

## Biomechanical Analysis of the Joint and Muscle Forces of the Lower Extremities in Walking of Rheumatoid Arthritis Patient

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**Summary.** Rheumatoid arthritis (RA) is an immunomodulated, chronic inflammatory disease, accompanied by the proliferation of the inflamed synovium and destruction of the articular cartilage, which leads to the formation of contracture of lower extremities joints and disability. Understanding the values of biomechanical loads on the articular surfaces with contracture of the joints of the lower extremities in patients with RA and the muscle forces (MF) participation in this process with the formation of adaptation and compensation mechanisms can contribute to the development of new views and approaches to the tactics of therapeutic measures specific to each stage of the disease. **Objective:** to analyze the behavior of the musculoskeletal system of an RA patient in his walking pattern by calculating the forces acting in the main muscle groups and joints of the lower extremities. **Materials and Methods.** Initial data were obtained from the examination of a female patient K., who was diagnosed with stage 2 phase 3 RA with a predominant lesion of the hip and knee joints and severe pain in the left hip joint. A video system of 6 cameras, reflective markers and a force platform were used for motion capture of the walking. A simulation musculoskeletal model of the gait of the RA patient using the AnyBody Modeling System 6.0 software (Denmark) was created. Joint reaction forces (JRF) and MF were calculated. **Results.** Normal mode of loading of the lower extremities was altered to compensate for structural disorders in joints of RA patients. The peaks of vertical component of the ground reaction force (GRF) are lower compared to the normal population; the gait is static and asymmetric, sparing. MF increase in *m. gluteus* (*maximus*, *medius*, *minimus*) with increasing amplitude of movements in the frontal plane. JRF of both hips increase in all planes. **Conclusions.** Walking of RA patients with limitation of active extensions in the hip and knee joints occurs due to an increase in the amplitude of the frontal plane compensatory movements. Postural muscle imbalance increases the *m. gluteus*, *m. biceps femoris*, *m. semitendinosus* and *m. semimembranosus* MF. Other lower extremities muscles decrease their MF. The MF redistribution is compensatory and aimed to keep the RA patient in the upright position and optimize the biomechanics of walking due to less painful movements. Biomechanical overloading of the hip and knee articular surfaces can serve as a factor in maintaining the inflammatory response, the development of degenerative processes, or the further progression of arthrosis and stiffness of the joints of the lower extremities in this category of patients.

**Key words:** rheumatoid arthritis; lower extremities contracture; AnyBody musculoskeletal model; joint reaction forces; muscle forces.

### Introduction

Rheumatoid arthritis (RA) is an immunomodulated, chronic inflammatory disease accompanied by the proliferation of the inflamed synovium and destruction of the articular cartilage, leading to disability [1].

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The etiopathogenesis of RA is still unclear; however, several stages of its pathophysiology have been elucidated, the key feature of which is inflammatory synovitis [1, 2]. Although historically cartilage has been considered an "innocent bystander," recent evidence suggests that cartilage degradation in RA is associated with an imbalance in the anabolic and catabolic activity of articular chondrocytes associated with synovitis and joint inflammation indirectly. In addition to inflammation factors, the metabolic activity of chondrocytes is also influenced by mechanical stress factors [3].

In particular, biomechanical factors in rheumatoid arthritis can play an important role in the initiation and progression of degenerative processes in the joint, secondary to the inflammatory process [4, 5, 6, 7, 8]. However, the sequence of biomechanical and biochemical processes that regulate these events in vivo is not yet clear enough.

With the development of clinical gait analysis techniques (3D kinetics and kinematics), a necessary tool has emerged for finding differences in pathological gait patterns from its normal gait parameters [9, 10]. The development of computer technology and software contributes to data collection, analysis and interpretation of gait data as a tool for studying the function of joints in RA [9, 10]. Thus, a significant decreased range of the hip, knee, ankle movements (external-internal rotation, abduction-adduction, flexion-extension) under contracture conditions make influence to walking style of RA patients. The walking conditions and pattern of the path violate gait parameters – a decrease in the force and stride interval – articular angular velocities, movement speed and support function in general [10]. In such conditions, along with a pronounced patient's pain reaction, the load on all elements of joints and muscle groups of the lower extremities increases significantly. An increase in mechanical stress, at the background of an inflammatory process, capsular-ligamentous disorders, cartilage degradation, subchondral bone changes and muscle imbalance contribute to the progression of articular and muscle contractures, as well as arthritic phenomena in joints of lower extremities, including the formation of erosions of the articular surfaces [2]. Thus, the importance of mechanical factors in the destructive cascade of processes in RA is beyond doubt [3-5, 8]. At the same time, there is insufficient data regarding the muscles functioning in different clinical variants of RA, and routine analysis of muscle activity in clinical practice in this category of patients is usually not performed. The decrease in muscle forces determined by a clinical study is associated with the activity of the inflammatory process, X-ray changes, and the severity of functional disorders [8]. Understanding the values of biomechanical loads on the articular surfaces in the lower extremities joints contracture of RA patients and the participation of muscle forces in this process with the formation of adaptation and compensation mechanisms can contribute to the development of new points of view and approaches to the tactics of therapeutic measures specific to each stage of the disease.

