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ASSOCIATION OF BODY MASS INDEX WITH GAIT CHARACTERISTICS IN PATIENTS WITH KNEE OSTEOARTHRITIS

DİZ OSTEOARTRİTİ OLAN HASTALARDA VÜCUT KİTLE İNDEKSİ İLE YÜRÜYÜŞ ÖZELLİKLERİNİN İLİŞKİSİ

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ABSTRACT

Aim: The development of osteoarthritis in a weight-bearing joint is influenced by cumulative stress on that joint. To determine the magnitude and distribution of the excessive stress and loading on the knee joint using gait analysis may enhance the therapeutic interventions. This study was performed to determine the association between body mass index and biomechanical gait characteristics of the knees.

Methods: Fifty patients, with a mean age of 63.2 ± 4.4 years, with bilateral Kellgren and Lawrence grade II or III knee osteoarthritis were enrolled into the study. Mean body mass index (BMI) was 33.7 ± 2.2 kg/m^2. Three dimensional gait data were collected using the Vicon 370 system and two Bertec forceplates. Time-distance (walking velocity, stride time, stride length), kinematic (joint rotation angle of knee in sagittal plane) and kinetic (scaled vertical forces, extensor and adductor moments of knee) variables were documented. The association of BMI with the assessed gait parameters were analyzed using Spearman correlation coefficient.

Results: There was a statistically significant relationship between BMI and walking velocity (r=-0.519), stride length (r=-0.426), extensor moment (r=0.440) and adductor moment (r=0.569) of the knees, and peak vertical ground reaction forces (r=0.434).

Conclusion: Greater body mass index is associated with higher loading of the knee joints in patients with knee OA. Controlling BMI may reduce the progress of the knee OA and should be an important part of the rehabilitation programs for patients with knee OA.

Key words: Knee, osteoarthritis, BMI, gait

ÖZET

Amaç: Yük taşıyan eklemlerde osteoartrit gelişimi, o eklem üzerinde artan kümülatif stresden etkilenmektedir. Aşırı yükün diz eklemi üzerindeki dağılımı ve büyüklüğünü bilgisayarlı yürüme analizi ile incelemek seçilecek terapötik yaklaşımlara yön verebilir. Bu çalışma, vücut kitle indeksi (VKİ) ile dizin biyomekanik özellikleri arasındaki ilişkiyi incelemek üzere yapılmıştır.

Metod: Ortalama yaşları 63.2 ± 4.4 yıl, Kellgren ve Lawrence skoru II veya III olan 50 bilateral diz osteoartritli hasta çalışmaya alındı. Ortalama VKİ 33.7 ± 2.2 idi. Bilgisayarlı yürüme analizi Vicon 370 sistemi ve 2 Bertec kuvvet platformu ile yapıldı. Zaman-mesafe (yürüme hızı, çift adım zamanı, çift adım uzunluğu), kinematik (sagital düzlemde diz eklemi rotasyon açısı) ve kinetik değişkenler (vertikal yer reaksiyon kuvveti, diz ekstensör ve adduktor momentleri) incelendi. Yürüme değişkenleri ve VKİ arasındaki ilişki Spearman korelasyon yöntemi ile araştırıldı.

Bulgular: VKİ ve yürüme hızı (r=-0.519), adım uzunluğu (r=-0.426), diz ekstensör momenti (r=0.440) ve diz adduktor momenti (r=0.569) ve pik vertikal yer reaksiyon kuvvetleri (r=0.434) arasında anlamlı ilişki saptandı.

Sonuç: Diz osteoartriti olan hastalarda yüksek VKİ dizde aşırı yüklenmeye neden olur. Vücut kitle indeksinin kontrol altına alınması diz OA'nin ilerlemesini yavaşlatabilir ve diz osteoartritli hastalarda rehabilitasyon programları içinde yer almalıdır.

