Russian
Journal
of Biomechanics
www.biomech.ac.ru

CHARACTERISTICS OF SUPPORT REACTIONS IN PATIENTS WITH GONARTHROSIS IN STABILOMETRIC MONITORING

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Abstract. The influence of articular pathology on support reactions participating in maintenance of body equilibrium was studied. 39 patients (17 males, 22 females) 20-62 years of age with unilateral and bilateral gonarthrosis of the second-third degrees were examined. The study also included healthy subjects (25 males, 21 females) 19-54 years of age. The essence of the study included stabilographic determination of projection of the general pressure center (GPC) using orthopaedic computer complex ORTHO-SYSTEM (Saint-Petersburg, "Bioimitator"). Stabilometric monitoring of activity of foot support reactions was done every minute with 4 seconds' test interval in a standing position without any means of support on special insoles with mechano-receptors. Total length was from 3 to 5 minutes.

The study showed that in patients with gonarthrosis stabilometric characteristics of static stability in voluntary standing were determined more by position of projection of the general pressure center in the stabilometric frame of reference then by severity and stage of the disease. Results of the analysis revealed that pain evoked by standing influenced support reactions considering an involved side, severity of pain and degree of functional asymmetry. Besides, severity of static stability disorders in every single patient is determined by direction and amount of deviation of the general pressure center at the moment of examination from individual values of functional optimum location of his support reactions.

Key words: stabilometric monitoring, support reactions, gonarthrosis

Introduction

With an increase of articular pathology of lower extremities not only the locomotor stereotype suffers but also disturbances of support functions of the involved extremity get increased [1, 3]. Study of disturbances of limb support ability in articular pathology using locomotor characteristics is very problematic because motions in the involved joint induced while walking provoke pain reflexes much greater compared to static support reactions.

The purpose of the investigation included study of the influence of the knee joint pathology on limb support reactions in a standing position by the method of stabilographic monitoring.

Materials and methods of the study

39 patients were examined at entrance to the Center (17 males and 22 females) from 20 to 62 years of age with unilateral and bilateral gonarthrosis of the second-third degree, healthy subjects (25 males, 21 females) from 19 to 54 years of age were also examined.

The essence of the study is in stabilometric determination of projection of the general pressure center (GPC) using orthopaedic computer complex ORTHO-SYSTEM (Saint-Petersburg, "Bioimitator"). Stabilometric monitoring of activity of foot support reactions was done every minute with 4 seconds' test interval in a standing position without any means of support on special insoles with mechano-receptors. Total length was from 3 to 5 minutes. In the process of examination the following characteristics of support reactions were registered: mean values of location of the GPC projection in frontal X(t) and sagittal Y(t) directions, ranges of variation of the GPC projection in the frame of reference dx and dy, amount of area variation of the GPC projection – dx*dy and a mean distance of the GPC projection from the center of the frame of reference (L) [2]. In addition to the calculated values of the L all mentioned characteristics of the general pressure center were showed at the final stage of the stabilographic study (Fig. 1-5).

Results of the study and discussion

Results of the study showed that changeability of the registered stabilographic parameters in all groups of the examined patients significantly varies (Table 1).

Table 1. Variations of stabilographic parameters in patients with gonarthrosis (n - number of observations).

Selective characteristics (n=144)	Stabilographic parameter (conventional units)					
	X(t)	Y(t)	L(vektor)	dx	dy	dx*dy
Arithmetical mean	51.79	63.14	23.81	12.56	10.11	188.79
Root-mean-square deviation	16.13	15.76	10.7	10.38	7.29	467.27
Coefficient of variation (%)	31.13	24.95	44.93	82.61	72.11	247.49

Indices characterizing location of the general pressure center in the frame of reference are less changeable versus parameters reflecting the range and area of the GPC variation in examination. The revealed tendencies of changeability of the indices preserved in the groups of patients formed by location and severity of articular pathology so the observed differences in the changeability of the indices are not connected with the character of pathology but they reflect various functional modality. Parameters specifying the GPC location characterize the purpose of regulation. Parameters determining range of the GPC variation in examination characterize efficiency and reliability of the processes regulating and controlling support reactions.

