1975 - 80	3	-
1981 - 85	7	-
1986 - 90	-	8
1991 - 95	7	-
1996 – 2000	10	-
2001 - 05	33	50
2006 - 10	23	34
2011 - 15	17	8

It was very agonizing to record **27 per cent** among transfemoral and eight per cent among transtibial belonging to the last quarter of the previous century coming for a refit. Nevertheless their passion to go for a refit despite so many years of life on an artificial limb has to be applauded and their interest in maintaining their values of independent living and self esteem has to be welcomed. Almost 75 per cent belonging to this century having fallen for such a living style is quite depressing. Here transtibial were too found to be more. For **69** per cent the cause of amputation **was accidents**, followed by diabetics (21%), vascular diseases (7%) and the rest cancer. Inevitably, the reasons and their proportion have remained the same. However, this again is a warning that if caution is not practiced, with the burgeoning population and the mushrooming vehicles

on the road, the City is destined to shoulder a larger population of prosthesis users. These aspects necessitated finding out the reasons for a refit.

2.1 Reasons for refit

An enquiry among the sample revealed that they were visiting the Centers not for a modification of the previous fit, but for a total change of prosthesis. The reasons stated were quite depressing. Physiological changes warranty change of device, availability of limb free of cost or at nominal cost, damage to the system due to materials of inferior quality, wear and tear and above all careless handling were but a few cited as very significant. Yet there also was a group who sincerely refused a refit on the grounds of hygiene and the principle of self care. (Plate-5)

3. Pointers for Accessibility

Responses received for a few questions discretely fitted in all the tools used for the study and the aftermath of observation revealed some valid points that reflect the opinion of the sample regarding access to the prosthetists and the device as such, which are explained in Table 67

Table: 67 Pointers of Accessibility

Driving forces	Factors of accessibility	Percent responding (n=142)		
		Positive	Negative	Positive and negative
Personal needs	Satisfy basic needs	*		*
	Enable mobility and balance	*	*	*
	Job reintegration	*		
	General awareness	*		
Personal factors	Age	*		*
	Gender – dependence (for visits)			*
	Personality issues		*	*
	Social status	*		*
	Dependence syndrome		*	*
	Restricted movement		*	
	Becoming a symbol of sympathy	*		*
Family support	Assistance at home (for daily chores)			*
	Assistance for mobility (for ambulation)	*	*	
	Visit prosthetist		*	

Driving forces	Factors of accessibility	Percent responding (n=142)		
		Positive	Negative	Positive and negative
	Living alone		*	
	Motivation from family	*		*
	Engage paid help		*	*
Service available	Access to Centers (prosthetist)	*		
	Nature of service provided	*	*	*
	Hospital support for on - site fabrication			*
	NGO/ Government/ philanthropist support	*		*
	Fabrication facilities available nearby	*	*	
	Counseling services	*	*	
	Prospects for customized fabrication	*		
	Procedural factors / lapses		*	*
Financial support	Affluent to meet the needs	*		*
	Support from family	*		*
	Free limb	*	*	
	People responsible for accidents		*	*
	Insurance cover		*	
	Compensation from employers		*	
	Reimbursement for prosthesis from employers		*	

The views of the sample on pointers for accessibility were culled out under five major driving forces. The findings revealed the mixed feelings they had for the stated factors. Statements for which they had responded in the neutral (positive and negative) shows their status of confusion and reflects the agony they would have undergone before being fitted with the prosthesis. Measures to create a general awareness among the public about the services available through **different media** may be more of assistance than the word of mouth strategy adopted until when one is destined to a need. In a developing country like India, earnest efforts from Government, employers, insurance companies and even hospitals to embrace those in needy on an '**insurance wrap'** can end up in making the accessibility prospects much brighter.

