ORIGINAL ARTICLE

Body mass index, pain and function in individuals with knee osteoarthritis

Adewale L. Oyeyemi

Department of Physiotherapy, College of Medical Sciences, University of Maiduguri, Maiduguri, Borno State, Nigeria

ABSTRACT

Background: Obesity is a risk factor for progression of knee osteoarthritis (OA), and high body mass index (BMI) may interfere with treatment effectiveness on pain and function in individuals with knee OA. This study investigated the effects of BMI on pain and function during a four-week exercise programme in patients with knee OA. **Materials and Methods:** Forty-six (31 women and 15 men) participants with knee OA of different BMI categories (15 normal weight participants, 13 over weight participants and 18 obese participants), received standardised exercise therapy programme twice a week for 4 weeks. Outcome included a 10-point pain rating scale for pain-intensity and the western Ontario and McMaster university osteoarthritis index (WOMAC) for physical function. **Results:** Two-way repeated measure analysis of variance (ANOVA) on pain assessment score revealed a significant effect of time ($F = 1049.401$, $P < 0.001$) and group ($F = 9.393$, $P < 0.001$) on pain. Similar significant effect of time ($F = 595.744$, $P < 0.001$) and group ($F = 5.431$, $P = 0.008$) was obtained for WOMAC score on function. *Post hoc* analysis revealed significant difference between the normal weight and overweight group ($t = 2.472$, $P = 0.016$) and between normal weight and obese group ($t = 3.893$, $P = 0.005$) on pain outcome at the 4th week post treatment. No significant difference was found at 4th week post treatment on WOMAC scores ($F = 2.010$, $P = 0.146$). **Conclusion:** Exercise improved pain and function scores in OA patients across the BMI groups. Overweight independent of obesity may interfere with effectiveness of pain control during the symptomatic treatment of knee OA patients.

Key words: Exercise therapy, obesity, osteoarthritis, overweight

Address for correspondence:
Dr. Adewale L. Oyeyemi,
Department of Physiotherapy,
College of Medical Sciences,
University of Maiduguri,
P.M.B. 1069, Maiduguri,
Borno State, Nigeria.
E-mail: alaoyeyemi@yahoo.com

INTRODUCTION

Overweight is a risk factor for developing osteoarthritis (OA) and being overweight accelerates the progression of the disease.[1] Previous studies have established causal link between obesity and osteoarthritis.[2-4] Two theories explained how obesity causes OA.[5-8] The mechanical theory of causation posited that obesity leads to repetitive application of increased load on the knee joint with consequent degeneration of articular cartilage and sclerosis of subchondral bone.[5,6] The metabolic theory of causation suggests that obesity act indirectly to increase the risk of OA via metabolic factors or associated factors that adversely affect cartilage and other joint structures.[7,8]

Access this article online	
Quick Response Code:	Website: www.nigeriamedj.com
	DOI: 10.4103/0300-1652.119610

Weight control is often considered a modifiable factor in the behavioural management of knee OA,[9] and there is ample evidence that obesity increases the progression of the disease. Manek *et al.*,[10] reported a strong association between high body mass index (BMI) and incidence of knee OA; and the prevalence of knee pain secondary to OA has been reported to increase with elevated BMI.[11] Dougados *et al.*,[12] in a longitudinal study of knee OA patients reported that obese patients are more likely to experience progressive disease than non- obese patients. Also, Felson *et al.*,[9] in the Framingham study reported that if obese men (BMI > 30 Kg/m^2) lost enough weight to fall into the overweight category (BMI 25-29.9 Kg/m^2), and if men in the overweight category lost enough weight to move into the normal category (BMI < 25 Kg/m^2), knee OA would decrease by 21.5%. Also, similar changes in weight categories by women would result in a 33% decrease in knee OA.[9]

The common symptoms of knee OA that make patients to seek treatment are pain and loss of function.[13,14] Modalities recommended for the management of OA could be pharmacological and non-pharmacological. While the pharmacological agents often recommended for the management of knee OA include acetaminophen, oral and topical Nonsteroidal anti-inflammatory drugs (NSAIDs), tramadol and intra articular corticosteroid injections, non-pharmacological modalities include instruction in joint protection techniques, provision of assistive devices, use of thermal modalities and therapeutic exercises.[15] Within the arrays of non-pharmacological modalities used for the management of OA, there is strong evidence for the benefits of exercise in relieving pain and improving functional status in patients with knee OA.[16-18] A local strengthening exercise programme of the quadriceps femoris can significantly improve pain status and reduce disability level with accompanying improvement in proprioception and balance in patients with knee OA.[19] Also, exercise therapy in conjunction with standardised analgesic has been advocated as a viable and effective first choice approach in the management of knee OA.[20] Further, a combination of supervised range of motion strengthening exercise and supervised bicycle ergometry[21] and dynamic or resistance exercise[22] have been found to improve functional ability and reduce knee joint pain in patients with knee OA.