The aim of our study was to analyze the behavior of the musculoskeletal system of a patient with RA in straight walking by calculating the forces acting to the joints of the lower extremities and the main muscle groups of the lower extremities using a simulated musculoskeletal AnyBody model.

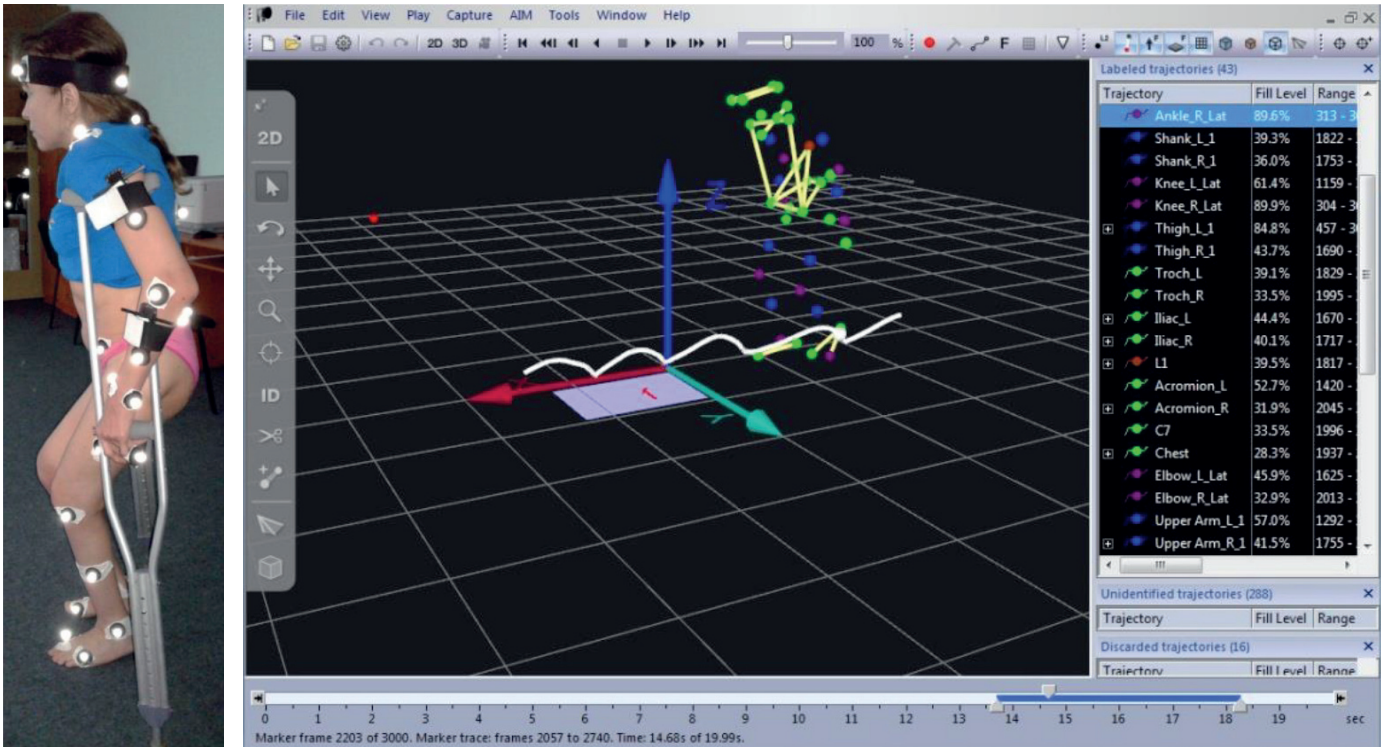
## Materials and Methods

The initial data for creating a simulation model were obtained from the examination of patient K. with a diagnosis of rheumatoid arthritis, stage 2 phase 3, with a predominant lesion of the hip and knee and severe pain in the left hip. The patient's weight is 50 kg, height is 150 cm. In clinical examination, the movements in both hips are significantly limited, acute painful. The flexion-adduction contracture in both hips is determined; the relative shortening of the right lower extremity is up to 1 cm. The range of motion in the hips according to the neutral (0 to zero) passing method: extension/flexion – right 0/0/90°, left 0/0/70°, abduction/adduction – rocking, external/internal rotation – rocking. The contours of the knee joints are changed, there is a deflection and deformation of both knees, palpation of both knees is painful, flexion-extension contracture is observed in both knees. Active and passive movements are markedly limited. The range of motion in the knee according to the neutral (0 to zero) passing method: extension/flexion – right 0/20/100°, left 0/20/100°. The contours of the ankle are changed, deformed. Active and passive movements in the ankle are preserved. In straight walking, the patient assumed a typical body position characteristic of severe forms of RA with combined contractures in the joints of the lower extremities, which determine the typical posture in walking.