Patients grouped according to the involved side (Table 2) have the biggest indices of reliability according to t-criterion of Student in parameters characterizing differences in the GPC location. The GPC is located in the left part of the frame of reference in patients with right-side gonarthrosis. In patients with left-side gonarthrosis it is in the right part.

Analysis of support reactions depending on severity of pathology (Table 3) revealed the biggest values of reliability for indices characterizing range and area of the GPC variation in the examination. That is efficiency and reliability of processes regulating support reactions is disturbed first when increasing a stage of the disease and severity of the pathology. So patients with unilateral gonarthrosis and the third stage of the disease have much greater ranges of the GPC variation and statistically more reliable differences during a 4-second interval of examination versus patients with the second stage of the disease.

Table 2. Selective characteristics of support reactions in patients with unilateral gonarthrosis (n - number of observations).

Group of patients	Statistic index	Stabilographic parameter (conventional units)					
		X(t)	Y(t)	L(vektor)	dx	dy	dx*dy
Left-side (n=39)	M	62.20	68.05	26.40	11.07	90.50	122.75
	σ^2	199.34	161.54	132.60	54.02	19.84	23716.71
	±m	0.36	0.33	0.29	0.18	0.11	3.94
Right-side (n=47)	M	47.57	60.96	21.41	14.74	11.25	276.58
	σ^2	201.66	241.99	105.76	185.42	87.87	472395.4
	±m	0.23	0.25	0.16	0.21	0.15	11.08
t-criterion		34.14	17.21	14.72	12.68	9.25	13.07

Table 3. Selective characteristics of support reactions in patients with unilateral gonarthrosis depending on a stage of the disease (n - number of observations).

Group of patients	Stage	Statistic index	Stabilographic parameter (conventional units)					
			X(t)	Y(t)	L(vektor)	dx	dy	dx*dy
Left-side gonarthrosis	Second (n=26)	M	57.48	69.26	24.16	9.703	8	83.88
		σ^2	128.49	138.50	103.84	16.21	7.69	3074.87
		±m	0.44	0.45	0.39	0.15	0.11	2.13
	Third (n=13)	M	64.11	69.67	35.66	16	11.44	229.33
		σ^2	270.11	210.25	138.89	175	29.28	85658.7
		±m	1.83	1.61	1.31	1.47	0.60	32.52
		t-criterion	3.53	0.24	8.41	4.26	5.64	4.46
Right-side gonarthrosis	Second (n=34)	M	49.54	60.94	21.14	10.8	9.74	113.14
		σ^2	198.90	263.46	125.57	19.51	15.49	6010.06
		±m	0.41	0.48	0.33	0.13	0.12	2.28
	Third (n=13)	M	45.76	61.60	22.51	20.44	13.08	515.04
		σ^2	214.27	233.83	79.28	392.09	195.82	111168
		±m	0.61	0.64	0.37	0.82	0.58	43.93
		t-criterion	5.13	0.83	2.75	11.54	5.61	9.14

In bilateral gonarthrosis the observed tendency remained (Table 4). Range and area of the GPC variation during a 4-second interval of examination increased with increasing a disease stage; however, mean values of the GPC variation in standing position were lower (with reliable possibility over 0.95) versus examined groups with unilateral location of the disease. Besides, all patients with bilateral gonarthrosis of the third degree appeared to have the closest to the center of the frame of reference mean values of the GPC location. So, if the purpose of regulation is to close to the biomechanical optimum of stability, that is to the center of the frame of reference the efficacy of systems controlling support reactions keeps at a high correction level even in the group with a more severe disease. Thus, it can be concluded that the GPC stability a lot depends on its position in the stabilometric frame of reference, so right-handers have the GPC correction less effective if it is located to the left from the center of the frame of reference versus to the right. Thus, patients with right-side gonarthrosis have range and area values of the GPC variation reliably higher versus patients with left side involved.

Table 4. Selective characteristics of support reactions in patients with bilateral gonarthrosis depending on the stage of the disease (n - number of observations).

