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Assessment of the mechanical properties of muscles in adults in relation to the position of the hip bones - preliminary study

Sebastian Szajkowski[1], Michał Dwornik[2], Jarosław Pasek[3*], Grzegorz Cieślar[4]

[1]Faculty of Medical and Social Sciences, Warsaw Medical Academy of Applied Sciences, Warsaw, Poland

[2]Center of Medical Rehabilitation and Osteopathy Rehapunkt, Piastów, Poland

[3]Collegium Medicum im. dr Władysława Biegańskiego, Częstochowa, Poland; Jan Długosz University in Częstochowa, Częstochowa, Poland

[4]Department of Internal Medicine, Angiology and Physical Medicine, Faculty of Medical Sciences in Zabrze, Medical University of Silesia in Katowice, Poland

[*]Corresponding author: Jarosław Pasek, Collegium Medicum im. dr Władysława Biegańskiego, Częstochowa, Poland; Jan Długosz University in Częstochowa, Częstochowa, Poland, e-mail address: jarus_tomus@o2.pl

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Abstract

Purpose: Asymmetry in the form of Lumbo–Pelvic–Hip Complex (LPHC) is a common phenomenon in the adult population. No consensus has been reached in the literature reviewed, as concerns the impact of posture defects upon the occurrence of muscle imbalance, faster development of degenerative changes in the joints, and pain intensity. Thus, it needs to be defined clearly in which cases the diagnosis of (LPHC) asymmetry in adults provides the basis for starting rehabilitation. The aim of the study is to determine whether in the case of this asymmetry changes in the viscoelastic and biomechanical properties of LPHC muscles occur.

Methods: The study comprised 64 adults, divided into two groups on the basis of physical examination: pelvic symmetrical (n=34),and pelvic asymmetrical (n=30). Myotonometric measurements of output parameters: tension, stiffness and elasticity were carried out to assess the mechanical properties of LPHC muscles in both groups.

Results: Tension, stiffness and elasticity of the examined muscles, namely: abdominal muscles, rectus femoris muscle, erector muscle of the spine, and biceps femoris muscle were measured; the pelvic symmetrical group, and the pelvic asymmetrical group did not differ with statistical significance as regards the comparison between the left and right sides of the body of the subjects. Also, no statistically significant differences in the occurrence of pain were found between the study groups.

Conclusions: Our findings have important clinical implications**.** The asymmetry of LPHC, commonly diagnosed in adults during functional examination for the purpose of physiotherapy, should not provide the basis for starting rehabilitation, in the absence of pain.

Key words: pelvic asymmetry, myotonometry, viscoelasticity, muscle tone, low back pain

Introduction

Asymmetry in the settings of the pelvis is described in the literature as a counter-clock wise rotation of the hip bones around the horizontal axis [4]. In literature, one can find evidence of Lumbo–Pelvic–Hip Complex (LPHC), commonly found in the population. It has been shown that in up to 98.74% of subjects some asymmetry in the height of pelvic girdle (a la of ilium) position has been revealed, in the range of 4-10 mm. Uneven pelvic girdle (a la of ilium) alignment is easily diagnosed during a routine physical examination as part of the screening examination of body posture, and its confirmation is provided by X-ray examination [43]. The influence of pelvic asymmetry upon the occurrence of functional elongation or shortening of one of the lower limbs is also commonly recognized. This impairs the transfer of loads between the lower limbs and the spine. Uneven loading of the lower limbs indirectly disrupts the LPHC biomechanics. The changed function has an impact on the anatomical structure, contributing to the faster development of degenerative changes in the joints of the spine and peripheral joints [2,4]. The most frequent cause of pain occurring within the LPHC area is deformation of intervertebral discs. Less often, especially in younger subjects, the pain is caused by degenerative changes caused by overload in facet (zygapophyseal) joints [29]. In contrast, pathologies within the sacroiliac joint are the least recognized causes of chronic pain in the lumbosacral spine [6]. It was confirmed in a model of human osteoarthritis (OA) that in degenerative cartilage significant changes taking the form of decreases in the modulus or stiffness of OA cartilage under tension, compression and shear loading, and lead to increases in the propensity to swell. Moreover, some changes in structure, composition and metabolism were found, such as deterioration of the collagen-proteoglycan solid network focused at the articular surface, causing initial disruptions of the cartilage surface as a direct result of mechanical forces or a product of altered chondrocyte activity [38].

