

# Functional Anatomy of the Hand: Prevalence of the Linburg–Comstock Anomaly in a Young Saudi Population

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## ABSTRACT

**Objectives:** Linburg–Comstock (LC) anomaly is a developmental defect, characterized by flexion of thumb causing flexion of the index finger with pain in the wrist and forearm due to a tendinous interconnection between the flexor pollicis longus and flexor digitorum profundus. **Methods:** We carried out a random cross-sectional study in 2016. Undergraduate students were recruited; we excluded those with inflammation, hand or forearm trauma or surgery. Data were analyzed descriptively and categorically using Microsoft Excel and SPSS-20. **Results:** The study included 331 individuals; 164 (49.5%) were male, and 167 (50.5%) were female, out of which 130 (39%) had LC anomaly. The mean age was 23 years (standard deviation  $\pm$  5.3). LC anomaly was found bilaterally in 43 (12.9%), in the right hand in 51 (15.4%) and in the left hand in 35 (10.5%). It was found bilaterally in females in 17 (10.1%) participants, and in males in 26 (15.8%),  $P = 0.37$ . The right-hand dominance was found in 294 (89%) versus left-hand in 37 (11%). **Conclusion:** The prevalence of LC anomaly was 39%, which matches with the global prevalence, the males showed slightly more prevalence of bilateral LC anomaly. The right-hand dominance was found in 89% as opposed to 11% having left-hand dominance.

**Keywords:** Hand anatomy, hand dominance, Linburg–Comstock anomaly, tendinous interconnection in hand, wrist pain

## INTRODUCTION

Linburg–Comstock (LC) anomaly is a common condition that affects the function of flexor digitorum profundus (FDP) and flexor pollicis longus (FPL) tendons of the anterior forearm characterized by a tendinous interconnection occurring between them, [Figure 1].<sup>[1]</sup> This interconnection has an average width of about 1 mm, and it usually remains occult under the thickened synovium.<sup>[2]</sup> It was reported historically that the connecting tendon slips were recognized as early as in the 1800s by the anatomists.<sup>[2]</sup>

FDP muscle is deeply located and it traverses a much longer distance for its insertion at the bases of the distal phalanges of all the four fingers. Due to the long course of its tendons, it crosses various joints on its way. Hence, it effectively exerts its action and causes the flexion of all the joints it crosses, for example, the wrist joint, intercarpal joints, carpometacarpal joints, metacarpophalangeal joints, proximal interphalangeal (IP) joints, and the distal IP joints inclusive. The FDP muscle acts on the index, middle, ring, and little

fingers. However, this muscle also has a freedom to act on various joints just indicated.

The structural and functional homologous muscle of the FDP muscle for the fingers in the thumb is the FPL muscle. The actions of FPL muscle are exactly on the same lines as those of FDP in the case of the fingers, i.e., it causes a powerful flexion of all joints it crosses proximally from the wrist joint till the distal-most joint in the thumb.<sup>[3]</sup> Anatomically and functionally, the thumb has more importance than the other digits in the entire hand. This is due to its much greater role played by it

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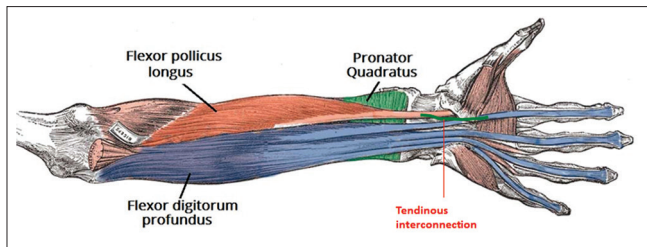
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**Figure 1:** The Linburg–Comstock anomaly showing the tendinous interconnection (in Green)<sup>[17]</sup>

in overall functions of the hand. The loss of the thumb due to any etiology (e.g., lesions pertaining to its innervation or a physical injury) produces great functional disability of the hand. Moreover, the reduction of thumb's function will affect the quality of the job and the manual skills of the person. This anomaly is usually asymptomatic, only causes pain in individuals doing jobs that require simultaneous flexion of the terminal phalanx of the index or thumb, for instance, surgeons, typists, musicians, carpenters, policemen, soldiers, and skilled workers.