Stage of the disease	Statistic index	Stabilographic parameter (conventional units)					
		X(t)	Y(t)	L(vektor)	dx	dy	dx*dy
Second (n=11)	M	43	80.27	35.30	8.09	5.45	59.36
	σ^2	337.2	87.42	115.75	25.69	16.87	7465.45
	±m	1.67	0.85	0.98	0.46	0.37	7.85
Third (n=33)	M	50.21	55.85	21.48	11.71	10.23	145.7
	σ^2	247.92	243.04	50.76	40.39	33.15	27287.7
	±m	0.47	0.47	0.21	0.19	0.17	5.01
	t-criterion	4.15	25.11	13.8	7.24	11.59	9.27

Healthy subjects when voluntary standing in 71% of cases had the GPC located to the right from the center of the frame of reference and only in 29% - to the left. Besides, patients and healthy subjects during 3-5 minutes of the monitoring a voluntary standing had areas in the stabilometric frame of reference with minimal range of the GPC variation (functional optimum). Normally location of the functional optimum of stability was registered for the second-third minute of the monitoring (Fig. 1). Asymmetry of support reactions showed through higher GPC instability observed when transferring support weightbearing to the side contralateral to the functional optimum. The examined patients with right-side asymmetry had GPC less stable when redistributing support weightbearing to the left extremity; the examined patients with left-side asymmetry - to the right (Fig. 2).

Reliable influence of functional asymmetry to support reactions of patients showed also through observing the corresponding types of the general pressure center deviations during the monitoring depending on functionally dominating sides and involved sides.

The majority of the examined patients with the unilateral articular pathology and low pain usually had the GPC location registered on the side of the functionally dominating extremity even if its the knee joint was functionally unwell. When the healthy extremity was functionally dominating the instability values and values of the GPC transfer were always