At the next stage, the motion capture in the walking was carried out using a video system of 6 cameras and a dynamometric platform. In combination with built-in specialized software modules, the used optical motion capture system (Qualisys Motion Capture System, Sweden) allows high-precision measurement of the position and movements of the fast-moving object or their elements with subsequent processing and analysis of the obtained data. For this, reflective markers were placed on the body of the investigated object, in the projection of the main anatomical landmarks. In straight walking with tread on the dynamometric platform, the trajectories of movement of each marker recorded by the video system and additionally three peak forces: longitudinal ( $F_x$ ), transverse ( $F_y$ ), vertical ( $F_z$ ) (Fig. 1).

The resulting data package in C3D format was exported to the AnyBody Modeling System 6.0 (AnyBody Technology, Denmark) software, which is a system of musculoskeletal modeling for biomechanical simulations based on inverse dynamics, which allows analyzing muscle and joint reactions in the human musculoskeletal system [11]. A musculoskeletal simulation model of the RA patient was created by AnyBody software (Fig. 2), and the calculation of joint and muscle forces was performed [12].

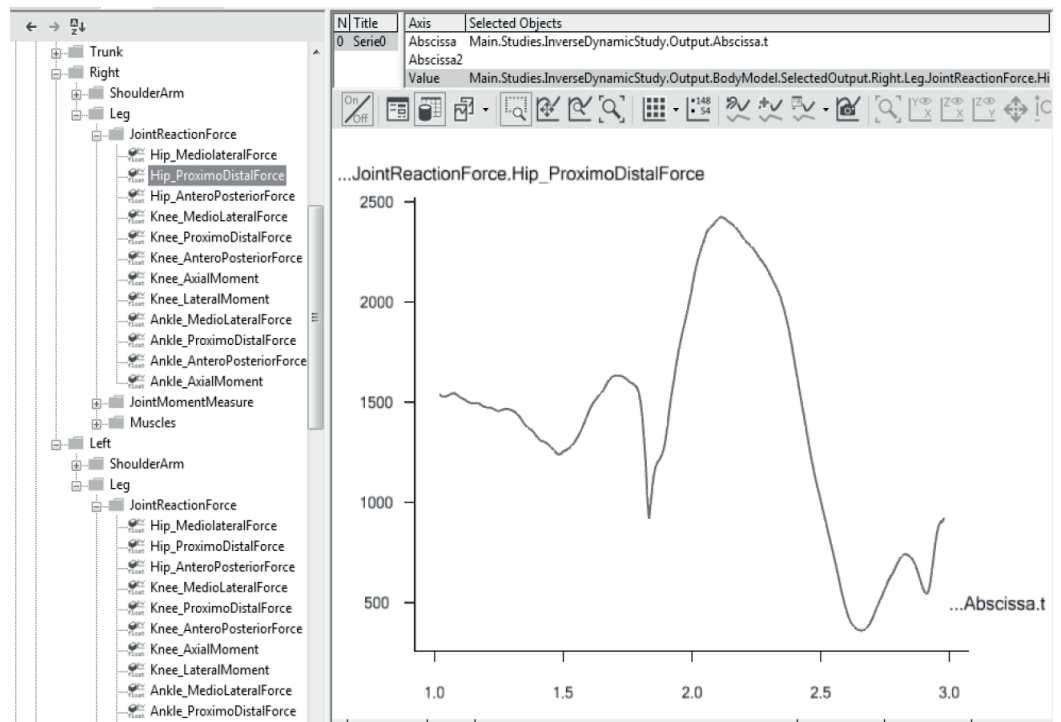
At the final stage, a comparative analysis of the patient's data with the standard model's data of the musculoskeletal system (StandingModel from the AnyBody



**Fig. 1.** Registration of the trajectory of markers movement and three peaks of GRF in the window of the software (Qualisys Motion Capture System, Sweden)



