

Innovative “RK Walker”: Transdisciplinary Multiphasic Observational Experimental Trial

Rima Jani¹, Priyanshu Rathod¹, Kartik Kothari²

¹Assistant Professor at Shree Bharatimaiya College of Physiotherapy, Surat, ¹Dean, Faculty of Medicine, Director, School of Physiotherapy, RK University, ²HOD Mechanical Department, RK University, Rajkot

Abstract

Activities of Daily Living (ADLs) involves several physical activities like walking, climbing, etc. However, such ADLs may get compromised because of disorders where assistive devices play a key role for functional independence. Walker is a device used by people with locomotor disabilities, where stair climbing remains challenge. **Objectives:** To understand the process of making an innovative walker for stair climbing, to test and re-test its applicability with healthy adults and patients with locomotor disabilities, to dedicate the outcome of research work to improve quality of care and life. **Methodology:** Multiphasic Observational Experimental Trial, **Phase I:** Identify the need of change in traditional walker by survey, **Phase II:** Designing a Walker in AutoCAD software and hardware (RK walker), **Phase III:** To assess the efficacy of “RK Walker” compared to Traditional Walker in healthy adults, **Phase IV:** With reference to data analysis from healthy adults, Traditional standard Walker and “RK Walker” was compared for walking (TUG) and “RK Walker” for Stair Climbing (SCT) on patients with partially and non-weight bearing gait due to spinal / lower limb musculoskeletal dysfunction. **Result:** Outcome measures and feedback reports show significant impact with RK Walker as compared to traditional walker especially in stair climbing. **Conclusion:** This multiphasic observational experimental trial and novel concept extend the functional ability for stair climbing for patients with disability.

Keywords: Spinal and lower limb dysfunction, stair climbing, walker

Introduction

Activities of daily living (ADLs) involves several physical activities, such as walking, climbing, grooming, etc. One needs to be ambulatory independent to carry out all these activities. Ambulation is one of the functional requirements which gets involved in fulfilling ADLs in all age groups.

Loss of independent ambulation due to various disorders will cause loss of mobility. To be living

optimally is to keep moving functionally. Loss of mobility will be a hindrance for functional tasks. Autonomy in the area of mobility is of high value.

Independent ambulation in cases of disability can be achieved with some kind of assistive mechanism. For several years, researchers have been addressing the needs of persons with disabilities through assistive device. There are different kinds of assistive devices available to meet requirements of user. Some of the various mobility assistive devices available are canes, walkers, wheelchairs, etc. Though such assistive devices has its own limitation / benefits in functional fulfillment. [1]

Corresponding Author:

Dr. Rima Jani (PT)

Designation: Assistant Professor at Shree Bharatimaiya College of Optometry & Physiotherapy

Address: B-107, Crystal Palace, VIP road, Vesu, Surat 395007.

However, walker is one of the common assistive devices routinely practiced by people with lower limb disabilities. Among the assistive devices, walkers assume an important role, due to the large number of

potential users, considering its simplicity and ambulatory potential.

Line of gravity passes through body's center of mass. To maintain balance body's center of mass should be maintained over base of support. Due to lower limb disability body's center of mass gets shifted from its original position and also, the base of support is reduced leading to increased risk of falls. Use of a walker will increase the base of support hence increases the balance. [2]

There are many types of walkers, considering their constitutive materials and configurations. However Standard walker is the most common variety of walker that is used because of high level of stability and mobility. Also, there are physiological benefits of limiting osteoporosis, reducing deconditioning effects and improving peripheral circulation compared to use of wheelchair. [1]

However, there are some limitations of traditional standard walker. This aspect is clear when considering stair-climbing. While modern architecture and government policies continue to make community accessible for disabled, steps cannot be completely eliminated. [4]

A walker which can be used for walking as well as stair climbing will be of great advantage to people using walker. There is increasing need to explore technology and use it for society. Technological advances in the walkers' field have a great potential on helping people with mobility disabilities.

