



Review Article

Research describing pelvifemoral rhythm: a systematic review

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Abstract. [Purpose] This systematic review was undertaken to synthesize what is known regarding pelvifemoral rhythm, that is, the coordinated flexion of the thigh and posterior tilting of the pelvis during hip flexion (HF). [Methods] Three databases were searched. [Results] Nine relevant articles were identified via independent database searches and a hand search by the authors. The articles were consistent in showing that pelvifemoral rhythm underlies the HF motion under conditions as varied as passive unilateral flexion while supine and active bilateral flexion while hanging from a bar. Posterior pelvic tilting, which begins early during HF, contributes between 13.1% to 37.5% of total HF. Pelvic tilting and HF excursions are highly correlated ($r=0.89$ to 1.00). [Conclusions] Pelvifemoral rhythm is present to varying degrees during hip flexion under diverse conditions.

Key words: Lower limbs, Kinematics, Coordination

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INTRODUCTION

Hip flexion (HF); that is, sagittal plane movement of the thigh toward the anterior trunk, is required for the successful performance of many every-day and sporting activities. An understanding of the kinematics of the movement is therefore important. Numerous researchers have described the kinematics of the movement and in doing so have noted that it is multifaceted. Specifically, it involves a simultaneous movement of the thigh (femur) on the pelvis and a posterior tilting of the pelvis (PTT)¹⁻⁹, together known as pelvifemoral rhythm. It also involves a flattening of the lumbar spine^{11, 12}. This review was undertaken to synthesize what is known about pelvifemoral rhythm during HF. Only the concentric phase of the movement was of interest and only during simple HF. Thus, the more complex kinematics observed during activities such as walking, climbing, and kicking were ignored.

METHODS

Relevant literature was identified through the search of 3 electronic databases: Scopus, PubMed, and EBSCOHost (CINAHL). The searches were conducted in February of 2017 and involved the search string (pelvic OR pelvis) AND (motion OR rhythm) AND thigh. Searches were limited, as possible, to articles in English and to adults. A hand search based on an examination of article reference lists was also conducted.

To be included an article had to quantitatively describe movement of both the thigh and pelvis during hip flexion. Articles were excluded if they described the position of the thigh and pelvis during the static maintenance of hip flexion or during complex activities such as walking¹.

Articles deemed appropriate based on inclusion and exclusion criteria were examined and information was extracted

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that related to participants, their postural orientation during testing, marking of the pelvis and lower limb, hip flexion task specifics, and findings regarding pelvifemoral rhythm (Table 1). The quality of articles contributing to the review were scored using a custom 8 item checklist with a maximum possible score of 16 (Table 2).

Table 1. Summary of articles addressing pelvifemoral rhythm in systematic review

Article	Participants	Postural orientation	Component segment marking	Hip flexion task specifics	Pelvifemoral rhythm findings
Bohannon (1982) ²⁾	Healthy young males & females (n=11)	Supine	Pelvis: Tape line between ipsilateral ASIS & PSIS Lower limb: Tape marker just distal to ipsilateral greater trochanter & just proximal to ipsilateral lateral malleolus	Pulley driven 5 minute passive straight leg raise.	85.5° HF accompanied by 22.9° PPT (26.8% of motion). Correlation of HF & PPT=0.93.
Bohannon et al. (1985) ³⁾	Healthy young males & females (n=17)	Supine	Pelvis: Tape line between left ASIS & PSIS Lower limb: Tape marker just distal to ipsilateral greater trochanter & just proximal to ipsilateral lateral malleolus	Manual passive straight leg raise.	87.3° HF accompanied by 32.1° PPT (36.8% of motion). Mean correlation of total HF & PPT=0.99.
Bohannon et al. (1985) ⁴⁾	Healthy young males & females (n=17)	Supine	Pelvis: Tape line between ipsilateral ASIS & PSIS Lower limb: Tape marker just distal to ipsilateral greater trochanter & just proximal to ipsilateral lateral femoral condyle	Active and passive unilateral & bilateral HF (knee free).	Active unilateral: 124.3° HF accompanied by 34.2° PPT (27.5% of motion). Active bilateral: 138.4° HF accompanied by 43.7° PPT (31.6% of motion). Passive unilateral: 125.9° HF accompanied by 35.4° PPT (28.1%). Passive bilateral: 123.7° HF accompanied by 37.8° PPT (30.6% of motion). Correlation of HF & PPT ranged from 0.89 to 1.00.
Elia et al. (1996) ⁷⁾	Healthy young male & female therapists (n=13) Healthy young male & female nontherapists (n=13)	Supine	Pelvis: Circular markers on ipsilateral PSIS & ASIS Lower limb: Circular markers on ipsilateral greater trochanter & lateral femoral epicondyle	Active bilateral HF (knee free)	Therapists: 90.0° HF accompanied by 21.0° PPT (23.3%). Nontherapists: 90° HF accompanied by 19.2° PPT (21.3%).
Murray et al. (2002) ⁹⁾	Healthy young males & females (n=14)	Standing upright	Pelvis: Spherical reflective markers on ipsilateral PSIS & ASIS Lower limb: Spherical reflective marker just distal to ipsilateral greater trochanter & just proximal to ipsilateral lateral femoral condyle	Active unilateral hip flexion (right) with & without resistance (knee free)	Not weighted: 102.3° HF accompanied by 19.1° PPT (18.7% of motion). Weighted: 98.3° HF accompanied by 21.1° PPT (21.5% of motion). Mean correlation of HF & PPT=0.96 to 0.97.
Dewberry et al. (2003) ⁶⁾	Healthy males & females (n=14)	Hanging by hands from bar with back rested against board inclined 10° from vertical	Pelvis: Spherical reflective markers on ipsilateral PSIS & ASIS Lower limb: Spherical reflective marker just distal to ipsilateral greater trochanter & just proximal to ipsilateral lateral femoral condyle	Active bilateral hip flexion with knees flexed or extended (knee free)	Short intrinsic hamstring length (<78° SLR) & knee extended: 90° HF accompanied by 31.9° PPT (35.5% of motion). Short intrinsic hamstring length (<78° SLR) & knee flexed: 90° HF accompanied by 17.1° PPT (19.0% of motion). Long hamstring length (>78° SLR) & knee extended: 90° HF accompanied by 19.0° PPT (21.1% of motion). Long hamstring length (>78° SLR) & knee flexed: 90° HF accompanied by 11.8° PPT (13.1% of motion).

