



## Impact of obesity and diabetes on arthritis: An update

PDF (Size:237KB) PP. 143-156 DOI: 10.4236/health.2013.51019

### Author(s)

Rajesh Pandey, Narendra Kumar, Seema Paroha, Ram Prasad, Mukesh Yadav, Shalini Jain, Hariom Yadav

### ABSTRACT

The incidence of obesity and diabetes has been increased with alarming rate in recent years and became a common problem around the globe including developing as well as in developed countries with incalculable social costs. Obesity and type 2 diabetes are two common co-morbidities occur together. Obesity and diabetes is closely associated with many diseases, osteoarthritis, hypertension, certain form of cancer, sleep-breathing disorders and coronary heart disease. Impacts of obesity and diabetes (insulin resistance) on arthritis have been seen in patients that we associated with combination of various factors like increased availability of high-energy foods, genetic susceptibility and decreased physical activity in modern society. Arthritis is becoming pandemic around the globe and its occurrence with obesity and diabetes has been observed more common than ever. Combination of these two chronic conditions makes these diseases more vulnerable for human health. Till now very limited information is established about the pathological and mechanistic correlation among these health ailments. In this review article we aimed to survey the literature covering the influence of obesity and diabetes on arthritis pathology and tried to establish correlation with these diseases.

### KEYWORDS

Obesity; Diabetes; Arthritis; Complications

### Cite this paper

Pandey, R. , Kumar, N. , Paroha, S. , Prasad, R. , Yadav, M. , Jain, S. and Yadav, H. (2013) Impact of obesity and diabetes on arthritis: An update. *Health*, 5, 143-156. doi: 10.4236/health.2013.51019.

### References

- [1] Zimmet, P. and Thomas, C.R. (2003) Genotype, obesity and cardiovascular disease—Has technical and social advancement outstripped evolution? *Journal of International Medicine*, 254, 114-125.
- [2] Rashid, M.N., Fuentes, F., Touchon, R.C. and Wehner, P.S. (2003) Obesity and the risk for cardiovascular disease. *Preventive Cardiology*, 6, 42-47. doi:10.1111/j.1520-037X.2003.01358.x
- [3] Calle, E.E., Thun, M.J., Petrelli, J.M., Rodriguez, C. and Heath, C.W. (1999) Body mass index and mortality in a prospective cohort of US adults. *England Journal of Medicine*, 341, 1097-1105.
- [4] Kopelman, P.G. (2000) Obesity as a medical problem. *Nature*, 404, 635-643.
- [5] McGinnis, J.M. and Foege, W.H. (1993) Actual causes of death in the United States. *JAMA*, 270, 2207-2212. doi:10.1001/jama.1993.03510180077038
- [6] Friedman, J.M. (2000) Obesity in the new millennium. *Nature*, 404, 632-634.
- [7] Loe, H. (1993) Periodontal disease. The sixth complication of diabetes mellitus. *Diabetes Care*, 16, 329-334.
- [8] Grossi, S.G. and Genco, R.J. (1998) Periodontal disease and diabetes mellitus: A two-way relationship. *Annual Periodontology*, 3, 51-61. doi:10.1902/annals.1998.3.1.51
- [9] Parkinson, L., Gibson, R., Robinson, I. and Byles, J. (2010) Older women arthritis: Tracking impact