Anahtar kelimeler: Diz, osteoartrit, vücut kitle indeksi, yürüme

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INTRODUCTION

Osteoarthritis (OA) is the most prevalent joint disease in older adults, and knee is the second most commonly afflicted joint of osteoarthritis (1). Several risk factors have been identified, including higher age (2), female sex (3), sport related joint stress (4) and higher body mass index (BMI) (2,5). Obesity is a modifiable risk factor among these risk factors. It has been shown that weight loss reduces the symptoms (6) and improves the functions of the patients with knee OA (7). There are mecanoreceptors at the surface of condrocytes, which are sensitive to pressure and link extracellular environment to intracellular signalling cascades (8). Overloading has been shown to trigger both inhibition of matrix synthesis and cartilage degradation in experimental studies (9,10). The development of osteoarthritis in a weight-bearing joint is influenced by cumulative stress on that particular joint. Determining the magnitude and distribution of the excessive stress and loading on the knee joint may enhance the therapeutic interventions. Although computerized gait analysis could not measure the loading of knee joint directly, adductor and extensor moments and scaled vertical ground reaction forces are shown to be reliable enough to demonstrate joint loading. This study was performed to determine the association between BMI and gait characteristics of the knees.

METHODS

Fifty patients, with a mean age of 63.2 ± 4.4 years, with Kellgren and Lawrence grade II or III knee were enrolled into the study. Mean BMI was 33.7 ± 2.2. Three dimensional gait data were collected using the Vicon 370 system and two Bertec forceplates. Five cameras recorded (at 60Hz) the three-dimensional spatial location of each marker as the subject walks. Time-distance (walking velocity, stride time, stride length, stride length), kinematic (joint rotation angle of knee in sagittal plane) and kinetic (scaled vertical forces, extensor and adductor moments of knee) variables were processed using Vicon Clinical Manager software. Data analysis was done using SPSS for Windows version 9.0. The association of BMI with the assessed gait parameters were analyzed using Spearman correlation coefficient.

Computerized gait analysis has been used to quantify objectively the changes on biomechanics of walking for patients with knee OA. Sagittal plane knee joint rotation angles, peak extensor and adduction moments and peak scaled vertical ground reaction forces are the most recommended variables for the outcome studies of knee OA (11-16). Fifteen passively reflective markers were placed on standard and specific anatomical landmarks: sacrum, bilateral anterior superior iliac spine, middle thigh, lateral knee (directly lateral to axis of rotation), middle shank (the middle point between the knee marker and the lateral malleolous), lateral malleolous, heel and forefoot between the second and third metatarsal head (17). After the subjects had been instrumented with retro-reflective markers, they were instructed to walk at a self-selected speed over a 10-meter walkway during which data capture was completed. Best data of three trials used in analysis. The trial, in which all the markers were clearly and automatically identified by the system, was determined as best data. Three dimensional gait data were collected with the Vicon 370 systema and two Bertec forceplates. Concomitant videotape recordings of the subjects' gait were also performed. Five cameras recorded (at 60Hz) the three-dimensional spatial location of each marker as the subject walks. Time-distance (walking velocity, stride time, stride length), kinematic (joint rotation angle of knee in sagittal and coronal plane) and kinetic (scaled vertical ground reaction forces, extensor and adductor moments of knee) variables were processed using Vicon Clinical Manager software. Calibration of the motion analysis system was performed daily. Anthropometric data including height, weight, leg length and joint width of the knee and ankle were collected. Data analysis was performed using SPSS for Windows version 9.0b.

RESULTS

Demographic characteristics of the patients (Table-1) and gait variables (Table-2) were presented. There was a significant relationship between BMI and walking velocity (r=-0.519), stride length (r=-0.426), knee extensor moment (r=0.440) and knee adductor moment

Tablo-I

Demographic characteristics of the patients. Values other than gender and Kellgren-Lawrence score are presented in mean±SD

		N=50
Age (years)		58.6±6.4
Weight (kg)		79.5±6.8
Height (m)		153.4±5.08
Body mass index (kg/m^2)		33.7±2.2
Disease duration (months)		79.7±8.0
Gender (%)	Female	46 (92%)
	Male	4 (8%)
Kellgren-Lawrence score	Grade II	28 (56%)
	Grade	22 (44%)

