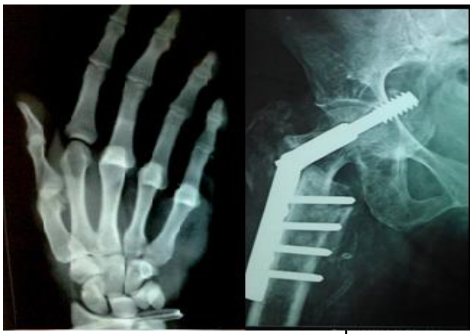

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The effect of limb length discrepancy on spinopelvic posture

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Abstract

Background: Limb Length Discrepancy (LLD) has been associated with many pelvic and lumber biomechanical conditions including: low back pain, scoliosis and osteoarthritis in the hip joint. No much studies shed the light on the relationship between LLD and pelvic obliquity. Thus, the aim of this study is to clarify if pelvic obliquity affected by LLD.
Methods: The search was conducted by using the databases: MEDLINE, Cochrane library and Google Scholar, PubMed, using the following keywords: "limb length discrepancy, spinopelvic abnormalities "for published studies from 2012-2022. PRISMA flowchart will be produced based on the search results and the inclusion/exclusion criteria. To facilitate the assessment of possible risk of bias for each study, information will be collected using the (Cochrane collaboration tool for assessing the risk of bias).
Results: Pelvic obliquity and pelvic tilt are changed by mild degrees of LLD while, compensations from the lower limbs begin to appear with LLD greater than 20 mm. Regarding Pelvic Obliquity changes, it was revealed that the mean baseline Pelvic Obliquity was 1.73 changes to 6.81. Two studies assessed pelvic torsion, showed significant decrease from baseline to after with mean difference of 1.437, 95%CI: (0.931 to 1.943), and p-value 0.0029. Two studies assessed Pelvic tilt, showed significant differences from baseline to after with mean difference of 0.492, 95%CI: (0.0393 to 0.944) and p-value 0.0013.
Conclusion: LLD has important effect on pelvic obliquity. LLD causes clinical symptoms such as back pain, gait abnormalities, back muscle imbalances. The adverse effects of LLD can be prevented by proper and early detection and management.

Keywords: Limb length discrepancy, spinopelvic alignment, pelvic obliquity

Introduction

Limb length discrepancy (LLD), is the term frequently used in the literature to describe the phenomenon of unequal lengths of the lower limbs [1, 2].

LLD is divided into two different types; first is structural LLD; which is innate or acquired difference in the actual lengths of the two limbs, the second one is functional LLD; where there is no actual difference in the limb length, but the difference in length may be due to changed status in the lower extremity such as joint contracture and limb mal-alignment [3].

LLD causes torsional changes in pelvic posture with posterior rotation of the ilium on the longer limb side and anterior rotation of the ilium on the short limb side, relative to the contralateral ilium [4].

LLD is associated also with several musculoskeletal disorders, including scoliosis and resultant degenerative spinal changes. This scoliosis is non-progressive and is termed functional lumbar rotatory scoliosis [5].

Some authors believe that functional scoliosis may become structural over time and can cause permanent spinal changes such as asymmetrical facet joint angles, disc degeneration, osteophytic spurs, facet joint OA, disc herniation and muscle imbalances. LLD can be measured by Scanogram (CT and X-ray). Surface topography is a method that allows evaluating the effects of LLD on the pelvic position and spinal posture, since it is a non-invasive imaging technique that uses light lines to scan and analyse the back surface of patients [6].

Although several studies have shown that changes in the sagittal spinopelvic alignment may occur in patients who have LLD, no review of this area has been completed so far [7].

Thus, the objective of this review was to summarize the evidence investigating changes in the spinopelvic alignment following LLD.

Materials and Methods

The literature search was performed using the following search terms.

MEDLINE, Cochrane library and Google Scholar, PubMed, using the following keywords: "limb length discrepancy, spinopelvic alignment, spine, pelvic" for published studies from 2001-2021.

Inclusion criteria: Publications from the year 2001 till 2021. Published only, full text articles. Article type: cluster RCTs, cluster trials, prospective and retrospective comparative cohort studies, and case-control or nested case-control studies.

Exclusion criteria: Cross-sectional Studies, case series and case reports. Non-English papers. Duplicate replications.

Points of comparison

The eligible study included two outcomes at least: Patient characteristics, mean follow up, and complications.

Spinopelvic alignment: is a complex chain of correlations from the spine to the pelvis and that changes in one region of the spine can result in reciprocal changes in other spinopelvic regions with potential alignment consequences.