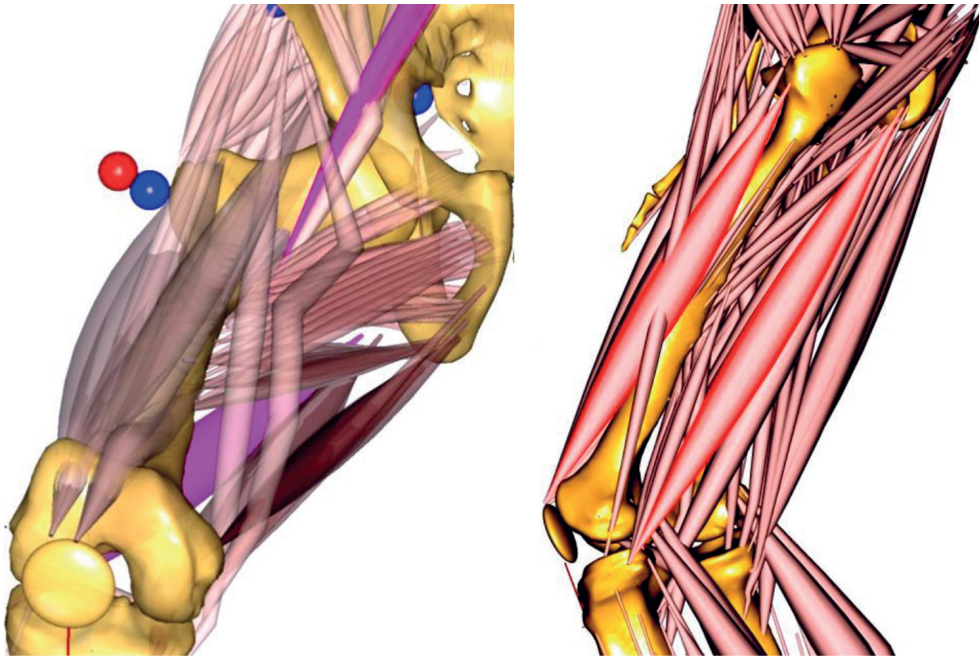
**Fig. 2.** Musculoskeletal simulation model of the RA patient



**Fig. 3.** Joint reaction forces of the hip (vertical component, Z-axis)

Repository AMMR Version 1.6.2 package) was carried out, taken as a conditional norm averaged for both lower extremities. In the context of this work, the joint reaction forces of the hip, knee and ankle were investigat-

ed along the X (longitudinal component), Y (transverse component), and Z (vertical component) axes (Fig. 3), as well as the muscle forces of the main muscle groups of the lower extremities (Fig. 4).



**Fig. 4.** Muscles of the lower extremities in the AnyBody model

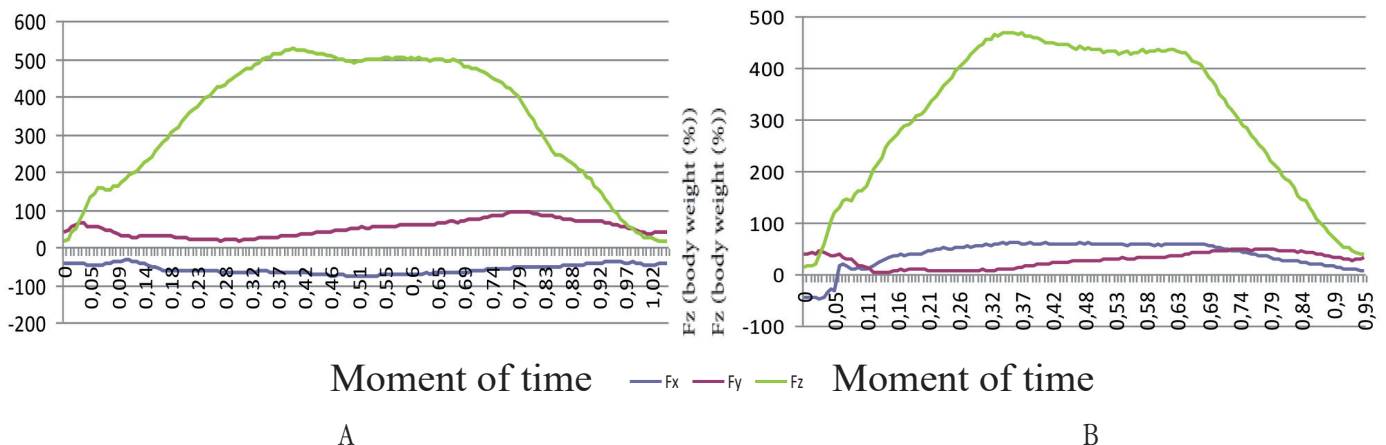
## Results and Discussion

According to the obtained GRF data of the patient, changes in the force and time parameters of the vertical component were revealed. If normally the vertical component of the GRF has two peaks (heel strike force, toe-off force) and a trough between them (mid-stance), then the typical changes in the vertical component of the RA patient were a distortion of the graph curve of GRF's vertical component – the heel strike, and toe-off forces decreasing by 7% on the right, smoothness of the mid-stance component on both sides and an increasing the single stance time parameters on the left extremity (by 8%). Due to the limitation of movements in joints because of pain, the graphs of the vertical component of the GRF acquired a widened form with increasing distance

between peaks (more on the left) (Fig. 5). Decreasing of walking speed, heel strike force and toe-off force on the right, increasing of the mid-stance force, show an attempt to unload the right extremity. In general, the gait is static and asymmetric, sparing, due to the fact that the lower extremities loading and push-off from the ground are accompanied by painful sensations.

