APPENDIX 5: PUBLICATION
1. Unsupported Upper Limb Endurance Training: An Alternative to Improve Functional Capacity & Quality of Life in Patients with Chronic Obstructive Pulmonary Disease
   Bijal K Dodia, Jaimala Shetye

2. An Interventional Study to assess the effect of Aerobic Training on Physiological Cost Index in Normal Individuals at a Tertiary Care Hospital, Mumbai
   Roshni Karnik, Khyati Kothary

3. Hip Rotation MWM for Sacroiliac Joint Dysfunction: A Case Report
   Supreet Bindra

4. A Critical Review: are Vaccine-Associated Paralytic Poliomyelitis and Acute Flaccid Paralysis a New Disaster?
   M G Mokashi

5. Comparison of Vascular Doppler and Sphygmomanometer for Measurement of Ankle-Brachial Index

6. Effect of Joint Traction and Approximation on H- Reflex in Normal Subjects
   Camy Bhagat, Paras Bhura

7. To Compare the effectiveness of Mulligan Bent Leg Raising and Slump Stretching in Patient with Low Back Pain
   Gajendrakumar Patel

8. The effect of Six Week Aerobic Dance Exercise Program on Body Composition
   Manisha Maurya, Shruti Mahajan

9. Back Care in Physiotherapy: A Comparative Study of Outcome Measures
   Malik Shazia, Y Pallavi

10. The effect of Mental Imagery on Balance in Young Adults
    Karajgi Asmita, Dias Jenesis, Pandit Umnati, Thakur Anuprita, Dabholkar Twinkle, Yardi Sujata

11. Effect of Diaphragmatic Breathing on Spirometric Parameters in Asthma Patients and Normal Individuals
    Devashri Salvi, Rosika Agarwal, Sundeep Salvi, Brig M S Bartiwal, Saee Khandagale
12. Effect of Yoga on Menopausal Symptoms in the Early Menopausal Period: A Randomized Controlled Trial
   Ruchi Vora, Ashwini Dangi

13. The effect of Static Stretch Versus Retrowalking on the Flexibility of the Hamstring Muscle
   Sagrika Popli, Joginder Yadav, Sheetal Kalra

14. A Comparative Study on Task Specific Strength Training and Resistance Training to Improve Lower Limb Strength and Function in Hemiparetic Patients
   Ena Bhatia, Tarpan Shah, Hiral Gandhi, D Sathees Kumar

15. A Comparative Study between the effect of Agility and Perturbation Training Versus Conventional Exercise in Improving Functional Status in Physically Active Individuals with Knee Osteoarthritis
   K Vaittianadane, Gajendrakumar Patel, Pratik M Vakhariya

16. Effect of Cavitation Versus Abdominal Exercise Programs on Abdominal Obese Subjects
   Mohamed Serag El-dein Mahgoub, Mohamed Taher Mahmoud El-desoky

   Abichandani Deepa, Twinkle Y Dabholkar, Sujata Yardi

18. Tolosa Hunt Syndrome - A Case Study
   Swati Chouhan, Sanjiv Kumar

19. Reciprocal Electrical Stimulation and Postural Stability in Diplegic Children
   Mohamed Ali Elshafey, Ahmed Mohamed El-Feke

20. Trunk Balance is Important to an Exercise Routine in Patients with Specific Low Back Pain
   Heena Lalit, Monika Moitra, Manu Goyal

21. The effectiveness of Mechanical Cervical Traction on Patients with Unilateral Mechanical Neck Pain
   Dibyendunarayan Bid, A Thangamani Ramalingam, Jahnvi A Bhatt, Prerna N Rathod, Krupali V Tandel, Soniya S Tandel

22. Correlation of Modified Ashworth Scale and Dynamic Gait Index in Chronic Stroke Patients with Middle Cerebral Artery Infarct
   Tejasree A Dabholkar, Sujata Yardi, Titiksha Pol

23. Comparison of Epley Maneuver and Brandt- Daroff Exercises on Short- Term Posterior Canal Benign Paroxysmal Positional Vertigo (BPPV) - Related Quality of Life
   Haripriya S, Ajith S, Padmanabhan Suresh Babu Roshan, Mohamed Faisal C K

24. Effect of Body Position on Peak Expiratory Flow Rate in Individuals Post Coronary Artery Bypass Graft Surgery
   Bhagwathi Nambi Rajan Yadav, Veena Kiran Nambar, Soni S
25. Effects of Scapula Focused Exercise Program on Shoulder Pain in Paraplegic Patients using Wheelchair
   Rajiv D Limbasiya, A Thangamani Ramalingam