4. Experiences on Adaptability

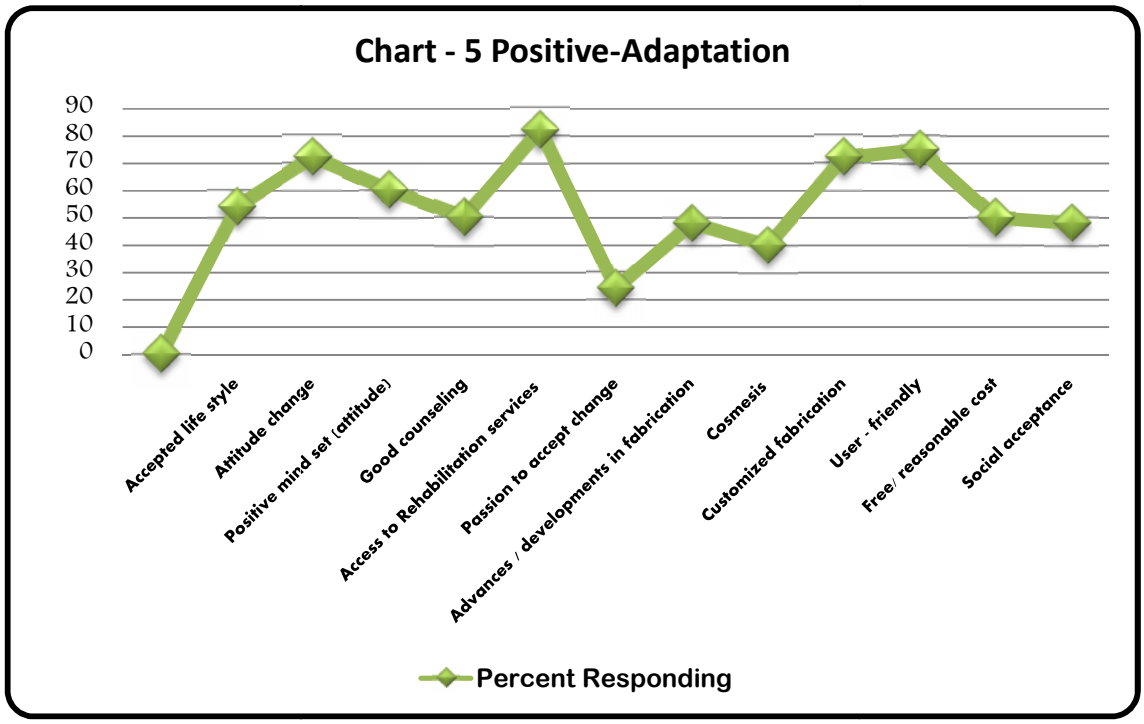
The responses received for accessibility issues have been concrete and were given after giving enough thought for each point, revealing their cognitive ability. Obviously, their reasons to adapt would also be on a higher plain. Table 68 presents the concerned data.

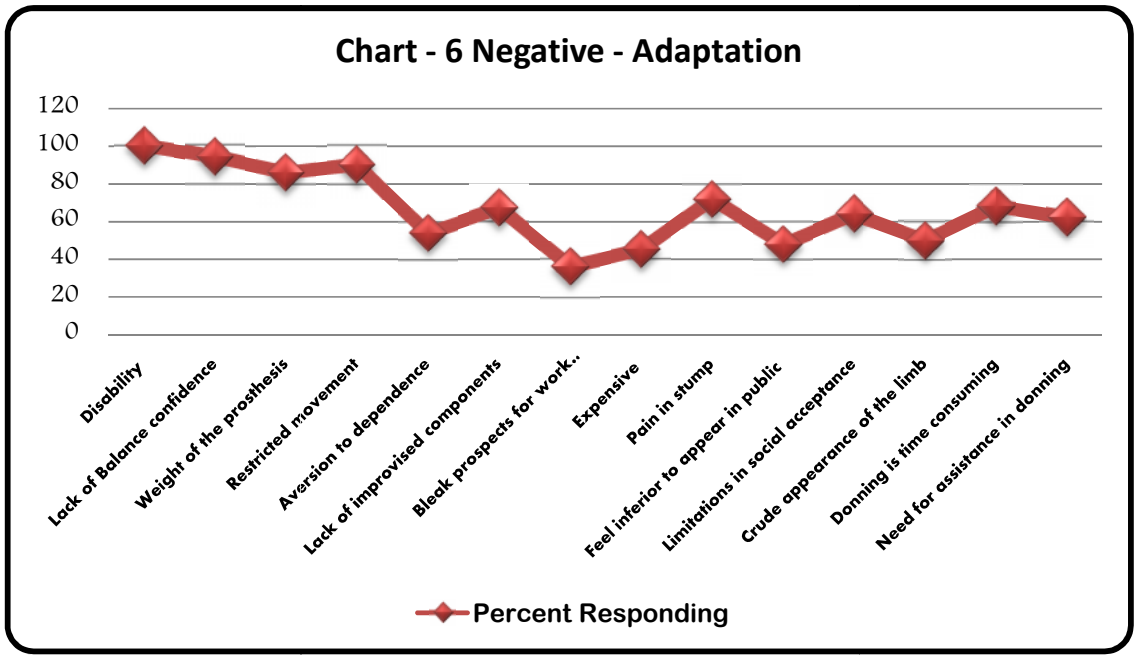
Table: 68 Responses for Adapting to Prosthesis