The values of the muscle forces of the main muscle groups of the lower extremities are presented in Table 1.

As a result of walking modeling in the RA patient with contracture of lower extremities joints, the force is increasing in almost all portions of m. gluteus (maximus, medius, minimus). It was noted in the range from 12% (GluteusMinimusMid) to 328% (GluteusMaximusInferior). Only the anterior portions of m. gluteus minimus and m. gluteus medius show decreasing in the force by



**Fig. 5.** Vertical GRF Fz of the left (A) and right (B) lower extremities

Table 1

**Muscle force parameters of the main muscle groups of the lower extremities**

Muscle	Normal	Patient D	Difference (%)	Patient S	Difference (%)
GluteusMinimusAnterior	128.41	95.49	-25.63	89.24	-30.50
GluteusMinimusMid	80.99	90.98	12.34	109.03	34.63
GluteusMinimusPosterior	57.51	89.10	54.94	112.53	95.69
GluteusMediusAnterior	50.18	30.21	-39.80	19.97	-60.20
GluteusMediusPosterior	87.27	180.61	106.97	228.07	161.35
GluteusMaximusSuperior	11.54	45.53	294.71	26.76	131.99
GluteusMaximusInferior	8.89	24.02	170.19	38.09	328.46
GastrocnemiusLateralis	314.63	248.19	-21.12	191.49	-39.14
GastrocnemiusMedialis	820.56	418.16	-49.04	582.81	-28.97
SoleusMedialis	411.27	233.06	-43.33	307.61	-25.20
SoleusLateralis	353.84	376.93	6.53	205.76	-41.85
Plantaris	8.31	8.48	2.05	4.81	-42.12
Poplitues	3.06	0.88	-71.19	1.74	-43.04
FlexorDigitorumLongus	1.64	16.10	884.71	0.00	-100.00
FlexorHallucisLongus	25.22	138.68	449.99	0.00	-100.00
TibialisPosteriorLateralis	13.61	67.70	397.43	0.00	-100.00
TibialisPosteriorMedialis	13.69	70.88	417.75	0.00	-100.00
TibialisAnterior	79.77	100.28	25.71	48.01	-39.81
BicepsFemorisCaputLongum	259.34	443.89	71.16	593.29	128.77
BicepsFemorisCaputBreve	10.05	19.75	96.62	20.94	108.46
Semitendinosus	168.01	221.97	32.12	196.95	17.23
Semimembranosus	193.04	225.70	16.92	251.70	30.39
RectusFemoris	271.05	79.16	-70.79	85.20	-68.57
VastusLateralisInferior	3.01	1.48	-50.83	3.26	8.31
VastusLateralisSuperior	201.18	102.68	-48.96	228.02	13.34
VastusMedialisInferior	13.57	6.35	-53.19	14.01	3.28
VastusMedialisMid	50.57	24.64	-51.27	54.35	7.49
VastusMedialisSuperior	12.09	6.10	-49.52	13.52	11.87
VastusIntermedius	20.25	10.32	-49.02	22.93	13.26

26-31% (GluteusMinimusAnterior) and 40-60% (GluteusMediusAnterior), respectively. Thus, there was the force increasing for GluteusMinimusMid – by 35-91%, GluteusMinimusPosterior – by 55-96% (2 times at the more affected side), GluteusMediusPosterior – by 107-161% (2-2.5 times), GluteusMaximusSuperior – 2-4 times, and GluteusMaximusInferior – 2.5-4 times. At the same time, the force decreasing of the anterior bundles

of m. gluteus minimus (by 26-31%) and m. gluteus medius (by 40-60%) demonstrate a lack of function associated with internal rotation of the femur.

This is associated with decreasing in hips range of motion in the sagittal plane due to contracture of the joint capsule itself and m. iliopsoas, accompanied by anterior pelvic tilt and hyperlordosis of the lumbar spine. To compensate for movements in the sagittal plane, a

group of femoral abductors (Gluteus Medius, Gluteus Minimus) are involved in the work. By the reason, amplitude of movements in the frontal plane increases. Thus, the patient's movement in hips flexion contracture and limitation of active extension in RA occurs because of amplitude of compensatory movements in the frontal plane increasing.