Ergonomics also play a very important role in this aspect. In designing such a medical product for the human use, the anthropometric data is an essential element that must be put in consideration. Without using the appropriate measurements, the product, layout or workspace may not function effectively. [5]

Smart walkers have emerged with the same structure as the conventional ones but they include additional robotic components that promote a better assistance to gait, especially considering navigation. [3]

Some of the modifications made for walker with stair climbing facility have been made. Boomer was designed by Daniel Molloy, Australia, has a futuristic

aesthetic. It allows the user to climb stairs: by pushing a button the front wheels move along to near the back wheels so that it becomes a kind of cane that helps in climbing the stairs. [6]

Great Lakes Innovations Inc. holds patent for the Stair Climber which is a walker, designed to make a regular walker adapt seamlessly to become stair-climbing walker. [7]

Still it is found that such walkers with advance mechanism are not so easily available in our present scenario. An online survey was conducted among physiotherapists to identify the need of change in traditional standard walker. Among different modifications suggested there was certain need to focus on modification in available design of traditional standard walker to use it for climbing staircase.

However, there is certain need to develop a walker which can be used by children with disability to climb staircase. A multiphasic experimental trial in which an innovative walker will be designed, manufactured and progressively tested on young healthy adults, followed by testing on adults with disability, then healthy children and finally testing on children with disability to evaluate effectiveness of the walker as well as user satisfaction with it. User feedback taken after the experimental trial in each phase will guide for further modification in innovative-walker.

Objectives

1. To understand the process of making an innovative walker for stair climbing
2. To test & re-test its applicability with healthy adults & patients with locomotor disabilities
3. To dedicate the outcome of the research work to society to add on quality of care and quality of life

Materials and Method

Materials:

- Innovative "RK Walker"
- Traditional Standard Walker
- AutoCAD software

- Metal rods & hardware parts
- SF 36 Health Questionnaire
- QUEST version 2.0 Quebec User Evaluation of Satisfaction with Assistive Technology
- Timed Up and GO (TUG) Test
- Stair Climbing Test (SCT)

PHASE III
 Young healthy Adults (SF 36 - General health status Good & above)

Age: 18 to 35 years (healthy subjects)
 Height: 5.4 to 5.6 feet

PHASE IV

Patients using walker with partial weight bearing in one lower limb

Age: 18 to 50 years
 Height: 5.4 to 5.6 feet

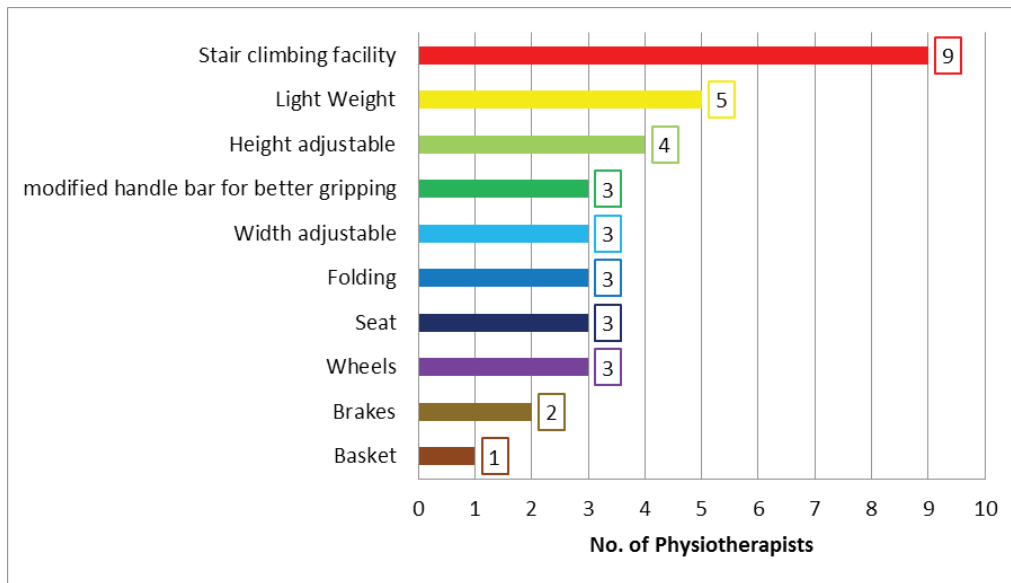
Methodology:

- Study Design:
 Multiphasic Observational Experimental Trial
- Inclusion Criteria:

PROCEDURE

PHASE I

It's a multiphasic study trial. After Ethical committee approval an online survey was conducted in Phase I using google form. Mailed to various leading Physiotherapists, who gave opinion about the need of modification in traditional walker.