• Open Special Issues

• Published Special Issues

• Special Issues Guideline

Health Subscription

Most popular papers in Health

About Health News

Frequently Asked Questions

Recommend to Peers

Recommend to Library

Contact Us

Downloads: 437,401

Visits: 1,109,485

Sponsors >>

- [10] Ndetan, H., Evans Jr., M.W., Felini, M., Bae, S., Rupert, R. and Singh, K.P. (2010) Chiropractic and medical use of health promotion in the management of arthritis: Analysis of the 2006 National Health Interview Survey. *Journal of Manipulative Physiology Therapy*, 33, 419- 424. doi:10.1016/j.jmpt.2010.06.008
- [11] Elders, M.J. (2008) The increasing impact of arthritis on public health. *Journal of Rheumatology*, 60, 6-8.
- [12] Janssen, I. and Mark, A.E. (2006) Separate and combined influence of body mass index and waist circumference on arthritis and knee osteoarthritis. *International Journal of Obesity*, 30, 1223-1228. doi:10.1038/sj.ijo.0803287
- [13] Zakkak, J.M., Wilson, D.B. and Lanier, J.O. (2009) The association between body mass index and arthritis among US adults: CDC' s surveillance case definition. *Prevention of Chronic Disease*, 6, A56.
- [14] Busija, L., Hollingsworth, B., Buchbinder, R. and Osborne, R.H. (2007) Role of age, sex, and obesity in the higher prevalence of arthritis among lower socioeconomic groups: A population-based survey. *Arthritis Rheumatology*, 57, 553-561.
- [15] Mili, F., Helmick, C.G. and Zack, M.M. (2002) Prevalence of arthritis: Analysis of data from the US Behavioral Risk Factor Surveillance System, 1996-99. *Journal of Rheumatology*, 29, 1981-1988.
- [16] James, N.T., Miller, C.W., Fos, P.J., Zhang, L., Wall, P. and Welch, C. (2003) Health status, physical disability, and obesity among adult Mississippians with chronic joint symptoms or doctor-diagnosed arthritis: Findings from the Behavioral Risk Factor Surveillance System. *Prevention of Chronic Disease*, 5, 85.
- [17] Manninen, P., Riihimaki, H., Heliovaara, M. and Makela P. (1996) Overweight, gender and knee osteoarthritis. *International Journal of Obesity Related Metabolism and Disorder*, 6, 595-597.
- [18] Centers for Disease Prevention and Health Promotion (2010) Arthritis: The nation' s most common cause of disability.
- [19] Wollenhaupt, J. and Zeidler, H. (1998) Undifferentiated arthritis and reactive arthritis. *Current Opinion in Rheumatology*, 4, 306-313. doi:10.1097/00002281-199807000-00005
- [20] Martin, J.A. and Buckwalter, J.A. (2003) Aging, articular cartilage chondrocyte senescence and osteoarthritis. *Biogerontology*, 3, 257-264. doi:10.1023/A:1020185404126
- [21] Dicesare, P.E. and Abramson, S.B. (2005) Pathogenesis of osteoarthritis. In: Harris, E.D., Budd, R.C., Genovese, M.C., et al., Eds., Kelley' s Textbook of Rheumatology, 7th Edition, Elsevier Saunders, St. Louis.
- [22] Chopra, A., Patil, J. and Bilampelly, V. (1997) The Bhigwan (India) COPCORD: Methodology and first information report, APLAR. *Journal of Rheumatology*, 1, 145- 154.
- [23] Chopra, A., Patil, J., Bilampelly, V., Relwane, J. and Tandle, H.S. (2001) Prevalence of rheumatic disease in rural population in Western India. *Journal of Association Physicians India*, 49, 240-246.
- [24] Mahajan, A., Jasrotia, D.S., Manhas, A.S. and Jamwal, S.S. (2003) Prevalence of major rheumatic disorders in Jammu. JK Science, 5, 63-66.
- [25] Hedley, A.A., Ogden, C.L., Johnson, C.L., Carroll, M.D., Curtin, L.R. and Flegal, K.M. (2004) Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. *JAMA*, 291, 2847-2850. doi:10.1001/jama.291.23.2847
- [26] Coggon, D., Reading, I., Croft, P., McLaren, M., Barrett, D. and Cooper, C. (2001) Knee osteoarthritis and obesity. *International Journal of Obesity*, 25, 622-627. doi:10.1038/sj.ijo.0801585
- [27] Parvizi, J., Trousdale, R.T. and Sarr, M.G. (2000) Total joint arthroplasty in patients surgically treated for morbid obesity. *Journal of Arthroplasty*, 15, 1003-1007. doi:10.1054/arth.2000.9054
- [28] Cooper, C., Inskeep, H., Croft, P., et al. (1998) Individual risk factors for hip osteoarthritis: Obesity, hip injury, and physical activity. *American Journal of Epidemiology*, 147, 516-522. doi:10.1093/oxfordjournals.aje.a009482
- [29] March, L.M. and Bagga, H. (2004) Epidemiology of osteoarthritis in Australia. *Medical Journal of Australia*, 180, S6-S10.

