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Crouch Gait: Evaluation and Management

Hitesh Shah MS Ortho[1], Dhiren Ganjwala MS Ortho[2]

Abstract

Crouch gait, a common gait abnormality in spastic diplegia, is characterized by increased knee flexion, ankle dorsiflexion, and reduced hip extension during the stance phase. It occurs due to impairments in anti-gravity muscles and is often aggravated during adolescence due to growth spurts. The condition can result from factors such as lever arm dysfunction, joint deformities, muscle elongation, and weakness. Crouch gait significantly affects mobility, causing early fatigue, patellar tendon elongation, and potential arthritis. Prevention involves strengthening anti-gravity muscles, maintaining proper weight, and using orthoses to correct deformities. Treatment options include surgical interventions like osteotomies, tendon lengthening, and patellar tendon advancement to address deformities and restore function. Non-surgical methods include muscle-strengthening exercises and the use of appropriate orthoses. A comprehensive assessment of modifiable and non-modifiable factors is crucial for tailored management, ultimately improving gait and reducing energy expenditure during walking.

Keywords: Crouch gait, Cerebral palsy, Patella alta, Planovalgus foot, Knee fixed flexion deformity

Dr. Hitesh Shah

Dr. Dhiren Ganjwala

Address of Correspondence
Dr. Dhiren Ganjwala,
Ganjwala Orthopaedic Hospital, Ahmedabad, Gujarat, India.
E-mail: ganjwala@gmail.com

[1]Department of Paediatric Orthopaedics, Kasturba Medical College, Manipal, Manipal academy of higher education, Manipal, Karnataka,
[2]Ganjwala Orthopaedic Hospital, Ahmedabad, Gujarat, India.

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Introduction

Crouch gait is a term that is used to describe a gait pattern characterized by increased knee flexion in the stance phase of the gait cycle. It suggests a failure of the mechanisms which maintain the body in an upright. Three muscle groups: the hip extensors, the knee extensors, and the ankle plantar flexors are primarily responsible for keeping the body upright. They are popularly known as anti-gravity muscles. Reduced ability of one or more muscles results in a crouch gait as the body fails to stay upright and collapses into a flexion posture. (Fig. 1)

To differentiate the crouch gait from other knee-flexion gait, three parameters are used to define the crouch gait.

- Increased ankle dorsiflexion
- Increased knee flexion and
- Diminished hip extension during late stance phase.

When crouch is severe it is very easy to identify this gait abnormality by observational or video gait analysis.

The exact incidence of this gait abnormality in the diplegic population is not known but gait evolution studies suggest that the incidence of crouch gait increases during adolescent years.

The article describes the causes, ill effects, prevention, and management of crouch gait.

Relevant biomechanics

The following three muscle groups maintain an erect posture. (Fig. 2)

- Hip extensors (gluteus maximus and hamstrings) generate about 20-30% of the force necessary to maintain erect posture. This group is mainly active during the

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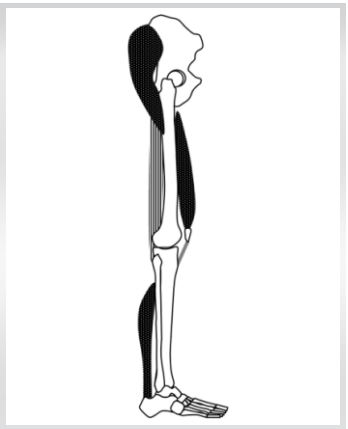

Figure 1: Shows four antigravity muscles.

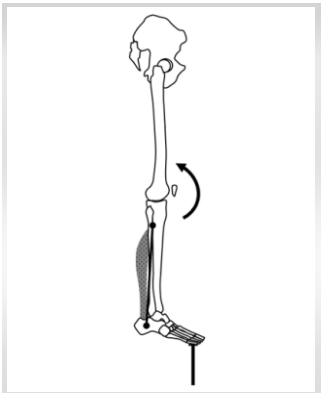

Figure 2: Mechanism of plantar flexorknee extension couple works

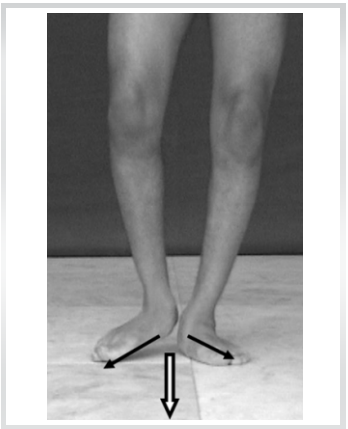

Figure 3: Out-toeing gait

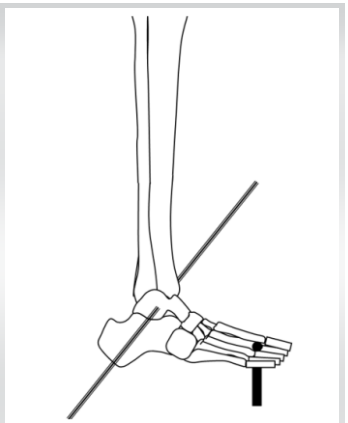

Figure 4: Axis of ankle joint and how force works on it

initial third of the stance phase.