Graph 1: Modifications suggested by Physiotherapists in Traditional Standard Walker

INTERPRETATION: 20 physiotherapists suggested the need of modification in traditional standard walker. Individual modification suggested and number of physiotherapists is represented in Graph 1. Stair climbing facility was suggested as modification in traditional standard walker by maximum physiotherapists who participated in survey.

PHASE II

A raw model of innovative walker was made inside RK University campus. There was some difficulty for locking stability while climbing staircase using it. Further, designing of final model of innovative RK walker with locking stability was done with help of

engineers using AutoCAD software. Bill of material and application was given for financial support to RK University for project funding which was granted. Final model of RK Walker was manufactured in collaboration with Kelco Industries.

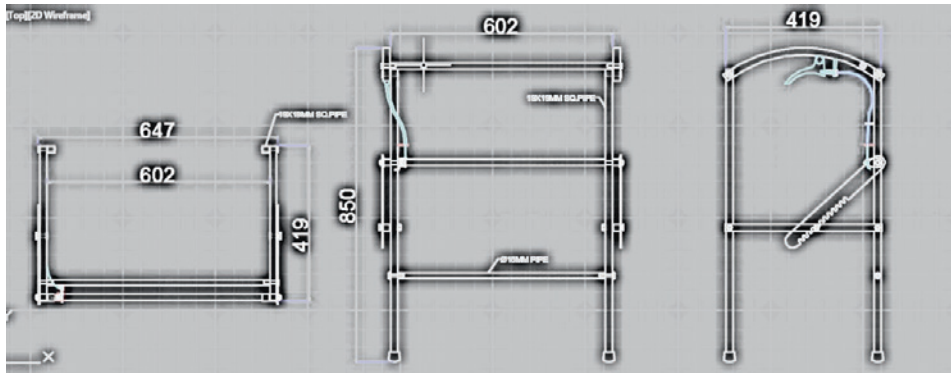


Fig. 1 AutoCAD

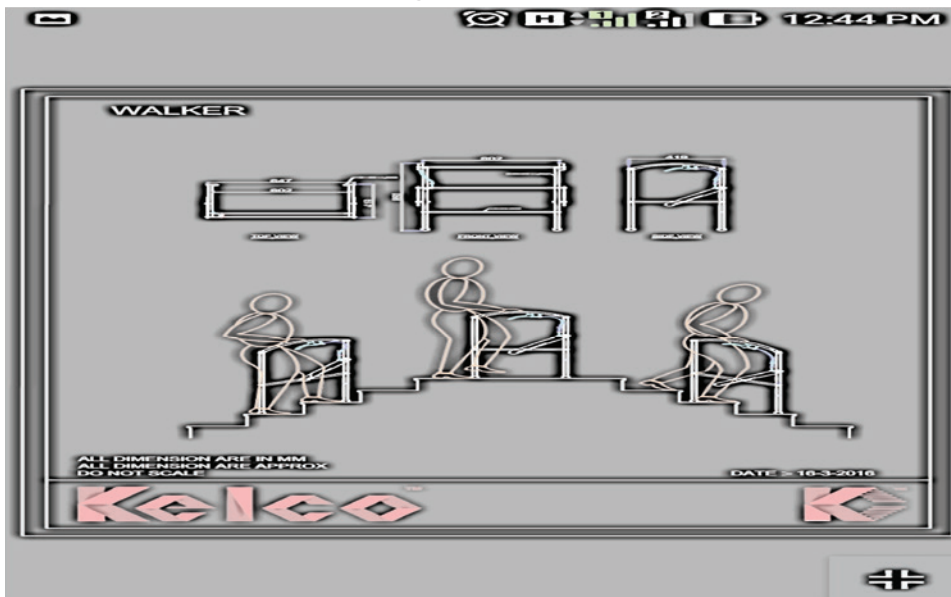


Fig. 2 AutoCAD simulating on steps

PHASE III

For testing of RK Walker subjects were selected based on inclusion criteria. Consent were taken, Timed Up and Go (TUG) Test was done with both traditional standard walker and RK Walker. And Stair Climbing Test (SCT) was done with RK Walker. Subject had to keep one leg in non-weight bearing during TUG Test and SCT.

In TUG Test time taken to rise from a chair, walk 3m, turn, walk back to the chair, then sit down wearing regular footwear and using walker was noted. Pulse rate (PR) was taken at rest and after TUG Test with traditional standard walker and RK Walker respectively.

In SCT time taken to ascend and descend a flight of stairs was noted. 10 steps with 18cm step height was used. PR was taken at rest and after SCT with RK Walker

After TUG Test and SCT subject's feedback for RK Walker was collected using QUEST 2.0

PHASE IV

