

# Morphometry of the Psoas Muscle in Individuals with Chronic Low Back Pain using Magnetic Resonance Imaging

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## ABSTRACT

**Introduction:** Psoas muscle is located in the iliopsoas compartment; it originates at the transverse process of the lumbar vertebrae; T12-L5 and inserts at the lesser trochanter of femur (Christiane, 2020). Chronic low back pain is low back pain lasting more than 12 weeks (Brian et al, 2012). **Aim:** To determine the dimensions of the psoas muscle in patients with chronic low back pain using magnetic resonance imaging (MRI). **Materials and Method:** This retrospective study was done in the Radiology department of the Rivers State University Teaching Hospital following ethical approval. Sixty MRI images of sixty patients, 18 years and above were used to study the psoas muscle. Data were analyzed using SPSS version 23.0 and excel 2019 edition. Sex differences were determined using T-test, while side differences were determined using paired T-test. Differences in measured parameters across body mass index (BMI) categories were determined using ANOVA. Confidence interval was set at 95% and  $P < 0.05$  was considered statistically significant. **Results:** Dimensions of right psoas muscle obtained were higher in male subjects compared to females. Sexual dimorphism was observed in the height ( $T = 2.30$ ;  $P = 0.02$ ) of the individuals with chronic low back pain. There was no sexual dimorphism in all measured parameters at  $P < 0.05$ , implying that the dimension of psoas muscle in chronic low back pain is same for both sexes. Mean width was higher in obese subjects ( $4.26 \pm 0.45$ cm), followed by overweight ( $4.19 \pm 0.41$ cm) and normal subjects ( $3.73 \pm 0.46$ ). Mean length of psoas muscle followed similar pattern. Mean length of psoas muscle followed similar pattern. **Conclusion:** Sexual dimorphism was observed in the height of individuals with chronic low back pain. However there was no sexual dimorphism in other parameters, suggesting that the dimensions of psoas muscle in chronic low back pain is same for both sexes.

**Keywords:** Psoas muscle, chronic low back pain, magnetic resonance imaging

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## INTRODUCTION

The psoas muscles (minor and major) are located in the iliopsoas compartment, posterior to the transversalis fascia, it originates at the transverse process of all the lumbar vertebrae; T12-L5, passes through the pelvis and inserts at the lesser trochanter of femur as iliopsoas tendon they are the only muscles that connect the spine to the legs (Christiane, 2020).

The actions of the psoas major muscle include flexion of the thigh/trunk, lateral rotation of the thigh and lateral flexion of the trunk; the psoas major muscle is innervated by the anterior rami of spinal nerves L1-L3, its blood supply is the lumbar branch of iliolumbar artery. (Niamh, 2021). Low back pain (LBP) is a common health challenge involving the muscles, nerves, and bones of the back (Brian et al, 2012). Low back pain can be classified into two groups based on duration and its underlying cause; Based on duration we have three types, acute low back pain (pain lasting less than 6 weeks), sub-chronic low back pain (pain lasting 6-12 weeks) and chronic low back pain (pain lasts more than 12 weeks); based on its underlying cause, we have mechanical low back pain (of a known origin or cause) and non-mechanical back pain (referred pain) (Brian, et al., 2012). Low back pain (LBP) is a common musculoskeletal condition in industrialized countries. Experts have estimated that approximately 80% of Americans will experience low back pain during their lifetimes; the annual prevalence of LBP is 15-45% with a point prevalence of approximately 30%, 60% of those who suffer from acute LBP recover in 6 weeks and up to 80-90% recover within 12 weeks; however, the recovery of the remaining patients with LBP is less certain (Jasvinder, 2018).

A population based systematic review done in Africa with majority of the studies done in Nigeria and South Africa reported a lifetime prevalence of LBP to be 47%, annual prevalence was estimated at 57% and the point prevalence was estimated at 39% (Morris et al., 2018). A study done in Southern Nigeria reported a point prevalence of LBP 42% (Nottidge et al., 2019). This study is aimed to determine the dimensions of the psoas muscle in patients with chronic low back pain using magnetic resonance imaging (MRI).