Regardless of the source of pain in the lower spine, if its intensity is substantial (which most often is the case in the acute phase) reflexively increased resting tonus of the para-spinal muscles is observed. It has been shown that the increase in resting muscle tone of LPHC muscles is correlated only with the pain experienced [9]. In the cited study, the tension and stiffness of the erector muscle of the spine in the lumbar region were higher, and elasticity was lower in individuals with chronic lumbosacral spine pain, as compared to healthy subjects. Pain intensity measured using Visual Analog Scale (VAS) was positively correlated with tension and stiffness values. However, no significant correlation was found between the curvature of the spine - defined by means of Cobb angle - and muscle tension, stiffness and flexibility of the spine erector muscle, both in patients with pain and without pain in the lumbosacral spine [41]. The above has been confirmed in the study of Lo et al [25]. The study of Alcazar-Clariana et al. demonstrated that there was no correlation between pain intensity and muscle tension and stiffness of LPHC muscles, measured statically [1]. However, the results of other studies prove that the increase in muscle LPHC tension and stiffness is the result of asymmetry of the position in this area, that is, it is associated with a posture defect [30,41].

The MyotonPRO (Myoton AS, Tallinn, Estonia) myotonometer has been used to quantify the mechanical properties of muscles in a non-invasive, simple, and fast way. Measurement results obtained in myotonometric test performed *in vivo* precisely determine the mechanical properties of tendons and muscles. They find application in both diagnosis and evaluation of treatment effects. They should also be used as input data for determining training programs and preventive actions. Previous studies have shown that this device is reliable and provides high repeatability of measurements, with Intraclass Correlation Coefficient (ICC)> 0.9 [8,11,21,22,25].

In our previous study, we demonstrated that asymmetrical movement of the sacroiliac joints in the forward bend test is in 77.55% of cases the result of asymmetry in the position of pelvic bones. The symmetrical movement of hip bones during the forward bend, however, promotes the absence of pain occurrence, both in case of symmetrical (22.99%) and asymmetrical (10.34%) hip bone position in static position [36].

So far, there has been no consensus in the literature as concerns the impact of posture defects, considered in this case to be the asymmetric setting of LPHC, upon the occurrence of muscle imbalance within it, which may be important in the planning of rehabilitation process in the case of this pathology.

Aim of the study

The aim of the study was to answer the following research questions: whether the LPHC setting, commonly diagnosed during functional examination for physiotherapeutic purposes causes changes in the viscoelastic and biomechanical properties of the muscles of this complex, and whether asymmetry affects the frequency of pain symptoms in the spine and pelvic girdle. Answering the above research questions is crucial within the context of physiotherapy development that meets the criteria of Evidence Based Medicine. An accurate clinical diagnosis is the basis for prescribing appropriate treatment.

Material and Methods

Recruitment and exclusion criteria

The study comprised 64 people (38 women and 26 men) who met the following inclusion criteria: age between 20 and 70 years. The topics discussed in the study concern adult populations of various ages. Participants from a wide age range were included in the study, in order to obtain the most reliable results [1,19,22]. Further inclusion criteria were as follows: no previous surgical procedures performed in the lumbar spine, pelvis and joints of lower limbs, absence of pain in the lumbo-sacral spine on the day of the examination, presence of chronic pain in the lumbo-sacral spine on the day of the examination, voluntary and informed consent to participate in the study. The criteria for exclusion from the study were: age below 20 or above 70 years, acute pain in the lumbo-sacral spine on the day of the examination, co-existence of post-traumatic pain in the spine and lower limbs, pregnancy, previous surgical procedures of the lumbar spine, pelvis and joints of the lower limbs, severe structural scoliosis already visible during physical examination, co-existence of connective tissue systemic diseases, neurological diseases, taking anti-inflammatory drugs and drugs that reduce muscle tone, as well as absence of voluntary and informed consent to participate in the study.