26. Effect of Pranayama on Diaphragmatic Excursion in Healthy Young Individuals
   Unnati Pandit, Anagha Palkar, Anuprita Thakur, Twinkle Dabholkar, Asmita Karajgi

27. Effect of 12-Weeks of Aerobic Exercise on Primary Dysmenorrhea
   Anu Arora, Sujata Yardi, Sreeram Gopal

28. Predicting Falls in Elderly: A Comparison between Berg Balance Scale & Dynamic Gait Index
   Snehal Joshi, Aparna Sadhale

29. Effect of Training Balance Under Dual Task with Fixed and Variable Priority
   Instructions with Balance Impairment in Institutionalized Elderly Population
   Bharti, Chandan kumar

30. Comparison of PNF Technique with NDS Technique for Hamstrings
   Tightness in Asymptomatic Subjects
   Shah Vidhi, Thakur Anuprita, Karajgi Asmita, Dabholkar Twinkle, Pandit Unnati, Yardi Sujata

31. Efficacy of Kaltenbohn Mobilization on Patients with Osteoarthritis of Knee Joint
   Sneha Narang, Suvarna Ganvir

32. Perceived Stress, Sources and Severity of Stress among Physiotherapy Students in an Indian College
   Tushar J Palekar, M G Mokashi

33. Effect of Eight Weeks of Walking on High Density Lipoprotein Cholesterol
   Fiddy Davis J, Sudha Vidyasagar, Arun Maiya G

34. Effect of Induced Muscular Fatigue on Balance and Core Strength in Normal Individuals

35. Quantitative Gait Analysis in Patients with Asymmetrically affected Osteoarthritis Knees
   Dinesh Sorani, Vasanti Joshi

36. A Study to Compare effectiveness of Closed Kinetic Chain Exercises Versus Open Kinetic Chain Exercises in Patients with Osteoarthritic Knee Joints
   Chandni Shah
39. To assess the effect of Modified Pilates Compared to Conventional Core Stabilization Exercises on Pain and Disability in Chronic Non-Specific Low Back Pain-Randomized Controlled Trial
Cassandra F Dsa, Kanagaraj Rengaramanujam, Mahendra S Kudchadkar

40. Occupational Therapy Rehabilitation of Post Operative Hand Injury Cases using Modified Low Cost Splints and Home Based Exercises: A Rural Indian Experience
Deepak Ganjiwale, Jaishree Ganjiwale

41. Impact of Computer Feedback on Hand Performance in Cerebral Palsied Children
Radwa S Abdel-Rahman, Amira M El-Gendy

42. Comparison between effectiveness of Maitland Compression Technique with Medial Glide and Conventional Therapy in Patients with Patellofemoral Osteoarthritis
Sneha Joshi, Namrata Srivastava, Saurav Singh Kushwah

43. A Review on Neural Factors Correlated with Resistance Training
Slawomir Kujawski, Agnieszka Gajos, Malgorzata Gajos, Zaneta Chatys
Quantitative Gait Analysis in Patients with Asymmetrically affected Osteoarthritis Knees

Dinesh Sorani¹, Vasanti Joshi²
¹Senior Lecturer, Govt Physiotherapy College, Jamnagar, ²Associate Professor, Sancheti Institute of College of Physiotherapy, Pune

ABSTRACT

Objective: Many studies have done gait analysis in osteoarthritis knee patients. However they have not compared gait parameters from more affected side to less affected side. Present study was aimed to find differences in quantitative gait parameters in patients with asymmetrically involved osteoarthritic knees.

Method: 31 patients with asymmetrical knee osteoarthritis participated in the study. The total population was subdivided into subgroups as per their gender, severity and presence or absence of quadriceps lag. Footprint method of gait analysis was used to evaluate quantitative gait parameters (step length, stride length, foot angle). The parameters were compared between more affected side and less affected side.

Results: Patients had reduced gait velocity and cadence and increased base of support. Intergroup difference did not show significant difference except lesser cadence values in tricompartmental osteoarthritis group when compared with bicompartamental osteoarthritis. All patients had significantly reduced foot angle on more affected side. Out of all subgroups females, patients with tricompartmental osteoarthritis and patients with quadriceps subgroups showed significant differences in foot angle. No step length difference was found between the two sides.

Conclusion: Reduced foot angle on more affected side might indicate an increased knee adduction moment on more affected side. Footprint method can be a useful tool of gait analysis in patients with knee osteoarthritis.