• The Vastii generate about 20-30% of force. This group is also active during the initial third of the stance phase.

• Soleus generates about 40-50% of the force to maintain an erect stance. Soleus pulls the tibia backward and stabilizes it concerning the foot. Ground reaction force now carries out knee extension. This is known as the 'ankle plantar flexion/knee extension couple'. (Fig. 3) This mechanism maintains an erect posture during the later part of the stance phase [1].

Causes

a) Lever arm dysfunction

Depending on the principle of levers for effective functioning when the lever arm is short muscles do not produce enough power. Bone and joint problems like torsional deformity of long bones or planovalgus deformity of foot reduce the lever arm. This is known as lever arm dysfunction (LAD).

(Fig. 4 and 5) shows how external tibial torsion results in a reduction of the lever arm. As the child develops planovalgus foot deformity, the foot becomes unstable and is not able to provide a rigid lever. This is similar to lifting a load with a rubber crowbar (Fig. 6-8) [2,3].

b) Joint deformity

Flexion deformity at the hip/knee or dorsiflexion deformity at the ankle can cause a crouch gait. Joint deformity can be fixed or dynamic. Knee flexion deformity is one of the common findings in crouch gait. There is no compensatory mechanism other than to crouch in the presence of knee flexion deformity.

c) Stretched out muscles

When a person walks with knee flexion for many months, the quadriceps mechanism becomes long. This is in response to constant stretch on the muscle. Even when knee flexion deformity is taken care of by non-operative or operative treatment, the quadriceps remains long. This overly long-muscle can not carry out the last few degrees of active knee extension. Soleus also becomes long in crouch gait and is not able to restrain forward movement of the tibia during the second rocker (Fig. 9). This results in excessive dorsiflexion at the ankle. As there is more dorsiflexion at the ankle there is compensatory increased flexion at the knee and hip.

d) Muscle weakness

Weakness is one of the primary impairments in cerebral palsy. Lack of physical activity, which is very common in diplegic children, is another reason for weakness. A few reasons specific for soleus weakness are:

• Tendo Achilles lengthening when only gastrocnemius is short results in undesirable lengthening of soleus resulting in weakness

• Prolonged use of AFO

• Repeated use of Botulinum injection

When the soleus is not able to provide enough strength, vasti and hip extensors have to work more to maintain an erect

