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Systematic review

Effects of external pelvic compression on form closure, force closure, and neuromotor control of the lumbopelvic spine – A systematic review

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ABSTRACT

Optimal lumbopelvic stability is a function of form closure (joint anatomy), force closure (additional compressive forces acting across the joints) and neuromotor control. Impairment of any of these mechanisms can result in pain, instability, altered lumbopelvic kinematics, and changes in muscle strength and motor control. External pelvic compression (EPC) has been hypothesised to have an effect on force closure and neuromotor control. However, the specific application parameters (type, location and force) and hypothesized effects of EPC are unclear. Thus, a systematic review was conducted to summarize the *in vivo* and *in vitro* effects of EPC. Eighteen articles met the eligibility criteria, with quality ranging from 33% to 72% based on a modified Downs and Black index. A modified van Tulder's rating system was used to ascertain the level of evidence synthesised from this review. There is moderate evidence to support the role of EPC in decreasing laxity of the sacroiliac joint, changing lumbopelvic kinematics, altering selective recruitment of stabilizing musculature, and reducing pain. There is limited evidence for effects of EPC on decreasing sacral mobility, and affecting strength of muscles surrounding the SIJ, factors which require further investigation.

1. Introduction

Sub-optimal pelvic joint stability can be associated clinically with lumbopelvic (Vleeming et al., 2007), groin (Jansen et al., 2009) and/or hamstring pain (Mason et al., 2007; Panayi, 2010). Prevalence rates for these conditions range between 22% (Albert et al., 2001) to 90% (Nwuga, 1982) for pregnancy-related lumbopelvic pain, 9% (Paajanen et al., 2011) to 32% (Gabbe et al., 2010) for sports-related groin pain, and 8% (D'Souza, 1994) to 22% (Brooks et al., 2006) for sports-related hamstring pain. Current management strategies suggest multi-modal approaches for these disorders or injuries (Lee, 2004; Mens et al., 2006a; Mason et al., 2007; Sole et al., 2008).

"Stability" is defined as "the effective accommodation of the (pelvic) joints to each specific load demand through an adequately tailored joint compression, as a function of gravity, coordinated muscle and ligament forces, to produce effective joint reaction forces under changing conditions" (Vleeming et al., 2008, p. 798). Optimal function of the passive, active and neuromotor joint control systems is required for effective load transfer and stability of the pelvis (Vleeming et al., 1990a; Panjabi, 1992; Snijders et al., 1993a). It has been proposed that sacroiliac joint (SIJ) stability is enhanced by the structural 'self-locking mechanisms' termed form and force closure (Vleeming et al., 1990a, 1990b; Snijders et al., 1993a, 1993b), and by neuromuscular control (Lee, 2004) of the surrounding muscles. In this model, form closure is a function of SIJ anatomy to resist shear forces, while force closure is primarily a dynamic process achieved through the muscular system, augmented by ligamentous and fascial structures (Vleeming et al., 1990a; Snijders et al., 1993a; Lee, 2004). Neuromuscular control is defined as the involuntary activation of dynamic restraints in preparation for (feedforward) and/or in response to (feedback) joint motion and loading, thereby maintaining and restoring joint stability under functional demand (Riemann and Lephart, 2002). These three systems are considered to work synergistically to establish optimal stability, mobility and neuromuscular performance of the lumbopelvic segments during gait and other activities (Lee, 2004; Vleeming et al., 2007).

A number of investigators accept that lumbopelvic stability can be optimised by either rehabilitative exercises (Stuge et al., 2003, 2004) and/or orthotics, such as pelvic compression belts (Lee, 2004). The belts apply external pelvic compression (EPC), which is thought to augment stability through additional force closure in lumbopelvic disorders where stability is compromised. Although EPC has been hypothesized to facilitate neuromuscular performance (strength and motor control) (Mens et al., 2006a; Takasaki et al.,

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through *in vivo* analysis of SIJ kinematics with EPC, through Roentgen stereophotogrammetric (Jacob and Kissling, 1995) or three-dimensional digitizing techniques (Bussey et al., 2009) is recommended.