Keywords: Osteoarthritis, Gait analysis

INTRODUCTION

Osteoarthritis (OA) is a major cause of disability in the adult population. An estimated 20% of all adults are affected by the disease¹ and its prevalence increases with age.² Symptomatic knee osteoarthritis affects 10% of adults over age 55 and, a quarter of those affected are severely disabled.³ The knee is the weight bearing joint most commonly affected with osteoarthritis.⁴ Although the exact mechanisms causing the osteoarthritis are unclear, repetitive high dynamic knee joint loads have been reported to be associated with the development and progression of the disease characteristics.⁵,⁶,⁷ Increased forces may be a contributing factor to the development or progression of osteoarthritis. During walking, the load on the medial compartment is approximately 2.5 times greater than that on the lateral compartment. This asymmetry in the distribution of the forces may help to explain the markedly higher prevalence of medial compartment involvement reported in subjects with tibiofemoral OA relative to the lateral compartment.³ Compensatory forefoot valgus and subtalar pronation can also be found along with the former deformities.⁸

Common alterations in gait observed in individuals with knee osteoarthritis have been described and include decreased knee excursion⁹, altered ground reaction force¹⁰, altered stride characteristics (i.e. velocity, cadence and stride length), joint kinematics, and joint kinetics.¹¹,¹²,¹³ The adduction moment in particular has been found to be relevant to knee OA.⁶,⁷,¹⁴,¹⁵,¹⁶,¹⁷
Walking is the most common activity of daily living. The use of quantitative gait analysis has been shown to be an important tool in the clinical evaluation of individuals with knee osteoarthritis. Although both knees are affected in osteoarthritis, asymmetrical involvement of knees is not uncommon. Different studies for gait analysis in osteoarthritis knee have considered only the most affected side and compared it to normal healthy controls. These studies assume that the most affected side shows the most significant changes. Understanding gait parameter differences for unequally involved lower extremities might show a different view. According to Owings et al (2004) right-left symmetry should not be assumed in any particular subject group, if there are musculoskeletal diseases as they are expected to influence gait asymmetry. Till date no studies have compared gait parameters from more affected side to less affected side in arthritic population. It remains unclear whether the asymmetrical involvement has any effect on foot fall variation.

Recently gait analysis has undergone technological advancements. However footprint data still can provide a simple and inexpensive and reliable method for measuring a gait.

In the present study, gait analysis was done by footprint method and data were collected to obtain quantitative spatial parameters (step length, stride length, foot angle) of patients with asymmetrically affected osteoarthritis knee. Also base of support, gait velocity and cadence were assessed. These parameters were than compared between the more affected and less affected side. Also correlation was assessed between these comparisons and pain.

MATERIAL AND METHODOLOGY

31 patients were selected from the Physiotherapy OPD and knee club at Sancheti Hospital. All patients were clinically diagnosed by orthopedic surgeons in Sancheti Hospital OPD, and radiological assessment of osteoarthritis was made by radiologists.

**Inclusion Criteria**

- Patients with asymmetrical knee osteoarthritis
- Patients with at least one knee assigned a Kellgren Lawrence grade ≥ 2

**Exclusion Criteria**

- Rheumatoid or other systemic inflammatory arthritis
- Avascular necrosis
- Periarticular fracture
- Paget’s disease of bone
- Chronic knee joint infection
- Gout
- Total knee replacement or other surgery in either knee
- Intraarticular corticosteroid injection within the previous 2 months,
- Hip or spine disease as the major source of disability
- Patients with neurological disorders.

**PROCEDURE**

All patients signed an informed consent form as given in appendix before they participated in the study. The clinical assessment was done before the gait analysis along with radiological assessment.

The clinical assessment included history taking, observation of posture, deformity and swelling, pain assessment by Visual Analogue Scale (0-10), palpation for tenderness and swelling, assessment of strength and range of motion, Q angle, special tests for knee instability. Hip, ankle and back were also examined to rule out any other musculoskeletal impairment. Assessment of strength was done by modified method as described by Olaf et al, 2003.

The clinical criteria to diagnose a patient as a case of knee osteoarthritis were followed as given by Altman.

The radiographic assessment was done by radiologists in Sancheti Institute of Orthopedics and Rehabilitation. Individual knees were graded separately to confirm asymmetrical involvement.

The total group was further subdivided in subgroups as per their gender and severity as follows.
GAIT ANALYSIS

Foot print analysis method by inking method was used as described by Wilkinson. A 15 inches wide and 40 feet long paper sheet was used. Two trials were taken for the same. At the same time their cadence was calculated. Initial 4 steps were excluded from the calculation as they were considered to be the steps to accommodate to their natural gait pattern. The following parameters were calculated from footprints: (step length, stride length, foot angle with ipsilateral line of progression, foot angle with central line of progression, and base of support). Velocity was calculated as the total distance covered divided by the time taken for the performance. Step length and stride length were also assessed as percentage of their body height (cm) as they are dependent on the individual’s height (Tammy et al).

