Short Communication

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An Evaluation of New Indices of Postural Sway in Patients with Knee Osteoarthritis

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ABSTRACT

BACKGROUND AND OBJECTIVE: Reduced joint proprioception plays an important role in the initiation and progression of the knee osteoarthritis. The present study aims to evaluate postural sway in three different positions and analyze its trends using relative indices.

METHODS: This cross-sectional study was conducted among 34 patients with knee osteoarthritis and 12 healthy people using selective sampling and convenience sampling. In order to evaluate the static equilibrium indices, patients were asked to sit on the force plate in three positions; Comfort Double Leg Standing (CDLS), Romberg Standing (RS) and Near Tandem Standing (NTS). The relative values of $\frac{\text{RS}}{CDLS}$ and $\frac{\text{NTS}}{CDLS}$ were used to determine the changes in postural sway in RS and NTS positions relative to CDLS.

FINDINGS: In CDLS position, the range and the standard deviation of lateral position in patients (0.019±0.010 and 0.003±0.001, respectively) was lower than healthy people (0.051±0.039 and 0.012±0.010, respectively). In this position, the displacement range in the anterior-posterior direction in patients (0.110±0.029) was also lower than healthy people (0.130±0.027). In RS position, standard deviation and the velocity of center of pressure displacement in the patients group (0.016±0.006 and 0.012±0.004, respectively) was significantly higher than healthy people (0.012±0.003 and 0.009±0.002, respectively). On the contrary, the ratio of $\frac{\text{RS}}{CDLS}$ and $\frac{\text{NTS}}{CDLS}$ values was higher in patients group.

CONCLUSION: Results of the study demonstrated that patients with more difficult positions (RS, NTS) have more sways than those with CDLS, especially in the lateral direction. Therefore, balancing and strengthening exercises are especially important in the lateral direction and in challenging situations.

KEY WORDS: *Knee osteoarthritis, Balance, Proprioception, Center of pressure*.

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Introduction

Osteoarthritis is a clinical syndrome of joint pain and a multifactorial, inflammatory and degenerative joint disease (1, 2). In Iran, the prevalence of knee osteoarthritis among the population aged 15 – 82.5 years is 15.3% in the urban community, and 19.3% in the rural community (3, 4). Symptoms of knee osteoarthritis include joint pain and dryness, swelling, decreased performance and click sounds during joint movements (5). Knee osteoarthritis not only disturbs the structures of the joints, but also causes changes in the tissues around the joint, such as the muscles (6, 7).

In addition to proprioception reduction, arthrogenic inhibition of quadriceps muscle causes poor posture control during standing and walking, which even increases the prevalence of falls in these patients (8, 9). Compared to healthy subjects, patients with knee osteoarthritis have a poor articulate position and higher threshold for detecting active and passive movements, resulting in an impaired proprioception in the affected joint (10, 11).

Decreased joint proprioception is known as a local risk factor in the onset and progression of knee osteoarthritis, because as the proprioception decreases, the walking pattern changes and the joint is exposed to abnormal loading (11 – 13). Moreover, some studies have considered poor proprioception associated with abnormal functional status (14).

The results of some studies indicate that postural oscillations are more prevalent in patients, compared to healthy subjects (15). Some studies have found no significant difference between the patient group and the control group (16). A team of researchers believes that knee osteoarthritis affects dynamic balance more and has less effect on postural oscillations in CDLS position (17). Using different assessment tools and different positions may lead to contradictory results. In this study, static equilibrium assessment was performed by measuring the oscillations of center of pressure on the force plate, which is considered as the Gold Standard for assessing postural control (8).

Regarding the contradictory results of previous studies, evaluation was carried out in three positions in this studies, including Comfort Double Leg Standing (CDLS), Romberg Standing (RS) and Near Tandem Standing (NTS) (a position where the non-dominant leg is 2.5 cm ahead), and relative values were used to compare the oscillations in the center of pressure in more difficult positions with comfort double leg standing.