Due to developmental reasons, the tendinous interconnections develop between the FPL and the FDP tendons. This constitutes the hallmark of the LC Anomaly. This structural anomaly is variable in the humans, on average it occurs in about 37% of the population.<sup>[4]</sup> In a study carried out in Manitoba on 200 individuals (90 males, 110 females), the incidence of the LC anomaly was found to be 19% in males and 21% in females. In that study, the male right-hand dominant individuals showed more prevalence. The LC anomaly is distinguished by the inability to actively flex the IP joint of the thumb without simultaneously flexing the distal IP joint of the index finger.<sup>[4]</sup>

The pain in case of LC anomaly is of tearing-character, which leads to an inability to flex the fingers, impeding the productivity of the said individuals and adversely affecting their performance. Therefore, the indicated jobs and the other jobs such as sewing, cooking, using scissors might produce pain in the forearm or wrist.<sup>[5]</sup> We lack the data about the prevalence of the LC anomaly, its related functional deficits resulting in the professional deficiency and the low economic output from Saudi Arabia.

The differential diagnosis of the LC anomaly relates more toward the median nerve compression in the carpal tunnel.<sup>[6]</sup> It becomes the main bell-ringer because it also produces hand pain. This was reported in 31 of 33 participants with the LC anomaly in a study carried out by Lombardi *et al.*,<sup>[7]</sup> In such cases, the treatment is directed toward the carpal tunnel syndrome itself.

We carried out a study to observe the prevalence of LC anomaly in Riyadh university students. The students from various parts of the country are enrolled in these universities as there are free education facilities so, our study encompasses a mix-up of individuals from entire Saudi Arabia.

## MATERIALS AND METHODS

This study was carried out in Riyadh, the capital city of Saudi Arabia after obtaining the ethical approval from the King Abdullah International Medical Research Center's Ethics Review Committee, Riyadh. We chose the four major universities located in Riyadh. The consent form was administered, and the signatures were obtained from the participating individuals.

This was a random cross-sectional 1-year study carried out in March 2016 on 331 participants; out of which 164 (49.5%) were male, and 167 (50.5%) were female. The mean age of participant was 23 years (standard deviation  $\pm$  5.3). The university undergraduate students were invited for recruitment from the four selected public universities, which had a total of 156, 733 registered students. The sample size was calculated using Raosoft Inc calculator,<sup>[8]</sup> and  $\approx$  284 subject size came up to carry out the study from this population with 95% confidence level and  $\pm$  5% margin of error and estimated ageness of 24.5%. The names of the selected universities were as follows: (i). King Saud bin Abdul-Aziz University for Health Sciences (KSAU-HS) College of Medicine, (ii). King Saud University, (iii). Imam Muhammad Ibn Saud Islamic University, and (iv). Princess Nourah Bint Abdulrahman University. Randomization was done by dividing each university into colleges, and each college was divided into specialties, and each specialty was divided into batches by academic year. Three colleges were chosen from each university by simple random sampling. In each college, we took three specialties by simple random sampling. In each specialty, we picked three batches randomly, and from each batch, we selected three students by systematic random sampling. Hence, total sample size was 3 students per batch  $\times$  3 batches per specialty  $\times$  3 specialties by college  $\times$  3 colleges per university  $\times$  4 universities = 324 subjects; however, we selected 331 participants to attain the total number if someone shows noncompliance.

After setting the inclusion and exclusion criteria, we recruited the undergraduate university students studying at any academic level, from both genders. We excluded any participant with the history of infection or underlying inflammatory process in the hands, participants with the previous history of moderate-or-severe trauma to the hand or lower forearm; any surgical procedure carried out on the forearm or hand and the presence of any obvious congenital anomaly of the hand.