- [30] Felson, D.T., Anderson, J.J., Naimark, A., Walker, A.M. and Meenan, R.F. (1988) Obesity and knee osteoarthritis. The Framingham Study. Annual International Medicine, 109, 18-24.
- [31] Felson, D.T., Zhang, Y., Anthony, J.M., Naimark, A. and Anderson, J.J. (1992) Weight loss reduces the risk for symptomatic knee osteoarthritis in women. The Framingham Study. Annual International Medicine, 116, 535- 539.
- [32] Felson, D.T., Zhang, Y., Hannan, M.T., Naimark, A., Weissman, B., Aliabadi, P., et al. (1997) Risk factors for incident radiographic knee osteoarthritis in the elderly: The Framingham Study. Arthritis Rheumatology, 40, 728- 733. doi:10.1002/art.1780400420
- [33] Hart, D.J., Doyle, D.V. and Spector, T.D. (1999) Incidence and risk factors for radiographic knee osteoarthritis in middle-aged women: The Chingford Study. Arthritis Rheumatology, 42, 17-24. doi:10.1002/1529-0131(199901)42:1<17::AID-ANR2>3.0.CO;2-E
- [34] Davis, M.A., Ettinger, W.H. and Neuhaus, J.M. (1988) The role of metabolic factors and blood pressure in the association of obesity with osteoarthritis of the knee. Journal of Rheumatology, 15, 1827- 1832.
- [35] Hochberg, M.C., Lethbridge-Cejku, M., Scott Jr., W.W., Reichle, R., Plato, C.C. and Tobin, J.D. (1995) The association of body weight, body fatness and body fat distribution with osteoarthritis of the knee: Data from the Baltimore Longitudinal Study of Aging. Journal of Rheumatology, 22, 488-493.
- [36] Bagge, E., Bjelle, A., Eden, S., and Svanborg, A. (1991) Factors associated with radiographic osteoarthritis: Results from the population study 70-year-old people in Goteborg. Journal of Rheumatology, 18, 1218-1222.
- [37] Cicuttini, F.M., Spector, T. and Baker, J. (1997) Risk factors for osteoarthritis in the tibiofemoral and patello-femoral joints of the knee. Journal of Rheumatology, 24, 1164-1167.
- [38] Anderson, J.J. and Felson, D.T. (1988) Factors associated with osteoarthritis of the knee in the first national Health and Nutrition Examination Survey (HANES I). Evidence for an association with overweight, race, and physical demands of work. American Journal of Epidemiology, 128, 179-189.
- [39] Schouten, J.S., van den Ouwehand, F.A. and Valkenburg, H.A. (1992) A 12 year follow up study in the general population on prognostic factors of cartilage loss in osteoarthritis of the knee. Annual Rheumatology Disease, 51, 932-937. doi:10.1136/ard.51.8.932
- [40] Ledingham, J., Regan, M. and Jones, A. (1995) Doherty M. Factors affecting radiographic progression of knee osteoarthritis. Annual Rheumatology Disease, 54, 53-58. doi:10.1136/ard.54.1.53
- [41] Kaipiainen-Seppanen, O., Aho, K., Isomaki, H. and Laakso, M. (1996) Incidence of rheumatoid arthritis in Finland during 1980-1990. Annual Rheumatology Disease, 55, 608-611. doi:10.1136/ard.55.9.608
- [42] Dougados, M., Gueguen, A., Nguyen, M., Thiesse, A., Listrat, V. and Jacob, L. (1992) Longitudinal radiologic evaluation of osteoarthritis of the knee. Journal of Rheumatology, 19, 378-384.
- [43] Andriacchi, T.P. and Mundermann, A. (2006) The role of ambulatory mechanics in the initiation and progression of knee osteoarthritis. Current Opinion Rheumatology, 18, 514-518. doi:10.1097/01.bor.0000240365.16842.4e
- [44] Cicuttini, F.M., Baker, J.R. and Spector, T.D. (1996) The association of obesity with osteoarthritis of the hand and knee in women: A twin study. Journal Rheumatology, 23, 1221-1226.
- [45] Manek, N.J., Hart, D., Spector, T.D. and MacGregor, A.J. (2003) The association of body mass index and osteoarthritis of the knee joint: An examination of genetic and environmental influences. Arthritis Rheumatology, 48, 1024-1029. doi:10.1002/art.10884
- [46] Cimen, O.B., Incel, N.A., Yapici, Y., Apaydin, D. and Erdogan, C. (2004) Obesity related measurements and joint space width in patients with knee osteoarthritis. Journal of Medicine and Science, 109, 159-164.
- [47] Spector, T.D., Hart, D.J. and Doyle, D.V. (1994) Incidence and progression of osteoarthritis in women with unilateral knee disease in the general population: The effect of obesity. Annual Rheumatology Disease, 53, 565- 568. doi:10.1136/ard.53.9.565
- [48] Szoere, C., Dennerstein, L., Guthrie, J., Clark, M. and Cicuttini, F. (2006) The relationship between prospectively assessed body weight and physical activity and prevalence of radiological knee osteoarthritis in post-menopausal women. Journal of Rheumatology, 33, 1835- 1840.