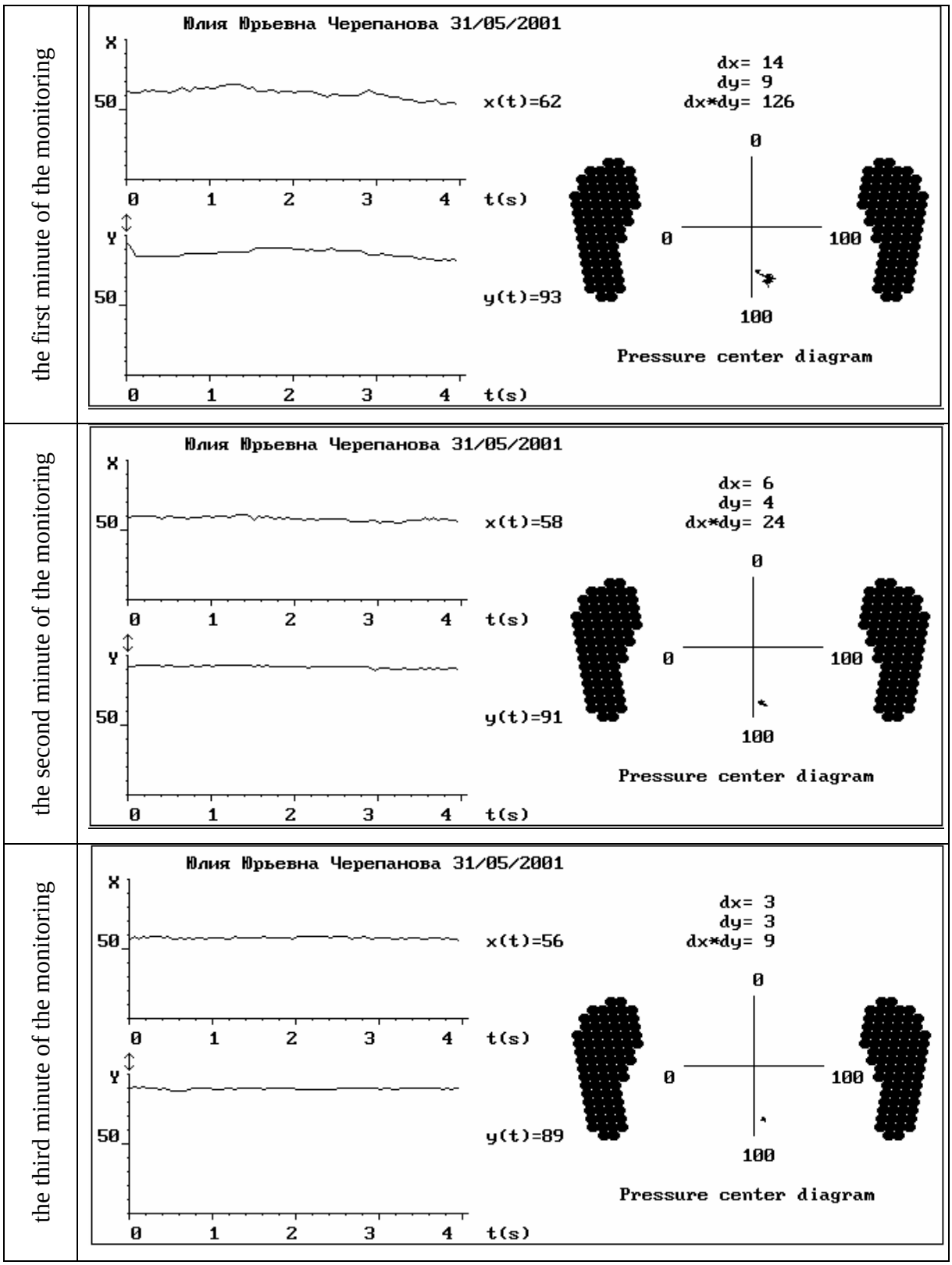

Fig. 1. Stabilographic monitoring of support reactions in a healthy female, 24 years of age, voluntary standing.

