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Original Article

Gait modeling in a patient with femoral lateralization after hip arthroplasty

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Abstract.
Objective: To assess the impact of increased offset and femoral axis lateralization after hip arthroplasty (THA) on the functional changes of the muscles within the "hip–pelvis–spine" system during walking. **Materials and Methods:** Gait simulation was performed in OpenSim using the modified gait2394 musculoskeletal model adapted for hip dysplasia (HD). The femoral head was displaced by 10 and 20 mm by changing the coordinates of the femur within the acetabulum. Muscle activity was analyzed using inverse kinematics, inverse dynamics, and computer-based muscle control algorithms. The study focused on the muscles surrounding the hip joint, with changes assessed in length, activation time, and force production during the phases of the gait cycle.**Results: Adductor muscles:** Increased offset led to a 30–45% reduction in activity during the swing phase due to pre-stretching, which reduced the force required for hip adduction. **Long anterior thigh muscles:** Rectus femoris, sartorius, and tensor fasciae latae demonstrated marked increases in activation (30–75%), particularly during stance, as greater offset disrupted the pelvis–femur–knee–foot balance. Rectus femoris activity rose up to sixfold, and TFL activation increased 4–6 times compared to the normal offset. **Gluteal muscles:** Gluteus medius activity increased up to 2.5 times, and gluteus minimus activity increased fourfold, with length changes up to 15% depending on gait phase. These adaptations were most evident in the stance and late swing phases. Changes in activation patterns included altered onset timing and prolonged or reduced activation intervals depending on muscle type and offset magnitude. Overall, the increased offset resulted in higher energy demands for balance maintenance, disrupting gait symmetry and rhythm. **Conclusions:** Femoral lateralization after THA significantly alters muscle function in the hip region. Short muscles contribute to joint stability within the prosthetic acetabulum, while long muscles support balance and limb transfer. Rehabilitation should initially target strengthening short-stabilizing muscles in the early postoperative period, followed by the integration of long muscles into functional gait patterns. Physical therapy should address the asymmetry and rhythm disturbances caused by altered muscle activation to optimize postoperative recovery.
Keywords: **developmental dysplasia of the hip, gait cycle, prosthetic offset, musculoskeletal modeling, biomechanics simulation, physical therapy, rehabilitation**

Introduction

Hip arthroplasty is a surgical procedure that, using artificial components, restores the normal relationships of the joint elements responsible for weight-bearing and movement, thereby relieving the patient from pain (Learmonth, I. D., et al., 2007; Morano, C. et al., 2025; Salman, L.A. et al., 2023; Widmer, P. et al., 2022). Implanting an artificial joint in cases of developmental dysplasia of the hip (DDH) is considered a complex surgery due to the unique course and formation of deformities in the bony ends of the joint under dysplastic conditions (Shanaa, J. et al., 2025; Vasina, P.G. et al., 2025). In addition to dysplastic changes in the joint's bony ends, several compensatory processes occur, affecting the lumbar spine and the muscles responsible for maintaining postural balance in DDH. Changes in postural balance and the prolonged course of the dysplastic pathological process of the hip joint produce a number of adaptive, neuromotor reactions that manifest themselves in the form of gait stereotype disorders typical for patients with DDT.

After prosthesis implantation, the "hip joint–pelvis–spine" system, which maintains postural balance, undergoes readjustment processes as the functional conditions of the hip joint change significantly. The structure that begins adapting during surgery is the muscular corset surrounding the "hip joint–pelvis–spine" system (Shi, A. et al., 2022; Sun, J. et al, 2021). During surgery, limb length is restored – a goal for every patient with DDH – and femoral lateralization is achieved by increasing the offset (the distance between the hip joint's center of rotation and the femoral shaft axis). These elements are incorporated into the prosthesis design because it aims to reconstruct the normal anatomy of the hip joint (Garofalo, S. et al. 2025).

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From the perspective of rehabilitation intervention, modern recovery programs outline general principles and approaches for rehabilitating patients after hip replacement. However, DDS is an example of a condition where changes in the musculoskeletal system involve a transformation that differs from similar changes seen in the development of conventional osteoarthritis (Chen, X. Et al., 2021).

It should be noted that understanding the processes occurring after artificial joint implantation in terms of muscle changes in the hip joint-pelvis-spine system contributes to targeted rehabilitation intervention in specific links and structures of this system (Stisen, M. B. et al., 2024; Widmer, P. et al., 2022). This approach allows for the individualization of rehabilitation programs, neutralizing and, in some cases, preventing potential adverse effects on the musculoskeletal system as a whole, as well as eliminating possible vulnerabilities in postoperative rehabilitation in the early and late postoperative periods (Esposito, C.I. et al., 2018). In addition, this allows us to identify the main problematic stages of the rehabilitation process for restoring the muscular system of the hip joint-pelvis-spine system. This will enable us to guide the process along a reasonable, logically correct path of rehabilitation interventions, taking into account all the nuances of dysplastic coxarthrosis (Skoffer, B. et al., 2015).