Since high BMI is known to increase the progression of knee OA, it is plausible that it may also interfere or mediate with pain control and physical function's outcomes during routine symptomatic treatment of knee OA. This study, therefore, aimed to investigate the effect of body mass index on pain and function during a four week exercise therapy programme among knee OA patients.

MATERIALS AND METHODS

Forty-six patients (31 women and 15 men) with a mean age of 55.5 years participated in this study. Participants were referred by their physician or were self-referred for physiotherapy treatment. Participants were selected for the study if they had radiographically confirmed unilateral or bilateral OA of the knee and had not previously received knee strengthening exercise. Lower quarter screening tests were conducted as described by Saunder[23] to rule out pain referred from elsewhere. The examination comprised a series of joint mobility and neurological tests to identify possible problems with the lumbar spine, hip, knee, ankle and the foot. Subjects were asked to refrain from taking medications or receiving treatment specifically for their knee pain during the course of the study.

At the first appointment, each participant's age, height and weight were measured and recorded. Height was measured to the nearest centimetres with a height metre (Baum WA, Company Incorporated New York), while weight was measured to the nearest kilogram with a weighing scale (Hana, Germany). The BMI was calculated as weight in kilogram divided by the square of height in meters. The BMI was then categorised as normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2) and obese (≥30.0 kg/m^2) according to the World Health Organisation (WHO) classification.[24]

Participants' knee pain was rated on a 10-point rating scale: Where 0 was labelled "no pain", 5 was labelled "moderate pain" and 10 was labelled "worst pain imaginable". Participants were asked to point to the number corresponding to his or her pain intensity and this was recorded. Pain rating was completed in full weight bearing and instructions were given to participants not to under- or over-estimate their pain. Subsequent ratings were conducted at the end of every treatment session.

Each participant's also completed the Western Ontario and McMaster University Osteoarthritis Index (WOMAC), which is reported to be valid for the assessment of symptoms and physical function disability in patients with OA of the knee.[25] Participants' rated the 24 questions (5 relating to pain, 2 to stiffness and 17 to function) of WOMAC on a five-point likert scale: 0 = none, 1 = slight, 2 = moderate, 3 = severe and 4 = extreme. Participants' attended two treatment sessions each week for 4 weeks (total, 8 treatments), with at least 24 hours between each treatment. WOMAC score was assessed at the end of each week of treatment (appointment number 1, 4, 6 and 8).

Exercise therapy

During each appointment, participants underwent an exercise programme. The exercises included isometric exercise of the quadriceps and bicycle ergometry. Quadriceps- strengthening exercise was performed using metallic interchangeable weights (Preston Corporation, Clifton, NJ, USA) fastened to the ankle of the affected legs. The Delorme and Watkin principle of 10-repetitive maximum (10 RM) was used to determine and standardise the weight used by each participant.[26] Participants' sat on the edge of a plinth with the back fully supported and the two hands holding the edges of the plinth. Participants' performed isometric knee extension exercise from a starting position of 0° knee flexion. Participants' were helped by a physiotherapy clinician to lift the weight through 90° to 180° extension. The extension was sustained for 10 seconds (isometric) before the leg was lowered (with help, if required) and rested for 5 seconds. Participants repeated the exercise 10 times to make one bout. A total of 10 bouts were performed with 2 minutes rest in between bouts (total of 100 contractions).[26] Each participant began with the maximum load that could be sustained for the first week and progressed in subsequent weeks depending on the new weight that could be sustained.