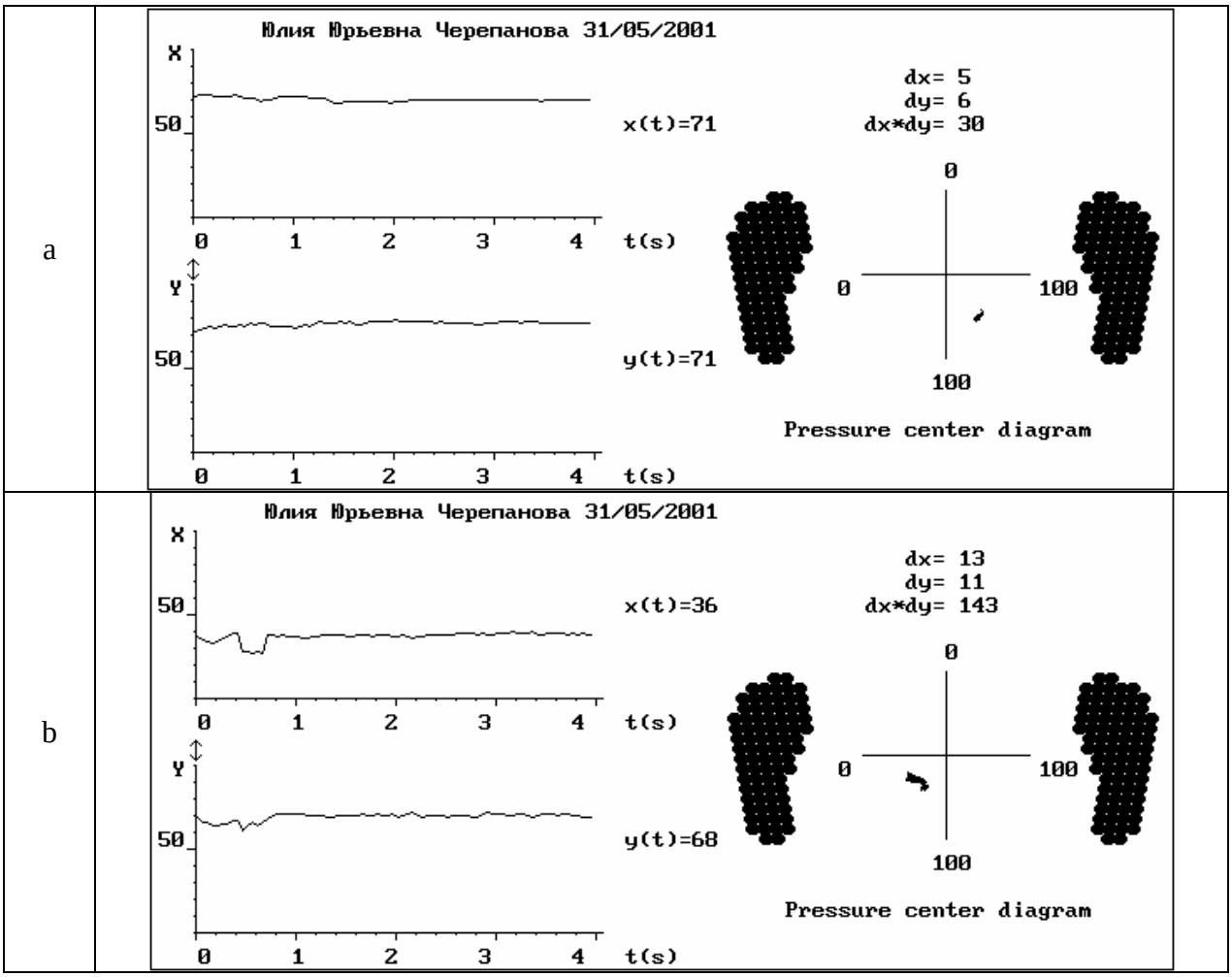

Fig. 2. Stabilographs of the healthy subject, voluntary transfer of support weightbearing mostly on the right extremity – a, on the left extremity – b.

minimal and the GPC was located on the side of the healthy extremity (Fig. 3). When the functionally dominating extremity was involved the GPC at the beginning of examination was often registered on the involved side and later from the second - third minute of monitoring it transferred to the side of the stabilometric system of the healthy extremity (Fig. 4). Finally, from the first sight paradoxical support reactions were observed in some cases with expressed pain and strongly functionally dominating extremity involved. In these cases changes of the GPC location started from the side of the healthy extremity and ended with adaptation of articular nociceptors to support weightbearing on the side corresponding to the involved extremity (Fig. 5).

Conclusions

The results of the stabilometric analysis allow making the following conclusions:

1. Characteristics of static stability registered in the examined patients with gonarthrosis are determined mostly not by the severity of the disease but depend on projection location of the general pressure center in the stabilometric frame of reference.
2. Depending on the involved side, pain severity and degree of functional asymmetry the feelings of pain induced by articular pathology remodel normal support reactions to changed types of support activity characterized by various static stability and corresponding direction of the general pressure center deviation.