Computer modeling is used to understand muscle adaptation and the related functioning of the hip joint-pelvis-spine system after total endoprosthesis with a change in offset length. The most common tool for analyzing and modeling human neuromusculoskeletal systems is the OpenSim program (Delp, S.L. et al., 2007). The program allows researchers to evaluate how changes in musculoskeletal system parameters affect walking patterns. In hip replacement for idiopathic hip osteoarthritis, a reduction in offset is typically observed, which affects muscle function and walking parameters. In their study (Strafun, S. et al., 2018), the authors examined how offset reduction after hip replacement impacts gait parameters. The results indicated that decreasing offset influences pelvic stability and disrupts the balance between the abductor and adductor muscles, ultimately leading to changes in gait patterns. These simulation findings were supported by a graph-analytical model of pelvic balance (Tyazhelov, A. et al., 2021; 2022) and by clinical studies (Strafun, S. et al., 2018; 2018) using the GaitRite system, which confirmed the theoretical conclusions about the offset's effect on walking. Using the mathematical model, the authors also investigated conditions of pelvic equilibrium in dysplastic coxarthrosis (Oliynyk, O. et al., 2025). This work will further explore the impact of offset changes on arthroplasty outcomes in dysplastic coxarthrosis.

Thus, determining the characteristics of changes in the muscular condition of the hip joint-pelvis-spine system for rehabilitation after hip replacement is relevant and has significant practical importance.

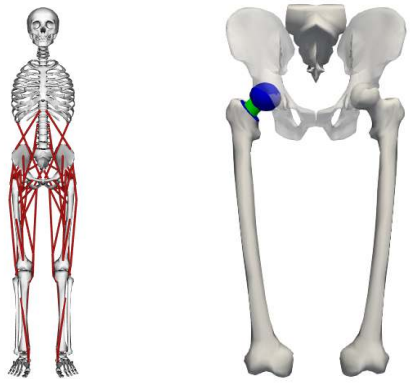
Objective: To identify changes in the muscular system of the “hip joint–pelvis–spine” complex caused by increased offset and lateralization of the femoral axis after hip arthroplasty during walking.

Materials and Methods.

Gait modeling after hip arthroplasty in patients with developmental dysplasia of the hip (DDH) was performed using OpenSim. OpenSim, developed at the NIH Center for Biomedical Computation at Stanford University, is a program that enables the creation of realistic models of human and animal movement by accounting for the contributions of various muscle groups, thereby providing a comprehensive simulation of movement mechanics (Delp, S. L., et al., 2007).

As the baseline model for analyzing muscle function in patients with femoral lateralization, the *gait2394* model (Fig. 1a) was used. This is a 3D computer model of the human musculoskeletal system with 23 degrees of freedom. The *gait2392* model includes 76 muscles of the lower limbs and trunk (Anderson, F.C., Pandy, M.G., 2001). The model serves as a foundation for simulating various conditions of the human musculoskeletal system.

The unscaled model represents an individual with a height of 1.8 m and a body mass of 75.16 kg. To create a model for gait analysis in patients after hip arthroplasty, geometric modifications were introduced, namely changes to the femoral shape: the normal femoral head was replaced with a prosthesis of predetermined parameters. The constructed geometric object was integrated into the model (Fig. 1b).



a b

Fig. 1. **Model for gait analysis in OpenSim:** (a) baseline model; (b) limb with a hip arthroplasty prosthesis and the contralateral normal limb in the analyzed model.

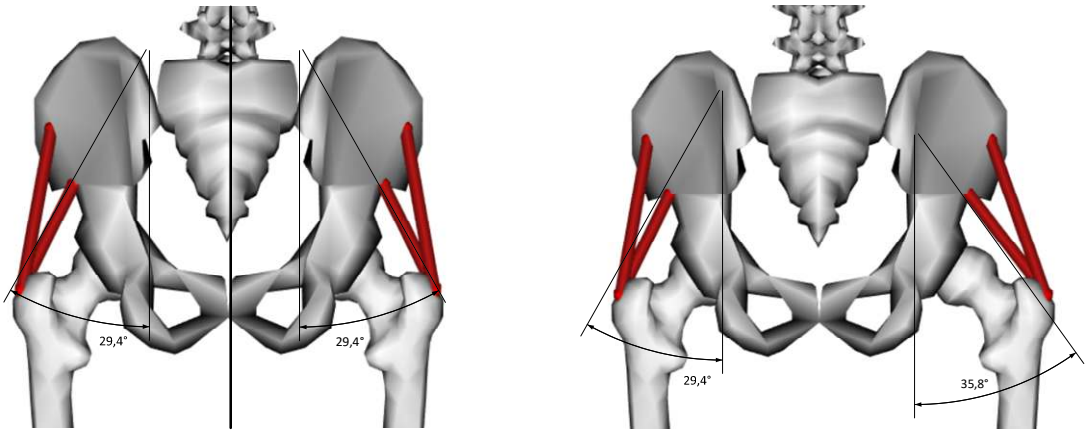
The work of the muscle function in the limb with a hip prosthesis was analyzed under three variations of the abductor lever arm length, as well as under the normal (baseline) length. Femoral lateralization (i.e., increased prosthetic offset) was modeled at 10 and 20 mm.