## MATERIALS AND METHODS

This study was a cross sectional retrospective study conducted in the Radiology department of the Rivers State University Teaching Hospital. Ethical approval was obtained from the ethical committee of the Rivers State University Teaching Hospital (RSUTH/REC/2021125). MRI done with 1.5 Tesla Magnetic Resonance System were retrieved from the archives, sixty images of 60 adults (18 years and above) were used for the study. Images of subjects below 18 years were excluded. Measurement of the psoas muscle (height, length and width) was done at the level of the degenerative change and lumbosacral abnormality and analyzed using statistical package for the social sciences (SPSS) version 23.0 and Microsoft excel data analysis tool pack (2019 edition) and the following results were obtained.

## RESULTS

We evaluated 60 MRI images of 60 patients, 40 (67%) of the subjects were females, while 20 (33%) were males.

**Table 1:** Anthropometric parameters of individuals with chronic low back pain

Parameters	Sex	N	Min	Max	Mean±SD
Age (years)	Male	20	44.00	87.00	62.70±11.29
	Female	40	43.00	86.00	59.03±10.32
	Total	60	43.00	87.00	60.25±10.70
Weight (Kg)	Male	20	54.00	98.00	68.50±10.04
	Female	40	55.00	88.00	70.05±7.63
	Total	60	54.00	98.00	69.53±8.45
Height (m)	Male	20	1.47	1.59	1.53±0.04
	Female	40	1.03	1.56	1.49±0.08
	Total	60	1.03	1.59	1.50±0.07
BMI (Kg/m <sup>2</sup> )	Male	20	23.07	41.86	29.44±4.64
	Female	40	23.81	65.98	32.15±6.47
	Total	60	23.07	65.98	31.24±6.02

*N* = Number of subjects; *Min* = Minimum; *Max* = Maximum; *SD* = Standard Deviation

Excluding age [Male (M) = 62.70±11.29; Female (F) = 59.03±10.32] and height (M = 1.53±0.04; F = 1.49±0.08), other parameters; weight (M = 68.50±10.04; F = 70.05±7.63) and BMI (M = 29.44±4.64; F = 32.15±6.47) were higher in females compared to males.

**Table 2:** Dimensions of the psoas muscle in individuals with chronic low back pain

Parameters	Male [N = 20]			Female [N = 40]			Total [N = 60]		
	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD
<b>Right Psoas</b>									
Height (cm)	3.70	4.70	4.20±0.38	2.00	5.20	4.12±0.68	2.00	5.20	4.15±0.59
Width (cm)	3.20	4.90	4.15±0.45	2.70	4.90	4.04±0.65	2.70	4.90	4.07±0.59
Length (cm)	12.20	16.47	14.14±1.37	11.68	16.60	13.79±1.16	11.68	16.60	13.90±1.23
<b>Left Psoas</b>									
Height (cm)	2.70	6.80	3.99±0.91	3.00	5.70	4.06±0.72	2.70	6.80	4.04±0.78
Width (cm)	3.00	4.90	4.10±0.50	2.70	4.90	4.01±0.63	2.70	4.90	4.04±0.59
Length (cm)	12.35	16.47	14.01±1.21	11.68	16.60	13.88±1.18	11.68	16.60	13.93±1.18

*N* = Number of subjects; *Min* = Minimum; *Max* = Maximum; *SD* = Standard Deviation

The dimensions of psoas muscle obtained include; for the right, all measured parameters were higher in male subjects compared to females. Measured parameters includes height (M = 4.20±0.38cm; F = 4.12±0.68cm), width (M = 4.15±0.45cm; F = 4.04±0.65cm) and length (M = 14.14±1.37cm; F = 13.79±1.16cm). While on the left, except height (M = 3.99±0.91cm; F = 4.06±0.72cm), all other measured parameters; width (M = 4.10±0.50cm; F = 4.01±0.63cm) and length (M = 14.01±1.21; F = 13.88±1.18) were higher in males.

**Table 3:** Sex differences in the anthropometric parameters of individuals with chronic low back pain

Parameters	MD	SEMD	95% C.I of the Difference		df	t-value	P-value
			Lower	Upper			
Age (years)	3.68	2.92	-2.16	9.51	58.00	1.26	0.21
Weight (Kg)	-1.55	2.33	-6.21	3.11	58.00	-0.67	0.51
Height (m)	0.04	0.02	0.01	0.08	58.00	2.30	<b>0.02*</b>
BMI (Kg/m <sup>2</sup> )	-2.71	1.62	-5.97	0.54	58.00	-1.67	0.10

\* = Significant at  $P < 0.05$ ; **MD** = Mean difference; **SEMD** = Standard error of mean difference; **C.I** = Confidence interval; **df** = degree of freedom. Except for height ( $T=2.30$ ;  $P=0.02$ ), all other parameters did not show sexual dimorphism at  $P < 0.05$ .