The parameters of spinopelvic unite are such as Pelvic incidence (PI), sacral slope (SS), pelvic tilts (PT), lumbar lordosis, thoracic kyphosis and pelvic obliquity.

Pelvic Torsion Angle (°) was the angular difference between the right-left hip bones in the anterior-posterior plane. The result is recorded as positive when the right side is further anterior and negative when the left side is further anterior.

The curvature of the Cobb method: is defined as the angle between the upper border of the upper vertebra and the lower borders of the lowest vertebra.

Spine and hip distress, and scoliosis.

Locating and selecting studies

Abstracts of articles identified using the above search strategy were viewed and articles that appear to fulfil the inclusion criteria were retrieved in full, when there is a doubt, a second reviewer assessed the article and consensus was reached.

Data extraction

Data were extracted from each study by reviewer (the researcher) independently according to the pre-specified selection criteria.

Statistical considerations

Outcomes from included trials were combined using the systematic review manager software and manually screened for eligibility to be included.

PRISMA flowchart was produced based on the search results and the inclusion/exclusion criteria.

Statistical analysis of the data

Data were fed to the computer and analysed using MedCalc software package version 15.8. Confidence interval (CI) was established at 95% and p-values of less than or equal 0.05 were considered statistically significant. Statistical heterogeneity was assessed using I2 (observed variance for heterogeneity) and Q (Total variance for heterogeneity). Quantitative data are reported as Mean and SD standard deviation.

Results

The updated search revealed 3853 studies in PubMed and 677 studies in Index to orthopedic Literature. After titles and abstracts were screened 296 studies were selected in PubMed and 67 studies in Index to Chiropractic Literature. The citations for the selected publications (n = 363) were imported into Endnote software, and duplicates (n = 11) were filtered automatically. After duplicates were removed (n = 11), abstracts of the remaining studies (n = 352) were assessed in depth. After that, 298 articles were excluded. Full texts of the remaining 54 articles were checked for eligibility criteria. Two articles were excluded due to lack of data. Of the remaining eleven articles were finally included and analyzed. (Figure 1).

Eleven studies were included six were prospective, four were retrospective and one were RCT as shown in table (1). A total of 1670 cases were included with mean age 24.8 years and male\female was 292\1231, mean BMI was 22.6 as shown in table (1).

Mean baseline Pelvic Obliquity was 1.73 changes to 6.81, mean Baseline Pelvic Torsion was 2.6 changes to 1.3, mean Kyphotic baseline Angle was 42.63±6.33 which changes to 42.96±8.01 as shown in table (2).

Mean baseline Pelvic tilt was 14.8 and changes to 11.2, mean baseline Sacral slope was 38.3 changes to 37.3, mean baseline Cobb angle (°) was 27.3 and changes to 17.2 as shown in table (3).

Two studies assessed pelvic torsion, showed significant decrease from baseline to after with mean difference of 1.437, 95% CI: (0.931 to 1.943), and p-value 0.0029.

Two studies assessed Pelvic tilt, showed significant differences from baseline to after with mean difference of 0.492, 95% CI: (0.0393 to 0.944) and p-value 0.0013.

Discussion

LLD is categorized as an anatomic or functional type and may result in multiple problems for the affected patient. The main aim of this study was to evaluate the effect of limb length inequality on spine and pelvic postures.

Gurney *et al*. States that the causes for the anatomic LLD are congenital or acquired. The most prevalent congenital ones are dislocation of the hip. LLD of > 5 mm is related to an increased risk of osteoarthritis of the hip and knee joints as well as low back pain and lumbar scoliosis [8].

In this study a total of 1530 cases were included with a mean age 24.8 years and male\female was 283\1247, mean BMI was 22.6.

Pelvic obliquity may result from intrinsic sacropelvic deformity, LLD, or a combination of both. The correlations between LLD, pelvic imbalance, and scoliosis have been investigated in several studies. Papaioannou *et al*. noted that lumbar scoliosis was associated with LLD in a static erect posture, possibly due to compensatory changes in the curvature of the spine to maintain proper balance [9].

Buyukaslan *et al*., found no significant association between scoliosis with age, gender or BMI in patients with LLD [10].

In this study, it showed that LLD could lead to functional scoliosis. The curve of the scoliosis can be lumbar, thoracic, thoracolumbar or double major curve.

Early intervention such as shoe lifts can correct scoliosis, reduce the pain, and decrease pelvic obliquity in patients with functional scoliosis due to LLD. Cobb angle and apical rotation are the features that differentiate Adolescent idiopathic scoliosis from functional scoliosis in patients with LLD.