Methods

After being approved by the ethics committee of Tarbiat Modares University (registration code I.R. Tmu. REC. 1394. 249), this cross-sectional study was conducted among 34 female patients and 12 healthy and matched women aged 40 to 73 years using convenience sampling method. Individuals with bilateral symptomatic knee osteoarthritis according to American College of Rheumatic Diseases, ranked 2nd and 3rd according to Kellgren-Lawrence Radiography (18, 19) were selected from among patients admitted to Rheumatology Clinic of Baqiyatallah Hospital and entered the study with the approval of rheumatology specialist. The control group was selected from asymptomatic individuals without a history of arthroplasty and neurologic disease. Subjects entered the study after completing the voluntary and informed consent form.

The inclusion criteria were people with no medical plan, no physiotherapy or intra-articular injection within the past 6 months, lack of any routine exercise program within the past 6 months, no serious neurological and systemic illnesses, no previous history of lower limb orthopedic surgery, no symptoms of hip and ankle osteoarthritis or any other joint disease other than knee osteoarthritis, lack of diabetes and diseases that affect the balance of the person.

In case a person was not willing to continue her cooperation or if the subject missed an entry criterion during the study, she was excluded from the study. Patients who had osteoporosis according to bone densitometry test were excluded from the study. According to the results of a study by Sorensen et al., regarding the difference in the values of equilibrium indices in the morning and evening, all evaluations were done in the morning (20).

Many studies have emphasized the importance of visual information in controlling the condition of older people, especially women (21, 22). Patients with an eye score of less than 0.7 or certain vision problems were excluded from the study. To assess static equilibrium indices, the AB 9286 force plate (Kistler Co., Swiss) was used. All volunteers stood on force plate in three positions (CDLS, RS, and NTS). In CDLS position, people stood with two legs on the force plate, so that they had the best and most comfortable position. In RS position, the person stood on the plate with perfectly paired legs. In NTS position, each person was asked to put the non-dominant leg 2.5 cm ahead and out of the dominant foot thumb. Path length in the center of pressure, anteroposterior and mediolateral range of displacement of COP, the mean velocity of the oscillation in the center of the pressure, which is achieved by dividing the length of the oscillation path in each of the anterior-posterior and mediolateral plates by the duration of the test (anteroposterior and mediolateral mean velocity), and standard deviation of anteroposterior and mediolateral range/velocity of COP were evaluated in each of the 3 positions during 20 seconds. Data from the force plate with 100-Hz frequency were recorded and analyzed by MATLAB software. Relative values were used to identify postural control strategies for patients in different positions. In this ratio, we set the values of the CDLS status as the free and selective position of the person as the denominator, and set the values of RS and NTS positions as the numerator (for example: $\frac{RS}{CDLS}$).

The more the number obtained from this fraction is above 1, it indicates that postural oscillations in the RS and NTS positions are greater than the CDLS positions, and the more the number is below 1, it indicates that postural oscillations in RS and NTS positions are less than CDLS. Data were analyzed using SPSS software version 22 and independent t-test. P<0.05 was considered significant.

Results

In this study, the mean age in the patients group was 52.7±7.8 and in healthy subjects was 48.7±4.8. The two groups were similar in all respects (table 1). In CDLS position, all indices of oscillation in the center of pressure in the patients group were lower than the healthy group (52.7±7.8 versus 48.7±4.8).

Table 1. Anthropometric characteristics of the participants in the study

Group / Variable	Control Mean±SD	Patients Mean±SD	P-value
Age(years)	48.7±4.8	52.7±7.8	0.117
Height(cm)	164.2±9.9	159.9±7.1	0.110
Weight(kg)	73.9±11.9	75.2±12.7	0.721
BMI(Kg/cm^2)	27.5±4.6	29.5±4.7	0.179

Displacement range of the center of pressure in the anterior posterior and lateral directions as well as the standard deviation of lateral displacement were significantly lower in the patients group. In RS position, the standard deviation of oscillation velocity and mean velocity of the center of pressure in the lateral side were significantly higher in the patients group than in the healthy group.