Continuation of **Table 1**.

Article	Participants	Postural orientation	Component segment marking	Hip flexion task specifics	Pelvifemoral rhythm findings
Congdon et al. (2005) ⁵⁾	Healthy young males & females (n=31)	Supine	Pelvis: Spherical reflective markers on ipsilateral PSIS & ASIS Lower limb: Spherical reflective marker just distal to ipsilateral greater trochanter & just proximal to proximal portion of ipsilateral knee brace	Active bilateral hip flexion with knees braced at 0°, 45°, and 90°	Short hamstring length (<75° SLR), knee 0°: 70° HF accompanied by 25.9° PPT (37.0% of motion). Short hamstring length, knee 45°: 70° HF accompanied by 21.4° PPT (30.6% of motion). Short hamstring length, knee 90°: 70° HF accompanied by 17.6° PPT (25.1% of motion). Long intrinsic hamstring length (>75° SLR), knee 0°: 70° HF accompanied by 21.7° PPT (31.0% of motion). Long hamstring length, knee 45°: 70° HF accompanied by 19.7° PPT (28.1% of motion). Long hamstring length, knee 90°: 70° HF accompanied by 17.6° PPT (25.1% of motion).
Gatti et al. (2006) ⁸⁾	Healthy young males & females (n=20)	Supine	Pelvis: Spherical reflective marker on ipsilateral ASIS Lower limb: Spherical reflective marker on ipsilateral greater trochanter & lateral femoral condyle	Active unilateral hip flexion with knee braced at 60° & loads of 0 kg, 2 kg & 8 kg applied	0 kg load: 40° HF accompanied by median 9.5° PPT (23.8% of motion). 2 kg load: 40° HF accompanied by median 10° PPT (25% of motion). 8 kg load: 40° HF accompanied by median 15° PPT (37.5% of motion).
Van Houcke et al. (2013) ¹⁰⁾	Healthy young males (n=12) Young males with FAI (n=17)	Supine	Pelvis: Magnetic sensor fixed to skin over contra-lateral ASIS Lower limb: Magnetic sensor fixed to orthosis worn on ipsilateral distal thigh	Active and passive unilateral hip flexion (knee free)	Healthy active: 113.4° HF accompanied by 9.1° PPT (8.0% of motion). FAI active: 105.9° HF accompanied by 12.5° PPT (11.8% of motion). Healthy passive: 118.9° HF accompanied by 10.0° PPT (8.4% of motion). FAI passive: 110.1° HF accompanied by 10.5° PPT (9.5% of motion).

ASIS: anterior superior iliac spine; PSIS: posterior iliac spine; HF: hip flexion; PPT: posterior pelvic tilt; FAI: femoroacetabular impingement

Angular measurements are means unless otherwise designated.

RESULTS

Database and hand searches yielded 203 non-duplicative articles. Of these, 9 (2 from hand-searches) were retained based on inclusion and exclusion criteria.