**Table 4:** Sex differences in the dimensions of Psoas muscle in individuals with chronic low back pain

Parameters	MD	SEMD	95% C.I of the Difference		df	t-value	P-value
			Lower	Upper			
<b>Right Psoas</b>							
Height (cm)	0.07	0.14	-0.20	0.35	57.21	0.53	0.60
Width (cm)	0.11	0.14	-0.18	0.39	52.07	0.75	0.46
Length (cm)	0.35	0.34	-0.33	1.02	58.00	1.03	0.31
<b>Left Psoas</b>							
Height (cm)	-0.08	0.21	-0.51	0.35	58.00	-0.36	0.72
Width (cm)	0.09	0.16	-0.23	0.41	58.00	0.56	0.58
Length (cm)	0.13	0.33	-0.52	0.78	58.00	0.40	0.69

**MD** = Mean difference; **SEMD** = Standard error of mean difference; **C.I** = Confidence interval; **df** = degree of freedom. Also Sexual dimorphism was not observed in all measured parameters at  $P < 0.05$ . This implies that the dimensions of psoas muscle in chronic low back pain is same for both sexes.

Dimensions of psoas muscle in male subjects with chronic low back pain in relation to Body Mass Index (BMI) was also analyzed; For the right, the mean height of psoas muscle was higher in subjects with normal weight ( $4.47 \pm 0.25$ cm), followed by obese ( $4.16 \pm 0.35$ cm) and overweight ( $4.14 \pm 0.42$ cm). Mean width was higher in obese subjects ( $4.26 \pm 0.45$ cm), followed by overweight ( $4.19 \pm 0.41$ cm) and normal subjects ( $3.73 \pm 0.46$ ). Mean length of psoas muscle followed a similar pattern. It was higher in obese subjects, followed by overweight and underweight. For the left, mean height of psoas was higher in obese

( $4.43 \pm 1.23$ cm), followed by normal ( $4.30 \pm 0.53$ cm) and overweight ( $3.59 \pm 0.56$ cm) subjects. While higher mean values were observed in the obese, followed by overweight and normal subjects for the width ( $4.23 \pm 0.46$ cm,  $4.11 \pm 0.53$ cm and  $3.73 \pm 0.46$ cm respectively) and length ( $14.89 \pm 1.22$ cm,  $13.57 \pm 1.06$ cm and  $13.43 \pm 0.31$ cm respectively) of psoas.

Significance difference was not observed in the measured parameters according to BMI categories at  $P < 0.05$ .

**Table 5:** Dimensions of Psoas muscle in male subjects with chronic low back pain according to BMI categories

Parameters	BMI Categories	N	Min	Max	Mean	SD	ANOVA		
							df	F-value	P-value
<b>Right Psoas</b>									
Height (cm)	18.5 - 24.9	3	4.20	4.70	4.47	0.25	2	0.91	0.42
	25.0 - 29.9	10	3.70	4.70	4.14	0.42			
	30.0 or greater	7	3.70	4.60	4.16	0.35			
	Total	20	3.70	4.70	4.20	0.38			
Width (cm)	18.5 - 24.9	3	3.20	4.00	3.73	0.46	2	1.65	0.22
	25.0 - 29.9	10	3.70	4.70	4.19	0.41			
	30.0 or greater	7	3.70	4.90	4.26	0.45			
	Total	20	3.20	4.90	4.15	0.45			
Length (cm)	18.5 - 24.9	3	12.48	14.30	13.33	0.92	2	1.51	0.25
	25.0 - 29.9	10	12.20	16.47	13.92	1.45			
	30.0 or greater	7	12.80	16.20	14.78	1.26			
	Total	20	12.20	16.47	14.14	1.37			
<b>Left Psoas</b>									
Height (cm)	18.5 - 24.9	3	3.70	4.70	4.30	0.53	2	2.23	0.14
	25.0 - 29.9	10	2.70	4.55	3.59	0.56			
	30.0 or greater	7	2.70	6.80	4.43	1.23			
	Total	20	2.70	6.80	3.99	0.91			
Width (cm)	18.5 - 24.9	3	3.20	4.00	3.73	0.46	2	1.05	0.37
	25.0 - 29.9	10	3.00	4.70	4.11	0.53			
	30.0 or greater	7	3.70	4.90	4.23	0.46			
	Total	20	3.00	4.90	4.10	0.50			
Length (cm)	18.5 - 24.9	3	13.20	13.78	13.43	0.31	2	3.72	0.05
	25.0 - 29.9	10	12.35	15.40	13.57	1.06			
	30.0 or greater	7	13.28	16.47	14.89	1.22			
	Total	20	12.35	16.47	14.01	1.21			