Evaluation of pelvic asymmetry

Physical examination was performed using both hands, on the left and right side at the same time. Palpation and visual assessment were used to examine the positioning of the posterior superior iliac spines, anterior superior iliac spines, and iliac crests, in erect position [32]. The examined subject was requested to stand still and symmetrically load the lower limbs, his eyes were directed forward, with his arms along the torso, and he was asked not to strain the muscles unnecessarily. The person conducting the examination did not know whether the subjects experienced pain and in what location the pain occurred. The following 2 results of the examination were possible: pelvic symmetrical when the height of posterior superior iliac spines, anterior superior iliac spines, and iliac crests on the left and right side was identical, and pelvic asymmetrical when the height at which one or more of the assessed items: posterior superior iliac spines, anterior superior iliac spines, and iliac crests, was not identical on the left and right side. Additional criteria for the assessment of LPHC symmetry, besides the location of hip plates comprised the assessment of the occurrence of asymmetrical lumbar spine scoliosis (“shaft”) in the forward bend position and functional shortening of the lower limb in recumbence. The additional assessment criteria we used were useful in the case of difficulties in examining the position of the hip plates in obese people. The occurrence of asymmetrical lumbar spine scoliosis ("shaft") caused by the rotation of the lumbar vertebrae and observed in the forward bend position, as well as functional shortening of the lower limb coexists with the rotation of the iliac plates [20,42]. Based on the results of physical assessment, the study participants were divided into 2 groups: pelvic symmetrical; (n=34), and pelvic asymmetrical; (n=30). In addition, pain reported during history taking has been recorded. The examinations for all participants were carried out by one experienced physiotherapist.

Measuring viscoelastic properties of muscles

The method is noninvasive. It has been shown to be highly reproducible, independent of the investigator [16,26,39]. The hand-held device for conducting myotonometry (MyotonPro, Tallinn, Estonia) provides a controlled preload of 0.18 N for an initial compression of the subcutaneous tissue, imposing an additional 15 ms pulse and mechanical force of 0.40 N, which induces a natural damped oscillation in the targeted tissue. This response is measured by an accelerometer [28]. The muscle viscoelastic and biomechanical properties recorded in this study included: F - frequency [Hz], representing muscle tone (the higher frequency, the higher the muscle tone), S – stiffness [N/m], representing muscle stiffness, which means the capacity of muscle to resist contraction or external pressure to deform (the higher the stiffness, the greater the muscle toughness), D - decrement [log], representing decrement of oscillation amplitude (the higher the decrement, the lower the elasticity) [31,39].

Before taking measurements with the use of MyotonPRO, patients were asked to assume a standing position, identical with that for the examination of pelvis. Participants were requested to perform a 5-s breath hold at the end of the inspiration phase [8]. Measurements were taken during the breath hold period, to minimize the influence of confounding factor on muscle properties, which was related to intra-abdomen pressure change occurring with natural respiratory cycles. The abdominal muscles were examined at the level of the lower abdomen at half the distance between the front midline and the anterior superior iliac spine (Fig.1A) [5]. Lumbar measurements were carried out by placing the probe of the device perpendicularly to the muscle belly of the erector spinae muscle, 2.5 cm from the midline of the spinous process of L5 (Fig.1B) [3]. The rectus femoris muscle of the thigh was examined in its initial section at the height of the pubic symphisis (Fig.1C) [13]. The biceps femoris muscle was examined in the initial section of its belly just behind the tendon passage into the muscle (Fig.1D) [14]. The choice of the place of examination of individual muscles is justified by the possible close location from the pelvis fulcrum line, in order to increase the probability of the influence of asymmetry on the examined viscoelastic and biomechanical parameters. First, the examination was carried from the front in the following order: rectus abdominis muscle on the left and right side, followed by the rectus femoris muscle on the left and right side. This was followed by the examination performed from the back by the person performing it: erector muscle of spine on the left and right side, after which the biceps femoris muscle on the left and right side was examined. During the examination, the coefficient of variation (CV) of each examination result was assessed, and if the CV exceeded 3%, the examination was repeated [41]. Myotonometric examinations were carried out by one experienced physiotherapist, trained in the examination methodology with the application of myotonometry.

The study received approval from the Bioethics Committee affiliated at the Medical University of Mazovia in Warsaw, Poland (approval reference number: 2022/09/MUM-01). The study protocol was strictly consistent with the Helsinki Declaration (1964).