Degenerative spinal diseases are more likely to occur in an unbalanced loading and under asymmetric force vectors.

According to Tuncer C *et al*., Pelvic incidence (PI) and lumbar lordosis (LL) are the most important spinopelvic parameters that form the lumbo-pelvic shape [11].

Moreover, Pelvic incidence is a constant structural parameter; thus, an individual with low PI who presents with LBP must be monitored to prevent the development of lumbar disc diseases.

Regarding its effect on pelvic posture, LLD induces pelvic motion in the sagittal and/or coronal plane with forward innominate bone rotation on the short limb and backward rotation on the long limb. According to Ashour *et al*., differences in forward/backward rotation and leveling of both innominate bones may change the rotation and inclination of the sacrum that is located between them [12].

In our study, it was reported that greater than 5 mm LLD was associated with low back pain and the risk of low back pain increased 5.3 times with a 15 mm LLD.

This study showed that pelvic obliquity and pelvic tilt are changed by mild degrees of LLD while, compensations from the lower limbs begin to appear with LLD greater than 20mm.

Regarding Pelvic Obliquity changes, it was revealed that the mean baseline Pelvic Obliquity was 1.73 changes to 6.81.

Kobayashi *et al*., revealed that the pelvic obliquity was significantly related to the severity of the LLD [13].

Knutson *et al*., showed that the reduction in the degrees of both pelvic tilt and torsion might be attributed to improving pelvic posture and mechanics by correcting the inequality between both limbs [14].

In addition, the pelvic torsion angle was affected by 15 mm artificial LLD, and the effect increased at the artificial LLD of 20 mm.

Treatment of LLD ranges from conservative intervention to various surgical techniques. The most common conservative treatment for mild LLD is the use of internal or external shoe lifts. Yet, there is great debate on shoe lifts regarding their efficacy.

Ashour *et al*., showed that shoe insert use is beneficial in improving spinopelvic alignment (pelvic tilt and torsion and vertebral rotation and lateral deviation) [12].

The current study showed the effect of using corrective shoe inserts for eight weeks on frontal and transverse plane spinopelvic alignment and dynamic balance. It was hypothesized that shoe insert use would improve spinopelvic alignment and dynamic balance.

This study recommended larger sample size are needed to confirm the current results, longer follow-up and Long-term studies are needed to examine the effect of LLD resolution on the elimination of scoliosis.