Muscle force increasing was also noted in the BicepsFemorisCaputLongum – by 71-129%, BicepsFemorisCaputBreve – by 97-108%, Semitendinosus – by 17-32%, Semimembranosus – by 17-30%. Muscle force decreasing took place in the Gastrocnemius Lateralis – by 21-39%, Gastrocnemius Medialis – by 29-49%, Soleus Medialis – by 25-43%, Poplitues – by 43-71%, and Rectus Femoris – by 69-71%. The weakness of the two-joint muscles with a decrease in their involvement occur due to the convergence of attachment zones at the background of a fixed contracture. Flexion position of the knees causes a decrease in the strength of the posterior muscle group of legs. At the same time, there is a compensatory increasing of the BicepsFemoris muscle force, which provides counteraction to the pelvis's anterior tilt.

At the more affected side (left), the FlexorDigitorumLongus, FlexorHallucisLongus, TibialisPosteriorLateralis, TibialisPosteriorMedialis, and TibialisAnterior demonstrate zero MF values in walking, corresponding to pronounced ankle's contracture when these muscles are not involved in the process. At the less affected side (right), these muscle groups have 5-10 times increased values of MF, apparently necessary to ensure compensatory stabilization of the left ankle in the double support

phase of the gait. A MF decreasing of the foot's flexor muscles and functional shortening of the lower extremity leads to a compensatory sharp increasing in the load on the Flexor digitorum longus, Flexor hallucis longus and Tibialis posterior muscles.

Asymmetric force values of other muscle groups of the lower extremities with their unilateral increasing and simultaneous decreasing of the contralateral extremity values can be regarded as a compensatory mechanism for the muscle activity distribution aimed at stabilizing the joints at the more affected side and muscle unloading at the less affected extremity.

The patterns of MF distribution in RA patients correspond to changes in the joint reaction forces (JRF) acting in the hip, knee and ankle along the X, Y and Z axes. JRF and the moments of forces are presented in Table 2.

As a result of modeling of the RA patient walking, there is all JRF vectors increasing acting in both hips: transverse (Y-axis) – by 143-181%, vertical (Z-axis) – by 10-52%, longitudinal (X-axis) – by 112-170%. Bio-mechanical overload of the articular surfaces of the hip joints can serve as a factor of the degenerative processes development or further progression of arthritis and joint stiffness.

In the knees, JRF acting in the longitudinal direction (X-axis), at the more affected side (left), are significantly increased – by 82%; on the less affected side – close to normal parameters (2% difference). Vertical JRF (Z-axis) are decreased by 10-36% at both sides. Lateral JRF (Y-axis) are increased by 18% at the more affected side (left) and decreased by 14% at the contralateral side compared to normal parameters. This difference

Table 2

**JRF of the hip and knee (D and S) of the RA patient**

Joint	Normal	Lower extremity D	Difference (%)	Lower extremity S	Difference (%)
Hip_MediolateralForce (Y)	674.81	1639.23	142.92	1895.59	180.91
Hip_ProximoDistalForce (Z)	2196.30	2418.05	10.10	3337.46	51.96
Hip_AnteroPosteriorForce (X)	209.12	443.04	111.86	565.19	170.27
Knee_MedioLateralForce (Y)	479.33	410.08	-14.45	564.50	17.77
Knee_ProximoDistalForce (Z)	2512.32	1613.18	-35.79	2265.62	-9.82
Knee_AnteroPosteriorForce (X)	804.20	820.35	2.01	1464.19	82.07
Knee_AxialMoment	6.40	22.46	250.94	29.45	360.16
Knee_LateralMoment	48.61	25.37	-47.80	49.05	0.92
Ankle_MedioLateralForce (Y)	901.07	806.69	-10.47	666.60	-26.02
Ankle_ProximoDistalForce (Z)	3864.81	3310.55	-14.34	2689.84	-30.40
Ankle_AnteroPosteriorForce (X)	619.29	341.01	-44.93	758.23	22.44
Ankle_AxialMoment	9.79	8.20	-16.20	5.17	-47.16

can be explained by the compensatory mechanism of load redistribution between the extremity more and less involved in the pathological process [13]. The decrease in the magnitude of vertical JRF can explain the increasing stiffness of the posterior parts of the knee's capsule as a result of a long-term inflammatory process, followed by its fibrosis and formation of contracture. Ultimately, an additional extra-articular point of rotation forms. At the same time, due to the compensatory increasing in the MF magnitude of the posterior femoral muscles involved in maintaining the knees flexion position in walking, the articular surfaces are unloaded by decreasing in the vertical JRF (Z-axis) magnitude.