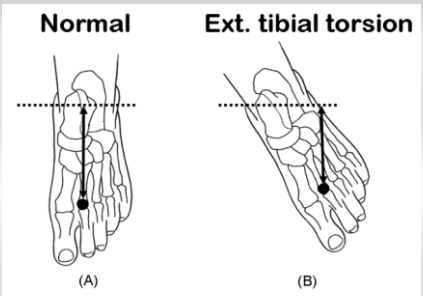

Figure 5: How the lever arm is reduced with out-toeing

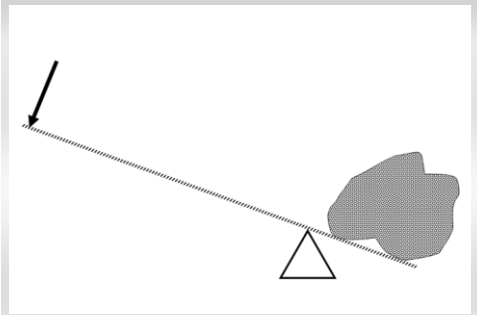

Figure 6: Type 1 lever

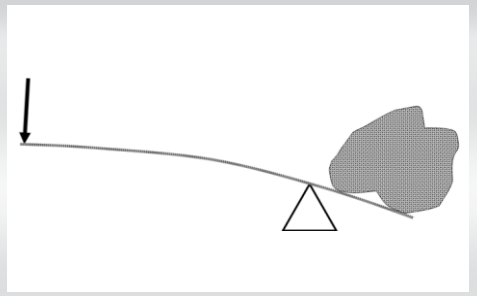

Figure 7: When lever is flexible, how dit becomes inefficient to lift the load

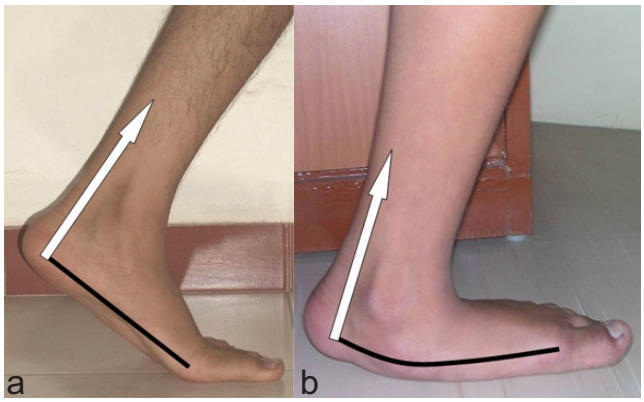

Figure 8: (A) Stable foot and (B) Unstable foot due to midfoot break

posture.

When more power is required as hip extensors, hamstrings join the gluteus maximus. When a person is erect, the hip and knee are extended. The lever arm for the hamstrings is longer at the hip than at the knee. But as the hip and knee are flexed, the lever arm at the knee becomes longer compared to that at the hip. So now hamstrings function more effectively as knee flexors than as hip extensors (Fig. 10).

To generate more power for knee extension, the rectus is called for to join the vasti. Rectus femoris is the knee extensor and hip flexors. So it helps to stabilize the knee but it causes flexion at the hip. This further accentuates the crouch problem (Fig. 11).

e) Adolescent growth spurt

During the adolescent years, the height and weight of the child increases. Muscle strength is proportionate to the cross-section area of muscle. Cross section area of muscle is proportionate to the square of height. Body weight depends on volume which in turn is proportionate to a cube of height. During the adolescent growth spurt, weight increases more than the strength of muscles. Before the adolescent growth spurt, muscles that were strong enough to maintain an erect posture, fail to maintain erect posture after the adolescent growth spurt.

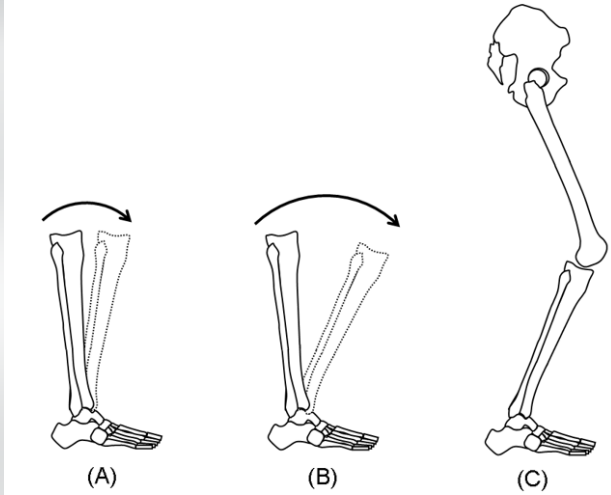

Figure 9: When soleus is inefficient, it allows excessive dorsiflexion at ankle and knee flexs to maintain upright posture

Effects

Most of the ill effects of crouch gait are seen at the knee. When one walks with the knee in flexion one requires more quadriceps power. Walking with 30 degrees of knee flexion requires the quadriceps muscle to work at around 50% of its maximum power [4]. The cyclic demand for extra power promotes fatigue at lesser distances (Fig. 12).

Another reason for early fatigue is the necessity of the quadriceps to stabilize the knee in the entire stance phase. Designed to be active only in the initial third of the stance phase, flexion of the knee due to persistent knee flexion tends to buckle it.

Standing with more than 30 degrees of knee flexion puts excessive tensile force on the patellar tendon which results in an elongated patellar tendon, and consequently either a patella alta (Fig. 13) or stress fracture at the inferior pole of the patella or tibial tubercle (Fig. 14 - 16) [5] In one study, 21% of the immature, ambulatory children with spastic cerebral palsy have such radiological abnormalities [6].

Walking with knee flexion also increases the loading of the patellofemoral joint. Needless to say this results in pain and an increased risk of later-date patellofemoral arthritis.

The above-mentioned effects work in tandem leading to gait deterioration, increased dependence on support, and sometimes even the need for a wheelchair to aid ambulation.