With reference to positive result and data analysis from healthy adults, Traditional standard Walker and "RK Walker" were compared for walking using TUG Test and "RK Walker" for SCT on patients with partially and non-weight bearing gait due to spinal and lower limb dysfunction.

For testing of RK Walker patients were selected based on inclusion criteria. Consent from patients were taken. TUG Test was done with both traditional standard walker and RK Walker. And SCT was done with RK Walker.

Pulse rate (PR) was taken at rest and after TUG Test with traditional standard walker and RK Walker respectively.

In SCT time taken to ascend and descend stairs was noted. 10 steps were used wherever possible. However, controlled environmental condition was not maintained as the test procedure was carried out at varied outpatient department where step height was not same. PR was taken at rest and after SCT with RK Walker.

Following tests, patients' feedback for RK Walker was collected using QUEST 2.0.



Fig. 3 SCT with RK Walker

Result

PHASE III:

On analyzing scores of TUG Test for both Traditional Standard Walker (21.40 seconds) and RK Walker (24.33 seconds) in healthy subjects, we have observed that both were efficient in walking on flat surface. However, time taken for TUG Test was few seconds less with standard walker than with RK walker in healthy subjects.

The mean score of resting PR (77.80) and PR (86.47) after TUG Test with Traditional Standard Walker, PR (86.43) after TUG Test with RK walker and PR (87.30) after SCT with RK Walker in healthy subjects which shows that exertion level during walking remained almost same with both the walkers and also

shows the exertion level during stair climbing with RK walker. Considering these information modifications can be done in model of RK walker.

QUEST 2.0:

QUEST version 2.0, includes 12 items to evaluate satisfaction with assistive device and its services. In that 8 questions are related to Assistive device and 4 questions are related to Services provided for assistive device. In this study first 8 questions related to 8 satisfaction items of assistive device were taken for RK Walker.