Participants' were allowed to rest for at least 5 minutes before riding the stationary bicycle ergometer with an initial resistance set at 25W for 6 minutes. The resistance was increased to 35, 45 and 55W in the second, third, and fourth week, respectively. The power output chosen was based on the recommendation of Pollock and Willmore[27] for middle aged and less fit patients. These progressions ensure gradual increase in demand for improve cardiovascular endurance gain and were tolerated by all patients. Bicycle ergometer is a form of aerobic exercise that has optimal health benefits in health-related quality of life and physical function.[28]

The exercise protocol was carried out at the exercise gymnasium of the Physiotherapy Department of the Obafemi Awolowo University Teaching Hospital Complex. Information about the study and the physiological and therapeutic effects of exercise was communicated to the participants verbally and in written form, and all participants gave signed informed consent. The Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Nigeria approved the study protocol, before the commencement of the study.

Data analysis

Descriptive statistics of mean and standard deviation was calculated for the physical characteristics of participants. A separate one-way analysis of variance (ANOVA) was performed to compare pain scores and WOMAC scores between the BMI categories at baseline and 4th week of treatment. Also, a two-way repeated measure ANOVA was performed to examine the effects of time and group on pain score and WOMAC score. The analysis was done using Statistical Package for Social Sciences (SPSS) for windows 10.0, and *P* value of less than 0.05 was accepted as significant.

RESULTS

The participants age ranged between 34 and 69 years (Mean = 55.5, SD = 9.0). Fifteen (32.6%) were males and 31 (67.4%) were females. The base line pain intensity and physical function scores were significantly different between the three groups. There was also a significant difference in post treatment pain score at the 4th week but not in the 4th week post treatment WOMAC score. The difference in mean age and treatment outcomes across the BMI group are shown in Table 1.

Post hoc analyses showed that both the overweight and obese group significantly had higher baseline pain intensity scores compared to the normal weight group. However, for physical function, obese participants had more functional limitation (higher WOMAC score) than both the overweight and normal weight participants [Table 2].

Table 3 shows the *post hoc* analysis of the 4th week post treatment outcome on pain intensity. Significant *post hoc* difference was found between the normal and overweight groups and between the normal and obese groups, but not between the overweight and obese groups. No significant difference exists in the 4th week post treatment scores of function across the three BMI groups.

The two way repeated ANOVA showed that time ($F = 1049.401$, $df = 1$, $P < 0.001$) and group ($F = 9.393$, $df = 2$, $P < 0.001$) had significant effect on change in mean pain intensity scores [Figure 1]. Also, significant effects of time ($F = 595.744$, $df = 1$, $P < 0.001$) and groups ($F = 5.431$, $df = 2$, $P = 0.008$) were found on changes in physical function scores over time [Figure 2].

DISCUSSION

The effect of three BMI categories (normal weight, over weight and obese) on pain and function during exercise

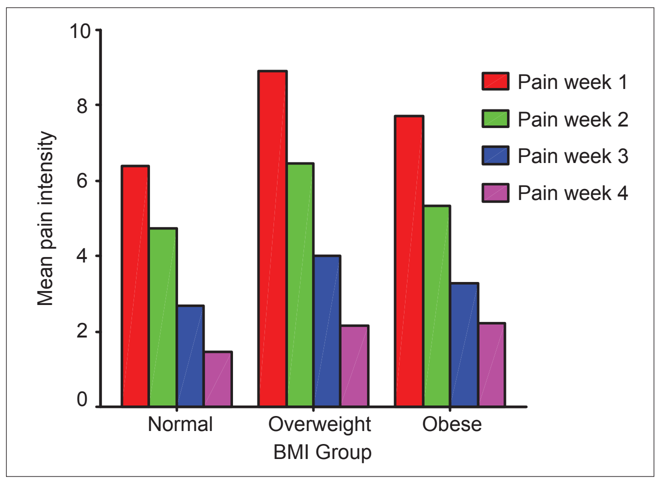

Figure 1: Mean pain intensity scores for each BMI group during the four weeks of treatment

Table 1: One-way ANOVA on age, pain intensity and WOMAC scores among normal weight, overweight and obese participants

Characteristics	Normal (*n*=15) mean (SD)	Overweight (*n*=13) mean (SD)	Obese (*n*=18) mean (SD)	*F* value	*P* value
Age	56.93 (9.56)	55.31 (8.07)	55.2 (9.04)	0.582	0.563
Week 1-Pain	6.40 (1.06)	8.92 (1.38)	7.72 (1.41)	13.288	<0.001
Week 4-Pain	1.47 (0.64)	2.15 (0.55)	2.22 (0.88)	5.129	0.010
Week 1-Function	33.83 (15.32)	40.66 (15.6)	52.87 (12.76)	7.464	0.002
Week 4-Function	16.75 (4.52)	19.81 (5.02)	19.58 (4.56)	2.010	0.146