All retained articles described the measurement of pelvifemoral rhythm in healthy young men and women. However, one article addressed pelvifemoral rhythm in participants with femoroacetabular impingement as well¹⁰⁾. The studies included 11 to 31 participants. Pelvifemoral rhythm was examined while participants were in 1 of 3 postural orientations: supine (n=7)^{2-5, 7, 8)}, standing (n=1)⁹⁾, hanging from a bar (n=1)⁶⁾. The capture of pelvic position during HF involved a tape line²⁻⁴⁾

Table 2. Summary of quality ratings of articles included in systematic review

Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Total
Bohannon (1982) ²	1	1	0	3	2	2	1	1	11
Bohannon et al. (1985) ³	1	2	0	3	2	2	1	0	11
Bohannon et al. (1985) ⁴	1	2	0	3	2	2	1	1	12
Congdon et al. (20) ⁵	2	2	0	3	2	2	1	0	12
Dewberry et al. (2003) ⁶	2	2	0	3	2	0	1	0	10
Elia et al. (1996) ⁷	2	2	0	3	2	1	0	1	11
Gatti et al. (2006) ⁸	2	2	0	3	2	1	0	0	10
Murray et al. (2002) ⁹	2	3	0	3	2	2	1	1	14
Van Houcke et al. (2013) ¹⁰	2	3	1	3	2	2	1	0	14

Items and scoring: 1) Participant inclusion/exclusion criteria explicit (2), 2) Sample adequately described: type, demographics (age, gender), anthropometrics (height, weight) (3), 3) Enrollment consecutive with timeframe (2), 4) Task described: Posture, hip flexion-active vs passive, unilateral vs bilateral (3), 5) Measurement adequately described: markers, motion capture (2), 6) Summary statistics (mean/median, SD/SE/range) provided for LE and pelvis (2), 7) Relationship between pelvic and lower limb motion described (r or graphically) (1), 8) Reliability of measures addressed (1)

or tape markers⁷) in early studies. Later, spherical reflective markers^{5, 6, 8, 9}) or a magnetic sensor¹⁰) were used. The capture of lower limb movement involved tape markers^{2-4, 7}), spherical reflective markers^{5, 6, 8, 9}), or a magnetic sensor¹⁰) on the lateral distal thigh or lateral leg proximal to the malleolus (when HF was performed in the context of straight-leg-raising). The manner in which HF was performed varied considerably. Specifically, it was performed passively^{2-4, 10}) and actively⁴⁻¹⁰), unilaterally^{2-4, 8-10}) and bilaterally⁴⁻⁷), and with the knee extended^{2, 3, 5, 6}) and flexed⁴⁻⁹).

The mean HF excursion over which pelvifemoral rhythm was examined ranged from 40.0° to 138.4°. The mean contribution of pelvic tilt to total HF ranged from a mean 13.1% to 37.5%⁶). Pelvic tilt tended to make a greater contribution to HF when the knee was extended rather than flexed and when the hamstrings were shorter rather than longer^{5, 6}). Pelvic tilt began almost as soon as HF and was highly correlated with HF regardless of postural orientation, method of motion capture, or specifics of the HF task ($r=0.89$ to 1.00)^{2-4, 9}).

The quality score of articles consolidated in this systematic review ranged from 10 to 14 (out of a possible 16 points). The most common shortcoming was a failure to clarify enrollment specifics.

DISCUSSION

The purpose of this review was to synthesize what is known about the coordinated movement of the thigh and pelvis (pelvifemoral rhythm) during HF. All the literature reviewed showed that pelvifemoral rhythm underlies the performance of HF²⁻¹⁰) just as scapulohumeral rhythm underlies the performance of shoulder elevation¹³). The literature also indicated that the contribution of pelvic tilting to HF^{3-6, 9, 10}), like the contribution of scapular rotation to shoulder elevation¹³), begins very early and continues throughout the range of motion. Consequently, attempts to stabilize the pelvis or limit the measurement of HF until posterior tilting of the pelvis begins¹⁴), makes no sense.

The contribution of pelvic tilt to HF varies widely but appears to be influenced by hamstring length as it tends to be greater when individuals have shorter hamstrings (a lower straight leg raising angle) or when the hamstrings are put on stretch (the knee is extended). This follows as a pull of the hamstrings on their insertion (ischial tuberosity) has the potential to foster a posterior pelvic tilt. As pelvic tilting occurs during both passive and active HF, it appears that the motion is not dependent on activation of the muscles that actively tilt the pelvis posteriorly (ie, rectus abdominus).

Our systematic review has several limitations. First, all studies but one used surface markers to capture movement of the ipsilateral pelvis and thigh. No study incorporated markers or sensors on both sides of the pelvis. Second, the studies had relatively small samples of young adults, with only one study involving individuals with a known pathology. Larger samples, as well as samples involving older adults and patients, should be examined to determine whether pelvifemoral rhythm differs between groups. Such groups might include patients with impaired hip or lumbar spine range of motion (eg, ankylosing spondylitis) or weak hip flexor or abdominal muscles (eg, stroke), or athletes for whom hip flexion is particularly important (eg, gymnasts). It would be interesting to know if pelvifemoral rhythm has implications or is modifiable in such groups. Third, the heterogeneity of studies included in this review precluded our conducting a meta-analysis. We are left, therefore, only able to indicate that pelvifemoral rhythm is a reality that should be considered when HF is performed under various circumstances.

Conflicts of interest

The authors have no conflicts of interest to declare.

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