Nature of response	Factors for adaptability	Percent responding (n=142)
Positive	Accepted life style	54
	Attitude change	72
	Positive mind set (attitude)	60
	Good counseling	50
	Access to Rehabilitation services	82
	Passion to accept change	24
	Advances / developments in fabrication	48
	Cosmesis	40
	Customized fabrication	72
	User - friendly	75
	Free/ reasonable cost	50
	Social acceptance	48
Negative	Disability	100
	Lack of Balance confidence	94
	Weight of the prosthesis	86
	Restricted movement	90
	Aversion to dependence	54
	Lack of improvised components	67
	Bleak prospects for work integration	36
	Expensive	45
	Pain in stump	72
	Feel inferior to appear in public	48
	Limitations in social acceptance	64
	Crude appearance of the limb	50
	Donning is time consuming	68
	Need for assistance in donning	62

Adaptation encompasses long term actions to recover from a crisis situation states Bomer (2004). Similar to the responses received for accessibility, the statements given for accepting prosthesis was also expressions of their mixed feelings. Dichotomy

prevailed in the way the samples accepted to adaptation – exhibiting both their positive and negative feelings towards it. Nevertheless the positive feelings highlighted the finer sentiments they had for product availability, access and services coupled with a changed positive outlook on life (on the personal front), both of which are profusely encouraging for those in the service. These facts prove that accessibility to prosthesis is profoundly acknowledged, proving the hypothesis. Contrarily, adaptability was found to be more or less individualistic, that is user – centered. These factors project a host of lame excuses individuals can state to avoid going in for prosthesis. They reflect the negative sentiments the sample's themselves attached to their predicament, giving vent to their emotions on helplessness, depression, pain, resource commitments, social rejection, personality issues and the like. Certain factors not afforded by them like social and family support, (psycho social support) social acceptance, insurance coverage, cost involved – all are witness to their lack of affordability. Perception of their body image complied with the concepts of embodiment on a negative track, prevents them from responding in the affirmative to the question of accessibility. These factors prompted the investigator to strike a balance by drafting a SWOC Analysis





5. SWOC Analysis

The strengths, weakness, opportunities and challenges concerned with the samples perceptions on **accessibility and adaptability** to prosthesis is depicted below. Exhibit () clearly shows the SWOC analysis.

Pointers or strengths vis- a vis weakness were found to vie with each other for special address. Nevertheless, the multiple-window options available for opportunities and challenges stage viable prospects for being in the lime light. A concerted effort from all stakeholders can enable a spectacular take off to the silver line of social responsiveness.

Table: 69 SWOC Analysis

S

- ✓ Self care
- ✓ Usability
- ✓ State of the art labs
- ✓ Trained Prosthetist
- ✓ Improvised Models
- ✓ Commitment and integrity of amputees
- ✓ Social support
- ✓ Expressiveness
- ✓ Service providers
- ✓ International Support
- ✓ Clinical/Hospital Support
- ✓ Net working
- ✓ Family Support
- ✓ Taking responsibility for self

W

- ✓ Job reintegration very bleak
- ✓ Non participatory fabrication of biomechatronics
- ✓ Long hours of consultation
- ✓ Unsatisfactory living arrangements/ modification
- ✓ Compromise on low capacity materials
- ✓ Snowballing attitude
- ✓ Rejection of insurance cover
- ✓ Poor (sparce) social acceptance
- ✓ Lack of advertisements on service providers
- ✓ Have to travel long distance
- ✓ Lack of family /social support

SWOC

C

- ✓ Strive for cost effectiveness
- ✓ R&D Projects on materials
- ✓ Mass production strategies
- ✓ Info transfer
- ✓ Media intervention
- ✓ General awareness campaign
- ✓ Motivation campaign
- ✓ Mobilizing funds
- ✓ Create prospects for job integration
- ✓ Correcting social myopia
- ✓ Government intervention

O

- ✓ Facilitate financial support
- ✓ Entrepreneurial prospects
- ✓ Corporate intervention
- ✓ Awareness generation- education/training
- ✓ Ensuring insurance cover
- ✓ Connectedness through media
- ✓ Advertising
- ✓ Interstate/International net working
- ✓ Technical training
- ✓ Informed self care counseling