Tablo-II

Spatiotemporal, kinematic and kinetic gait variables of the patients with knee OA

	Mean±SD
Walking velocity (m/s)	0.76±0.17
Stride time (s)	1.27±0.23
Stride length (m)	0.96±0.13
Excursion of knee in sagittal plane (degrees)	43.50±10.63
Knee extensor moment (Nm/kg)	0.18±0.16
Knee adductor moment (Nm/kg)	0.49±0.19
Peak ground reaction forces (N bodyweight %)	90.08 ±3.5

(r=0.569) of the knees, and peak vertical ground reaction forces (r=0.434). Knee excursion in sagittal plane was not associated with BMI (r=0.016).

DISCUSSION

In the present study, BMI is associated with spatiotemporal, kinematic and kinetic gait characteristics of the patients with knee OA. Previous studies which analyzed the gait characteristics of obese patients with knee OA presented that, obese subjects walked slower, taking shorter steps and greater step widths. (18-21). Spatiotemporal abnormalities are highly related with the presence of knee pain, knee instability and impaired knee proprioception (22). However spatiotemporal variables do not provide information on the underlying causes. On the other hand kinetic variables are considered to be more reliable to show the effect of overloading in obese patients with knee OA.

Higher adductor and extensor moments are the major determinants of the higher loading at the knees with OA (14,15). They are responsible for the biomechanical abnormality of the medical compartment of the knee OA. The external knee adductor moment is related to the distribution of forces between the medial and lateral compartment of the knee joint. It is defined as the torque that tends to adduct the knee during gait and an indicator of increased loads on the medial compartment relative to the lateral compartment (21). An excessive loading on the medial compartment of the knee leads to varus osteoarthritis. Al-Zahrani and Bakheit reported higher knee moments during gait in knee OA (22). They suggested that increased compressive forces at the knee represent an adaptive gait strategy to increase dynamic stability in the presence of a high external adductor moment. However, they have not evaluated the relationship between BMI and gait kinetics. The current study further examines the possible role of greater BMI on higher knee moments.

To our knowledge, there are two studies except this one which investigate the relationship between obesity and knee joint moments. Meisser et al investigated the relationship between weight loss and knee joint moments and found that increased weight loss is strongly associated with decreased knee extensor and adductor moments in patients with knee OA (23), supporting the results of our study. On the other hand, contrary to our results and that of Meisser et al's, Devita et al have compared the obese subjects to nonobese subjects and have not observed relationship between obesity and increased knee joint torque (24). However our study group is different than their group. Their subjects were healthy and did not have knee pain or knee OA. They suggested that some of the obese subjects may reorganize their neuromuscular function to produce a gait pattern with less total load on the knee joint and reduce the risk of OA (24).

There are some limitations of our study such as lack of a normal age-matched control group and the unexpectedly high BMI scores of the study population. Further research is needed to determine the effects of weight loss programs on gait deviations and long-term morbidity of the patients with knee OA.

In conclusion, greater BMI is associated with increased loading on knee joint which is expressed by increased knee extensor and adductor moments. Controlling BMI may reduce the burden of the knee OA.

REFERENCES

1. Hochberg MC, Altman R, Brandt K, Clark B, Dieppe P, Griffin M, Moskowitz RW, Schnitzer TJ. Guidelines for the medical management of osteoarthritis: part II. Osteoarthritis of the knee. Arthritis Rheum 1995;38:1541-46.
2. Felson DT. The epidemiology of knee osteoarthritis: results from the Framingham Osteoarthritis Study. Semin Arthritis Rheum 1990;20:42-50.
3. Nevitt MC, Felson DT. Sex hormones and the risk of osteoarthritis in women: epidemiological evidence. Ann Rheum Dis 1996;55:673-6.
4. Kujala UM, Kaprio J, Saran S. Osteoarthritis of weight-bearing joints of lower limbs in former elite male athletes. BMJ 1994;308:231-4.
5. Davis MA, Ettinger WH, Neuhaus JM. Obesity and osteoarthritis of the knee: evidence from the National Health and Nutrition Examination Survey (NHANES I). Semin Arthritis Rheum 1990;20:34-41.
6. Felson DT, Zhang Y, Anthony JM, Naimark A, Anderson JJ. Weight loss reduces the risk for symptomatic knee osteoarthritis in women: The Framingham Study. Ann Intern Med 1992;116:535-9.