In the ankles, there is a decrease in lateral JRF (Y-axis) – by 10-26% and vertical JRF (Z-axis) – by 14-30%, while the longitudinal JRF (X-axis) increased by 22% at the more affected side (left) and decreased by 45% at the less affected side. This can also explain the compensatory load redistribution between the extremities.

In addition, axial rotational moment magnitude increasing in both knees by 3-4 times compared with the normal parameters, as well as a 16-47% decreasing in the ankle axial moment, should be noted. According to the study, deviations of the force moments from the reference values can explain the phenomena of the knee and ankle instability in RA patients.

Thus, the load distribution changes, caused by joints contractures and pain syndrome, have a certain positional adaptation of the pelvis and lower extremities. This is due to activation of the body compensatory mechanisms associated with the muscle activity transfer from one group to others, which ultimately results in functional antalgic intraarticular relationships. The most common lower extremity joint conditions in RA patients are flexion-adduction contracture in the hip and flexion-valgus position of the knee. Joint capsule relaxation and intra-articular pressure decreasing can reduce the pain response. However, the intra-articular relationships achieved in this case significantly impair the biomechanical functions of support and movement of the lower extremities, which are compensated by additional muscle tension. Unilateral flexion-adduction position of the lower extremity leads to its functional shortening, femoral internal rotation, and a decrease in the area of ground contact. Bilateral functional shortening of the lower extremities is compensated by pelvic anterior rotation with formation of permanent m. iliopsoas contracture and lumbar hyperlordosis. Maintaining the obtained vertical body position is accompanied by postural muscle imbalance, which reduces the MF of m. quadriceps femoris. Adduction and flexion of the thigh leads to reflexive activation of the antagonist muscles (m. gluteus maximus and m. gluteus medius) to stabilize the extremity. The convergence of attachment points of the m. gluteus maximus and anterior portion of the m. gluteus medius leads to their weakness. For

compensation of decrease in the area of ground contact, the muscles turning knees in valgus position are activated (m. biceps femoris and m. tensor fasciae latae with an active role of m. gluteus maximus). Fixed position of the knee leads to the lateral and medial head of the m. gastrocnemius and m. soleus weakness. An attempt to compensate functional shortening of the extremity leads to fixation of the ankle in the plantar flexion position with formation of its contracture. The etiopathogenetic factor of inflammation plays a secondary role in this case.

The MF redistribution is compensatory and aimed to keep the RA patient in upright position and optimize the biomechanics of walking due to the less painful movements.

## Conclusions

1. According to the study of the RA patient walking with flexion-adduction lower extremities joints contractures, a compensatory redistribution of muscle forces was revealed, aimed at keeping the body in an upright position and optimizing the biomechanics of walking by increasing the amplitude of compensatory movements in the frontal plane.

2. The presence of the hip and knee contractures is accompanied by postural muscle imbalance with a decrease in the muscle forces of the lower extremities, except for the m. gluteus, m. biceps femoris, m. semitendinosus and m. semimembranosus, demonstrating a compensatory increase in their force characteristics.

3. A significant increase in biomechanical loads on the articular surfaces in RA patients with contracture of the lower extremities joints, as well as the contribution of muscle forces to this process, can be both a factor supporting the inflammatory response of the joints and a factor in the development of degenerative processes or further progression of arthrosis phenomena in the hips and knees.

**Conflict of interest.** The authors declare no conflict of interest. This publication has not been, is not, and will not be the subject of commercial interest in any form.

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### Біомеханічний аналіз суглобових і м'язових сил нижніх кінцівок в акті ходьби при ревматоїдному артриті