To establish the relevant conditions for simulating and analyzing human gait under joint lateralization, the standard OpenSim package's transformation and analysis tools were used. To model increased offset, the coordinates of the femoral orientation within the acetabulum were modified. Gait simulation was performed using inverse kinematics and inverse dynamics algorithms. Computed Muscle Control algorithms were applied to analyze muscle force characteristics.

It should be noted that the model simulates only changes in the abductor lever arm length and does not account for pain symptoms that can distort walking. The model consists of seven main segments: pelvis, femur, patella, tibia, fibula, talus, and foot (calcaneus, navicular, cuboid, cuneiforms, metatarsal bones, and toes). The relative movements of these segments define the lower limb joint models.

During each step, the stance limb rotates approximately 57° relative to the pelvis, with the femoral articular surface sliding along the acetabular surface and covering a path equal to its radius of about 2 cm.
According to the morphology of the hip joint and the condition of surrounding tissues, the maximum range of motion is: flexion–extension, 140°; adduction–abduction, 75°; rotation, 90°. During walking, the flexion–extension range of motion at the hip joint does not exceed 50–60° (Knudson, D., 2007).

Changes in the abductor lever arm length alter the angle of muscle attachment and muscle length, with the most pronounced effects observed in the posterior thigh muscles: gluteus maximus and gluteus medius. In shorter muscles, changes in the abductor lever arm primarily affect their spatial orientation. Longer muscles, such as the tensor fasciae latae, rectus femoris, and sartorius, show almost no change in length. The changes in geometric and spatial muscle parameters vary with the magnitude of the abductor lever arm, i.e., the offset value. Figure 2 illustrates an example of muscle direction changes with variations in the abductor lever arm length in a static pose.



a b

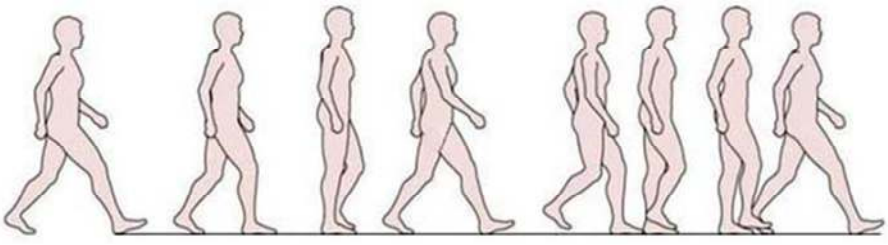
Fig. 2. Change in spatial orientation of the gluteus medius and gluteus minimus muscles after hip arthroplasty of the left lower limb (posterior view):
(a) normal; (b) with increased offset.

In the presented model, it can be observed that as the femoral abductor lever arm length increases, the muscles increase their adduction angle and, according to the rules of geometry, their length as well. The greater the increase in the abductor lever arm, the greater the increase in the muscle's adduction angle.
To determine the stages of lower limb muscle activation during walking, the phases of the gait cycle should be considered, as they allow conclusions about muscle function under altered abductor lever arm length (Alharbi, A. et al., 2021).

A gait cycle consists of two main periods: the stance phase, or double-support period, and the swing phase, or single-support period with foot transfer (Loudon, J.K., et al., 2008). The gait cycle is more commonly represented using an eight-phase model (Fig. 3) (Badiye, A., 2025).
For convenience in describing gait, we will consider the time intervals of the gait cycle phases.
Initial contact (0% of the gait cycle) corresponds to the beginning of stance, when the heel first touches the ground.
Loading response (10% of the gait cycle) occurs when the contralateral foot lifts off the ground.
Heel-off (30% of the gait cycle) corresponds to the moment the heel leaves the ground.
Opposite initial contact (50% of the gait cycle) occurs when the opposite limb's foot contacts the ground.
Toe-off (60% of the gait cycle) happens when the toes lift from the ground.
Feet adjacent (73% of the gait cycle) is the period when the foot of the contralateral swing leg is alongside the stance leg foot.

Vertical tibia (87% of the gait cycle) corresponds to the moment when the tibia of the swing limb is oriented vertically.

The final event is again **initial contact**, which marks the beginning of the next gait cycle.



Time, s	0.65	0.83	0.87	1.15	1.27	1.48	1.63	1.8
% Cycle	0	10	30	40	60	73	87	100
Event	Initial contact	Loading responding	Heel-off	Opposite initial contact	Toe-off	Feet adjacent	Vertical tibia	Next initial contact

Period	Response to stress	Middle stand	End stand	preparation for a swing	Start swing	Middle swing	End swing
Tasks	Acceptance of weight	Single-point support		Moving the limb forward			
Phase	Standing phase			Фаза маху			
Cycle	Right limb gait cycle						

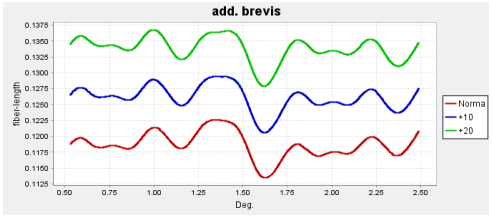
Fig. 3. Correlation between gait phases and time scale

To take a single step, a person engages approximately 200 muscles of the lower limbs, trunk, and upper limbs. The muscles of the foot play an active role in maintaining body balance. For the simulation, it was assumed that after hip arthroplasty, only the muscles directly surrounding the hip joint were altered during walking. We examined the effect of femoral axis lateralization on thigh muscle function. In the development of developmental dysplasia of the hip (DDH), the first muscles to be affected are the hip adductors.