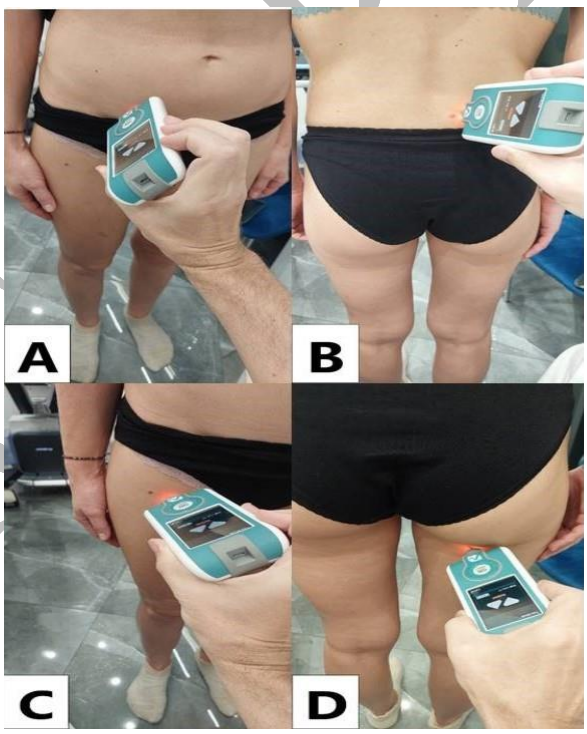

Figure 1. The MyotonPRO measurement technique.

Statistical analysis

Statistical analysis of the obtained results was performed using Statistica 13.1 PL software (StatSoft, Kraków, Poland). Consistency of variables with normal distribution was verified by means of the Shapiro-Wilk test. The Pearson Chi-square test was used to assess the relationship between symmetry and asymmetry of pelvic positions, Body Mass Index (BMI) value, and pain symptoms. The intergroup comparison of demographic data was performed using the Student's t-test. The comparison of myotonometry parameters between left and right sides in the pelvic symmetrical group and pelvic asymmetrical group, respectively, was performed using the Student's t-test. The results were considered statistically significant, if the $p<0.05$. G*power software (version 3.1.9.7; Heinrich – Heine – Universität Düsseldorf, Düsseldorf, Germany; (http://www.gpower.hhu.de) [15] was used to determine the power analysis using 2-sided testing, $\alpha = 0.05$, and sample size = 64. The outcome used for power analysis was tone [Hz]. The effect size was 0.31. The power (1-β err prob) was calculated as 0.27. Test family was “t-test” and statistical test was difference between two independent means (two groups). Type of power analysis was ”Post hoc: Compute achieved power – given α, sample size, and effect size”.

Results

Demographic data pertaining to age, weight, height, BMI, and pain duration, with division into the groups: pelvic symmetrical (n=34) and pelvic asymmetrical (n=30) are presented in Table 1. Both groups were homogeneous in all parameters assessed.

Table 1. General characteristics of participants.

	Pelvic symmetrical group n=34 Mean ± SD	Pelvic asymmetrical group n=30 Mean ± SD	p-value*
Age (years)	46.94 ± 13.68	48.70 ± 13.07	0.602
Weight (kg)	78.76 ± 13.62	74.30 ± 14.2	0.204
Height (cm)	170.65 ± 8.93	167.90 ± 7.98	0.202
BMI (kg/m^2)	27.00 ± 3.87	26.20 ± 3.58	0.394
Duration of pain (months)	60.16 ± 22.69	55.33 ± 19.53	0.787

* Student's t-test

Table 2 contains the results of analysis concerning the dependence between the position of the pelvis and occurrence of pain. The frequency of pain symptoms experienced in the pelvic symmetrical group and pelvic asymmetrical group was of no statistical significance (p=0.994), with pain occurring somewhat more often in subjects from pelvis symmetrical group.

Table 2. The incidence rate of pain symptoms in relation to symmetrical and asymmetrical pelvic position.

		Pelvic symmetrical group total=34	Pelvic asymmetrical group total=30	p-value*
		n (%)	n (%)	
Pain	yes	19 (55.88)	15 (50.00)	0.994
	no	15 (44.12)	15 (50.00)	

*Chi-square test

Table 3 contains the results of analysis concerning the dependence between position of the pelvis and BMI, as well as the occurrence of pain. The frequency of pain symptoms experienced in both groups showed no statistically significant relations with the range of BMI (p=0.734), with pain occurring most frequently in subjects with obesity, and least frequently in subjects with normal BMI values.