- [49] Sharma, L., Lou, C., Cahue, S. and Dunlop, D.D. (2004) The mechanism of the effect of obesity in knee osteoarthritis: The mediating role of malalignment. *Arthritis Rheumatology*, 43, 568-575. doi:10.1002/1529-0131(200003)43:3<568::AID-ANR13>3.0.CO;2-E
- [50] Felson, D.T., Goggins, J., Niu, J., Zhang, Y. and Hunter, D.J. (2004) The effect of body weight on progression of knee osteoarthritis is dependent on alignment. *Arthritis Rheumatology*, 50, 3904-3909. doi:10.1002/art.20726
- [51] Jordan, J.M., Luta, G., Stabler, T., Renner, J.B., Dragomir, A.D. and Vilim, V. (2003) Ethnic and sex differences in serum levels of cartilage oligomeric matrix protein: The Johnston County Osteoarthritis Project. *Arthritis Rheumatology*, 48, 675-681.
- [52] Mouritzen, U., Christgau, S., Lehmann, H.J., Tanko, L.B. and Christiansen, C. (2003) Cartilage turnover assessed with a newly developed assay measuring collagen type II degradation products: influence of age, sex, menopause, hormone replacement therapy, and body mass index. *Annual Rheumatology Disease*, 62, 332-336. doi:10.1136/ard.62.4.332
- [53] Ding, C., Cicuttini, F., Scott, F., Cooley, H. and Jones, G. (2005) Knee structural alteration and BMI: A cross-sectional study. *Obesity Research*, 13, 350-361. doi:10.1038/oby.2005.47
- [54] Majithia, V. and Geraci, S.A. (2007) Rheumatoid arthritis: Diagnosis and management. *American Journal of Medicine*, 120, 936-939. doi:10.1016/j.amjmed.2007.04.005
- [55] Alamanos, Y., Voulgari, P.V. and Drosos, A.A. (2005) Incidence and prevalence of rheumatoid arthritis, based on the 1987 American College of Rheumatology Criteria: A systematic review. *Arthritis Rheumatology*, 36, 182-188.
- [56] Lee, D.M. and Weinblatt, M.E. (2001) Rheumatoid arthritis. *Lancet*, 358, 903-911. doi:10.1016/S0140-6736(01)06075-5
- [57] Kobelt, G., Jonsson, L. and Lindgren, P. (2002) Modeling the progression of rheumatoid arthritis: A two country model to estimate costs and consequences of rheumatoid arthritis. *Arthritis Rheumatology*, 46, 2310-2319. doi:10.1002/art.10471
- [58] Malaviya, A.N., Kapoor, S.K. and Singh, R.R. (1993) Prevalence of rheumatoid arthritis in the adult Indian Population. *Rheumatology International*, 13, 131-134. doi:10.1007/BF00301258
- [59] Kumar, N., Singh, S., Patro, N. and Patro, I. (2009) Evaluation of protective efficacy of Spirulina platensis against collagen induced arthritis in rats. *Inflammopharmacology*, 17, 181-190. doi:10.1007/s10787-009-0004-1
- [60] Symmons, D.P. (2005) Looking back: Rheumatoid arthritis Etiology, occurrence and mortality. *Rheumatology*, 44, iv14-iv17. doi:10.1093/rheumatology/kei055
- [61] Symmons, D.P., Bankhead, C.R., Harrison, B.J., Brennan, P., Barrett, E.M. and Scott, D.G. (1997) Blood transfusion, smoking, and obesity as risk factors for the development of rheumatoid arthritis: Results from a primary care-based incident case-control study in Norfolk, England. *Arthritis Rheumatology*, 40, 1955-1961. doi:10.1002/art.1780401106
- [62] Voigt, L.F., Koepsell, T.D., Nelson, J.L., Dugowson, C.E. and Daling, J.R. (1994) Smoking, obesity, alcohol consumption, and the risk of rheumatoid arthritis. *Epidemiology*, 5, 525-532.
- [63] Escalante, A. and Haas, R.W. (2005) Paradoxical effect of body mass index on survival in rheumatoid arthritis: Role of comorbidity and systemic inflammation. *Arch Internal Medicine*, 165, 1624-1629. doi:10.1001/archinte.165.14.1624
- [64] Perrot, S., Dickenson, A.H. and Bennett, R.M. (2008) Fibromyalgia: Harmonizing science with clinical practice considerations. *Pain Practice*, 8, 177-189. doi:10.1111/j.1533-2500.2008.00190.x
- [65] Lawrence, R.C., Felson, D.T., Helmick, C.G., Arnold, L.M., Choi, H., Deyo, R.A., Gabriel, S., Hirsch, R., Hochberg, M.C., Hunder, G.G., Jordan, J.M., Katz, J.N., Kremers, H.M. and Wolfe, F. (2008) Estimates of the prevalence of arthritis and other rheumatic conditions in the United States, part II. *Arthritis Rheumatology*, 58, 26-35. doi:10.1002/art.23176
- [66] Marcus, D.A. (2009) Fibromyalgia diagnosis and treatment options. *Gender Medicine*, 2, 139-151. doi:10.1016/j.genm.2009.01.004
- [67] Williams, D.A. and Clauw, D.J. (2009) Understanding fibromyalgia: Lessons from the broader pain research community. *Journal of Pain*, 10, 777-791. doi:10.1016/j.jpain.2009.06.001