Results.

We begin the analysis of the effect of increased offset on locomotor function by examining the medial thigh muscles, which primarily function in hip adduction.

The adductor brevis muscle (Fig. 4) is a flat, triangular muscle located on the medial surface of the thigh. It extends from the pubis to the medial surface of the femur. As this is a relatively short muscle, changes in the offset length of the hip prosthesis affect its length (Fig. 4a).



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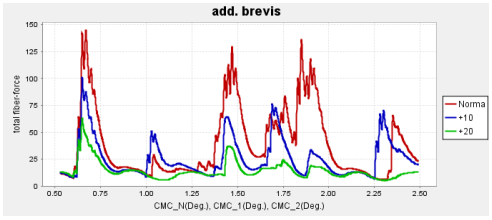

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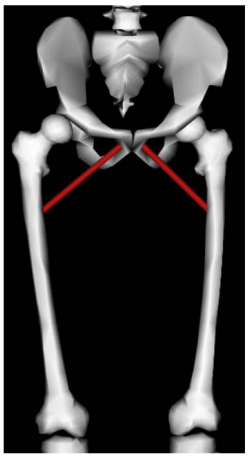


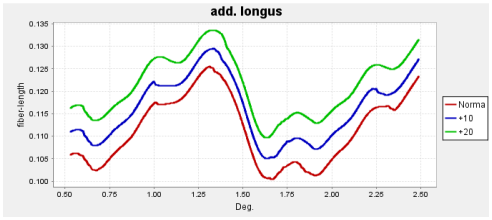
c

Fig. 4. M. adductor brevis

a – muscle length, m; b – muscle force, N; c – view in the model.

According to the analysis, the change in muscle length is approximately 7 mm per 1 cm of lateralization of the femoral axis. Based on the analysis of muscle force during walking, under normal conditions, its primary activity occurs during the swing phase between 1.4 and 1.7 s (Fig. 4b), indicating that in this period of the gait cycle, the muscle performs hip adduction. An increase in its length results in the need to generate less force to perform this function due to the presence of “excess length,” i.e., when the foot is swung forward, there is no need for additional muscle lengthening. The muscle thus transitions to a more “economical” mode of operation.

The adductor longus muscle (*m. adductor longus*) is a large, fan-shaped muscle located in the medial part of the thigh (Fig. 5c). The primary function is to adduct the thigh at the hip joint.)



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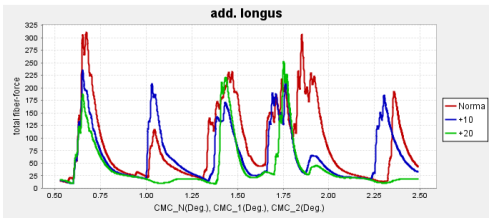

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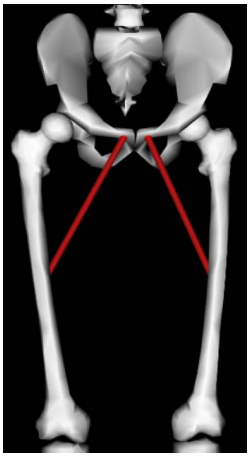
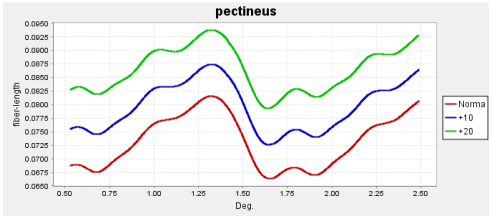


c

Fig. 5. M. adductor longus:
a – muscle length, m; b – muscle force, N; c – view in the model

With femoral lateralization, the length of the muscle increases by approximately 5 mm for every centimeter (Fig. 5a). The muscle is predominantly active throughout the entire swing phase – from 1.3 s until heel strike at 1.9 s (Fig. 5b). Lengthening reduces its activation time during the swing phase to 1.8 s, meaning that the muscle is unable to perform its function at maximum forward foot swing – the end of the swing phase occurs almost without the participation of the adductor longus. When the abductor lever arm is increased by 2 cm, a "deactivation" zone is observed during the toe-off phase (from 1.0 s to 1.3 s). In contrast, under normal conditions and with a 2 cm lever arm increase, the muscle remains active during this phase.
The pectineus muscle – a medial thigh muscle – lies in the upper inner part of the thigh (Fig. 6c) and functions in both adduction and flexion of the hip.