ANOVA – Analysis of variance; WAMAC – Western Ontario and McMaster university osteoarthritis index

Table 2: Least significant difference *post hoc* comparison of pain and function at baseline (week 1)

Group	Mean difference	*P* value	C.I.
Normal vs. overweight			
Pain	−2.52*	<0.001	−3.51 to −1.53
Function	-6.84	0.216	−17.82 to 4.15
Normal vs. obese			
Pain	−1.32*	0.006	−2.24 to −0.41
Function	−19.04*	<0.001	−29.17 to −8.91
Overweight vs. obese			
Pain	1.20*	0.015	0.25 to 2.15
Function	−12.21*	0.052	−22.17 to −8.91

C.I. – Confidence interval; *The mean difference is significant at the 0.05 level

Table 3: Least significant difference *post hoc* comparison of pain intensity score at 4th week post treatment

Group	Mean difference	*P* value	C.I.
Normal vs. overweight	−0.69*	0.016	−1.24 to −0.13
Normal vs. obese	−0.76*	0.005	−1.27 to −0.25
Overweight vs. obese	−0.00684	0.696	−0.60 to −0.46

C.I. – Confidence interval, *The mean difference is significant at the 0.05 level

therapy among individuals with symptomatic OA of the knee was examined in this study. There was no significant difference in age between the BMI groups, indicating that the participants in this study were comparable by age at baseline. Overall significant post treatment benefits of exercise on pain and function were found in the three BMI groups. These results reaffirm that exercise is beneficial in the management of knee OA. Previous studies have reported that well-developed exercise therapy involving strengthening of the quadriceps can significantly relief pain, improve function and lessen drug use in patients with knee OA.[18,22,29]

The finding of higher baseline pain intensity score among the overweight and obese group than the normal weight group is understandable. Previous studies have reported the prevalence of knee OA to be higher among patients with higher body weight than those with lower body weight.[9,11] Clearly, being overweight increases the load placed on the knee joints, and possibly elevate mechanical stress that hasten the break-down of joint cartilage with concomitant increase in joint pain.[1] Moreover, the mechanical irritation that accompanied compressive force on the subchondral bones of the knee joint has been reported as a potential initiator of pain, and being overweight or obese increases this pain.[30] It is estimated that a force of nearly three to six times the body's weight is exerted across the knee joint while walking, and an increase in body weight elevates the impact of this force on the knee.[5]

At the fourth week of treatment, a significant *post hoc* difference in pain intensity between the normal weight and overweight group and also between the normal and obese group but not between the overweight and obese group was found. It is not clear while no difference in treatment effect was found between the overweight and obese group. The finding, however, reflects that the post treatment effect in the overweight and obese group may be different from those in the normal weight group. However, when view in the context that differences exists across the three BMI groups at baseline, it is potentially likely that overweight contribute as much as obesity in militating against treatment benefit on pain in this study. It is also plausible that being overweight is sufficient to exert the minimum amount of axial compressive force needed to excite pain receptors in the subchondral bone, hence, a likely reason for the no significant difference found in the overweight and obese group.

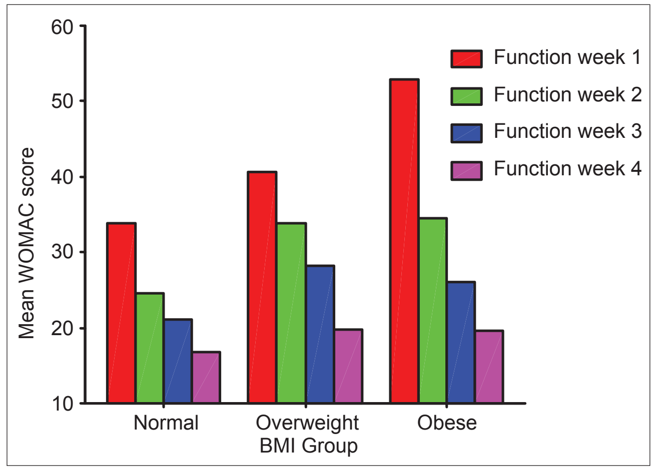

Figure 2: Mean WOMAC osteoarthritis index score for each BMI group during the four week treatment