All the participants (331), were distributed equally to the group of the co-investigators (i.e., medical students), who were trained for the clinical test used for the diagnoses of LC anomaly. These training sessions were carried out by the Principal investigator who is a medically qualified clinician as well as a senior faculty member of this organization. Although the LC anomaly can be diagnosed by sonography and other advanced techniques such as magnetic resonance imaging (MRI), we used the clinical diagnostic test for its

ease. From the available literature, it is known that the MRI is not only the best method to diagnose the LC anomaly accurately, but it also helps the surgeon to accurately repair the tendon connection fault.<sup>[9]</sup> Due to the cost issues and also because of the high diagnostic accuracy of the clinical test, we employed it in our study. This test also helps to confirm the correlation of the symptomatology with the diagnosis.<sup>[10]</sup> Data collected comprised of participant's serial number, name, sex, and the date of birth or age. We also documented the dominance of the hand of the participants.

Data about the four main parameters of this anomaly were documented which included the presence of this anomaly in both hands, absence in both hands or presence in one hand only. The following protocol and the steps were used in the clinical test to diagnose these parameters:

1. The examiner restricted the distal IP joints of all the fingers of the participant by holding all the fingers in their fully extended position
2. Then, the examiner asked the participant to actively perform full flexion of the thumb
3. The LC anomaly test was regarded as positive if the participant felt pain in the wrist or the lower forearm (This happens due to an anomalous FPL and FDP tendon connection by means of a slip)
4. The test was further confirmed by noting a simultaneous flexion of the index finger while performing an active flexion of the thumb [Figure 2].<sup>[11]</sup>

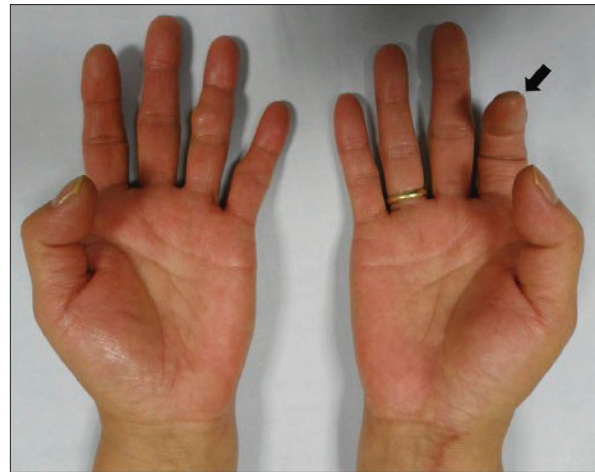
The status of the prevalence of the LC Anomaly was documented and the data were analyzed descriptively and categorically using Microsoft Excel and the SPSS Version-20 (IBM SPSS Statistics 20.0, USA).

## RESULTS

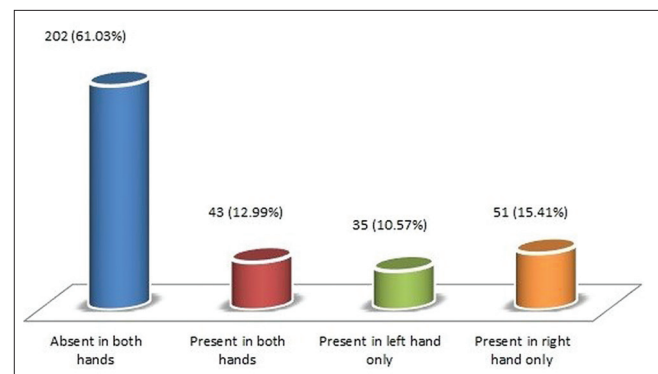
The LC anomaly was present in 130 (39.2%) of the participants. The analysis of the entire population showed the presence of LC anomaly at both hands of 43 (12.9%) of the individuals and absence of the anomaly in both hands in 202 (61%), [Figure 3]. This population revealed the presence of LC anomaly in the right hand only in 51 (15.4%) and presence in the left hand only in 35 (10.5%) subjects, [Figure 3].

Gender-based analysis of the studied population showed that 17 (10.1%) females had LC anomaly in both hands as opposed to 26 (15.8%) males,  $P = 0.37$  [Figure 4]. The absence of the anomaly in both hands was in 108 (64.6%) females while in the males was noted in 94 (57.3%), [Figure 4]. The LC anomaly was seen in the right hand only 26 (15.5%) females versus 25 (15.2%) males. The LC anomaly was seen in the left hand only in 16 (9.5%) females versus 19 (11.5%) males,  $P$  value (0.38), [Figure 4].