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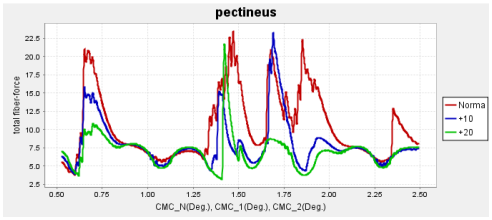

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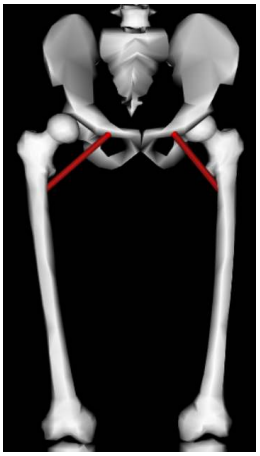
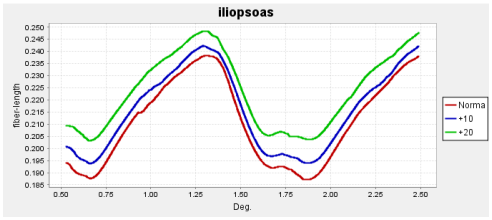


c

Fig. 6. M. pectineus:
a – muscle length, m; b – muscle force, N; c – view in the model

Femoral lateralization has a strong effect on the length of this muscle (Fig. 6a), with a change of the length of approximately 7 mm for each centimeter increase in the abductor lever arm. Muscle activity (Fig. 6b) is mainly observed during the swing phase, from 1.3 s to 1.8 s. Increasing the lever arm shifts the activation time. With femoral lateralization of 1 cm, activation ends around the phase of maximum forward foot swing. In contrast, at 2 cm, it ends during the phase when the foot passes beyond the vertical balance point (feet-adjacent phase). At a 2 cm increase in lever arm, pectineus muscle activity is markedly reduced.

The iliopsoas muscle – a large muscle located in the inner group of pelvic muscles – consists of two main parts: the iliacus (*m. iliacus*) and the psoas major (*m. psoas major*) muscles (Fig. 7c). It plays a key role in hip flexion and postural support.



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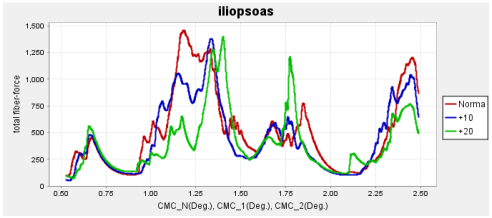

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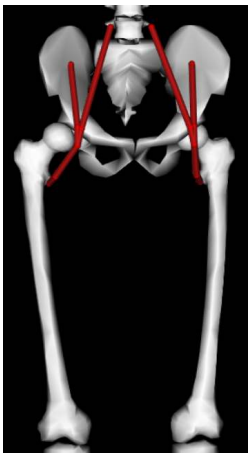


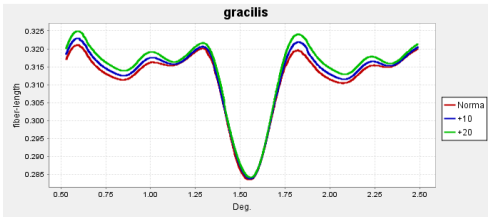
c

Fig. 7. Mm. iliacus + psoas:
a – muscle length, m; b – muscle force, N; c – view in the model.

With femoral lateralization, the length of the muscle changes by approximately 5 mm for every centimeter (Fig. 7a). Based on its function in hip flexion, its primary activity occurs during the swing phase (Fig. 7b). Under normal conditions, the muscle is active throughout the entire period from toe-off (1.1 s) to the feet adjacent phase (1.5 s). Increasing muscle length shifts the onset of activation closer to the pre-swing phase, and the greater the muscle length, the more its activation time is reduced.

During walking, the primary work of hip flexion and foot transfer over the stance leg is performed by the anterior thigh muscles.

The muscle gracilis – a long, slender muscle located in the medial (adductor) compartment of the thigh – belongs to the adductor muscle group (Fig. 8c). It is the only adductor muscle of the thigh that crosses and acts on two joints: the hip and the knee. Its primary functions are adduction and flexion of the hip and knee.



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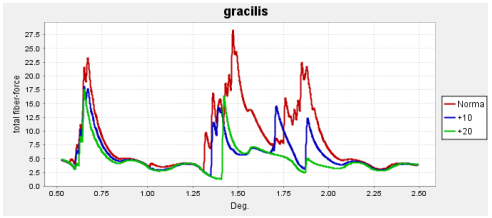

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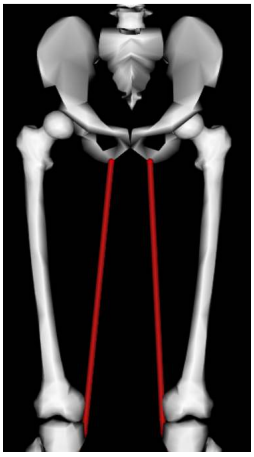
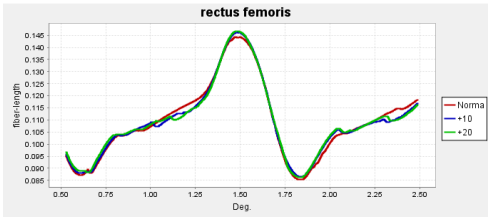


c

Fig. 8. M. gracilis:
a – muscle length, m; b – muscle force, N; c – view in the model.