OUTCOME MEASURES

0-10 VAS scores for pain.

Step length difference from more affected side to less affected side.

Stride length difference from more affected side to less affected side.

Foot angle from ipsilateral line of progression difference between more affected side to less affected side.

Foot angle from central of progression difference between more affected side to less affected side.

Knee society knee function score.

Statistical Analysis

Mean and standard deviations were calculated for the age, height, weight, BMI, pain score on VAS 0-10 scale, knee function score, knee flexion range of motion, and strength of quadriceps and hamstrings.

Student’s paired t test was used to calculate the difference between the pain scores, step length, stride length, foot angle with ipsilateral line of progression (ILOP) and foot angle with central line of progression (CLOP), height to stride ratio and height to step ratio in all subgroups. Unpaired t test was used to compare differences between subgroups like male vs. female, and bicompartimental osteoarthritis vs. tricompartmental group. Unicompartmental group was excluded from the calculation because of very small no of patients (3). Correlation was assessed of pain with step length, stride length, ipsilateral line of progression, and central line of progression in all subgroups. p < 0.05 was considered as the significant difference for all the parameters.

RESULTS

31 patients with asymmetrical osteoarthritis participated in the study. The demographic data of these patients is described in table 1.
Velocity (mean ± sd) for total population was 0.76 ± 0.23 m/sec. No significant difference was found between male and female subgroups. Significance difference (p < 0.05) was found between bicompartmental and tricompartmental subgroups.

Base of support (mean ± sd) for total population was 11.46 ± 4.12 steps/sec.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>Uni</th>
<th>bi</th>
<th>Tri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean ± sd)</td>
<td>58.48 ± 5.61</td>
<td>58.08 ± 6.20</td>
<td>58.73 ± 6.20</td>
<td>53.67 ± 3.21</td>
<td>56.94 ± 5.54</td>
<td>62.2 ± 4.98</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>162.76 ± 8.05</td>
<td>167.32 ± 9.32</td>
<td>159.89 ± 5.7</td>
<td>157.48 ± 5.08</td>
<td>163.2 ± 7.37</td>
<td>163.58 ± 9.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>66.45 ± 8.09</td>
<td>69.25 ± 6.5</td>
<td>64.89 ± 8.69</td>
<td>60.67 ± 6.66</td>
<td>67.68 ± 10.28</td>
<td>68.6 ± 10.28</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>25.1 ± 2.57</td>
<td>24.77 ± 1.9</td>
<td>25.14 ± 2.88</td>
<td>20.44 ± 2.16</td>
<td>25.09 ± 5.51</td>
<td>29.71 ± 4.4</td>
</tr>
<tr>
<td>Knee function score (mean ± sd)</td>
<td>51.29 ± 7.52</td>
<td>57 ± 12.74</td>
<td>47.68 ± 11.79</td>
<td>64 ± 17.14</td>
<td>50.89 ± 17.81</td>
<td>48.2 ± 17.18</td>
</tr>
</tbody>
</table>

All values are expressed as mean ± sd, Uni = unicompartimental osteoarthritis, bi = bicompartmental osteoarthritis, tri = tricompartimental osteoarthritis, q lag = quadriceps lag.

Cadence (mean ± sd) for total population was 92.9 ± 16.8 steps/sec. No significant difference was found between male and female subgroups. Significance difference (p < 0.05) was found between bicompartmental and tricompartmental subgroups.