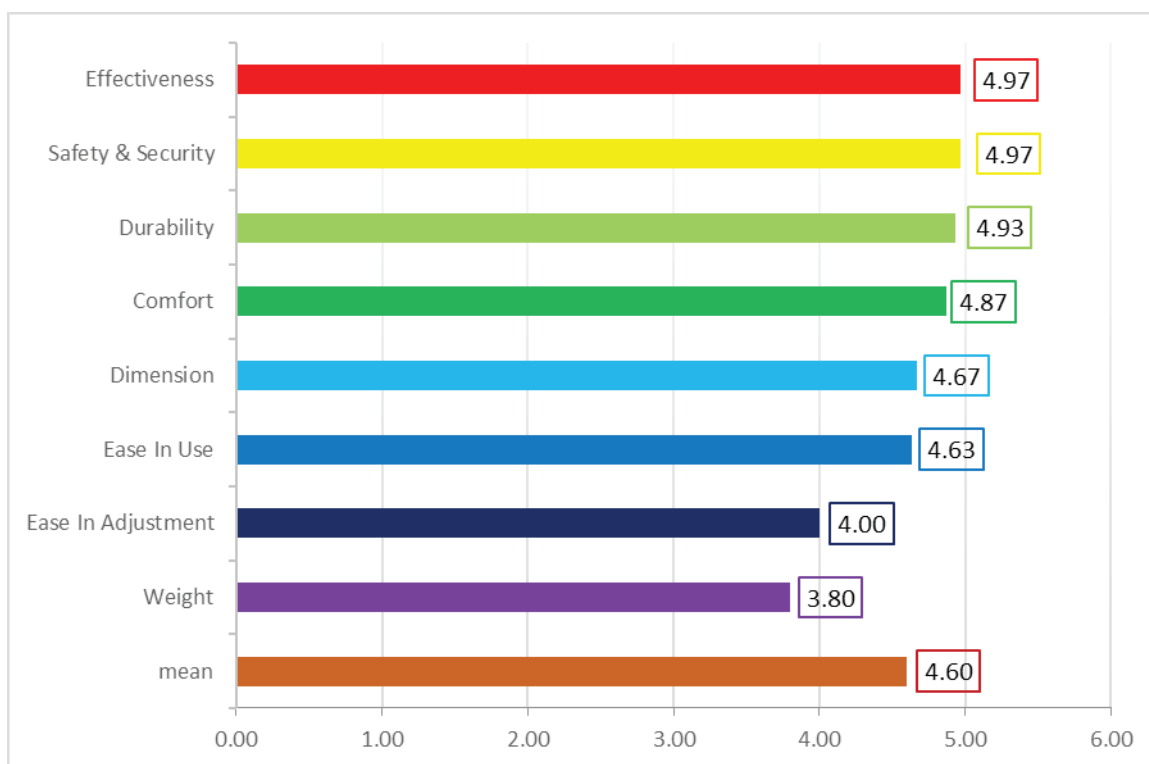
The first 8 satisfaction items include dimensions, weight, ease in adjustment, safety & security, durability, ease in use, comfort and effectiveness.

Scoring:

- 1: Not satisfied at all
- 2: Not very satisfied
- 3: More or less satisfied
- 4: Quite satisfied
- 5: Very satisfied

Mean of each question was taken.

Areas of QUEST 2.0 and their mean scores were taken. Total mean score is 4.60 out of 5 which suggest that overall RK walker is quite satisfactory in meeting needs for stairclimbing and walking on flat surface by healthy subjects.



Graph 2: Mean value of individual feedback from QUEST 2.0 by healthy subjects

INTERPRETATION: On analyzing Graph 2, the scores from QUEST 2.0, we have observed that weight (3.8 out of 5) and ease in adjustment (4 out of 5) has shown less impact for RK walker. Whereas, effectiveness (4.97 out of 5), safety and security (4.97 out of 5), durability (4.93 out of 5), comfort (4.87 out of 5) has shown efficient scores for satisfaction with RK walker.

Results for Phase IV

On analyzing, the scores of TUG Test for both Traditional Standard Walker (55.2 seconds) and RK Walker (60 seconds) for patients, we have observed that both were efficient in walking on flat surface. However, time taken for TUG Test was few seconds less with standard walker than with the RK walker in patients.