Femoral lateralization has almost no effect on the length of this muscle (Fig. 8a). Under normal conditions, muscle activity is observed from mid-swing to the end of the gait cycle, i.e., during hip and knee flexion (Fig. 8b). With femoral lateralization, muscle activity decreases by almost half (from 27.5 N to 15 N) during the toe-off phase. It continues to decline until the end of the gait cycle.

The rectus femoris muscle (*m. rectus femoris*) – one of the four muscles forming the quadriceps femoris – is located in the anterior part of the thigh (Fig. 9c). It crosses two joints (hip and knee). The primary functions of the rectus femoris are knee extension and hip flexion.



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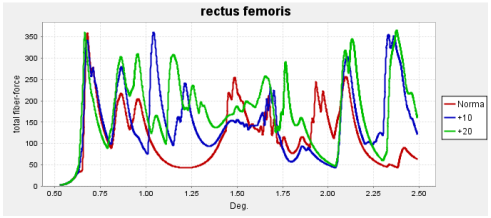

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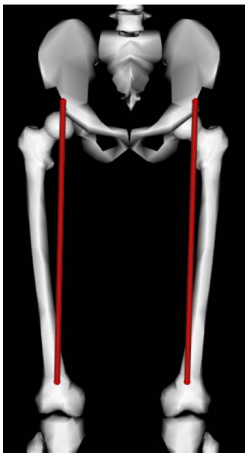
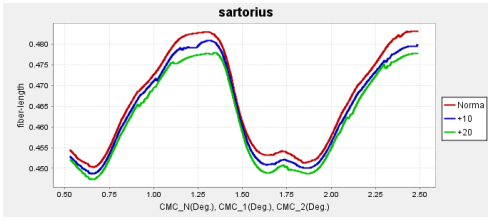


c

Fig. 9 M. rectus femoris:
a – muscle length, m; b – muscle force, N; c – view in the model

Due to its considerable length, femoral lateralization has virtually no effect on the length of this muscle (Fig. 9a). Still, it does influence the change in the force vector of the muscle. Under normal conditions (Fig. 9b), muscle activity occurs predominantly during the hip flexion phase, i.e., from 1.5 to 1.8 s. In contrast, with femoral lateralization, activity is observed during almost the entire gait cycle – from heel strike of the stance limb at 0.65 s to the end of the cycle at 1.9 s. Femoral lateralization increases muscle activity.

The sartorius muscle (*m. sartorius*) is a thin, long, superficial muscle located in the anterior thigh. It runs along the thigh, crossing two joints – the hip and the knee (Fig. 10c) – and plays a vital role in pelvic stabilization.



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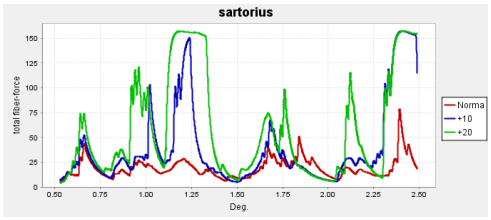

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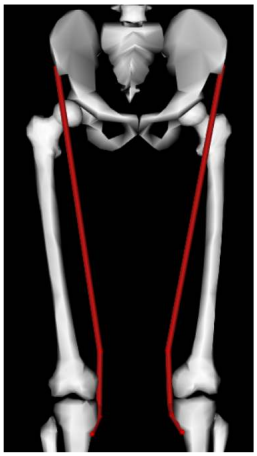
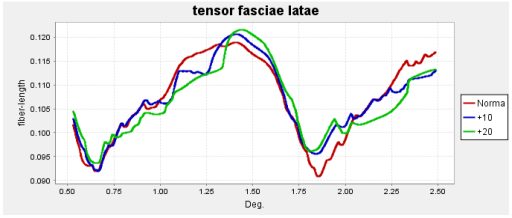


c

Fig. 10 Кравецький м'яз:
a – muscle length, m; b – muscle force, N; c – view in the model

Given the considerable length and complex trajectory of this muscle, changes in its length with femoral lateralization do not exceed 1–2 mm (Fig. 10a). Under normal conditions, the primary function of the muscle is pelvic stabilization; thus, when anatomical relationships are preserved, muscle activity during walking is very low (Fig. 10b). However, femoral lateralization alters the pelvis–femur relationship, disrupting balance both during stance (from 0.6 s to 1.15 s) and during swing – up to the feet adjacent phase and further into maximum forward foot swing – resulting in several episodes of excessive muscle activation. With increased offset, the activation periods become longer.

The tensor fasciae latae (*TFL*) muscle is located in the upper lateral part of the thigh (Fig. 11c). It plays a key role in movements of the hip and knee, particularly in pelvic stabilization during walking and running.