The study found no significant difference in the post treatment physical function scores across the three BMI groups at the 4th week of treatment. This may suggests that BMI have little effect on the outcome of function during treatment; as comparable improvement was found in post treatment function scores between the normal weight, overweight and obese group. This finding is important when compared with the post treatment outcome on pain. It may be that function rather than pain is better influenced by exercise therapy regardless of BMI status in knee OA patients. The result of Deyle *et al.*,[17] though not statistically significant reflects that function is better influenced by exercise and manual therapy than pain and stiffness in OA patients. The finding from the present study, however, needs to be interpreted with caution as function reported in this study was self-reported and not based on actual functional performance of the participants. It has been suggested that self-report of function and physical performance of function represent different domains that should be measured differently in OA patients.[13,31]

The present study has some limitation that should be considered when interpreting the findings. First, generalisation of the findings is limited because the effect of BMI was only evaluated on outcomes from a single treatment approach (exercise therapy alone) within a gamut of other approaches available to the management of knee OA. Furthermore, the small sample size utilised within the BMI categories provided limited power for the study to detect significance differences, thereby, increasing the chance of occurrence of type two errors.[32] Also, because the study did not utilise a prospective (longitudinal) cohort design, it would be difficult to speculate on the long term benefits of exercise on the symptomatic relief of pain and function in individuals with knee OA.

CONCLUSION

The findings from the present study indicate that structured exercise programme is beneficial in the treatment of knee OA among patients with varying BMI, and being overweight independent of being obese may mediate on pain outcome effectiveness during the symptomatic treatment of knee OA patients. It is, however, imperative that future studies should confirm these findings in large sample and also explore the effects of overweight and/or obesity on pain and function during routine pharmacological intervention and other available non pharmacological modalities.

ACKNOWLEDGMENT

Author wishes to thank Dr. Rufus A. Adedoyin of the Department of Medical Rehabilitation, Obafemi Awolowo University, Ile-Ife, Nigeria for providing overall coordination and supervision of this research.