6. Conclusion

There is moderate evidence to support the role of EPC in altering lumbopelvic kinematics, improving form closure by decreasing laxity in the SIJ, and augmenting force closure and motor control by selectively decreasing recruitment of stabilizing musculature in individuals with and without lumbopelvic dysfunction. There is limited evidence for the effects of EPC on decreasing mobility between the ilium and sacrum, and improving strength of muscles surrounding the SIJ, factors which need further investigation. The evidence based on this review substantiates immediate effects of EPC and might not necessarily apply to sustained application of EPC.

Conflict of interest

The authors state that there are no conflicts of interest, which might have influenced the preparation of this manuscript. No external funding was received for this study.

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Appendix I

Medline search (via Ovid).

Searches	Terms	Results
1	Humans/	11,708,152
2	Biomechanics/	65,688
3	Cadaver/	27,331
4	asymptomatic.mp.	85,762
5	athlet$.mp.	39,675
6	Low back pain.mp. or Low Back Pain/	16,535
7	Pelvic Pain/or pelvic girdle pain.mp.	2835
8	Sacroiliac Joint/or sacroiliac joint pain.mp.	2862
9	Groin/or groin pain.mp. or Athletic Injuries/	20,717
10	Postpartum Period/or post-partum.mp.	20,830
11	Joint Instability/	12,127
12	Pelvis/	13,422
13	force closure.mp.	10
14	Movement/or Motor Control.mp. or Motor Activity/	113,810
15	Active Straight Leg Raise.mp.	44
16	Pelvic Belt.mp.	25
17	manual pelvic compression.mp.	1
18	Pelvic compression.mp.	21
19	1 or 2 or 3	11,727,491
20	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15	303,737
21	16 or 17 or 18	46
22	19 and 20 and 21	27

AMED, EMBASE, Cochrane Library search (via Ovid).

Searches	Terms	Results
1	Humans/	12,941,726
2	Biomechanics/	75,068
3	Cadaver/	34,473
4	asymptomatic.mp.	120,646
5	athlet$.mp.	52,345
6	Low back pain.mp. or Low Back Pain/	40,101
7	Pelvic Pain/or pelvic girdle pain.mp.	7707
8	Sacroiliac Joint/or sacroiliac joint pain.mp.	4070
9	Groin/or groin pain.mp. or Athletic Injuries/	31,300
10	Postpartum Period/or post-partum.mp.	36,114
11	Joint Instability/	8491
12	Pelvis/	31,703
13	force closure.mp.	21
14	Movement/or Motor Control.mp. or Motor Activity/	76,420
15	Active Straight Leg Raise.mp.	66
16	Pelvic Belt.mp.	54
17	manual pelvic compression.mp.	1
18	pelvic compression.mp.	31
19	1 or 2 or 3	12,979,537
20	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15	389,081
21	16 or 17 or 18	85
22	19 and 20 and 21	37
23	remove duplicates from 22	33

Electronic search strategy for other databases.

Terms	Databases	Results
(human OR cadaver OR biomechanic*) AND (asymptomatic OR healthy OR athlet* OR "Low Back Pain" OR "Pelvic Girdle Pain" OR "Sacroiliac Joint Pain" OR "Groin Pain" OR "Post-partum" OR "Joint Laxity" OR instability OR "Sacroiliac Joint" OR pelvi* OR "Force Closure" OR "Motor Control" OR "Active Straight Leg Raise") AND ("Pelvic Belt" OR "Pelvic Compression" OR "Manual Pelvic Compression") AND (electromyogrph* OR "muscle firing pattern" OR ultraso* OR radiograph* OR strength OR isokinetic OR isometric OR proprioception OR pain)	ScienceDirect	149
	Scopus	71
	ISI Web of Knowledge	140
	Academic Search Complete, CINAHL, SPORTDiscus (via EBSCO)	9
	PROQUEST (including Conference Papers & Proceedings, Dissertations & Theses)	486

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