7. Messier SP, Loeser RF, Miller GD, Morgan TM, Rejeski WJ, Sevick MA, Ettinger WH Jr, Pahor M, Williamson JD. Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis: The Arthritis, Diet and Activity Promotion Trial. Arthritis Rheum 2004;50:1501-10.
8. Pottie P, Presle N, Terlain B, Netter P, Mainard D, Berenbaum F. Obesity and osteoarthritis: more complex than predicted. Ann Rheum Dis 2006;65:1403-5.
9. Wang N, Butler JP, Ingber DE. Mechanotransduction across the cell surface and through the cytoskeleton. Science 1993;260:1124-7.
10. Ajubi NE, Klein-Nulend J, Nijweide PJ, Vrijheid-Lammers T, Alblas MJ, Burger EH. Pulsating fluid flow increases prostaglandin production by cultured chicken osteocytes-a cytoskeleton dependent process. Biochem Biophys Res Commun 1996; 23: 1221-6.
11. Schnitzer TJ, Popovich JM, Andersson GBJ, Andriacchi TP. Effect of piroxicam on gait in patients with osteoarthritis of the knee. Arthritis Rheum 1993;36:1207-13.
12. Crenshaw SJ, Pollo FE, Ericka FC. Effects of lateral-wedged insoles on kinetics at the knee. Clin Orthop Relat Res 2000;375:185-92.
13. Goh JCH, Mech MI, Bose K, Khoo BC. Gait analysis study on patients with varus osteoarthrosis of the knee. Clin Orthop Relat Res 1993;294:223-31.
14. Kaufman KR, Hughes C, Morrey BF, Morrey M, An KN. Gait characteristics of patients with knee osteoarthritis. J Biomech 2001;34:907-15.
15. Hurwitz DE, Ryals AR, Block JA, Sharma L, Schnitzer TJ, Andriacchi TP. Knee pain and joint loading in subjects with osteoarthritis of the knee. J Orthop Res 2000;18:572-9.
16. Kerrigan DC, Riley PO, Nieto TJ, Croce UD. Knee joint torques: a comparison between women and men during barefoot walking. Arch Phys Med Rehabil 2000;81:1162-5.
17. Kadaba MP, Ramakrishan HK, Wootten ME. Measurement of lower extremity kinematics during level walking. J Orthop Res 1990;8:383-92.
18. McGraw B, McClenaghan BA, Williams HG, Dickerson J, Ward DS. Gait and postural stability in obese and nonobese prepubertal boys. Arch Phys Med Rehabil 2000;81:484-9.
19. Meisser SP. Osteoarthritis of the knee and associated factors of age and obesity: effects on gait. Med Sci Sports Exerc1994;26:1446-52.
20. Meisser SP, Ettinger WH, Doyle TE, Morgan T, James MK, O'Tool ML, Burns R. Obesity: effects on gait in an osteoarthritic population. J Applied Biomech 1996;12:161-72.
21. Spyroploulos P, Pisciotta JC, Pavlou KN, Cairns MA, Simon SR. Biomechanical gait analysis in obese men. Arch Phys Med Rehabil 1991;72:1065-70.
22. Al-Zahrani KS, Bakheit AMO. A study of the gait characteristics of patients with chronic osteoarthritis of the knee. Disabil Rehabil 2002;24:275-80.
23. Meisser SP, Gutekunst DJ, Davis C, DeVita P. Weight loss reduced knee-joint loads in overweight and obese older results with knee osteoarthritis. Arthritis Rheum 2005;52:2026-32.
24. DeVita P, Hortobagyi T. Obesity is not associated with increased knee joint torque and power during level walking. J Biomech 2003;36:1355-62.w

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b Statistical Package for the Social Sciences (SPSS) for Windows, Version 9.0; SPSS Inc., 444 N. Michigan Avenue, Chicago, IL.