Table 3. The incidence rate of pain symptoms in relation to BMI value.

		BMI			p-value*
		Normal total=24	Overweight total=28	Obese Class I total=12	
		n (%)	n (%)	n (%)	
Pain	yes	10 (41.67)	15 (53.57)	9 (75.00)	0.734
	no	14 (58.33)	13(46.43)	3 (25.00)	

*Chi-square test

Tension, stiffness, and elasticity of the examined muscles, namely: abdominal muscles, rectus femoris muscle, erector muscle of the spine, and biceps femoris was examined in both groups of subjects, on the left and right sides of the body. The results of myotonometric measurements have proven that both in the pelvic symmetrical group, and the pelvic asymmetrical group the values of tension, stiffness, and elasticity of all muscles examined did not differ with statistical significance between the left and right side of the body (Tables 4 and 5).

Table 4. The scores in all myotonometric measurement outcomes on both the left and right sides in participants from pelvic symmetrical group.

Muscle	Side	Pelvic symmetrical group								
		Frequency [Hz]			Stiffness [N/m]			Decrement [log]		
		Mean ± SD	95% CI	p*	Mean ± SD	95% CI	p*	Mean ± SD	95% CI	p*
abdominal muscles	left	12.16 ± 1.90	11.50 – 12.82	0.506	199.12 ± 61.84	177.54 – 220.69	0.908	1.28 ± 0.28	1.19 – 1.38	0.953
	right	12.46 ± 1.80	11.83 – 13.09		200.85 ± 61.53	179.39 – 222.32		1.29 ± 0.30	1.18 – 1.39	
rectus femoris muscle	left	14.95 ± 2.29	14.15 – 15.75	0.964	259.79 ± 74.40	233.84 – 285.75	0.974	1.07 ± 0.21	1.00 – 1.14	0.538
	right	14.93 ± 1.93	14.25 – 15.60		259.26 ± 56.48	239.56 – 278.97		1.10 ± 0.20	1.03 – 1.17	
erector spinae muscle	left	15.40 ± 3.55	14.15 – 16.63	0.272	308.97 ± 131.11	233.84 – 354.72	0.462	1.25 ± 0.31	1.00 – 1.35	0.994
	right	22.24± 3.83	9.74 – 34.74		333.59 ± 142.88	283.74 – 383.44		1.24 ± 0.29	1.14 – 1.35	
biceps femoris muscle	left	14.33 ± 1.74	13.72 – 14.94	0.654	222.29 ± 54.52	203.27 – 241.32	0.930	1.26 ± 0.32	1.14 – 1.37	0.438
	right	14.14 ± 1.76	13.52 – 14.75		221.18 ± 49.70	203.84 – 238.51		1.20 ± 0.31	1.09 – 1.30	

Abbreviations: *Student's t-test.

Table 5. The scores in all myotonometric measurement outcomes on both the left and right sides in participants from pelvic asymmetrical group.

Muscle	Side	Pelvic asymmetrical group								
		Frequency [Hz]			Stiffness [N/m]			Decrement [log]		
		Mean ± SD	95% CI	p*	Mean ± SD	95% CI	p*	Mean ± SD	95% CI	p*
abdominal muscles	left	11.74 ± 1.38	11.22 – 12.26	0.755	176.37 ± 28.48	165.73 – 186.99	0.431	1.23 ± 0.33	1.11 – 1.36	0.947
	right	11.87 ± 1.73	11.22 – 12.51		184.63 ± 49.51	166.15 – 203.12		1.23 ± 0.25	1.13 – 1.32	
rectus femoris muscle	left	14.53 ± 2.54	13.58 – 15.48	0.762	256.13 ± 79.78	226.34 – 285.92	0.984	1.08 ± 0.23	0.99 – 1.17	0.441
	right	14.74 ± 2.88	13.67 – 15.82		255.70 ± 84.43	224.17 – 287.23		1.04 ± 0.18	0.98 – 1.11	
erector spinae muscle	left	14.96 ± 3.19	13.76 – 16.15	0.790	289.73 ± 142.87	236.38 – 343.08	0.829	1.29 ± 0.39	1.15 – 1.44	0.995
	right	15.18 ± 3.28	13.96 – 16.40		297.27 ± 125.98	250.22 – 344.30		1.29 ± 0.40	1,14 – 1.44	
biceps femoris muscle	left	14.35 ± 1.80	13.68 – 15.02	0.138	219.27 ± 52.04	199.83 – 238.70	0.257	1.19 ± 0.32	1.06 – 1.30	0.417
	right	13.71 ± 1.47	13.16 – 14,26		206.03 ± 36.08	192.56 – 219.50		1.13 ± 0.22	1.04 – 1.20	

Abbreviations: *Student's t-test.