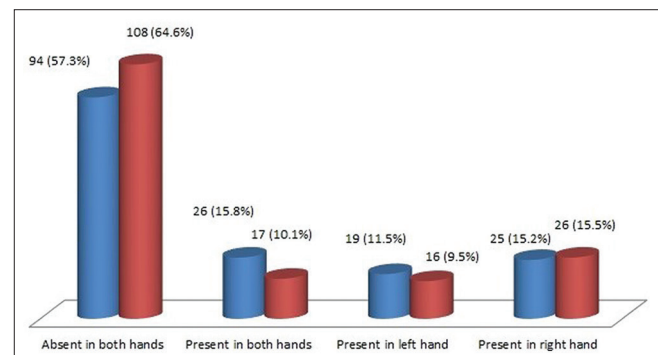
On analysis of the hand dominance, it was observed that 294 (88.8%) individuals were right-hand dominant as opposed to 37 (11.2%) individuals who had the left-hand dominance.



**Figure 2:** The Linburg–Comstock anomaly in the right hand showing simultaneous flexion of the index and thumb distal phalanges. The left hand shows the absence of anomaly



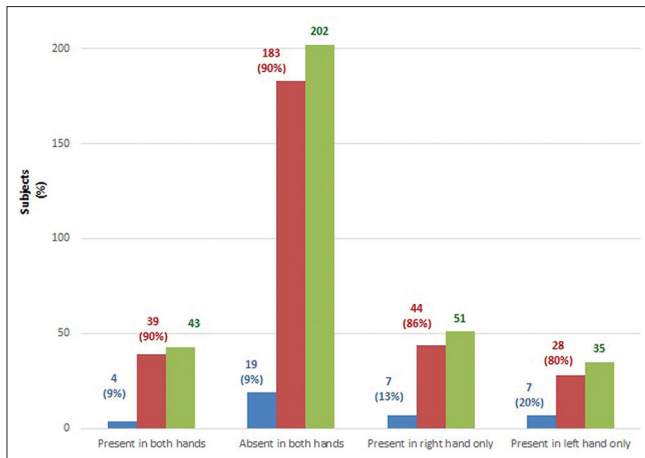
**Figure 3:** The prevalence of the Linburg–Comstock anomaly in the study population of ( $n = 331$ ) participants



**Figure 4:** Gender-based prevalence of Linburg–Comstock anomaly in the study population of ( $n = 331$ ) participants, males 164 shown in blue and females 167 shown in red

The participants with the bilateral LC anomaly ( $n = 43$ ), 39 (90.6%) had right dominant hand while only 4 (9.3%) had left-dominant hand, [Figure 5]. Participants showing a bilateral absence of LC anomaly ( $n = 202$ ), 183 (90.5%) had right-hand dominant versus 19 (9.4%) had left-hand dominance, [Figure 5].





**Figure 5:** The prevalence of Linburg-Comstock anomaly based on the dominance of the hands in the study population ( $n = 331$ ), (Right-hand dominance shown in red, left-hand dominance in blue and green shows the total of both)

## DISCUSSION

The anomaly is associated with the change in the strength of the force of the thumb and index finger. Studies about the LC anomaly have been carried out and published worldwide. The deficits in the occupational skills associated with this anomaly have also been investigated. These functional deficits are regarded as the important disabilities associated with this condition. The said anomaly has secondary complications such as hidden tenosynovitis due to adhesion formation in the tendon interbridge sites.<sup>[2]</sup> In a Malaysian study, the LC anomaly was present in 101 (35%) in the 292 participants.<sup>[12]</sup> The anomalous tendinous interconnection results in a compulsory secondary synkinesis (i.e., flexion of the index finger) when attempting to flex the thumb. This adds to the pain and difficulty to perform tasks such as using chopsticks, tying shoelaces, typing and writing. Synkinesis of the index finger and the thumb is found in about 20%–31% of the population as observed by Linburg and Comstock,<sup>[1]</sup> and Rennie and Muller.<sup>[5]</sup> The activity of the four tendons of the FDP can be given an analogy like the four reins of horses used to drive the chariots, for example Roman or the Mahabharata battle chariots. The disproportionate pulling on any one of the reins will result in a disturbed running style of the connected horses producing disharmony in the desired movement.