- [68] Thompson, D., Lettich, L. and Takeshita, J. (2003) Fibromyalgia: An overview. Current Psychiatry Report, 5, 211-217. doi:10.1007/s11920-003-0045-x
- [69] Shapiro, J.R., Anderson, D.A. and Danoff-Burg, S. (2005) A pilot study of the effects of behavioral weight loss treatment on fibromyalgia symptoms. Journal Psycho-somatic Research, 59, 275-282.
- [70] Moskowitz, R.W. (2001) Musculoskeletal findings in obese subjects before and after weight loss following bariatric surgery. International Journal of Obesity, 31, 114-120
- [71] Bonjour, J.P., Theintz, G., Buchs, B., Slosman, D. and Rizzoli, R. (1991) Critical years and stages of puberty for spinal and femoral bone mass accumulation during adolescence. Journal of Clinical Endocrinology and Metabolism, 73, 555-563. doi:10.1210/jcem-73-3-555
- [72] Theintz, G., Buchs, B., Rizzoli, R., Slosman, D., Clavien, H., Sizonenko, P.C. and Bonjour J.P. (1992) Longitudinal monitoring of bone mass accumulation in healthy adolescents: Evidence for a marked reduction after 16 years of age at the levels of lumbar spine and femoral neck in female subjects. Journal of Clinical Endocrinology and Metabolism, 75, 1060-1065. doi:10.1210/jc.75.4.1060
- [73] Nguyen, T.V., Kelly, P.J., Sambrook, P.N., Gilbert, C., Pocock, N.A. and Eisman, J.A. (1994) Lifestyle factors and bone density in the elderly: implications for osteoporosis prevention. Journal of Bone Miner Research, 9, 1339-1346. doi:10.1002/jbmr.5650090904
- [74] Bauer, D.C., Browner, W.S., Cauley, J.A., Orwoll, E.S., Scott, J.C. and Black, D.M. (1993) Factors associated with appendicular bone mass in older women. The Study of Osteoporotic Fractures Research Group. Annual International Medicine, 118, 657-665.
- [75] Kroger, H., Tuppurainen, M., Honkanen, R., Alhava, E. and Saarikoski, S. (1994) Bone mineral density and risk factors for osteoporosis population-based study of 1600 perimenopausal women. Calcified Tissue International, 55, 1-7. doi:10.1007/BF00310160
- [76] Pluijm, S.M., Visser, M., Smit, J.H., Popp-Snijders, C., Roos, J.C. and Lips, P. (2001) Determinants of bone mineral density in older men and women: body composition as mediator. Journal of Bone Miner Research, 16, 2142-2151. doi:10.1359/jbmr.2001.16.11.2142
- [77] Felson, D.T., Zhang, Y., Hannan, M.T. and Anderson, J.J. (1988) Effects of weight and body mass index on bone mineral density in men and women: The Framingham study. Journal Bone Miner Research, 8, 567-573. doi:10.1002/jbmr.5650080507
- [78] Edelstein, S.L. and Barrett-Connor, E. (1993) Relation between body size and bone mineral density in elderly men and women. American Journal of Epidemiology, 138, 160-169.
- [79] Liel, Y., Edwards, J., Shary, J., Spicer, K.M., Gordon, L. and Bell, N.H. (1988) The effects of race and body habitus on bone mineral density of the radius, hip, and spine in premenopausal women. Journal of Clinical Endocrinology Metabolism, 66, 1247-1250. doi:10.1210/jcem-66-6-1247
- [80] Halioua, L. and Anderson, J.J. (1990) Age and anthropometric determinants of radial bone mass in premenopausal Caucasian women: A cross-sectional study. Calcified Tissue International, 11, 50-55. doi:10.1007/BF01880416
- [81] Dawson-Hughes, B., Shipp, C., Sadowski, L. and Dallal, G. (1987) Bone density of the radius, spine, and hip in relation to percent of ideal body weight in postmenopausal women. Calcified Tissue International, 40, 310-314. doi:10.1007/BF02556691
- [82] Ribot, C., Tremolieres, F., Pouilles, J.M., Louvet, J.P. and Guiraud, R. (1988) Influence of the menopause and aging on spinal density in French women. Bone Miner, 5, 89-97. doi:10.1016/0169-6009(88)90009-8
- [83] Riedt, C.S., Cifuentes, M., Stahl, T., Chowdhury, H.A., Schlussel, Y. and Shapses, S.A. (2005) Overweight post-menopausal women lose bone with moderate weight reduction and 1 g/day calcium intake. Journal Bone Miner Research, 20, 455-463. doi:10.1359/JBMR.041132
- [84] Villareal, D.T., Fontana, L., Weiss, E.P., Racette, S.B., Steger-May, K. and Schechtman, K.B. (2006) Bone mineral density response to caloric restriction-induced weight loss or exercise-induced weight loss: A randomized controlled trial. Archive International Medicine, 166, 2502-2510. doi:10.1001/archinte.166.22.2502
- [85] Hogan, S.L. (2005) The effects of weight loss on calcium and bone. Critical Care Nurses, 28, 269-275.
- [86] Terkeltaub, R.A. (2003) Clinical practice. Gout—The New England Journal of Medicine, 349, 1647-