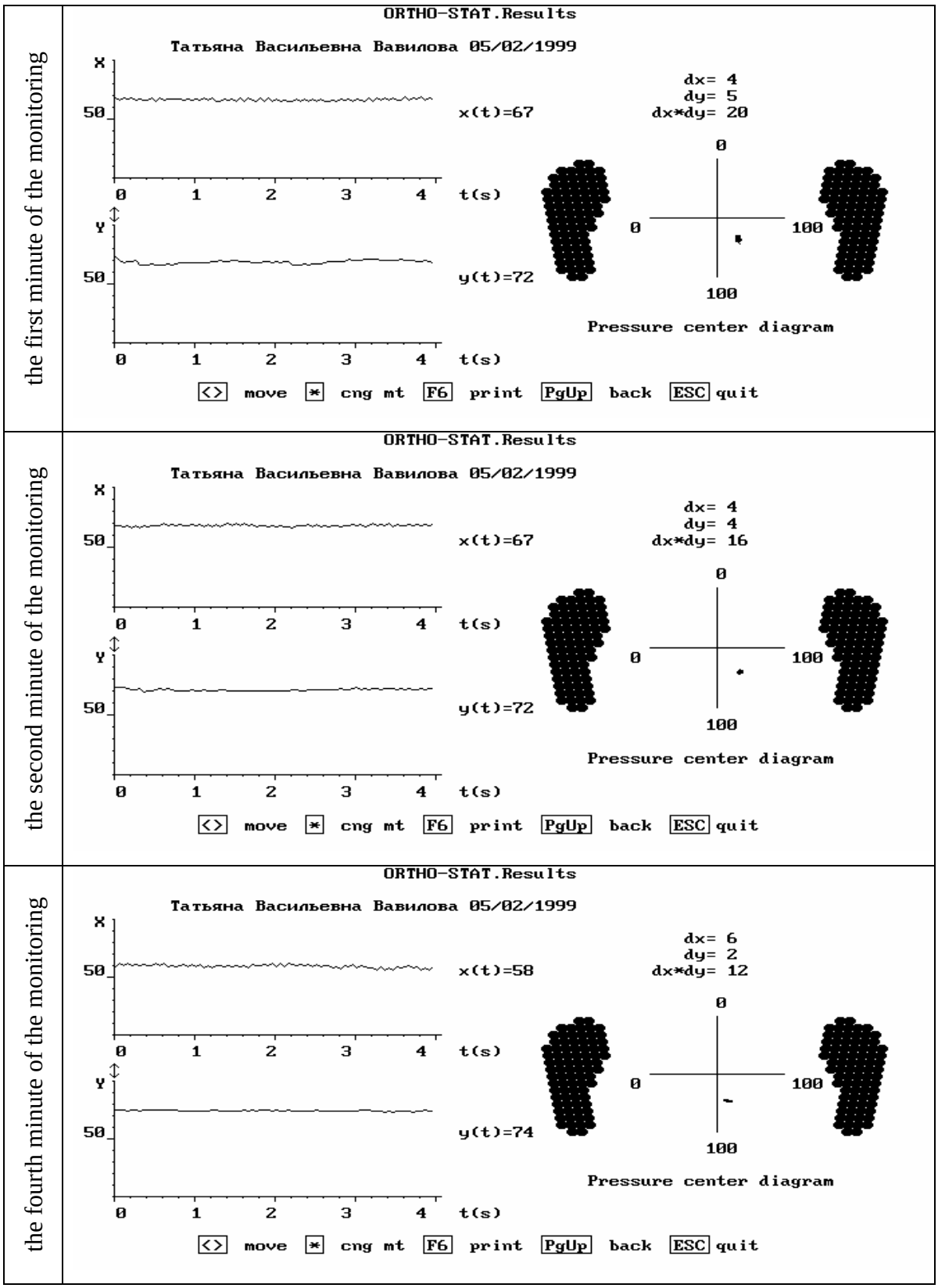

Fig. 3. Female patient, 46 years of age, left-side gonarthrosis of the second stage, functional domination of the right lower extremity.