In addition to the preexisting congenital defect, further local morbid effects such as impending injury, stiffness due to a routine usage of tendons and the adhesions formed locally produce further functional problems adding to the severity of the symptoms, for example, progressive pain in the affected individuals.<sup>[13]</sup> These patients develop pain at the wrist or lower forearm to perform the tasks requiring the thumb movements. In a study carried out on 136 musicians, the prevalence of LC anomaly was appreciably low only 13% were found to be affected (9% bilaterally and 4% unilaterally). A postoperative

follow-up of these participants showed promising results after surgical correction of the anomalous defect.<sup>[14]</sup> The musicians get disturbances in playing on the keys of harmonium, piano and org keyboards and playing the stringed musical instruments.<sup>[15]</sup>

A study carried out on the active soldiers who were allowed to use the guns ( $n = 108$  participants) at Turkey showed that 37% participants felt pain on attempting to touch the pulp of the thumb with the head of the 5<sup>th</sup> metacarpal.<sup>[16]</sup> The simultaneous flexion of the index finger during this attempt was also noted. An interesting observation was noted in two participants who unwillingly pushed the trigger while simultaneously pulling the hammer of the gun. This anomaly-related movement might be leading to fatal accidents sometimes.<sup>[16]</sup> It, therefore, becomes very important to thoroughly examine the individuals who are applying for the police, military, and the security personnel for training and recruitment and also for the selection to join respective jobs. Remarkably large data are available globally; however, the knowledge about LC anomaly is not available sufficiently from our country (Saudi Arabia).

In the present study, the LC anomaly mainly affected the right hand as observed in 15.4% participants. The LC anomaly was slightly more prevalent bilaterally in the male participants (15.9%) as compared to the females (10.2%). In general, our findings matched well with the globally existing observations. The analysis about the dominance of the hand and the LC anomaly opens up a door for further studies as it has a direct relation with the quality of the job and needs a comparative observation for the matching evidence with the globally occurring cases of the said anomaly. In our study, the right versus left-handed dominance gender wise did not reveal any significant difference between the two genders, females with right dominant versus males right dominant 26 (15.6%) and 25 (15.2%), respectively ( $P = 0.276$ ). The same pattern was found in the left-hand dominance ( $P = 0.276$ ). As the present study was carried out in Riyadh inhabiting participants from multiple areas of the country, it does not provide prevalence about the entire country. This indicates an obvious weakness of this study in terms of not recruiting individuals from other widespread regions of the country. Riyadh itself has less number of participants as compared to country as a whole. The other weakness was not taking participants from both the genders doing exactly similar jobs for the reason explained below.

There is a further important question as to why the males are having more prevalence of LC anomaly in some nations as opposed to the females? This may be due to a possibility of the role played by the gender as being males exposes them to be more involved in jobs than females who in some nations are more housewives and not exposed to active jobs. Hence, statistical data obtained for the males is exaggerated as compared to that for the females. If the females were also employed in similar occupations with same sample size and then studied for prevalence, it was quite possible to get

matching results from both genders. We recommend that this needs further research for the comparative study of the males and the females involved in an exactly similar profession (i.e., the participants from both genders would have an equal exposure of the tendon friction and pain produced by it, which is the hallmark of LC anomaly). We also recommend that the individuals applying for jobs in the security, police, and military should be investigated for the presence of LC anomaly.

## CONCLUSION

The prevalence of LC anomaly in the studied population was 39%, which matches with the global prevalence, the males showed slightly more prevalence of bilateral LC anomaly. The right-hand dominance was found in 89% as opposed to 11% having left-hand dominance.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

## Author contributions

All authors contributed in design of project, analysis and write-ups. We also checked the article in Turnitin software for plagiarism and found clear. All authors have intellectual input in this work and had critically reviewed the article and finally approved it.

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