Discussion

This study has investigated the relation between symmetrical and asymmetrical positions of pelvic and mechanical parameters of muscles in standing position, measured by means of MyotonPro device. This topic often discussed in research is that concerning the impact of pain on mechanical properties of muscles, which is described by measuring their tone, stiffness, and elasticity. However, in the available literature we find different conclusions regarding the mechanical parameters of the assessed muscles. The results of study [22] indicate the occurrence of statistically significantly higher tension of the para-spinal muscles on that body side at which after patients experience pain. A different conclusion comes from a study concerning the effect of pain upon the mechanical properties of muscles within LPHC, in which no correlation was found between pain and muscle tension, as well as stiffness [25]. In in the study [22], in turn, no correlation between the lumbar spine setting (Cobb angle) and pain was found, at the same time, there was no statistically significant effect of lumbar spine curvature upon physiological tension parameters in paraspinal muscles. Other authors emphasize that there are significant relationships between tension, stiffness, and elasticity of muscles and pain depends on more of factors, such as the age of the subjects, the degree of severity of symptoms and time over which symptoms occur. We took this into account by including participants of different ages in our study (ranging from 20 to 70 years old), in order to obtain the most reliable results [1,19,22,24]. Moreover, this resulted in substantial homogeneity and absence of significant differences in demographic data between study groups.

The results of our work showed that the incidence of pain in pelvic symmetrical group and pelvic asymmetrical group did not differ statistically significantly. This has been partly confirmed by the study of Shah et al. [34]. There was no difference in the degree of elimination of lordosis in women with back pain and without such pain. However, in men suffering from pain in the lumbar spine, lordosis was usually more substantially eliminated. The difference has not reached the level of statistical significance. Basing on the above observations and taking into account that Wu et al. [41] did not find significant correlation between the curvature of the spine and muscle tension, stiffness, and flexibility of the spine erector muscle, both in patients with pain and without pain in the lumbosacral spine, it seems that the ”liminal lumbar lordosis” (hypolordosis) often described in radiological examination should be considered to be only a weak clinical symptom of lumbar spine pain.

The study of Shortz and Haas, in which the authors studied the relationship of different Cobb angle values and degree of pain intensity in the group of 352 patients and confirmed the existence of a statistically significant relationship of lumbar spine asymmetry with the incidence of pain symptoms [35]. Hansen et al., in turn, have shown in their study that pain is not directly related to the asymmetry of the lower section of spine but with the degree of severity of degenerative changes of intervertebral discs, closely related to age. The formation of pathological curvatures of the spine contributes to the occurrence of degenerative changes, due to the disturbed biomechanics and uneven distribution of forces affecting the motion segments of the spine, yet this occurs with inter-individual variations and in fact the degenerative changes of discs, and intervertebral joints are the cause of the occurrence of pain symptoms, which ultimately contributes to changes in mechanical parameters of muscles, not the very asymmetry of the spine and pelvis [10]. Sufficiently long degenerative changes of intervertebral discs are associated with changes in the intervertebral joints and their capsular ligament system, which is the cause of pain and is associated with reflex changes in the form of stiffening of motion segments and changes in LPHC muscle stiffness and flexibility [36].

The results of our work also showed that the frequency of pain incidence does not differ statistically significantly in relation to the value of BMI. This is not confirmed by the results of the study conducted by Shariat et al. [33]. In this study, the analysis was based on the larger research material of 752 subjects. The authors identified a significant association between the severity of low back pain and BMI. Another large population-based epidemiological study with a total of 92.936 persons eligible for participation, indicates that obesity is associated with a high prevalence of low back pain [10]. It has been shown that body weight is a factor that triggers overload mechanisms within LPHC and it is the current state of the pathogenesis of overloaded structures upon which depends the occurrence of changes in physiological muscle tension parameters, by reflex response to pain. The inconsistency of our results regarding the impact of BMI on the occurrence of low back pain with those of other authors may result from a smaller, non-representative sample [24].