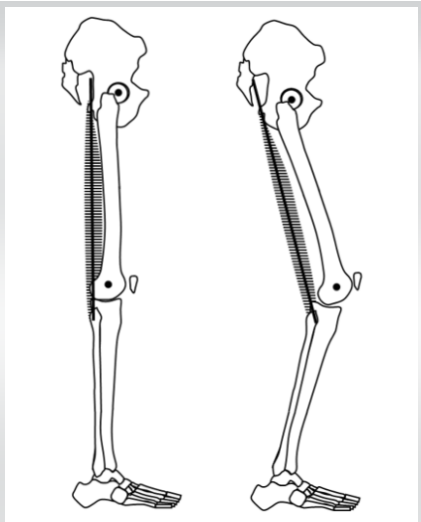

Figure 10: When knee is flexed, the lever arm of hamstrings at the knee increases

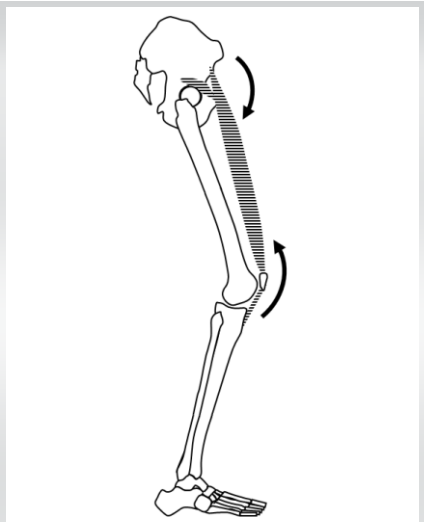

Figure 11: Overactive rectus leads to hip flexion and knee extension

Prevention

Crouch gait reduces the functioning ability of the child. An aggressive effort is the keyword for

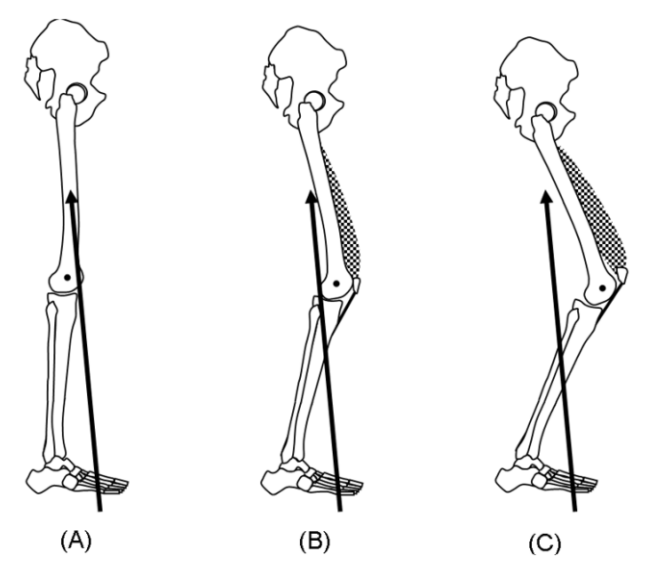

Figure 12: (A) The ground reaction force is anterior to the center of knee (B) It shift osterior the center of knee (C) It moves further posteriorly

controlling crouch gait.

Strengthening exercises, mainly for antigravity muscles, should be encouraged from an early age.

In the diplegic child, bi-articular muscles are more involved than uni-articular muscles. Commonly they have a shortened gastrocnemius and a normal-length soleus. Tendo Achilles surgery in such a case will lead to unnecessary lengthening of the soleus and weaken the soleus. Strayer's or Baumann's procedure which can selectively lengthen Gastrocnemius is preferred to avoid iatrogenic weakening of the soleus.

Lever arm deformities like planovalgus foot can be prevented or can be controlled well by the effective use of orthosis.

If the child tends to develop a crouch then floor reaction orthosis should be used to support the upper leg from the front and to avoid tibia going forward. (Fig. 17)

Knee flexion deformity should be prevented by the use of stretching splints.

Children tend to gain weight during their adolescent years. Muscles that were able to maintain an upright posture when the

Figure 13: Radiograph showing patella alta due to elongation of patellar tendon

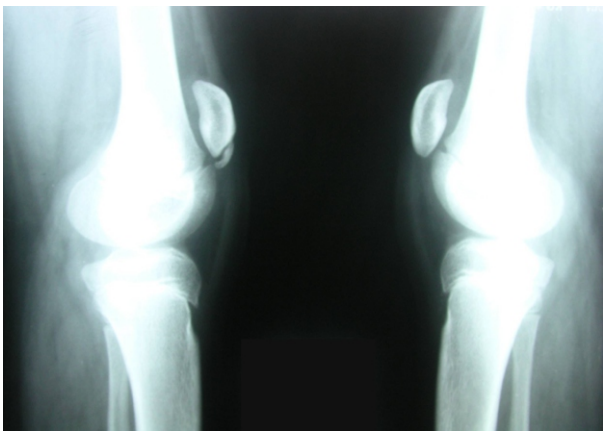

Figure 14: Radiograph showing bilateral patella alta and stress fracture at inferior poll of patella