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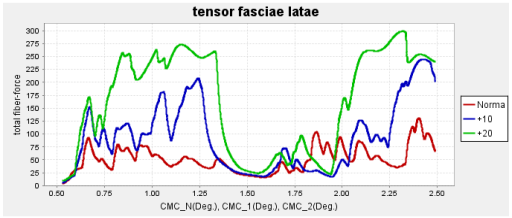

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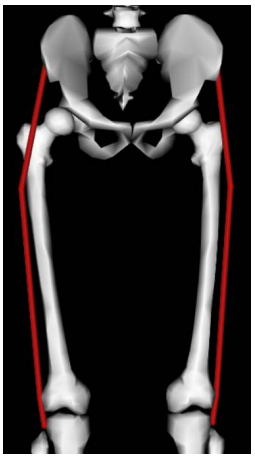
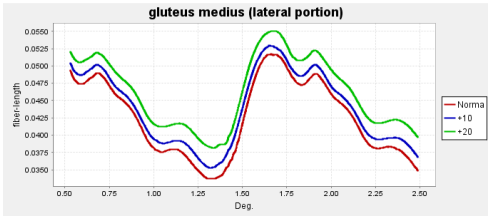


c

Fig. 11 Tensor fasciae latae:
a – muscle length, m; b – muscle force, N; c – view in the model

The change in prosthetic offset has virtually no effect on the length of the muscle (Fig. 11a). However, since the primary function TFL is pelvic stabilization, under normal anatomical relationships its activity is minimal – that is, it does not generate excessive force to maintain balance during walking (Fig. 11b). Femoral lateralization disrupts balance, leading to an increased force requirement to maintain stability. The greater the lateralization, the more the strength of the wide fascia tensioner is needed to maintain body balance. Muscle activity increases predominantly during the stance phase, i.e., throughout the entire period of foot contact with the ground.

The gluteal muscles, and particularly the gluteus medius, perform most of the work of hip flexion (anterior portion of the muscle) and extension (posterior portion). The gluteus medius is a fan-shaped muscle located in the gluteal region between the gluteus maximus and gluteus minimus (Fig. 12c). It attaches to the ilium and the greater trochanter of the femur. Its main functions are hip abduction (moving the leg laterally) and pelvic stabilization during walking and running, helping prevent the pelvis from dropping.



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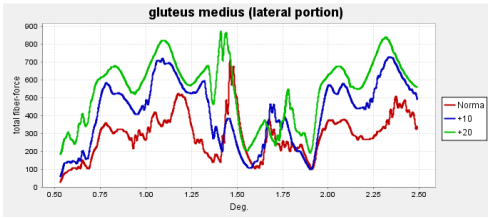

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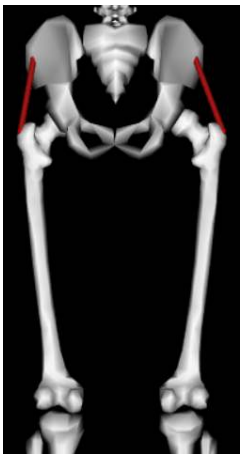


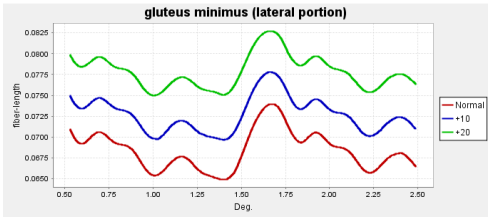
c

Fig. 12. M. gluteus medius (lateral potion):
a – muscle length, m; b – muscle force, N; c – view in the model

Lengthening of the gluteus medius does not exceed 3 mm with a femoral lateralization of 1 cm (Fig. 12a). However, this noticeably affects its activity change during walking. The muscle is most active in the first phase of the gait cycle, i.e., during the stance phase, but under normal conditions its activity does not exceed 700 N during single-leg vertical stance (1.4–1.5 s) (Fig. 12b).

Femoral lateralization leads to a marked increase in activity during the foot roll-over period (stance phase) and at the end of the swing phase, i.e., at maximum forward foot placement. Lateralization of the femur increases muscle activity to maintain balance.

The gluteus minimus is the smallest of the three gluteal muscles, located beneath the gluteus medius (Fig. 13c). It plays a vital role in hip stabilization, abduction, and internal rotation.



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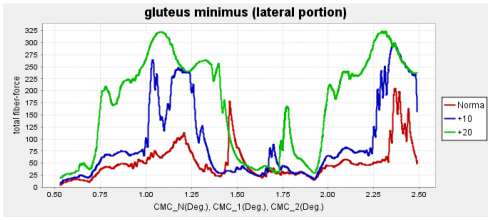

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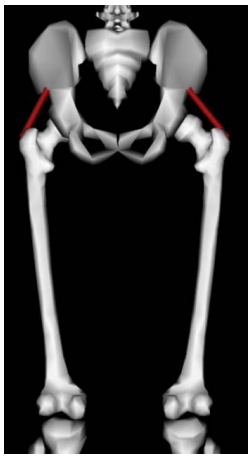

c

Fig. 13 M. gluteus minimus (lateral potion):
a – muscle length, m; b – muscle force, N; c – view in the model

Femoral lateralization of 1 cm leads to an increase in the length of the muscle by up to 5 mm (Fig. 13a). These changes result in a significant rise in activity (Fig. 13b). Under normal conditions, muscle activity is nearly constant throughout the gait cycle, with a slight increase during vertical stance (1.5 s). Femoral lateralization increases the periods of muscle activity during the stance phase (foot roll-over), and with greater offset, both the duration of activity and the force produced by the muscle increase.

Discussion.