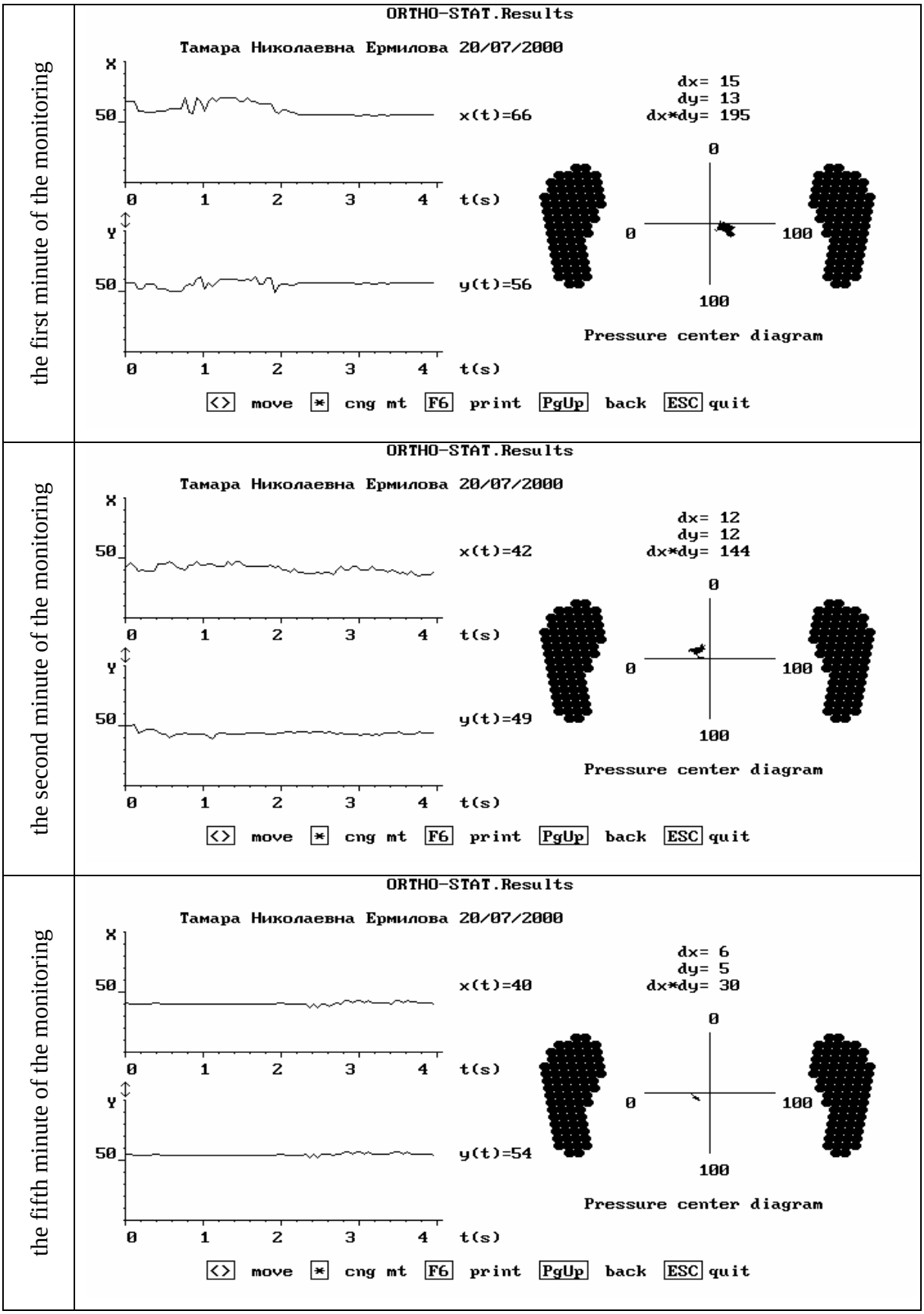

Fig. 4. Female patient, 47 year of age, right-side gonarthrosis of the second stage, functional domination of the right lower extremity.