It can be noted that while in the literature there are no clear proofs and consistent opinions whether LPHC asymmetry and BMI value influence the pain experienced and mechanical parameters of muscles, there are also no studies assessing the influence of LPHC asymmetry - regardless whether subjects suffer pain or not - upon tension, stiffness, and elasticity of muscles in that area. In our opinion, such a study is indispensable as part of further research on pain in ,lower spine, connected with the mechanics of the latter. In the course of the study reported here, we have measured the tension, stiffness, and elasticity of the following muscles: abdominals, erector muscle of the spine, rectus femoris muscle, and biceps femoris at the left and right side of the body in the group of subjects with symmetry and LPHC asymmetry found on the physical performed statically. The results of the measurements showed that tension, stiffness, and elasticity have not revealed statistically significant differences between the left and right side of the body in the pelvic symmetrical group or pelvic asymmetrical group. Therefore, it seems reasonable to conclude that the change of muscle parameters within LPHC depends on the coexistence of the discussed factors, such as: pain [30], BMI value [24], body structure asymmetry [25] and others, which has been confirmed in other studies. Meints provides examples of the influence of psychological and social factors [27], Hu et al. [11] refer to the influence of stress, Iacovides et al. [12] comment on the influence of menstruation cycle and gender, while Cricco et al. [7] indicated the influence of endometriosis upon pain intensity and muscle tone changes in the sacrolumbar area. Kowalski et al. [18], in turn, confirmed the impact of idiopathic scoliosis, while Wu et al. [40] - the influence of age on pain symptoms, muscle tension, and LPHC symmetry. The age range from 20 to 70 years old, that we included in the study, remains consistent with the study of Wu et al. [40]. The results of the latter study indicate that the global prevalence of low back pain increased with age, and years lived with disability peaked at around 35 to 49 years of age [37]. The authors explain the validity of conducting our study on participants of significantly different ages, because the disease affects the entire population. Simple everyday activities also affect the mechanical properties of muscles within the LPHC, such as e.g. the prolonged assumption of incorrect sitting posture. Such posture may strengthen the increased LPHC muscle tension and contribute to the occurrence of pain [17]. Thus, the final functional state of LPHC is influenced by many different factors, and the mechanical properties of muscles examined in this study are the result of their mutual influence. Due to the complexity of this issue, the authors of the study reported here recognize the need to conduct further research with the use of objective measurement tools. Results of studies that meet stringent criteria of Evidence Based Medicine, as well as conclusions and guidelines ready for application in clinical practice will contribute to increasing the effectiveness of rehabilitation conducted.

Study limitations

The study reported here has some limitations. Muscles were examined by means of MyotonPro device in one point only. Despite taking into account the principles of methodology of myotonometric examination of muscle functioning assessed in the study, resulting from the literature data, it cannot be ruled out that in other regions the results of muscle measurements could differ from those presented in the study. The assumption of the authors of the study was that the methodology of studying LPHC symmetry should not differ from the typical physical examination performed by physiotherapists. For this reason, the typical error assumed during the measurement of the pelvis was, for palpation examination, at the level of +/- 0.5 cm. Limited sample size and absence of the determination of sample size entail that the results obtained should not be over-generalized.

Conclusions

The results of myotonometric measurements showed that the asymmetry of the LPHC setting, commonly diagnosed during functional examination for the purpose of physiotherapy, does not significantly change the mechanical properties of muscles of that complex. Studies have also shown that the frequency of pain symptoms in the spine and pelvic girdle has no connection with the asymmetry of LPHC setting. Thus, the diagnosis of slight asymmetry in adults, with the simultaneous absence of pain should not provide the basis for starting rehabilitation.

Ethics statement

The study received approval from the Bioethics Committee affiliated at the Medical University of Mazovia in Warsaw, Poland (approval reference number: 2022/09/MUM-01). The study protocol was strictly consistent with the Helsinki Declaration (1964).

Author contributions

SSz – study design, data collection, data interpretation, statistical analysis, manuscript preparation, literature search
MD – data collection, data interpretation, manuscript preparation
JP – data interpretation, data collection, literature search
GC – manuscript preparation

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