N = Number of subjects; Min = Minimum; Max = Maximum; SD = Standard Deviation; df = degree of freedom

Also dimensions of psoas muscle in female subjects with chronic low back pain according to BMI was also done; On the right, all measured parameters were higher in obese, followed by overweight and normal subjects.

Mean psoas height was 4.25±0.62cm (obese), 3.94±0.80cm (overweight) and 3.90±0.00cm (normal). Mean psoas width; 4.15 ± 0.65cm (obese), 3.99 ± 0.59cm (overweight) and 3.10±0.14cm (normal). Mean psoas length; 13.86±1.14cm (obese),

13.70±1.20cm (overweight) and 13.54 ± 1.78cm (normal). On the left, mean psoas height was higher in the obese (4.13±0.74cm), followed by overweight (4.06±0.69cm) and normal weight (3.40±0.57cm). Same pattern was observed for psoas width, with the obese having higher mean psoas width (4.11 ± 0.65cm), followed by overweight (3.96±0.56cm) and normal weight (3.10±0.14cm). While mean psoas length was higher in obese (13.90 ± 1.24cm) and overweight (13.90 ± 1.19cm) subjects, followed by normal weight (13.54 ± 0.37cm).

**Table 6:** Dimensions of Psoas muscle in female subjects with chronic low back pain according to BMI categories

Parameters	BMI Categories	N	Min	Max	Mean	SD	ANOVA		
							Df	F-value	P-value
<b>Right Psoas</b>									
Height (cm)	18.5 - 24.9	2	3.90	3.90	3.90	0.00	2	0.99	0.38
	25.0 - 29.9	14	2.00	4.90	3.94	0.80			
	30.0 or greater	24	2.90	5.20	4.25	0.62			
	Total	40	2.00	5.20	4.12	0.68			
Width (cm)	18.5 - 24.9	2	3.00	3.20	3.10	0.14	2	2.67	0.08
	25.0 - 29.9	14	2.70	4.70	3.99	0.59			
	30.0 or greater	24	3.00	4.90	4.15	0.65			
	Total	40	2.70	4.90	4.04	0.65			
Length (cm)	18.5 - 24.9	2	12.28	14.80	13.54	1.78	2	0.13	0.88
	25.0 - 29.9	14	11.68	16.60	13.70	1.20			
	30.0 or greater	24	11.68	16.30	13.86	1.14			
	Total	40	11.68	16.60	13.79	1.16			
<b>Left Psoas</b>									
Height (cm)	18.5 - 24.9	2	3.00	3.80	3.40	0.57	2	0.95	0.40
	25.0 - 29.9	14	3.00	5.20	4.06	0.69			
	30.0 or greater	24	3.00	5.70	4.13	0.74			
	Total	40	3.00	5.70	4.06	0.72			
Width (cm)	18.5 - 24.9	2	3.00	3.20	3.10	0.14	2	2.60	0.09
	25.0 - 29.9	14	2.70	4.70	3.96	0.56			
	30.0 or greater	24	3.00	4.90	4.11	0.65			
	Total	40	2.70	4.90	4.01	0.63			
Length (cm)	18.5 - 24.9	2	13.28	13.80	13.54	0.37	2	0.09	0.92
	25.0 - 29.9	14	11.68	16.60	13.90	1.19			
	30.0 or greater	24	12.00	16.35	13.90	1.24			
	Total	40	11.68	16.60	13.88	1.18			

**Table 7:** Side difference in psoas dimensions for male subjects with chronic low back pain

Comparison	Paired Differences						Paired T-test		
	MD	SD	SE	95% C.I of the Difference		t-value	df	P-value	
				Lower	Upper				
RT-Height - LT-Height	0.21	1.04	0.23	-0.28	0.69	0.89	19	0.38	
RT-Width - LT-Width	0.05	0.17	0.04	-0.03	0.13	1.34	19	0.20	
RT-Length - LT-Length	0.12	1.05	0.23	-0.37	0.61	0.52	19	0.61	

RT = Right, LT = Left, MD = Mean difference, SD = Standard deviation, SE = Standard error of mean difference, C.I = Confidence interval, df = degree of freedom

Side differences in psoas dimensions for male subjects with chronic low back pain was also reported. In male subjects with chronic back pain, psoas height, width as well as length were all higher on the right side, but the difference was not statistically significant at  $P < 0.05$ . Hence side differences or asymmetry does not exist in the dimensions of psoas muscle in male subjects with chronic low back pain.