There was no significant difference between the two groups in NTS position in any of the indices (table 2). The $\frac{RS}{CDLS}$ ratio in the patients group in all indices was higher than the healthy group. The higher proportion of this ratio was significant in lateral indices. The $\frac{NTS}{CDLS}$ ratio in all of the indicators (except for ML Velocity SD) was higher in the patients group than in healthy subjects, which was significant in the indices of displacement range, standard deviation of lateral displacement range and displacement range in the anterior direction (table 3).

Table 2. Comparing the oscillation indices in the center of pressure in 3 positions of CDLS, RS, NTS (mm)

Variable	CDLS Healthy people Mean±SD	CDLS Patients Mean±SD	CDLS Probability	RS Healthy people Mean±SD	RS Patients Mean±SD	RS Probability	NTS Healthy people Mean±SD	NTS Patients Mean±SD	NTS Probability
Path length(cm)	10.206±1.64	9.425±1.803	0.133	10.296±1.459	9.717±1.621	0.259	10.545±1.584	10.130±1.788	0.395
MLRange(cm)	0.051±0.039	0.019±0.010	0.006 *	0.030±0.019	0.024±0.010	0.562	0.148±0.027	0.145±0.037	0.712
AP Range(cm)	0.130±0.027	0.110±0.029	0.048 *	0.144±0.025	0.134±0.040	0.442	0.026±0.012	0.029±0.010	0.293
ML SD(cm)	0.012±0.010	0.003±0.001	0.003 *	0.006±0.005	0.004±0.002	0.626	0.026±0.003	0.025±0.004	0.536
AP SD(cm)	0.026±0.006	0.023±0.004	0.276	0.026±0.005	0.025±0.005	0.299	0.005±0.001	0.005±0.001	0.513
ML Velocity SD(cm/s)	0.010±0.003	0.010±0.002	0.949	0.012±0.003	0.016±0.006	0.016 *	0.809±0.118	0.779±0.144	0.355
AP Velocity SD(cm/s)	0.779±0.128	0.719±0.139	0.140	0.790±0.108	0.748±0.126	0.238	0.016±0.003	0.019±0.007	0.223
ML Mean Velocity(cm/s)	0.010±0.003	0.008±0.002	0.264	0.009±0.002	0.012±0.004	0.041 *	0.657±0.099	0.631±0.111	0.381
AP Mean Velocity(cm/s)	0.637±0.102	0.588±0.112	0.133	0.642±0.091	0.606±0.101	0.259	0.013±0.003	0.014±0.004	0.343

*p–value<0.05

Table 3. Values of relative oscillation indices in the center of pressure in RS and NTS positions relative to CDLS

Variable		$\frac{RS}{CDLS}$			$\frac{NTS}{CDLS}$	
	Patients	Healthy people	Probability	Patients	Healthy people	Probability
Total distance traveled by center of pressure (cm)	1.043	1.017	0.719	1.080	1.044	0.147
The displacement range in the center of pressure in the lateral direction (cm)	1.446	0.770	0.001 *	9.241	5.089	0.005 *
The displacement range in the center of pressure in the anterior-posterior direction (cm)	1.224	1.121	0.629	0.373	0.212	0.026 *
The standard deviation of displacement range in the center of pressure in the lateral direction (cm)	1.439	0.724	0.001 *	8.324	4.389	0.002 *
The standard deviation of displacement range in the center of pressure in the anterior-posterior direction (cm)	1.086	1.053	0.778	0.244	0.197	0.085
Standard deviation of velocity of displacement in the center of pressure in the lateral direction (cm/s)	1.552	1.167	0.041 *	74.673	78.748	0.532
Standard deviation of velocity of displacement in the center of pressure in the anterior-posterior direction (cm/s)	1.060	1.024	0.837	0.027	0.022	0.079
Mean velocity of the displacement in the center of pressure in the lateral direction (cm/s)	1.516	1.072	0.021 *	76.234	71.256	0.456
Mean velocity of the displacement in the center of pressure in the anterior-posterior direction (cm / s)	1.042	1.017	0.681	0.025	0.021	0.130

Discussion

Comparing $\frac{RS}{CDLS}$ and $\frac{NTS}{CDLS}$ ratios showed that when patients are in challenging positions of RS and NTS, they exhibit more oscillations than CDLS position, especially in lateral side, compared with healthy subjects; While the rate of oscillations in the center of pressure in healthy subjects in RS and NTS positions is similar to that of the CDLS.