REFERENCES

1. Creamer P, Hochberg MC. Osteoarthritis. Lancet 1997;350:503-8.
2. Oliveria SA, Felson DT, Cirillo PA, Reed JI, Walker AM. Body weight, body mass index and incident of symptomatic osteoarthritis of the hand, hip and knee. Epidemiology 1999;10:161-6.
3. Sandmark H, Hogstedt C, Lewold S, Vingård E. Osteoarthrosis of the knee in men and women in association with overweight, smoking and hormone therapy. Ann Rheum Dis 1999;58:151-5.
4. Vitanzo PC, McShane JM. Osteoarthritis of the knee: Keeping aging adult active. A special report. New York: McGraw Hill Companies; 2002. p. 1-12.
5. Felson DT. Weight and osteoarthritis. J Rheumatol Suppl 1995;43:7-9.
6. Hartz AJ, Fischer ME, Bril G, Kelber S, Rupley D Jr, Oken B, *et al*. The association of obesity with joint pain and osteoarthritis in the HANES data. J Chronic Dis 1986;39:311-9.
7. van Saase JL, Vandebroucke JP, van Romunde LK, Valkenburg HA. Osteoarthritis and obesity in the general population. A relationship calling for an explanation. J Rheumatol 1988;15:1152-8.
8. Acheson RM, Collart AB. New Haven survey of joint diseases. XVII. Relationship between some systemic characteristic and osteoarthrosis in a general population. Ann Rheum Dis 1975;34:379-87.
9. Felson DT, Zhang Y, Hannan MT, Naimark A, Weissman B, Aliabadi P, *et al*. Risk factors for incidents radiographic knee osteoarthritis in the elderly: The Framingham Study. Arthritis Rheum 1997;40:728-33.
10. Manek NJ, Hart D, Spector DT, MacGregor AJ. The association of body mass index and osteoarthritis of the knee joint: An examination of genetic and environmental influences. Arthritis Rheum 2003;48:1024-9.
11. Andersen RE, Crespo CJ, Barlett SJ, Bathon JM, Fontaine KR. Relationship between body weight gain and significant knee, hip, and back pain in older Americans. Obes Res 2003;11:1159-62.
12. Dougados M, Gueguen A, Nguyen M, Thiesce A, Listrat V, Jacob L, *et al*. Longitudinal radiographic evaluation of osteoarthritis of the knee. J Rheumatol 1992;19:378-84.
13. Adegoke BO, Babatunde FO, Oyeyemi AL. Pain, balance, self-reported function and physical function in individuals with knee osteoarthritis. Physiother Theory Pract 2012;28:32-40.
14. Rubinow A. Pain in osteoarthritis and its management. In: Rheumatic Pain. Newsletter of the IASP Special Interest Group on Rheumatic Pain; 1998.
15. Hochberg MC, Altman RD, April KT, Benkhalti M, Guyatt G, McGowan J, *et al*. American College of Rheumatology. American College of Rheumatology 2012 recommendations for the use of nonpharmacologic and pharmacologic therapies in osteoarthritis of the hand, hip, and knee. Arthritis Care Res (Hoboken) 2012;64:465-74.
16. Adedoyin RA, Olaogun MO, Oyeyemi AL. Transcutaneous electrical nerve stimulation and interferential current combined with exercise for the treatment of knee osteoarthritis: A randomized controlled trial. Hong Kong Physiother J 2005;23:13-9.
17. Deyle GD, Allisson SC, Matekel RC, Ryder MG, Stang JM, Gohdes DD, *et al*. Physical therapy treatment effectiveness for osteoarthritis of the knee: A randomized comparison of supervised clinical exercise and manual therapy procedures versus a home exercise program. Phys Ther 2005;85:1301-17.
18. Goldberg J, Sullivan SJ, Seaborne DE. The effect of two intensities of massage on H-reflex amplitude. Phys Ther 1992;72:449-57.
19. Messier SP, Royer TD, Craven TE, O'Toole ML, Burns R, Ettinger WH Jr. Long-term exercise and its effect on balance in older osteoarthritis adults: Results from the Fitness, Arthritis and Senior Trial (FAST). J Am Geriatr Soc 2000;48: 131-8.
20. Kon E, Filardo G, Drobnic M, Madry H, Jelic M, van Dijk N, *et al*. Non-surgical management of early knee osteoarthritis. Knee Surg Sports Traumatol Arthrosc 2012;20:436-49.
21. Deyle GD, Henderson NE, Matekel RL, Ryder MG, Garber MB, Allison SC. Effectiveness of manual physical therapy and exercise in osteoarthritis of the knee. A randomized, controlled trial. Ann Intern Med 2000;132:173-81.
22. Topp R, Woolley S, Hornyak J 3rd, Khuder S, Kahaleh B. The effect of dynamic versus isometric resistance training on pain and functioning among adults with osteoarthritis of the knee. Arch Phys Med Rehabil 2002;83:1187-95.
23. Saunder HA. Evaluation of musculoskeletal disorders. In: Gould JA, Davis GJ, editors. Orthopaedic and Sport Physical Therapy. St Louis: Mosby; 1986. p. 169-80.
24. World Health Organization: Obesity; preventing and managing the global epidemic. Geneva; 2000. p. 1-18.
25. McConnell S, Kolopack P, Davis AM. The Western Ontario and McMaster University Osteoarthritis Index (WOMAC): A review of its utility and measurement properties. Arthritis Rheum 2001;45:453-61.
26. Kisney C, Colby LA. Therapeutic exercises, foundation and

technique. 3rd ed. Philadelphia: FA Davis Company; 1990. p. 109-16.
27. Pollock ML, Willmore JH. Exercise in health and disease: Evaluation and prescription for prevention and rehabilitation. 2nd ed. Philadelphia: WB Saunder; 1990. p. 259-66.
28. Bischoff HA, Roos EM. Effectiveness and safety of strengthening, aerobic, and coordination exercises for patients with osteoarthritis. Curr Opin Rheumatol 2003;15:141-4.
29. Fransen M, McConnell S, Bell M. Exercise for osteoarthritis of the hip or knee. Cochrane database Syst Rev 2004.
30. Doherty M. Pain in osteoarthritis. In: Giamberandino MA, editor. Pain, Ipdated Review. Seattle: IASP Press; 2002. p. 51-7.
31. Harrison AL. The influence of pathology, pain, balance and self-efficacy on function in women with osteoarthritis of the knee. Phys Ther 2004;84:822-31.
32. Cohen JA. Statistical Power Analysis for the Behavioural Sciences. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.

How to cite this article: Oyeyemi AL. Body mass index, pain and function in individuals with knee osteoarthritis. Niger Med J 2013;54:230-5.

Source of Support: Nil, **Conflict of Interest:** None declared.