Figure 16: Fracture patella with a big piece

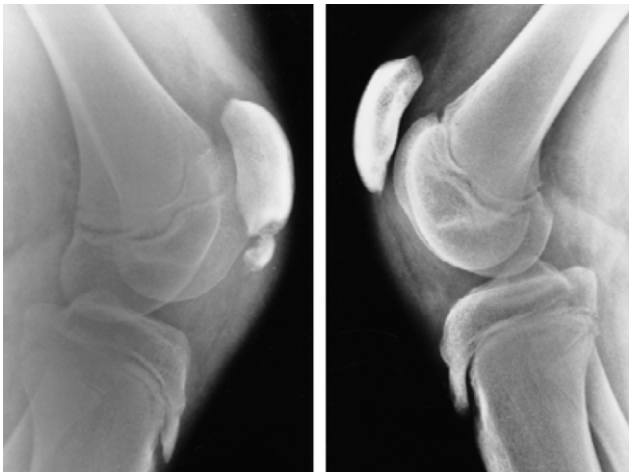

Figure 15: fracture of inferior pole of patella and healed fracture of inferior pole of patella

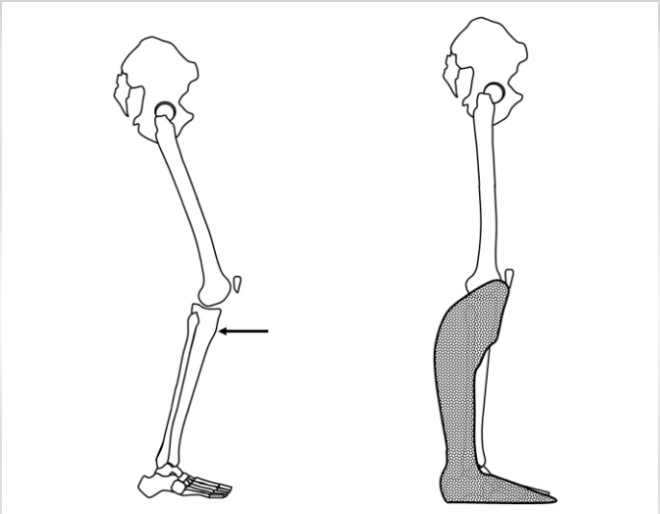

Figure 17: The mechanism of floor reaction orthosis to correct knee flexion

child was young may fail to maintain an upright posture with weight gain. Excessive weight gain should be avoided.

Treatment

Crouch can be a serious problem for a child. It cripples the child and significantly decreases his capacity to walk.

All factors causing the crouch should be identified and managed. The following factors need surgical treatment.

External tibial torsion can be managed by derotation osteotomy at the distal tibia. Similarly, femoral torsion can be corrected by derotation osteotomy.

Planovalgus foot is managed by lateral column lengthening.

If there is instability at midfoot, a lengthening fusion of the calcaneo-cuboid joint is required.

If hindfoot valgus is not completely corrected with lateral column lengthening then medial displacement osteotomy of calcaneus is carried out.

If a person is walking with a crouch gait for a long time he may have developed flexion deformity at the knee. Knee flexion deformity is corrected by capsulotomy or temporary anterior epiphysiodesis by staple or 8 plates [7]. When limited growth potential remains and deformity is more than 20* supracondylar osteotomy with or without shortening is preferred [8, 9, 10, 11].

Elongated patellar tendon is an important cause of failed treatment and needs to be addressed. Patellar tendon plication or distal transfer of tibial tuberosity can effectively take care of overstretched muscles. When the child is young and skeletally immature one can correct other factors and use GRO for a few months so that the longitudinal growth can take up the slack of the patellar tendon [11, 12, 13, 14].

Short muscles: Psoas, hamstrings, and Gastrocnemius are lengthened if they are short on clinical examination.

Weak muscles: In addition to surgical treatment, strengthening exercises of all anti-gravity muscles should be carried out.

Like any other diseases, crouch gait also requires thorogh assement to find out possible mechanisms for it. Once we identify them, we should divide them in the two groups: modifiable and non-modifiable factors. Correction of modifiable factors by non-surgical and surgical treatments leads to improvement in gait. This results into reduction in energy require for walking.

Conclusion

Crouch gait requires detailed assessment and management of contributing factors. Correcting modifiable issues through surgical and non-surgical means significantly enhances mobility and reduces fatigue. Early intervention and prevention strategies are vital to improve the quality of life in affected individuals.

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Declaration of patient consent : The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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