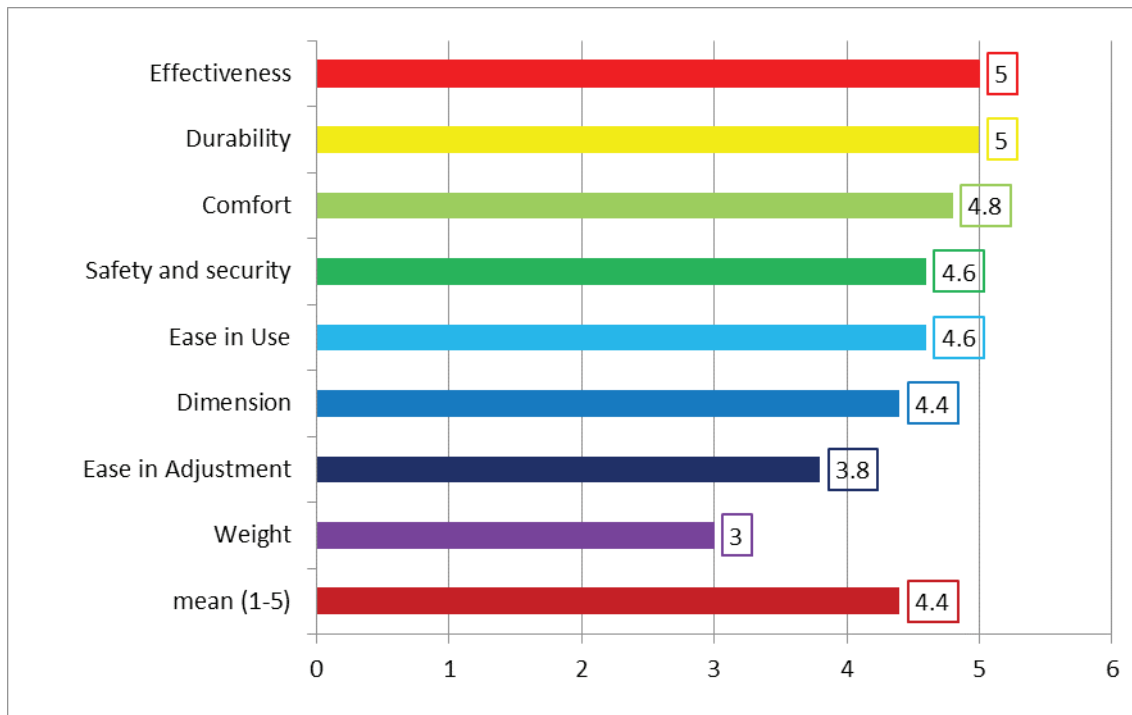
The mean score of resting PR (80), PR (86) after TUG Test with Traditional Standard Walker, PR (86.4)

after TUG Test with RK walker and PR (87.2) after SCT with RK Walker in patients which shows that exertion level during walking remained almost same with both the walkers and also shows the exertion level during stair climbing with RK walker. Considering these information modifications can be done in model of RK Walker and training can be imparted regarding its efficient use in future to reduce exertion level during use of RK walker in stair climbing and walking.

QUEST 2.0:

QUEST 2.0 was taken from patients in same way as described for healthy adults for evaluating satisfaction with RK Walker.

Total mean score was 4.4 out of 5 which suggested that overall RK walker was quite satisfactory in meeting needs for stairclimbing and walking on flat surface.



Graph 3: Mean value of individual feedback from QUEST 2.0 by patients

INTERPRETATION: On analyzing scores from QUEST 2.0 we have observed that weight (3 out of 5) and ease in adjustment (3.8 out of 5) has shown less impact for RK walker. Whereas, effectiveness (5 out of 5), safety and security (4.6 out of 5), durability (5 out of 5), comfort (4.8 out of 5) has shown efficient scores for satisfaction with RK walker by patients.

Discussion

As per the need of users and innovative design - a model with adjustment for stair climbing up and down requires quality training to its users. However, the quality of material and testing tools must be validated

for higher research. Interdisciplinary approach from patients, physiotherapists, engineers, industrial experts, and software designers remain the integral part of designing innovative “RK Walker”.

Comparison of difference between mean score of TUG Test with traditional standard walker and RK Walker among healthy subjects and patients shows that on average healthy subjects took 2.93 seconds while patients took 4.8 seconds in TUG Test with RK Walker than with Traditional Standard Walker. So, patients took 1.87 seconds more than healthy subjects for TUG Test with RK Walker which is very less.

Tuck-Voon H et al (2013) found increase in satisfaction score in QUEST 2.0 with intelligent wheelchair system after few numbers of trial and training. [10] Further training with RK Walker may increase patients' performance and confidence level and minimize time taken with RK Walker. Training and familiarization with the device may also increase performance with the device. [10]

Efficacy of RK Walker among healthy adults was evaluated first and then among patients to assure safety of patients with all trials. After successful trial with adult patients such device can be manufactured considering pediatric age group.