- [87] Schlesinger, N. and Schumacher Jr., H.R. (2001) Gout: Can management be improved? *Current Opinion Rheumatology*, 13, 240-244. doi:10.1097/00002281-200105000-00016
- [88] Kramer, H.M. and Curhan, G. (2002) The association between gout and nephrolithiasis: The National Health and Nutrition Examination Survey III, 1988-1994. *American Journal of Kidney Disease*, 40, 37-42.
- [89] Arromdee, E., Michet, C.J., Crowson, C.S., O' Fallon, W.M. and Gabriel S.E. (2002) Epidemiology of gout: Is the incidence rising? *Journal of Rheumatology*, 29, 2403- 2406.
- [90] Saag, K.G. and Choi, H. (2006) Epidemiology, risk factors, and lifestyle modifications for gout. *Arthritis Research & Therapy*, 8, S2. doi:10.1186/ar1907
- [91] Roubenoff, R., Klag, M.J., Mead, L.A., Liang, K.Y., Seidler, A.J. and Hochberg, M.C. (1991) Incidence and risk factors for gout in white men. *JAMA*, 266, 3004- 3007. doi:10.1001/jama.1991.03470210072035
- [92] Takahashi, S., Yamamoto, T., Tsutsumi, Z., Moriwaki, Y., Yamakita, J. and Higashino, K. (1997) Close correlation between visceral fat accumulation and uric acid metabolism in healthy men. *Metabolism*, 46, 1162-1165. doi:10.1016/S0026-0495(97)90210-9
- [93] Atkinson, M. and Maclaren, N. (1994) The pathogenesis of insulin-dependent diabetes mellitus. *Natural England Journal of Medicine*, 331, 1428-1436. doi:10.1056/NEJM199411243312107
- [94] DeFronzo, R.A., Bonadonna, R.C. and Ferannini, E. (1992) Pathogenesis of NIDDM: A balanced overview. *Diabetes Care*, 15, 318-368. doi:10.2337/diacare.15.3.318
- [95] Magnusson, I., Rothman, D.L., Katz, L.D., Shulman, R.G. and Shulman, G.I. (1992) Increased rate of gluconeogenesis in type II diabetes mellitus. A <sup>13</sup>C nuclear magnetic resonance study. *Journal of Clinical Investigation*, 90, 1323-1327. doi:10.1172/JCI115997
- [96] Shah, P., Vella, A., Basu, A., Basu, R., Schwenk, W.F. and Rizza, R.A. (2000) Lack of suppression of glucagon contributes to postprandial hyperglycemia in subjects with type 2 diabetes mellitus. *Journal of Clinical Endocrinology Metabolism*, 85, 4053-4059. doi:10.1210/jc.85.11.4053
- [97] Ali, Y.S., Linton, M.F. and Fazio, S. (2008) Targeting cardiovascular risk in patients with diabetes: Management of dyslipidemia. *Current Opinion in Endocrinology, Diabetes and Obesity*, 2, 142-146. doi:10.1097/MED.0b013e3282f5ff98
- [98] Xie, W., Xing, D. and Zhao, Y. (2005) A new tactic to treat postprandial hyperlipidemia in diabetic rats with gastroparesis by improving gastrointestinal transit. *Euro- pion Journal of Pharmacology*, 510, 113-120.
- [99] Xie, W. and Du, L. (2005) High-cholesterol diets impair short-term retention of memory in alloxan-induced diabetic mice, but not acquisition of memory nor retention of memory in prediabetic mice. *Life Science*, 77, 481-495. doi:10.1016/j.lfs.2004.08.044
- [100] Xie, W.D., Nie, Y., Du, L.J., Zhang, Y.O. and Cai, G.P. (2007) Preventive effects of fenofibrate and vitamin C on the development of type 2 diabetes and its complications in NIH mice induced by small-dose streptozotocin and lard. *Pharmacology Research*, 55, 392-399. doi:10.1016/j.phrs.2007.01.014
- [101] Zimmet, P., Alberti, K.G.M.M. and Shaw, J. (2001) Global and societal implications of the diabetes epidem- ics. *Nature*, 414, 782-787. doi:10.1038/414782a
- [102] Pandey, R., Kumar, N., Yadav, M., Nagpal, R., Jain, S. and Yadav, H. (2013) Anti-diabetic compounds and their patent information: An update. *Recent Patents on In- flammation & Allergy Drug Discovery*, in Press. doi:10.2174/187221313804004745
- [103] Knowler, W.C., Barrett-Connor, E. and Fowler, S.E. (2002) Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with life-style intervention or metformin. *England Journal of Medicine*, 346, 393-403.
- [104] Scarvell, J. and Elkins, M.R. (2011) Aerobic exercise is beneficial for people with rheumatoid arthritis. *Brazilians Journal of Sports Medicine*, 45, 1008-1009. doi:10.1136/bjsports-2011-090388
- [105] Batterham, S.I., Heywood, S. and Keating, J.L. (2011) Systematic review and meta-analysis comparing land and aquatic exercise for people with hip or knee arthritis on function, mobility and other health outcomes. *BMC Musculoskeleton Disorder*, 12, 123. doi:10.1186/1471-2474-12-123