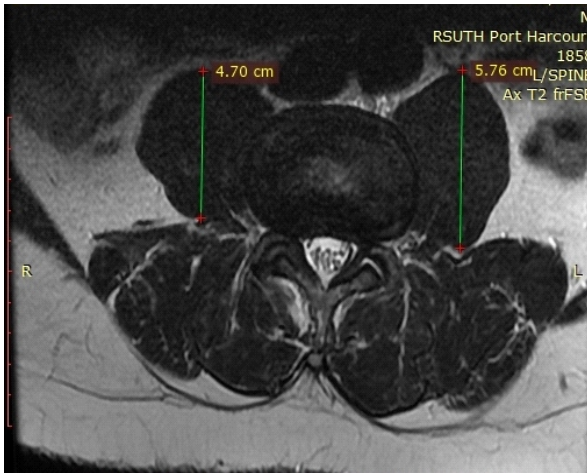
**Table 8:** Side difference in psoas dimensions for female subjects with chronic low back pain

Comparison	Paired Differences					Paired T-test		
	MD	SD	SE	95% C.I of the Difference		t-value	df	P-value
				Lower	Upper			
RT-Height - LT-Height	0.06	1.12	0.18	-0.30	0.41	0.33	39	0.75
RT-Width - LT-Width	0.03	0.15	0.02	-0.02	0.08	1.36	39	0.18
RT-Length - LT-Length	-0.09	0.45	0.07	-0.24	0.05	-1.32	39	0.20

RT = Right, LT = Left, MD = Mean difference, SD = Standard deviation, SE = Standard error of mean difference, C.I = Confidence interval, df= degree of freedom

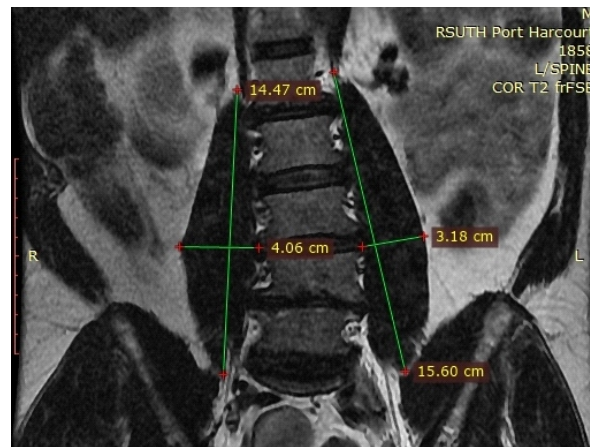
Side differences in psoas dimensions for female subjects with chronic low back pain was presented in Table 8. In female subjects with chronic back pain, except psoas length, all other measured parameters (height and width) were both higher on the right limb, but these differences were not statistically significant at  $P < 0.05$ . Hence side differences or asymmetry does not exist in the dimensions of psoas muscle in female subjects with chronic low back pain.

*Below 18.5 = Underweight; 18.5 – 24.9 = Healthy weight; 25.0 – 29.9 = Overweight; 30.0 or greater = Obese*

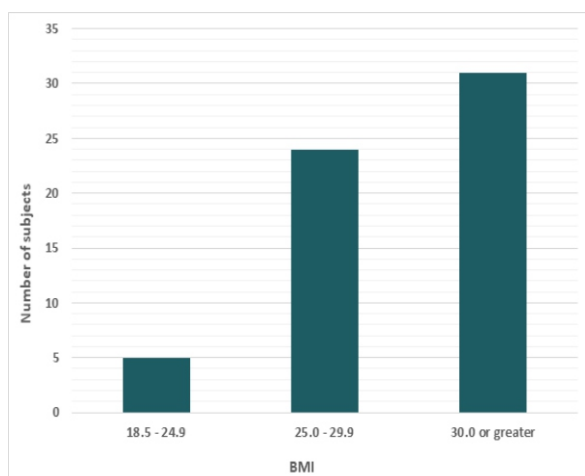


**Figure 1:** Distribution of the subjects according to BMI categories

Distribution of the subjects according to BMI was done; BMI categories were considered. Below 18.5 as underweight, 18.5 – 24.9 as healthy weight, 25.0 – 29.9 as overweight and 30.0 or greater as obese. None of the subjects was underweight, while 5 (8.33%) was normal, 24 (40.0%) was overweight and 31 (51.67%) obese. More of the subjects with chronic low back pain were obese.