Femoral lateralization after hip arthroplasty leads to changes in the function of muscles responsible for hip functionality. During walking, the most pronounced functional impairments are observed in muscles responsible for hip flexion and pelvic stabilization in the stance phase. The rectus femoris increases its activity during stance by almost sixfold – from 50 Nm under normal conditions to 300–350 N with increased offset. The tensor fasciae latae, whose primary function is pelvic stabilization during stance, also increases the required force by 4–6 times depending on the degree of offset, from around 50 N in normal conditions to 200–275 N with increased abductor lever arm. The sartorius muscle, which performs multiple functions including hip and knee flexion as well as pelvic stabilization, shows the greatest functional changes with increased offset: from relatively low regular activity of about 20–25 N, offset increase leads to a sharp rise in activation up to 150 N.

Such an increase in activation of the anterior and lateral thigh muscles is associated with disruption of the “pelvis–femur–knee–foot” balance. Under normal offset, muscles operate in an economical mode; a change in balance – lateralization of the femur’s reference point – takes the system out of equilibrium, and additional muscle activation is required to maintain stability. In the stance phase, single-leg support is performed, primarily activating the muscles responsible for maintaining balance; a change in the coordinates of the rotation points (in this case, the displacement of the hip joint rotation center) increases energy expenditure of the entire balance-support system (Kizilova, N. et al., 2014).

Activation of the lateral parts of the gluteal muscles – the gluteus medius and gluteus minimus – also increases during the swing phase, when the foot passes over the stance limb. The gluteus medius increases activation nearly 2.5 times, from an average of 300 N in normal conditions to 800 N with increased offset. The lateral position of the gluteus minimus relative to the hip joint influences changes in its activation due to prosthetic offset adjustment. First, its length increases significantly – up to 15% - depending on the gait phase; second, the activation required for pelvic stabilization rises fourfold – from an average of about 75 N to 325 N with increased offset. In the adductor muscles of the medial thigh, activity decreases during walking. Their activation occurs mainly during the swing phase to adduct the hip. A pre-stretched muscle is already under tension, so only a relatively small force is required for hip adduction. Short muscles ensure stability and retention of the femoral head within the acetabular component of the prosthesis, while long muscles support balance, stability, and limb transfer. In practice, proper regulation of the system cannot be achieved without the coordinated work of both groups.

Based on the results, a rehabilitation approach can be proposed to restore the muscles responsible for hip joint function – specifically, gradual strengthening and restoration of the short muscles in the hip area during the initial stage of early postoperative rehabilitation, followed by incorporating the long muscles into the movement system.

Conclusions.

Dynamic modeling in the OpenSim environment showed that lateralization of the head center (an increased offset) after hip replacement affects the function of the thigh and pelvic muscles.

The muscles responsible for hip adduction (m. adductor longus, m. adductor brevis, m. adductor magnus, m. gracilis, m. pectineus) decrease their activity by 30–45% compared to a healthy joint. The long hip flexor muscles (m. iliopsoas, m. rectus femoris, m. tensor fasciae latae), which lift the leg during the swing phase, show a 30–75% increase in contraction strength depending on the degree of lateralization and the angle of anteversion of the prosthesis neck.

The most significant changes in muscle activity are recorded in the swing phase, when the requirements for simultaneous stabilization of the pelvis and active hip flexion are maximal. Lateralization of the hip joint rotation center increases the amplitude of muscle activation during the phase of their primary responsibility. It shifts the peak of activity by 0.1–0.3 s relative to the physiological norm.

These changes in the muscle complex's functioning disrupt symmetry and rhythm. of the step cycle, namely, a reduction in the duration of the support phase on the limb with increased offset, and an increase in the time of the transfer phase.

The changes in muscle activity identified during the modeling process provide a tool that demonstrates the main areas of application for rehabilitation interventions in the early and late postoperative periods. The data obtained indicate that the rehabilitation process for patients with DC should begin in the preoperative period, since the degree of changes in motor patterns is so great that it requires longer and more persistent physiotherapy interventions.

In clinical practice, these biomechanical disorders must be corrected during postoperative rehabilitation. The key areas of physiotherapy interventions in the postoperative period after total endoprosthetics in patients with DC are as follows. Local sequential strengthening of the short pelvic stabilizers: gluteus medius, gluteus minimus, quadratus femoris, deep external rotators. Influence on gait pattern, namely, practicing step rhythm, step symmetry, and step length. Performing physiotherapy interventions aimed at physiological loading of the lumbar spine.

Considering the changes in muscle activity helps develop personalized rehabilitation programs aimed at reducing the risk of Trendelenburg syndrome and improving hip replacement outcomes. This also applies to group programs, depending on the stage of the dysplastic process when the hip replacement was performed, which guides future research directions.

Conflicts of interest: The authors declare no conflict of interest regarding the content of this publication.

Disclosure of Delegation to Generative AI

The authors declare the use of generative AI in the research and writing process. According to the GAIDeT taxonomy (2025), the following tasks were delegated to GAI tools under full human supervision:
Responsibility for the final manuscript lies entirely with the authors.
GAI tools are not listed as authors and do not bear responsibility for the final outcomes.
Declaration submitted by: [unspecified]

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