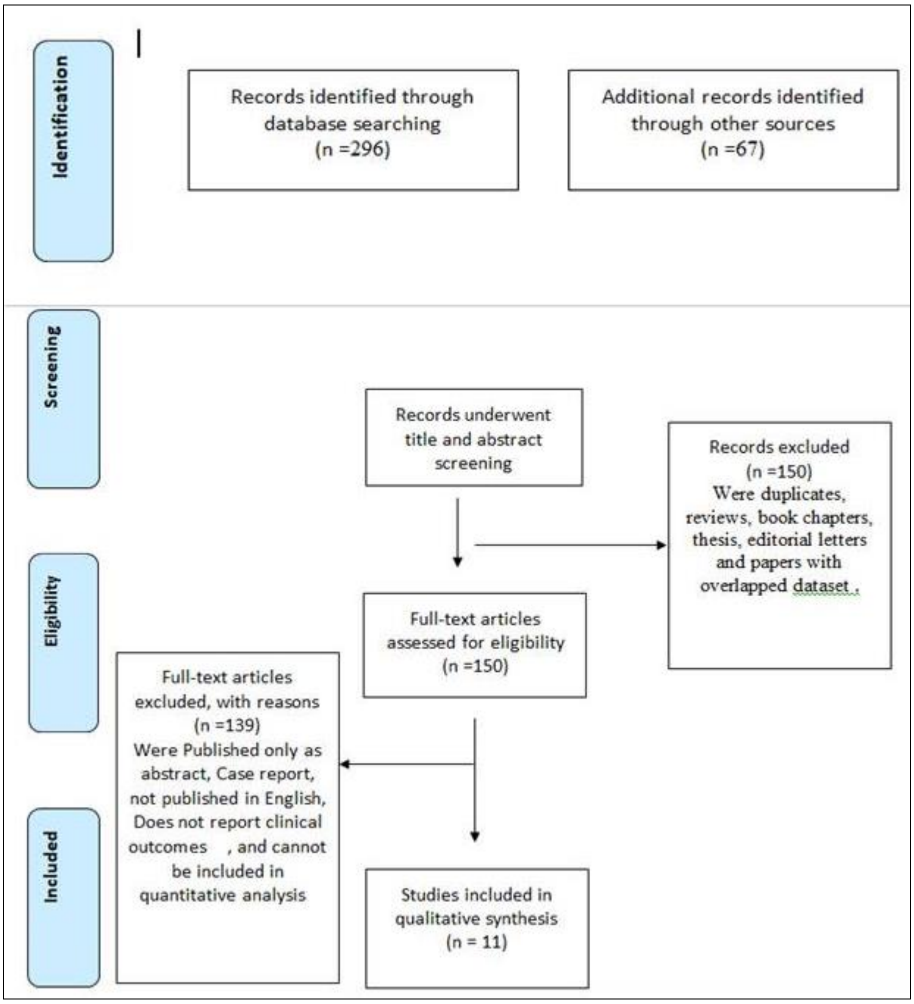

Fig 1: PRISMA flow diagram showing process of studies selection

Table1: Study and patient characteristics

Author	Number	Age	m\f	BMI (kg/m2)	type of study
Balci A *et al*., 2022 [12]	24	17.13	14\10	21.53	prospective
Kobayashi K *et al*., 2020 [13]	23	14	9\14	19.1	prospective
Pinto EM *et al*., 2019 [14]	80	12.44	19\61	-	prospective
TUNCER C *et al*., 2019 [15]	147	44.41	-	-	prospective
Facione J *et al*., 2019 [16]	5	43	1\4	25.5	prospective
Sekiya T *et al*., 2018 [17]	82	13.7	12\70	-	prospective
Buyukaslan A *et al*.,2021 [18]	37	12.5	13\24	19.2	retrospective
Saeedi M *et al*., 2020 [19]	25	12.7	2\23	Not mentioned	retrospective
Burkus M *et al*., 2018 [20]	458	16.8	82\376	-	retrospective
Lafage R *et al*., 2016 [21]	773	53.7	132\641	-	retrospective
Ashour R *et al*., 2019 [22]	16	32.9	8\8	27.8	RCT

Table 2: Pelvic diameter changes

Author	baseline Pelvic Obliquity	after Pelvic Obliquity	Baseline Pelvic Torsion	After Pelvic Torsion	Kyphotic baseline Angle	Kyphotic after Angle
Balci A *et al.*, [12]	0.54±4.16	9.63±5.85	0.42±2.50	−2.25±2.95	42.63±6.33	42.96±8.01
Buyukaslan A *et al.*, [18]	-	1.8±1.5	-	-	-	-
Kobayashi K *et al.*, [13]	-	9.0±6.3	-	-	-	-
Pinto EM *et al.*, [14]	0.55±0.55	-	-	-	-	-
Ashour R *et al.*, [22]	-	-	3.7±1.1	1.3±0.6	-	-
Sekiya T *et al.*, [17]	4.1±3.0	-	-	-	-	-

Table 3: Changes in Different angles

Author	Baseline Pelvic tilt	After Pelvic tilt	Baseline Sacral slope	After Sacral slope	Baseline Cobb angle (°)	After Cobb angle (°)
Buyukaslan A *et al.*, [18]	-	-	-	-	-	16.2±7.3
Kobayashi K *et al.*, [13]	-	-	-	-	-	13.0±7.0
Saeedi M *et al.*, [19]	10.9±7.5	11.1±7.5	38.3±10.8	37.7±8.6	31.8±5.9	22.5±6.9
Ashour R *et al.*, [22]	12±5.8	4.7±3.1	-	-	-	-
TUNCER C *et al.*, [15]	-	24.91°±6.03°	-	33.00°±7.98°	-	-
Facione J *et al.*, [16]	-	8±8	-	39±12	-	-
Sekiya T *et al.*, [17]	-	-	-	-	22.8±12.5	-
Burkus M *et al.*, [20]	-	7.5±8.3	-	39.6±10.3	-	-
Lafage R *et al.*, [21]	21.5±11.2	-	-	-	-	-

Conclusion
LLD has significant impact on spinopelvic alignment. LLD has serious clinical symptoms such as low back pain, sacroiliac joint disorders, and scoliosis and muscle imbalances. Adverse outcomes of LLD can be prevented or delayed through early detection and management.

Statements and Declarations
Competing Interests
"The authors have no relevant financial or non-financial interests to disclose."

Author Contributions
"All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by [Ahmed Sobhy Nasr] [Mahmoud A. El-Rosasy] [Mohamed Osama Ramadan] and [Mohamed Roshdy ElTabakh]. The first draft of the manuscript was written by [Ahmed Sobhy Nasr], and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethical Approval
The study fulfilled the Egyptian Ethics Code of Research (Approval code 36264PR145/3/23).

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Availability of data and materials
Not applicable.

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