**Fig. 2.** Coronal section of T2 weighted Magnetic resonance image of the lumbosacral spine showing the psoas muscle and its insertion.



**Fig. 3. Fig. 2. Axial section of T2 weighted Magnetic resonance image at the level of the intervertebral disc of the lumbosacral spine showing the psoas and other paravertebral muscles.**

## DISCUSSION

### Length of the psoas muscle

In this study, the mean length for the right psoas muscle is  $13.90 \pm 1.23$  cm and the left psoas muscle is  $13.93 \pm 1.18$  cm. Previous study done by Juraj et al, (2013) on the psoas major muscles in patients with low back pain showed that the patients had bigger cross sectional area of the psoas muscle than controls at the levels of L3/L4 and L4/L5 intervertebral disc. Also Cooper et al, (1992) did a research on the radiographic demonstration of paraspinal muscle wasting in patients with chronic low back pain, the cross-sectional area (CSA) of spinal and paraspinal structures were measured radiographically in 43 patients with recent low back pain and 44 patients with chronic low back pain at the level of L4; results showed that there was significant reduction in the paraspinal and psoas dimensions in patients with chronic low back pain compared to patients with recent onset low back pain. Muzeyyen et al, (2007) carried out a study with 36 patients with chronic low back pain and 34 healthy volunteers with the purpose of determining the cross-sectional area changes of the paraspinal, isolated multifidus, quadratus lumborum and psoas; results showed that there was a reduced cross-sectional area of psoas in the patient group than in the control group, hence they concluded that there is atrophy of the psoas muscle in patients with chronic

low back pain. Parkkola et al, (1993) carried out research on 60 middle-aged healthy volunteers and 48 chronic low back pain patients with the aim to evaluate the lumbar intervertebral discs and the maximum isometric strength and size of the trunk muscle; results showed that the psoas and back muscles (erector spinae and multifidus) of the patients were smaller than those of the volunteers.

### Sex differences in the anthropometric parameters of individuals with chronic low back pain

With respect to height, the males were observed to be taller than the females with a mean value of  $1.53 \pm 0.04$  and  $1.49 \pm 0.08$  respectively with P-value = 0.02. This may be due to the presence of higher testosterone level released into the bloodstream by the testicles, this makes males grow faster than females; during puberty, an average boy's production of testosterone increases ten-fold and more testosterone is released into the blood stream as the males mature (BBC Science, 2014). Therefore sexual dimorphism was observed in the height of the individuals with chronic low back pain. All other anthropometric parameters measured did not show sexual dimorphism at  $P < 0.05$ .

### Sex differences in the dimensions of Psoas muscle in individuals with chronic low back pain

Sexual dimorphism was not observed in all measured parameters at  $P < 0.05$ . This implies that the dimension of psoas muscle in chronic low back pain is same for both sexes. However previous study done by Jan et al, (2013) on the cross sectional area of the psoas reported that the psoas muscle was larger in males compared to females.

### Side differences

In this study it was observed that side differences (asymmetry) do exist in the dimensions of the psoas muscle in both males and females with chronic low back pain.

## CONCLUSION

This research has provided data for the dimensions (length, width and height) of the psoas muscle in individuals with chronic low back pain in our



population. This study also observed sexual dimorphism in the height of the individuals with chronic low back pain. However there was no sexual dimorphism in other measured parameters at  $P < 0.05$ . This implies that the dimension of psoas muscle in chronic low back pain is same for both sexes. Furthermore, in this study it was also observed that side differences (asymmetry) does exist in the dimensions of the psoas muscle in both males and females with chronic low back pain.

### Recommendation

Further comparative studies are needed to compare the psoas muscle in normal subjects and those with chronic low back pain, this may help determine the effect of chronic low back on the of the psoas muscle.

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