The application of different methods and tools has led to inconsistent results in previous studies. Using different assessment devices, different device settings (such as the duration of each record, the frequency of record, etc.), the position of standing on the Force Plate, the evaluation indicators and the time of the tests (morning, noon, evening) are the cases of difference between the various studies. In previous studies, increasing the amplitude and velocity of oscillation in the center of the pressure is considered as weaker posture control (16).

In our study, the total COP Path Length in all three CDLS, RS, and NTS positions was less than that of the healthy group. This finding is in line with the findings of Hunt et al. They reported that at higher intensities,

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COP Path Length is reduced (23). Regarding the range of COP oscillations, a team of researchers reported that the range of oscillatory pressure in patients was less than healthy subjects (16, 24).

This finding matches our results in CDLS and RS positions. In these studies, researchers reported a possible cause of COP Path Length and the range of oscillations to be contraction of the quadriceps and hamstring muscles in order to increase the articular joint stability.

The situation is called the Postural Stiffening Strategy. Mancini et al. in their study among patients with Parkinson's disease found that these patients were faced with oscillations and movements in the center of the pressure, compared to matched healthy people due to the adoption of rigid body posture and muscle contraction (25).

Therefore, the necessity to lower the amount of oscillations cannot be considered equivalent to a better equilibrium position. On the other hand, Birmingham et al. concluded that there is a direct relationship between the severity of the disease and the COP Path Length in standing position on one leg (26). They also reported that this correlation becomes more when standing on a foam, compared with standing on a flat surface. Two other studies also reported that the oscillation range in the center of pressure in the knee osteoarthritis group was more than that of healthy subjects (15, 27).

However, one of them performed oscillation measurements using a tool called Swaymeter, which naturally cannot be compared with a force plate. According to Petrella et al., although the amount of oscillations in the anterior – posterior and lateral directions in the knee osteoarthritis group is higher, the difference is not significant (28).

The standard deviation of oscillation velocity as well as the mean velocity of the center of pressure in the anterior-posterior direction in the Relax and Romberg positions were lower in patients, compared with the healthy group.

While the two indicators in the Near Tandem position in patients were higher than the healthy people. In this context, we can mention the study of Park et al. They stated that in the position of relaxed standing, there is a significant reverse relationship between the severity of knee osteoarthritis and the mean velocity in the posterior – anterior direction; that is, the higher the severity of the disease, the lower the mean oscillation velocity in the center of pressure in the posterior–anterior direction. This significant correlation was not observed in the mean velocity of the displacement in the center of pressure in the lateral direction (29).

Our findings in CDLS and RS positions are consistent with the study of Park et al. It seems that many COP indices in patients and healthy subjects do not follow the same trend in NTS, RS, and CDLS positons. That is, an index in a position in the patients group may be higher than in the healthy group, but the same index in another position in the patients group may be lower than the healthy group.

The standard deviation of the velocity of the center of pressure in the lateral side in the CDLS position in the patients group was also lower than the healthy subjects, while the same index in the RS position was significantly higher than healthy subjects.

Therefore, the important issue here is the relative index, or, in other words, the difference in the values of an index in different positions. Relative data showed that patients with knee osteoarthritis in CDLS position have more oscillations than in healthy subjects in more difficult situations.

The reason for this may be the fact that a simple muscle activity is required in simple situations such as CDLS to control postural oscillations, while muscle strength becomes more important in more difficult situations, such as RS and NTS (30).

Due to the muscle weakness in these patients, the oscillations of the center of the pressure in positions that are more dependent on muscle strength is justifiable.

These results are particularly evident in the case of lateral displacement of the center of pressure in the RS position relative to the CDLS position. In the RS position, the lateral level of reliance increases the lateral displacement range in the center of pressure in the patient group and decreases it in healthy subjects.

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Therefore, in the rehabilitation of patients with osteoarthritis, the emphasis on balancing exercises and strengthening muscle in lateral, unstable and challenging positions should be more considered by researchers.

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