The RK Walker is designed and developed to benefit the community. Also person using walker when come across steps cannot always put walker aside and use hand rails for support. Independent access to steps with use of walker by disabled improves quality of life.

Conclusion

In context to the result and discussion, aids for stair climbing remains important area for patients and therapists' perspectives. Skill, time and cost-effective approach in designing and testing a walker with support from industrial experts has shown advantages of interdisciplinary research.

Limitations

Difficult to practice on staircase having different size of steps, though it's rare to be possible but must be taken into consideration.

Future Scope

Further study can be done in controlled environmental conditions with patients.

RK Walker can be modified & made more user friendly, based on suggestions obtained in QUEST 2.0

Experts and collaboration:

· Dr. Kartik Kothari, HOD, Mechanical Engineering Dept., School of Engineering, RK University.

· Mr. Anil Kachhadiya and Mr. Pratik Muliya, Faculties, Mechanical Engineering Dept., School of

Engineering, RK University.

· Mr. Bharat Kakadiya, Proprietor, Kelco Industries, Rajkot.

Received financial support: RK University, Rajkot

Ethical Approval: Ethics Committee (EC), School of Physiotherapy, RK University, Rajkot approved by The Central Drugs Standard Control Organization.

Conflict of Interest: Nil

References

1. M. M. Martins, Cristina P. Santos, Anselmo Frizera-Neto, Ramon Ceres. "Assistive Mobility Devices focusing on Smart Walkers: Classification and Review". *Journal of Robotics and Autonomous Systems*.2012; 60: 548-562
2. Hamid Batani, Brian E. Maki. "Assistive Devices for Balance and Mobility: Benefits, Demands, and Adverse Consequences". *Archives of Physical Medicine and Rehabilitation*.2005; 86: 134-145
3. A. Morris, R. Donamukkala, A. Kapuria, A. Steinfeld, J. T. Matthews, J. Dunbar-Jacob, S. Thrun. "A Robotic Walker That Provides Guidance". *Robotics and Automation IEEE International Conference*.2003; 1: 25-30.
4. Lawn, Murray John. "Study of stair-climbing assistive mechanisms for the disabled". Diss. Nagasaki University,2002.
5. Nurul Ariffah, Hamidi. "Design and Fabrication of Adjustable and Portable 4- Legs Walker". Project Paper, Universiti Malaysia Pahang,2012
6. Molloy, D.. Boomer. [<http://www.tuvie.com/boomer-a-user-friendly-walking-aid-for-elderly-people/>] Accessed-12 February 2016
7. Tianfu Li, Great Lakes Innovations Inc. Stair Climber. [<http://www.tinventor.com/Patent-Stair%20Climbing%20Walker.htm>] Accessed-12 February 2016
8. Shalini, K. Modified walker with adjustable legs. [http://nif.org.in/innovation/modified_walker_with_adjustable_legs/672] Accessed on 7 March 2016
9. Demers L, Weiss-lambrou R, Ska B: "The quebec user evaluation of satisfaction with assistive

- technology (QUEST 2.0): an overview and recent progress”. *PsycINFO Assist Technol* 2002, 14(2):101–105.
10. Tuck-Voon H, Rosalie H W, and Alex M. “Evaluation of an intelligent wheelchair system for older adults with cognitive impairments”. *Journal of NeuroEngineering and Rehabilitation* 2013, 10:90
 11. Bennell, K., Dobson, F. and Hinman, R. (2011), “Measures of physical performance assessments: Self-Paced Walk Test (SPWT), Stair Climb Test (SCT), Six-Minute Walk Test (6MWT), Chair Stand Test (CST), Timed Up & Go (TUG), Sock Test, Lift and Carry Test (LCT), and Car Task”. *Arthritis Care & Research*, Vol. 63, No. S11, November 2011
 12. J. Majumder. “Anthropometric dimensions among Indian males — A principal component analysis”. *Euras J Anthropol*. October, 2014, (2):54–62.