- [106] Soni, A. (2011) Top 10 most costly conditions among men and women, 2008: Estimates for the US civilian non-institutionalized adult population, age 18 and older. [http://www.meps.ahrq.gov/mepsweb/data\\_files/publications/st331/stat331.pdf](http://www.meps.ahrq.gov/mepsweb/data_files/publications/st331/stat331.pdf).
- [107] Cowie, C.C., Rust, K.F. and Ford, E.S. (2009) Full accounting of diabetes and pre-diabetes in the US population in 1988-1994 and 2005-2006. *Diabetes Care*, 32, 287- 294. doi:10.2337/dc08-1296
- [108] Centers for Disease Control and Prevention (CDC) (2008) Arthritis as a potential barrier to physical activity among adults with diabetes-United States, 2005 and 2007. *Morbidity and Mortality Weekly Report*, 57, 486-489
- [109] Centers for Disease Control and Prevention (CDC) (2007) National and state medical expenditures and lost earnings attributable to arthritis and other rheumatic conditions-United States, 2003. *Morbidity and Mortality Weekly Report*, 56, 4-7.
- [110] Centers for Disease Control and Prevention (CDC) (2011) Prevalence of doctor-diagnosed arthritis and arthritis-attributable effects among Hispanic adults, by Hispanic subgroup-United States, 2002, 2003, 2006, and 2009. *Morbidity and Mortality Weekly Report*, 60, 167-171.
- [111] Nolan, C.J., Damm, P. and Prentki, M. (2008) Type 2 diabetes across generations: From pathophysiology to prevention and management. *Lancet*, 378, 169-181. doi:10.1016/S0140-6736(11)60614-4
- [112] Murphy, L., Schwartz, T.A. and Helmick, C.G. (2008) Lifetime risk of symptomatic knee osteoarthritis. *Arthritis Rheumatology*, 59, 1207-1213. doi:10.1002/art.24021
- [113] Furtner, S.E., Hootman, J.M., Helmick, C.G., Bolen, J. and Zack, M.M. (2011) Health-related quality of life of US adults with arthritis: Analysis of data from the behavioral risk factor surveillance system, 2003, 2005, and 2007. *Arthritis Care Research*, Hoboken.
- [114] Chenge, Y.J., Imperatore, G., Caspersen, C.J., Gregg, E.W., Albright, A.L. and Helmick, C.G. (2011) Prevalence of diagnosed arthritis and arthritis-attributable activity limitation among adults with and without diagnosed diabetes: United States, 2008-2010. *Diabetes Care*, 8, 1686-1691.
- [115] Susan, F.K. and Simon, L. (1994) Joint and bone manifestations of diabetes mellitus in Joslin's Diabetes Mellitus. In: Ronald, K.C. and Weir, G.C., Eds., 13th Edition, Lea & Febiger, Philadelphia, 912-917.
- [116] Jung, Y., Hohmann, T.C. and Gerneth, J.A. (1998) Diabetic hand syndrome. *Metabolism*, 20, 1008-1015. doi:10.1016/0026-0495(71)90023-0
- [117] Grgic, A., Rosenbloom, A.L. and Weber, F.T. (1976) Joint contractures common manifestation of childhood diabetes mellitus. *Journal of Pediatrics*, 88, 584-588. doi:10.1016/S0022-3476(76)80011-X
- [118] Kapoor, A. and Sibbitt Jr., W.L. (1980) Contractures in diabetes mellitus: The syndrome of limited joint mobility. *Arthritis Rheumatology*, 18, 168-180.
- [119] Rosenbloom, A.L., Silverstein, J.H. and Lezotte D.C. (1981) Limited joint mobility in childhood diabetes mellitus indicates increased risk for microvascular disease. *England Journal of Medicine*, 305, 191-194. doi:10.1056/NEJM198107233050403
- [120] Steinbrocker, O. (1947) The shoulder-hand syndrome: Associated painful ho-molateral disability of the shoulder and hand with swelling and atrophy of the hand. *American Journal of Medicine*, 3, 402-407. doi:10.1016/0002-9343(47)90170-8
- [121] Steinbrocker, O. and Argyros, T.G. (1958) The shoulder-hand syndrome: Present status as a diagnostic and therapeutic entity. *Medicine Clinical North America*, 42, 1533- 1553.
- [122] Crisp, A.J. and Heathcoate, J.G. (1984) Connective tissue abnormalities in diabetes mellitus. *Journal of the Royal College of Physicians*, 18, 132-141.
- [123] Gray, R.G. and Gottlieb, N.L. (1976) Rheumatic disorders associated with diabetes mellitus: Literature review. *Arthritis Rheumatology*, 6, 19-34.
- [124] Holt, P.J.L. (1981) Rheumatological manifestations of diabetes mellitus. *Clinical Rheumatology Disease*, 7, 723- 746.
- [125] Solomon, D.H., Love, T.J., Canning, C. and Schneeweiss S. (2010) Risk of diabetes among patients with rheumatoid arthritis, psoriatic arthritis and psoriasis. *Annual Rheumatology Disease*, 69, 2114-