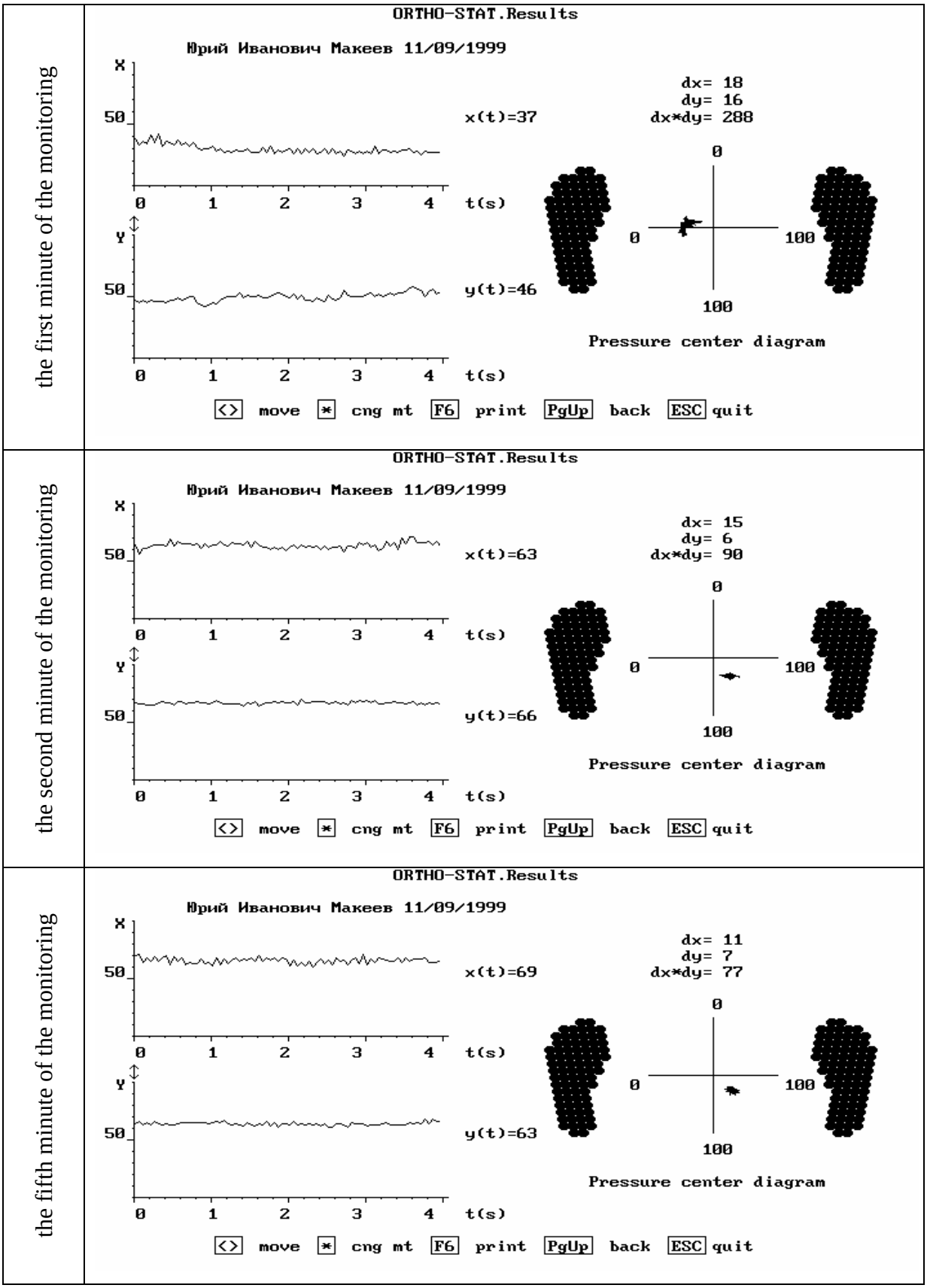

Fig. 5. Male patient, 58 year of age, right-side gonarthrosis of the third stage, expressed functional domination of the right lower extremity.

3. Severity of static stability disturbance in every patient is finally determined by direction and amount of the general pressure center deviation at the moment of examination from individual values of its location which keep body balance in the functionally most optimal mode.

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ХАРАКТЕРИСТИКИ ОПОРНЫХ РЕАКЦИЙ У БОЛЬНЫХ С ГОНАРТРОЗОМ ПРИ СТАБИЛОМЕТРИЧЕСКОМ МОНИТОРИНГЕ

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С целью изучения влияния суставной патологии на опорные реакции, участвующие в поддержании равновесия тела, обследованы 39 больных (17 мужчин и 22 женщины) в возрасте от 20 до 62 лет с односторонними и двусторонними гонартрозами 2-3 стадии, а также здоровые люди (25 человек мужского и 21 женского пола) в возрасте от 19 до 54 лет. Суть обследования заключалась в стабилографическом определении проекции общего центра давления с использованием ортопедического компьютерного комплекса ORTHO-SYSTEM (Санкт-Петербург, «Биоимитатор»). Каждую минуту, с четырехсекундным интервалом тестирования при стоянии обследуемого без вспомогательных средств опоры на специальных стельках с механорецепторами проводился стабилометрический мониторинг активности опорных реакций стоп общей продолжительностью от 3 до 5 мин.

В результате проведенного исследования установлено, что у больных с гонартрозами стабилометрические характеристики статической устойчивости при произвольном стоянии в большей мере определяются не тяжестью и стадией заболевания, а во многом зависят от местоположения проекции общего центра давления в стабилометрической системе координат. Из результатов анализа следует, что вызываемые при стоянии у обследованных пациентов болевые ощущения перестраивают опорные реакции с учетом стороны поражения, выраженности болевого синдрома и степени функциональной асимметрии. Кроме того, тяжесть нарушений статической устойчивости у каждого конкретного больного, в конечном счете, определяется направлением и величиной отклонения общего центра давления на момент обследования от индивидуальных значений локализации функционального оптимума его опорных реакций.

Ключевые слова: стабилометрический мониторинг, опорные реакции, гонартроз

Received 11 February 2002