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**Резюме.** Ревматоїдний артрит (РА) – імунomodульоване хронічне запальне захворювання, яке супроводжується розростанням запаленої синовіальної оболонки та руйнуванням суглобового хряща, що призводить до утворення контрактури суглобів нижніх кінцівок та інвалідності. Розуміння значень біомеханічних навантажень на суглобові поверхні при контрактурі суглобів нижніх кінцівок у хворих на РА та участі м'язових сил у цьому процесі з формуванням механізмів адаптації та компенсації може сприяти розробці нових поглядів та підходів до лікування, тактики терапевтичних заходів, специфічних для кожної стадії захворювання. **Мета дослідження.** Аналіз поведінки скелетно-м'язової системи пацієнта з РА при ходьбі шляхом розрахунку сил, що діють в основних м'язових групах і суглобах нижніх кінцівок. **Матеріали і методи.** Вихідні дані отримані на підставі даних дослідження пацієнтки К. з діагнозом: ревматоїдний артрит, 2 ст., 3 фаза з переважним ураженням кульшових і колінних суглобів, вираженим больовим синдромом у лівому кульшовому суглобі. Відеосистема з 6 камер, світловідбивних маркерів і динамометричної платформи використовувалася для відеореєстрації ходьби. Створено імітаційну скелетно-м'язову модель ходи пацієнта з РА в програмному забезпеченні AnyBody Modeling System 6.0 (Данія). Розраховано суглобові (JRF) та м'язові сили (MF). **Результати.** Для компенсації структурних порушень у суглобах хворих на РА змінюється звичайний режим навантаження кінцівок. Піки вертикальної складової опорних реакцій знижені порівняно з показниками нормальної популяції, хода статична та асиметрична, щадна. MF зростають в т. gluteus (maximus, medius, minimus), збільшується амплітуда рухів у фронтальній площині. JRF обох стегон збільшуються у всіх площинах. **Висновки.** Ходьба хворих на РА з обмеженням активного розгинання у кульшових та колінних суглобах відбувається за рахунок збільшення амплітуди компенсаторних рухів у фронтальній площині. Постуральний дисбаланс м'язів зменшує MF нижніх кінцівок, за винятком сідничних, двоголових м'язів стегна, напівсухожильного та напівперетинчастого м'язів, MF яких збільшуються. Перерозподіл MF є компенсаторним і спря-



мований на утримання пацієнта з РА у вертикальному положенні та оптимізацію біомеханіки ходьби за рахунок менш болючих рухів. Біомеханічне перевантаження суглобових поверхонь кульшових і колінних суглобів може служити чинником підтримки запальної реакції, розвитку дегенеративних процесів або подальшого прогресування артрозу та скутості суглобів нижніх кінцівок у цієї категорії хворих.

**Ключові слова:** ревматоїдний артрит; контрактури суглобів; скелетно-м'язова модель AnyBody; суглобові сили; м'язові сили.

### **Биомеханический анализ суставных и мышечных сил нижних конечностей в акте ходьбы при ревматоидном артрите**

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**Резюме.** Ревматоидный артрит (РА) – иммуномодулированное хроническое воспалительное заболевание, сопровождающееся разрастанием воспаленной синовиальной оболочки и разрушением суставного хряща, что приводит к образованию контрактуры суставов нижних конечностей и инвалидности. Понимание значений биомеханических нагрузок на суставные поверхности при контрактуре суставов нижних конечностей у больных РА и участия мышечных сил в этом процессе с формированием механизмов адаптации и компенсации может способствовать разработке новых взглядов и подходов к лечению, тактике терапевтических мероприятий, специфичных для каждой стадии заболевания. **Цель исследования.** Анализ поведения скелетно-мышечной системы пациента с РА при ходьбе путем расчета сил, действующих в основных мышечных группах и суставах нижних конечностей. **Материалы и методы.** Исходные данные получены на основании данных исследования пациентки К. с диагнозом: ревматоидный артрит, 2 ст., 3 фаза с преимущественным поражением тазобедренных и коленных суставов, выраженным болевым синдромом в левом тазобедренном суставе. Видеосистема из 6 камер, светоотражающих маркеров и динамометрической платформы использовалась для видеорегистрации ходьбы. Создана имитационная скелетно-мышечная модель походки пациента с РА в программном обеспечении AnyBody Modeling System 6.0 (Дания). Рассчитаны суставные (JRF) и мышечные силы (MF). **Результаты.** Для компенсации структурных нарушений в суставах пациентов с РА изменяется обычный режим нагрузки нижних конечностей. Пики вертикальной составляющей опорных реакций снижены по сравнению с показателями нормальной популяции, походка статическая и асимметричная, щадящая. MF возрастают в т. gluteus (maximus, medius, minimus), увеличивается амплитуда движений во фронтальной плоскости. JRF обоих бедер увеличивается во всех плоскостях. **Выводы.** Ходьба больных РА с ограничением активного разгибания в тазобедренных и коленных суставах происходит за счет увеличения амплитуды компенсаторных движений во фронтальной плоскости. Постуральный дисбаланс мышц уменьшает MF нижних конечностей, за исключением седалищных, двуглавых мышц бедра, полусухожильной и полуперепончатой мышц, MF которых увеличиваются. Перераспределение MF является компенсаторным и направлено на удержание пациента с РА в вертикальном положении и оптимизацию биомеханики ходьбы за счет менее болезненных движений. Биомеханическая перегрузка суставных поверхностей тазобедренных и коленных суставов может служить фактором поддержания воспалительной реакции, развития дегенеративных процессов или дальнейшего прогрессирования артроза и скованности суставов нижних конечностей у данной категории больных.

**Ключевые слова:** ревматоидный артрит; контрактуры суставов; скелетно-мышечная модель AnyBody; суставные силы; мышечные силы.