- [126] Han, C., Robinson, D.W. and Hackett, M.V. (2006) Cardiovascular disease and risk factors in patients with rheumatoid arthritis, psoriatic arthritis, and ankylosing spondylitis. *Journal of Rheumatology*, 33, 2167-2172.
- [127] Rincon, I.D., Williams, K., Stern, M.P., Freeman, G.L. and Escalante, A. (2001) High incidence of cardiovascular events in a rheumatoid arthritis cohort not explained by traditional cardiac risk factors. *Arthritis Rheumatology*, 44, 2737-2745. doi:10.1002/1529-0131(200112)44:12<2737::AID-ART460>3.0.CO;2-#
- [128] Chung, C.P., Oeser, A. and Solus, J.F. (2008) Prevalence of the metabolic syndrome is increased in rheumatoid arthritis and is associated with coronary atherosclerosis. *Atherosclerosis*, 196, 756-763. doi:10.1016/j.atherosclerosis.2007.01.004
- [129] Dessein, P.H., Joffe, B.I. and Stanwix, A.E. (2002) Effects of disease modifying agents and dietary intervention on insulin resistance and dyslipidemia in inflammatory arthritis: A pilot study. *Arthritis Research*, 4, 12-21. doi:10.1186/ar597
- [130] Simard, J.F. and Mittleman, M.A. (2007) Prevalent rheumatoid arthritis and diabetes among NHANES III participants aged 60 and older. *Journal of Rheumatology*, 34, 469-473.
- [131] Liao, K.P., Gunnarsson, M. and Kallberg, H. (2009) Specific association of type 1 diabetes mellitus with anticyclic citrullinated peptide-positive rheumatoid arthritis. *Arthritis Rheumatology*, 60, 653-660. doi:10.1002/art.24362
- [132] Harris, M.I., Flegal, K.M., Cowie, C.C., Eberhardt, M.S., Goldstein, D.E., Little, R.R., Wiedmeyer, H.M., Byrd-Holt, D.D. (1998) Prevalence of diabetes, impaired fasting glucose, and impaired glucose tolerance in US adults: The Third National Health and Examination Survey, 1988-1994. *Diabetes Care*, 21, 518-524. doi:10.2337/diacare.21.4.518
- [133] Boyle, J.P., Honeycutt, A.A., Narayan, K.M., Hoerger, T.J., Geiss, L.S., Chen, H. and Thompson, T.J.