Table 2: Gait variable comparison between more and less affected side

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Step Length</td>
<td>5.03 ± 2.10</td>
<td>4.70 ± 2.10</td>
<td>0.24 ± 0.19</td>
<td>3.84 ± 2.10</td>
<td>4.06 ± 2.10</td>
<td>0.19 ± 0.30</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.19 ± 0.46</td>
<td>3.82 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stride Length</td>
<td>5.03 ± 2.10</td>
<td>4.70 ± 2.10</td>
<td>0.24 ± 0.19</td>
<td>3.84 ± 2.10</td>
<td>4.06 ± 2.10</td>
<td>0.19 ± 0.30</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.19 ± 0.46</td>
<td>3.82 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foot Angle with ILOP</td>
<td>5.03 ± 2.10</td>
<td>4.70 ± 2.10</td>
<td>0.24 ± 0.19</td>
<td>3.84 ± 2.10</td>
<td>4.06 ± 2.10</td>
<td>0.19 ± 0.30</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.19 ± 0.46</td>
<td>3.82 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height to Stride Ratio</td>
<td>5.03 ± 2.10</td>
<td>4.70 ± 2.10</td>
<td>0.24 ± 0.19</td>
<td>3.84 ± 2.10</td>
<td>4.06 ± 2.10</td>
<td>0.19 ± 0.30</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.19 ± 0.46</td>
<td>3.82 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height to Step Ratio</td>
<td>5.03 ± 2.10</td>
<td>4.70 ± 2.10</td>
<td>0.24 ± 0.19</td>
<td>3.84 ± 2.10</td>
<td>4.06 ± 2.10</td>
<td>0.19 ± 0.30</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.19 ± 0.46</td>
<td>3.82 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td>3.73 ± 2.10</td>
<td>3.96 ± 2.10</td>
<td>0.09 ± 0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step length, stride length, height to stride ratio and height to step ratio did not show significant differences between more and less affected sides in total as well as sub groups. However foot angle both CLOP and ILOP showed significant differences in total as well as female and tricompartmental subgroups.

Correlation study was assessed between pain and gait parameters. No significance correlation was found in all groups.

DISCUSSION

Walking is the most common activity of daily living. The use of quantitative gait analysis has been shown to be an important tool in the clinical evaluation of individuals with knee osteoarthritis.5,18

The mean velocity for the total population in the study was 0.8 m/sec. Al Zahrani et al found significantly reduced mean velocity of arthritic patients...
(0.55 m/sec) as compared to (1.17 m/sec) healthy age matched controls (mean age 69 years). 20 Gok et al (mean age 58 years) found significantly reduced mean velocity of arthritic patients (0.9 m/sec) as compared to normal group (1.0 m/sec). 22

Although the present study had not taken any healthy age matched group mean velocity was decreased for all populations when compared from those of healthy adult subjects of same age groups from other studies. 20, 22 Females showed lesser velocity when compared to males. Patients with tricompartmental osteoarthritis group showed lesser velocity when compared with bicompartmental osteoarthritis group. The lesser values were not statistically significant.

Mean stride length was 98 cm for all arthritic subjects. Al Zahrani et al found significantly reduced stride length of arthritic patients (75cm) as compared to (127 cm) healthy age matched controls. Gok et al found significantly reduced stride length of arthritic patients (100 cm) as compared to normal group (110 cm).

According to Andriacchi et al. (1982), reduced walking speed and stride length were part of the adaptive mechanism to reduce pain by decreasing knee moments as the double support time is increased. 11 However knee moments were not studied in the present study.

Mean cadence was decreased for all populations when compared from those of healthy adult groups of same age groups from other studies. The values were significantly lesser in patients with tricompartmental osteoarthritis group when compared with bicompartmental osteoarthritis group indicating that patients with more severe knee osteoarthritis walk with more reduced cadence.

Comparison between subgroups showed no significant difference in gait velocity. The gender difference did not have significant effect on gait velocity or cadence. Cheing et al found an inverse correlation between the magnitude of impairment of proprioception and subject’s cadence, though not with walking speed. 28 However proprioception was not objectively assessed in the present study.

Statistical analysis of foot angle revealed significant intoeing of foot on more affected side in total population. Teichtahl et al found that offspring of people with medial tibiofemoral osteoarthritis walked with less external rotation at the foot than the control subjects during the early subjects. 29

When subgroups were compared females and patients with tricompartmental osteoarthritis showed significant intoeing on more affected side. The results of these sex specific and quadriceps lag specific differences are not clear.

**CONCLUSION**

The study demonstrates that footprint method of gait analysis can be used effectively to document gait adaptations found in patients with asymmetrical knee osteoarthritis. Quantitative spatial gait parameters like step length, stride length do not show difference in such patients. Significant intoeing is found on more affected side.

Also the result of the study supports the hypothesis that the gait parameters show differences between more affected and less affected osteoarthritic knees. These differences are evident in form of foot angle which shows significant intoeing on more affected side as compared to less affected side. This may indirectly suggest the increased knee adduction moment on the more affected side.

**Ethical Clearance:** The article has been approved by the ethical committee of the institute.

**Funding:** No funds were required to conduct this study.

**Aknowledgment:** The authors are thankful to Dr Dhara Kapoor and Dr Gupte for their assistance during the work.

**Conflict of Interest:** There is no conflict of interest.

**REFERENCES**

1. Badley, EM, Rasooly I, Webster, GK, “Relative importance of musculoskeletal disorders as a cause of chronic health problems, disability, and